Oct — R. L. Olson

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U. S. Bureau of reclamation

PROBLEMS OF IMPERIAL VALLEY AND VICINITY

4

LETTER FROM THE SECRETARY OF THE INTERIOR

TRANSMITTING

PURSUANT TO LAW A REPORT BY THE DIRECTOR OF THE RECLAMATION SERVICE ON PROBLEMS OF IMPERIAL VALLEY AND VICINITY WITH RESPECT TO IRRIGATION FROM THE COLORADO RIVER

TOGETHER WITH

THE PROCEEDINGS OF THE CONFERENCE ON THE CONSTRUCTION OF THE BOULDER CANYON DAM HELD AT SAN DIEGO, CALIF.

FEBRUARY 23 (calendar day, MARCH 1), 1922.—Referred to the Committee on Irrigation and Reclamation

MARCH 9 (calendar day, MARCH 13), 1922.—Maps and illustrations ordered printed

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

SUBMITTED BY MR. JOHNSON.

IN THE SENATE OF THE UNITED STATES,
February 23 (calendar day, March 3), 1922.

Ordered, That the part of the report of the Secretary of the Interior relative to the irrigation of the Imperial Valley, California, transmitted to the Senate on the 1st instant, dealing with the conference held at the U. S. Grant Hotel, San Diego, Calif., December 12, 1921, concerning the construction of the Boulder Canyon Dam, be printed as a Senate document.

Attest:

GEORGE A. SANDERSON,
Secretary.

By H. M. ROSE,
Assistant Secretary.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
Washington, February 28, 1922.

The PRESIDENT OF THE SENATE.

SIR: Section 1 of the act of Congress approved May 18, 1920 (41 Stat., 600), authorized and directed the Secretary of the Interior to have studies made of Imperial Valley, Calif., and related subjects with respect to irrigation from the Colorado River. Section 2 of the act required the Secretary to report to Congress the result of such examination not later than December 6, 1920. On that day a report was accordingly transmitted by letter from Secretary Payne in which the following statement was made:

> Because of the limited time since the passage of the act, further restricted by the regular high-water period of the river, the investigations begun have not been completed. The studies will be continued as rapidly as the physical conditions and available funds permit, and their results will be forwarded to Congress as promptly as possible.

I now have the honor to send herewith the more complete report by the Director of the Reclamation Service contemplated by the foregoing language. The submission of this report has been greatly delayed not only by the physical limitations but by human considerations. Section 4 of the act required the Secretary of the Interior to report, among other things, "what assurances he has been able to secure as to the approval of, participation in, and contribution to the plan or plans proposed by the various contributing agencies."

It followed from this language that the nature of the report to be submitted depended on the attitude of the various local communities interested, and to determine that attitude it was necessary to refer to or discuss with them the report to be made. That was first done by correspondence and at meetings with their representatives held in this city, following which the report was placed in my hands last July. However, the same day that I received it I received also a telegram from one of the local communities asking further delay and discussion before submission of a report to Congress. In order to secure as near as might be unanimity of those involved, the report was held for further discussion and consideration. This continued by correspondence, wide publicity in the local press, and extended discussions in various meetings in the Southwest. Finally, I personally proceeded to San Diego, Calif., where on December 12, 1921, I held an open hearing on the subject, so that everyone interested might have an opportunity to express his views.

The result has been virtual unanimity regarding the desirability of constructing the large project outlined in the report. This general agreement is well illustrated by the discussion at San Diego. This was stenographically reported, and for the information of Congress I am sending herewith the transcript of that hearing, in which will be found not only the oral testimony of the numerous representatives at the San Diego meeting but various formal expressions from some of the southwestern communities interested in this project.

The act of May 18, 1920, requires from the Secretary of the Interior not only a report but recommendations on various points, all of which are treated in the report sent herewith. The findings and recommendations (p. 21) included in the report have my hearty concurrence and approval. I earnestly hope that the report will be favorably received and acted upon by Congress. As a first step in that direction, it is hoped the report may be printed because of the wide and intense interest in the great interstate and international project with which it deals.

Respectfully,

ALBERT B. FALL, *Secretary.*

PLATE I.

Sheridan
Yellowstone L.
Boise
Pocatello
Lander
W Y O M I N G
Bear L.
Green River
FLAMING GORGE RES. SITE
Ogden
Cheyenne
Salt Lake City
JUNIPER RES. SITE
Utah L.
Denver
N E V A D A
Eureka
U T A H
Grand Junction
Sevier L.
DEWEY RES. SITE
C O L O R A D O
Pueblo
Trinidad
St. George
San Juan R.
BOULDER CANYON RES. SITE
Las Vegas
Santa Fe
Gallup
Albuquerque
COLORADO RIVER
Little Colorado River
Prescott
A R I Z O N A
N E W M E X I C O
CALIF.
Rio Grande
Phoenix
Gila River
Yuma
Tucson
El Paso
Nogales
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COLORADO RIVER BASIN
SCALE OF MILES
50 0 50 100 200

LETTER OF SUBMITTAL.

Department of the Interior,
United States Reclamation Service,
Washington, D. C., February 4, 1922.

The Secretary of the Interior.

Sir: Transmitted herewith is report on the problems of the Lower Colorado Basin, required by the act of Congress approved May 18, 1920, entitled "An act to provide for an examination and report on the condition and possible irrigation development of the Imperial Valley in California." (41 Stat., 600.)

This report supersedes the preliminary report transmitted to you on November 27, 1920, in which it was stated that further report would be made.

The study of the Colorado River Basin from the standpoint of its use in irrigation and otherwise may be said to have begun by the establishment of stations for the measurement of stream discharge in various parts of the basin in 1894 and 1895 by the United States Geological Survey. One of these stations was established at Yuma, Ariz., to intercept and measure the discharge of the entire stream, there being no tributaries below this point. It was found that gage-height readings had been kept for a considerable period by the Southern Pacific Railroad Co. at Yuma, and these were utilized so far as possible, but the shifting nature of the channel made their use of doubtful value and also to a considerable extent vitiated the records kept at Yuma by the Geological Survey for the first few years.

After the passage of the reclamation act in 1902 the Reclamation Service took up the systematic study of the lower river, provided for more frequent and systematic gagings at Yuma and other points, and made a topographic survey of the lower valleys of the Colorado River from Bulls Head to the Mexican boundary. The investigations were continued particularly as regards stream measurements and the survey of reservoir sites and borings at the necessary dams. In the stream-measurement work substantial cooperation was extended by the Geological Survey and the results were assembled in the publications of that bureau from time to time, particularly in Water Supply Paper No. 395, by E. C. La Rue.

A more intensive study of the entire basin was inaugurated in 1914 by a special allotment of $50,000 for this purpose, supplemented by annual allotments in subsequent years, and this work was finally assembled in three large volumes of manuscript by Mr. John T. Whistler. It included a reconnaissance of practically all of the proposed reservoir sites and irrigation projects in the basin above the Arizona line and the compilation of all existing data including the water filings and water rights throughout the basin. The study did not stop with the rendition of Mr. Whistler's report, but was transferred to the lower basin, where the topographic survey of the basin was continued up the river from Bulls Head and a detailed survey made of the proposed reservoir site at and above Boulder Canyon.

This report has drawn freely upon all previous investigations so far as necessary and applicable to the solution of the problems of the lower valley, as required in the act authorizing the report.

The investigations for this report have been under the direction of Mr. F. E. Weymouth, the chief engineer of this service, and the detailed studies very largely are the work of Mr. Harold Conkling. Acknowledgments are also due to Mr. C. A. Bissell, engineer, who has made supplemental studies and assisted in arranging and editing the report.

Respectfully,

A. P. Davis, *Director.*

PROBLEMS OF IMPERIAL VALLEY AND VICINITY.

The control of the floods and development of the resources of the Colorado River are peculiarly national problems for several good reasons:

1. The Colorado River is international.
2. The stream and many of its tributaries are interstate.
3. It is a navigable river.
4. Its waters may be made to serve large areas of public lands naturally desert in character.
5. Its problems are of such magnitude as to be beyond the reach of other than national solution.

That these problems are national in character, scope, and magnitude was recognized by the act of Congress approved May 18, 1920, entitled, "An act to provide for an examination and report on the condition and possible irrigation development of the Imperial Valley in California," which forms the authority for this report.

A broad consideration of the various problems of the Imperial Valley and of the lands "which can be irrigated at a reasonable cost from known sources of water supply by diversion of water from the Colorado River at Laguna Dam," as required by the act under which this report is made, involves a comprehensive study of the entire Colorado Basin, which the law recognized in section 3, where report was required upon "the effect on the irrigation development of the other sections or localities * * *."

This report will, therefore, include a general review of the conditions and water resources of the entire Colorado Basin.

To make the report complete, data were required on five principal lines:

1. Quantity and regularity of water supply for irrigation.
2. Protection from the floods of Colorado River.
3. Storage facilities available.
4. Available land for irrigation.
5. Canal systems required to serve these lands.

The water supply of the Colorado Basin has been measured at various points for many years, and a large number of gaging stations in different parts of the basin has been maintained for varying periods. The measurements have mostly been made by the Geological Survey, but some of them have been conducted by the Reclamation Service and some by the interested States. So far as available and pertinent they are condensed in this report and are an essential part thereof.

PHYSIOGRAPHIC FEATURES.

The Colorado River is formed by the junction of the Grand [1] and Green Rivers in southeastern Utah. The Grand, which by reason of its volume may be considered the upper continuation of the main

[1] Recent action of the United States and of Colorado and Utah has changed the name from "Grand" to "Colorado."

stream and is also in an approximate alignment therewith, rises in northeastern Colorado and has a length above its junction of about 450 miles. Its principal tributaries are Frazer, Blue, Eagle, Williams, and Roaring Forks, and the Gunnison River.

The Green is the longest branch, rises in the Wind River mountains of Wyoming, flows in a southerly direction into Utah, and then turns eastward flowing into Colorado and back into Utah, and has a length of about 700 miles from its source to its mouth at the junction with the Grand. Its principal tributaries are Blacks Fork, Henrys Fork, Yampa River, Ashely Creek, Duchesne River, White River, Minnie Maud Creek, Price River, and San Rafael River.

The length of the Colorado from the junction of the Green and the Grand to the Gulf of California is about 1,050 miles, thus making, with the continuation of the Green, 1,750 miles total length. Below the junction with the Green it flows southwesterly into Arizona across the northwest corner of that State, then turning south forms the boundary between Arizona on the east and Nevada, California, and Mexico on the west, reaching the Gulf of California about 120 miles below Yuma.

The drainage area of the Colorado River is 244,000 square miles, distributed as shown in the following table:

TABLE NO. 1.—*Average discharges of principal tributaries.*

	Per cent of total discharge.	Discharge in acre-feet.	Square miles.	Per cent of total area.	Acre-feet per square mile.
Green River	32	5,510,000	44,000	18	125
Upper Colorado (Grand River)	40	6,940,000	26,000	10	267
San Juan River	14	2,700,000	26,000	10	104
Other areas except Gila	8	1,560,000	91,000	39	16
Gila	6	1,070,000	57,000	23	19
Total	100	17,780,000	244,000	100	70

The water supply from the various branches is also shown in this table and is by no means in proportion to the area drained, the discrepancy being due to the wide diversity of climatic and topographic conditions.

The rim of the basin whence the streams take their sources is composed largely of high mountain ranges. On the north and east the Wind River Mountains and the ranges of the Continental Divide are the highest and furnish the greatest water supply. This is especially true of the Rocky Mountains in north central Colorado, and for this reason the run-off from that region is far greater in proportion to area than that of any other part of the basin.

The lower third of the basin is composed mainly of hot, arid plains of low altitude, broken here and there by occasional short mountain groups or ranges reaching elevations of 3,000 to 6,000 feet. The central portion of the basin is a high plateau, through which the streams have cut narrow canyons, often of great depth. Every tributary through this region is in canyon, so that much of the central and upper part of the basin is traversed by deep gorges and is exceedingly rough. At its mouth the river has built up a great delta from the materials eroded in the canyons described and has by this means encroached upon the Gulf of California at its mouth, and finally cut off the upper end of this gulf entirely. The isolated portion, forming a deep depression below sea level, is known as the Salton Basin and includes the Imperial Valley, of great extent and remarkable fertility, with a saline lake in the bottom, known as Salton Sea.

The area of the drainage basin of the Colorado River, of approximately 244,000 square miles, is divided among the political divisions as follows:

TABLE No. 2.—*Drainage basin area by States.*

	Square miles.
Wyoming	19,000
Colorado	39,000
New Mexico	23,000
Arizona	103,000
Utah	40,000
Nevada	12,000
California	6,000
Area in United States	242,000
Area in Mexico	2,000
Total	244,000

Some of the areas in Arizona and California are very indefinite, owing to the absence of definite topographic divides, and the contributions of water from California and Mexico are negligible. The volume of contributory water from the different States, while not separately measured, is in the following order: Colorado, Utah, Wyoming, New Mexico, Arizona, Nevada, Mexico, and California.

The various branches of the Colorado drain the following areas:

TABLE No. 3.—*Drainage basin area by stream basins.*

	Square miles.
Green River	44,000
Upper Colorado (or Grand River)	26,000
San Juan River	26,000
Fremont River	4,600
Paria	1,400
Escalante	1,800
Kanab	2,200
Little Colorado	26,000
Virgin	11,000
Miscellaneous	44,000
Gila	57,000
Total	244,000
Area including San Juan and all above	108,000
Above Boulder Canyon and below mouth of San Juan	53,000
Below Boulder Canyon and above Gila	24,000
Gila River Basin	57,000
Total	242,000

SILT DEPOSIT DATA.

The Colorado River and most of its tributaries have been for many centuries, and still are, eroding their beds and banks and carrying large quantities of sediment a part of which is deposited on the alluvial valleys during periods of overflow, and part reaches the Gulf of California where it is continually extending and enlarging its delta.

Observations of silt carried have been taken periodically at Yuma just below the mouth of the Gila River for a long series of years and show an average annual amount by volume of 113,000 acre-feet, on the assumption that 85 pounds of dry matter is equivalent to a cubic foot of solid. Most of the time the Gila River is nearly dry and the little water it discharges is clear. The observations at Yuma, therefore, indicate the silt traveling at that time in the Colorado above the Gila, and by difference at other times, the quantity discharged by the Gila during its relatively short high-water periods. Observations on the Gila have also been taken at Buttes above Florence and at San Carlos. A few observations have also been taken on the San Juan, the Green, and the Grand, but these are too few to be conclusive, and any statement concerning these streams must be considered as a very rough estimate. The following table shows the estimates on which this report is based:

TABLE No. 4.—*Silt content, main stream and tributaries.*

	Annual water.	Annual silt.	Per cent silt.
	Acre-feet.	*Acre-feet.*	
Colorado at Yuma	17,740,000	113,000	0.65
Gila	1,070,000	15,000	1.40
San Juan	2,700,000	29,000	1.07
Green	5,510,000	30,000	0.54
Grand	6,940,000	20,000	0.29
Other tributaries	1,560,000	19,000	1.22

The silt content of the Colorado, with the Gila not in flood, has averaged about 0.5 of 1 per cent, and this is fairly representative of the silt conditions at Boulder Canyon reservoir. The discharge at Boulder Canyon is estimated at 17,500,000 acre-feet annually. On this basis the average annual silt discharge is about 88,000 acre-feet per annum.

POWER POSSIBILITIES.

The development of the best reservoir sites on the main branches of the Colorado River, if used for irrigation in the lower basin, would affect the conditions of power development in their basins below, because the water would be regulated in accordance with the needs of irrigation rather than of power. The power possibilities which would be affected thereby are shown in the following table, which is expressed in horsepower, continuous output, 88 per cent efficiency at the turbines.

TABLE No. 5.—*Power possibilities.*

	Present.	After irrigation develops above.
Green River Basin:		
Yampa, below Juniper Reservoir	289,000	244,000
White, below Rangely Reservoir	24,000	16,000
Main stem, below Flaming Gorge Reservoir	1,080,000	729,000
Total, Green River Basin	1,393,000	989,000
Grand River Basin, below Dewey Reservoir	210,000	210,000
Colorado, exclusive of Grand Canyon Park	4,410,000	3,260,000
Total	6,013,000	3,459,000
In round figures	6,000,000	3,400,000

The above power developments would be further diminished by evaporation from the reservoirs built for power which would depend largely upon the plan of development.

It is believed to be possible to develop on the above streams approximately 3,000,000 continuous horsepower below the reservoirs after they are built without interfering with irrigation in the upper basin or entering the Grand Canyon Park if these reservoirs are not used for irrigation in the lower basin.

Any construction of reservoirs for irrigation above those mentioned in the above table would affect other additional power resources, but those mentioned are believed to be the most feasible, in an economic sense, upon their respective streams.

The Dewey Reservoir on the Grand is below any considerable feasible irrigation development on that river, but all the other reservoirs listed are above proposed irrigation projects and might, to some extent, affect them either beneficially or adversely in accordance with the plans under which the storage was developed and used.

URGENCY OF RELIEF.

In the valleys of the lower Colorado, and especially the Imperial Valley, storage is needed for the extension of irrigation and for safety against drouth of the areas already irrigated when the cycle of low years rolls around.

The need is also vital for protection from floods of the Colorado which threaten the levees along the river valley and which are a constant menace to the Imperial Valley, threatening a repetition of the experience of 1906. Both of these problems are urgent and vital.

The years 1902, 1903, 1915, and 1919 were years of low-water flow, the first two being shortly after the beginning of irrigation in the lower valleys and when the area irrigated was so small that no shortage occurred. In the year 1915 irrigation had proceeded to a substantial degree.

The records of the Imperial irrigation system show that for a considerable period in 1915 the waters of the Colorado River were all, or practically all, diverted at the intake of that canal and applied in irrigation of Imperial Valley, with the result that an actual shortage existed there part of the time. The shortage was not severe nor disastrous, but it had a value as indicating the actual state of the water supply in relation to use. The shortage would have been still greater had a period as low as that of 1902 and 1903 occurred at that time. This relation appears in the following table showing the annual discharge of the Colorado River at the Laguna Dam. It will be noted that 1915, when the first shortage occurred, was by no means the lowest year of record. A shortage also occurred in 1919, and the years 1902, 1903, and 1904 all show a less discharge than 1915.

TABLE No. 6.—*Discharge of Colorado at Laguna Dam.*

Year.	Acre-feet.	Per cent of mean.	Year.	Acre-feet.	Per cent of mean.
1899	21,700,000	132	1911	17,600,000	107
1900	16,800,000	102	1912	18,200,000	111
1901	15,200,000	93	1913	11,800,000	72
1902	9,110,000	56	1914	20,200,000	123
1903	11,300,000	69	1915	12,900,000	79
1904	9,890,000	60	1916	18,900,000	115
1905	16,000,000	98	1917	20,000,000	122
1906	17,700,000	108	1918	13,100,000	80
1907	24,800,000	151	1919	11,000,000	67
1908	12,600,000	77	1920	21,100,000	129
1909	25,400,000	155			
1910	14,200,000	87	Mean	16,400,000	....

Since 1915 there has been considerable improvement in the application of water in the Imperial Valley, but recent experience shows that storage is needed to supplement the low-water flow before any large irrigable areas can be added.

Since 1915 Imperial Valley has increased its irrigated area over 60,000 acres in the United States and about 150,000 acres in Mexico. The Imperial irrigation district contains more than 100,000 acres of irrigable land not yet irrigated and the same valley in Mexico can increase over 40,000 acres, and is in a physical position to take the necessary water from the Imperial Canal before it reaches the California line.

The Yuma project is increasing its irrigated area and has a recognized right to extend up to a limit of 120,000 acres.

The Palo Verde Valley has increased its irrigated area since 1915 by about 15,000 acres and is in physical position to increase this area up to 78,000 acres.

Two Government projects in Colorado taking water from the Colorado River drainage have increased their acreage since 1915 about 30,000 acres and have established rights by which these can be further increased by over 50,000 acres. In addition to the above, irrigation uses are increasing in the Uinta and Spanish Fork basins in Utah and at numerous other points in the upper Colorado Basin, most of which are small in amount, but which aggregate a considerable acreage and will reduce the water supply of the lower basin to a substantial degree. These may be taken as offsetting the improvements in duty of water in the Imperial Valley.

Assembling the more important of the known data, we have the following table showing increase over 1915:

TABLE NO. 7.—*Increases in irrigated area.*

Project.	Acres irrigated.		
	1915	1920	Ultimate.
Imperial district	336,000	415,000	515,000
Mexico	40,000	190,000	(?)
Yuma	28,000	54,000	120,000
Palo Verde	20,000	35,000	78,000
Grand Valley project	....	13,000	53,000
Uncompahgre project	50,000	70,000	110,000
Total	474,000	777,000	....

This table indicates that the increased irrigation in the basin in 1920 over 1915 is about 300,000 acres and that the desired expansion in the Imperial irrigation district and incontestible or unpreventable expansion in other regions will bring this acreage up to 877,000 acres, or about 400,000 acres more than in 1915, besides the various increases in the upper basin.

In addition to this, there are large areas in the Colorado River Reservation, the Mohave Valley, and at some other points where development has been undertaken, or is likely to be undertaken in the near future, which should be taken into account.

The above data are certainly convincing that no large area, such as the East Mesa lands and Coachella Valley, can be added to the irrigated acreage without certainty of water shortage, or if so added would constitute a serious menace to the water supply of the present irrigated lands in the Imperial and Yuma valleys unless a large amount of storage be provided.

For full development of all the lands that can be reached by gravity and reasonable pumping lifts on the Lower Colorado River large storage capacity will be required, estimated at about 6,000,000 acre-feet, if provided by a reservoir below the Grand Canyon of the Colorado. If storage is provided above the Canyon, this must be increased by at least 2,000,000 acre-feet on account of the unavoidable losses due to the impossibility of regulating the flow in exact accordance with the needs of irrigation from a reservoir so far distant, and for other reasons. This capacity can be somewhat reduced if the acreage be reduced by cutting off the more doubtful and less desirable areas which have been included.

To remove the menace of flood from the Colorado River will require a much larger storage capacity than that above given.

Owing to the gradual upbuilding of its deltaic bed and banks the flood menace from the Colorado River is an increasing and ever-recurring problem of great importance.

The Gulf of California formerly extended northwestward to a point a few miles above the town of Indio, about 144 miles from the present head of the gulf. The Colorado River, emptying into the gulf a short distance south of the present international boundary, carried its heavy load of silt into the gulf for centuries, gradually building up a great delta cone entirely across the gulf and cutting off its northern end, which remains as a great depression from which most of the water has been evaporated, leaving in its bottom the Salton Sea of 300 square miles, with its surface about 250 feet below sea level.

The river flowing over its delta cone steadily deposits silt in its channel and by overflow on its immediate banks, so that it gradually builds up its channel and its banks and forms a ridge growing higher and higher until the stream becomes so unstable that it breaks its banks in the high-water period and follows some other course. In this manner the stream has in past centuries swung back and forth over its delta, until this exists as a broad, flat ridge between the gulf and the Salton Sea, about 30 feet above sea level, and on the summit of this has formed a small lake, called Volcano Lake, into which the river flows at present, the water then finding its way to the southward into the gulf.

The direct distance from Andrade on the Colorado River, where it reaches Mexico, to the head of the gulf is about 75 miles, and the distance to the margin of Salton Sea is but little more. As the latter is about 250 feet lower than the gulf, the strong tendency to flow in that direction needs no demonstration. This, coupled with the inevitable necessity for such an alluvial stream to leave its channel at intervals, constitutes the menace of the lands lying about Salton Sea, called the Imperial Valley. As there is no escape of water from Salton Sea except by evaporation, the river flowing into this sea would, unless diverted, gradually fill it to sea level or above and submerge the cultivated land and the towns of Imperial Valley, nearly all of which are below sea level. Any flood waters that overflow the bank to the north must therefore without fail be restrained and not allowed to flow northward into Salton Sea. This is now prevented by a large levee, north of Volcano Lake, extending eastward and connecting with high land near Andrade. This levee is in Mexico and its maintenance is complicated thereby.

In 1905 the river scoured out the channel of the Imperial Canal and turned its entire volume into the Salton Basin, eroding a deep gorge and raising the level of Salton Sea. It submerged the salt works and forced the removal of the main line of the Southern Pacific Railroad. At great difficulty and expense, after several unsuccessful attempts, the river was returned to its old channel in February, 1907. The control of the river would be greatly facilitated if the floods were reduced in volume by storage. Investigations have been made concerning the feasibility of storing the floods and reducing their volume to an amount easily controlled.

The floods divide themselves naturally into two general classes—those from the Colorado River, which drains large areas in Wyoming, Colorado, New Mexico, Utah, and Arizona, and those from the Gila basin, which lies mostly in Arizona and partly in New Mexico and Mexico. While the area drained is much larger for the Colorado than for the Gila and the water supply vastly greater, the habits of flow are such that the Gila River, owing to its flashy character, sometimes furnishes flood waves at its mouth near Yuma almost as large as the maximum discharge of the Colorado at the same point. These floods from the Gila, however, are infrequent and of relatively short duration. While their sudden character and erratic occurrences make them peculiarly menacing to the levees or other property on the banks of the river, they do not present so great a menace to the Imperial Valley on account of their short duration and relatively small volume. The Colorado River rises gradually, carries a large volume of water for several weeks, and declines gradually. Should it break into the Imperial Valley at time of flood, the long duration of high water would cause great erosion and render its control exceedingly difficult. This is the experience actually obtained when this occurred. The Gila, on the other hand, might break into the Imperial Valley but the relatively short duration would not furnish nearly so much water to the Salton Sea, and consequently not incur the danger of submerging the entire valley. The quick decline would make its control comparatively easy. The great floods of the Gila occur in the winter, while those of the Colorado occur in summer. So far as known, they never have coincided; but if this ever should occur, it would greatly increase the menace.

A reservoir site of 2,200,000 acre-foot capacity has been investigated near Sentinel, on the lower Gila, which, if built and maintained, would practically eliminate the menace from the floods of the Gila, but the investigations show such poor conditions for foundation and abutments that the feasibility of this reservoir is subject to doubt.

The control of the Colorado River proper is, for the reasons above stated, the main element involved, and this has been investigated extensively.

Possible reservoir sites have been found on the Grand and the Green rivers, which, if constructed and operated for the purpose of flood protection, would greatly reduce the volume of the floods, for though the areas intercepted by each are small compared with the total area of the Colorado River Basin, they drain mountains with high precipitation that furnish a relatively large volume of water. A reservoir site also exists on the San Juan River, which is the next tributary of importance, but the feasibility of this has not been established.

Of the total area drained by the Colorado River, 244,000 square miles, 96,000 is drained by the Grand, the Green, and the San Juan, which, though draining less than two-fifths of the total area, furnish approximately 86 per cent of the total water supply. There is still, however, nearly 100,000 square miles below these rivers, exclusive of the Gila, which would be uncontrolled by such reservoirs. These areas, though furnishing a relatively small quantity of water, owing to their aridity, are yet of such extent and declivity that they furnish occasional floods of magnitude from direct precipitation, due to which their control is important from the standpoint of the flood menace.

In the study of this problem it has been demonstrated that for several reasons it is desirable to have a reservoir below the Grand Canyon of the Colorado, which will intercept most of the drainage of the Colorado River and, therefore, be a more complete solution of the flood-control problem. This method of control is important for other reasons.

The large areas of very fertile and valuable lands now developed and being rapidly developed require immediate relief by extension of storage for irrigation, and if such storage is constructed in the upper basin it will of course be operated in conformity with the requirements of irrigation in the lower valley as nearly as this can be predicted, but a large percentage of the water will be lost owing to the great distance and the impossibility of predicting the exact requirements a month or more ahead. In order to provide against embarrassing shortage, it will be necessary to turn out at all times sufficient water to provide for the most extreme conditions that may occur, but which seldom do occur, and this will mean that nearly all the time a large amount of water will be flowing to waste. A large part of this waste can be obviated by an adequate reservoir on the lower river.

In addition to the above waste, any water supply appropriated above for use in the lower valley would not be available for irrigation in the upper valley. The most feasible sites occur at points where this would be an objection to such use, because it would leave in an arid state lands that might otherwise be irrigated in the upper basin. Such a result would be a distinct waste of resources, as investigations show that there is a sufficient quantity of water to furnish an adequate supply to all of the lands in the basin that can be feasibly reached by gravity or reasonable pumping lifts. There will, of course, be local exceptions to this where the areas can be reached only by tributaries in which the local supply is insufficient, but this is aside from the main question.

In addition to the above waste the regulation of waters from the upper river in accordance with irrigation needs in the lower valley would be distinctly out of harmony with the best use of these waters for power in the canyon regions where the power resources predominate.

In the upper and lower regions of the Colorado Basin irrigation interests should and must predominate, although power resources are very important. In the middle or canyon region of the basin power resources predominate and irrigation interests are small. In general, where irrigation interests are practicable, they should be given preference over power interests, and this rule requires storage of water in Boulder Canyon, or below, for the use of the lower valleys. The States in the upper basin are therefore vitally interested in seeing that such development takes place before the natural resources are depleted by storage above for use in the lower valleys.

Likewise the States containing the lower valleys are interested in having storage in the lower basin on account of the economies thereby obtained and the greater convenience and ease of control of a reservoir near the point of use. Incidentally it will have large power resources which are important in the development of the resources of the Southwest.

Recognizing the importance of developing the Colorado Basin on broad lines in such a way as to realize the greatest benefits therefrom, the States of the Colorado River Basin took steps to organize a commission upon which each of the seven States interested is represented and on which the United States is also represented in order to work out and recommend to their respective States and to Congress such action as will bring about the best use of the water resources of this great river system, the largest and most important river system lying entirely within the arid region.

Fortunately, the investigations at Boulder Canyon have shown the feasibility of a high dam at that point, which if built would furnish storage as shown in the following table:

TABLE No. 8.—*Capacity Boulder Canyon Reservoir.*

[Computed from original plane-table sheets; scale, 2 inches equals 1 mile.]

Contour elevations.	Area.	Capacity.	Contour elevations.	Area.	Capacity.
	Acres.	*Acre-feet.*		*Acres.*	*Acre-feet.*
700			1,100	67,740	10,153,000
750	2,350	58,750	1,150	84,110	13,949,250
800	7,950	316,250	1,200	105,100	18,679,500
850	15,260	846,500	1,250	127,660	24,498,500
900	21,620	1,818,500	1,260	131,000	26,000,000
950	29,160	3,088,000	1,280	142,000	28,600,000
1,000	39,690	4,609,250	1,300	152,000	31,600,000
1,050	53,160	7,130,500			

NOTE.—The canyon walls extend up to above the 2,000-foot contour, or about 700 feet higher than the last one for which capacity is calculated.

PROGRESS OF INVESTIGATIONS.

The preliminary report on the problems of Imperial Valley and vicinity, published in January, 1921, described the progress of investigations up to that date, and these have been continued up to the preparation of this report.

Soil surveys under the direction of Prof. Charles F. Shaw have been prosecuted, and land classification based upon this examination has been made and shown upon maps. These subjects are treated in this report on subsequent pages.

Borings have been prosecuted at the proposed dam site in Boulder Canyon, and the cross section of the canyon has been fairly well worked out. A large amount of additional borings is, however, necessary to develop the entire foundation of the proposed dam, and this will probably modify its location. Similar information is also necessary for the cofferdam which must precede the main construction, and must be, for temporary work, of a rather substantial character. Results of the borings are shown in the accompanying diagrams and indicate the maximum depth to bedrock of about 135 feet below low-water level. This is regarded as feasible, although the foundation work will of course be difficult and expensive in view of the great volume of the river when in freshet.

Various studies have been made on the basis of the information available, and these studies indicate the cost of a dam with flow line at 1,230 feet to be about $45,000,000. This would have a storage capacity of about 21,000,000 acre-feet. Increased height of dam to provide greater storage can be provided at an additional cost of about $1 per acre-foot for the next 10,000,000 acre-feet. A capacity of 31,000,000 acre-feet would require a flow line at about 1,296 feet above sea level.

These figures include preliminary work and the completion of the dam in shape to serve for storage purposes and upon which to install power plants, but do not include any other cost of power development or transmission.

A reconnaissance has been made for two possible railroad lines—one approaching from the west and joining the Salt Lake & Los Angeles Railroad near Las Vegas, the other approaching from the north, being a continuation of the branch which runs from Moapa to St. Thomas. A reconnaissance should be made also of a possible connection with the Santa Fe system to the south, with a comparison of the cost and results.

THE HIGH LINE CANAL.

The construction of a high-line canal connecting Laguna Dam with Imperial Valley was investigated and reported upon by a board representing the State of California, the Imperial irrigation district, and the United States under date of July 22, 1919, and a report was published under the title "Report of the All-American Canal Board. A canal located entirely within the United States from the Colorado River at Laguna Dam into the Imperial Valley, California." Reference is made to that report for the details of such a plan, and its unit estimates of cost are accepted for the purposes of this report. It is necessary, however, to modify acreages and other details in view of the information recently collected. The agricultural lands that it would serve in addition to Imperial irrigation district are given in the following table:

TABLE No. 9.—*Irrigable acreages, Imperial Valley.*

	Irrigable lands.	Doubtful lands.	Total.
	Acres.	*Acres.*	*Acres.*
East Mesa	160,000	10,000	170,000
Dos Palmas tract	5,000	2,000	7,000
Coachella Valley	72,000	63,000	135,000
West Mesa	33,000	87,000	120,000
	270,000	162,000	432,000

The above table includes only lands which require the construction of the high-line canal to reach them. In addition to this the Imperial irrigation district is heavily interested in having a high line built for the reasons stated in the board report above referred to. The construction of a high-line canal is provided for in a contract with the United States dated October 23, 1918. In addition to this the district is pledged to connection with the Laguna Dam by contract with the Yuma County Water Users' Association in order to terminate the dangerous practice of maintaining a diversion dam at Hanlon Heading. This connection should be made at the earliest possible date in accordance with the existing understandings and contracts. The distribution of the cost of the high-line canal would be according to the following table:

TABLE No. 10.—*Division of costs of canal between Yuma project and Imperial Valley.*

Cost of high-line canal:	
To connect with dam	$1,843,000
Canal	28,930,000
Total	30,773,000
Division of costs of canal: Yuma project by contract	980,000
Remainder for Imperial Valley	29,793,000

TABLE No. 11.—*Division of costs of canal by acreage benefited.*

	Acres.	Amount.
Imperial district	515,000	$18,826,000
Extensions in United States	270,000	9,870,000
Extensions in Mexico	30,000	1,097,000
Total	815,000	29,793,000

Cost per acre, Imperial Valley, $36.55.

Division of costs of power installations along canal:	
Plant No. 1	$1,380,000
Plant No. 2	1,927,000
Total	3,307,000
Divided as follows—	
Yuma project	528,000
Imperial district	2,051,000
Pumping	728,000
	3,307,000

TABLE No. 12.—*Pumping and distribution system.*

	New lands.	Average per acre.	Total.
Pumping is divided as follows:	*Acres.*		
United States	270,000	$2.21	$596,000
Mexico	30,000	4.40	132,000
Total			728,000
Division of costs of distribution system, including pumps:			
United States	270,000	53.57	14,461,000
Mexico	30,000	21.67	650,000
Total			15,111,000

TABLE No. 13.—*Summary of distribution of costs per acre, Imperial Valley.*

	High-line canal.	Power.	Distribution system.	Total.
Imperial district	$36.55	$3.98		$40.53
Extensions:				
United States	36.55	2.21	$53.57	92.33
Mexico	36.55	4.40	21.67	62.62

TABLE No. 14.—*Allocation of costs to classes of lands in Imperial extensions.*

	Private.	Entered.	Public.	Indian.	California.	Southern Pacific R. R.	Total.
United States	$1,339,000	$1,420,000	$15,400,000	$1,062,000	$1,348,000	$4,359,000	$24,927,000
Mexico							1,879,000
Total							26,806,000

TABLE No. 15.—*Imperial Valley extension—Irrigable area (acres).*

Imperial Valley extension.	Private.	Entered.	Public.	Indian.	California.	Southern Pacific R. R.	Total.
East side mesa	1,200	1,200	148,100		8,300	1,200	160,000
Dos Palmas	200	1,400	700		300	2,400	5,000
Coachella Valley	12,100	3,400	3,800	11,400	4,400	36,900	72,000
West side	10,000	9,300	14,300	100	1,600	6,700	33,000
United States lands	14,500	15,300	166,900	11,500	14,600	47,200	270,000
Mexican lands							30,000

FLOOD PROTECTION AND IRRIGATION STORAGE BENEFITS.

The distribution of benefits from water storage is perhaps the most complicated and difficult to determine and involves questions of law which it is neither possible nor desirable to determine at the present time.

The Yuma project of the United States Reclamation Service claims an early valid right to the diversion of water, based upon an act of Congress (33 Stat., 224) authorizing the diversion of water for the Yuma project and including Indian lands. The Imperial irrigation district, on behalf of the lands within its boundaries, claims a right based upon filings under California laws. Similar claims are asserted by the Palo Verde irrigation district and some other tracts in the Colorado Valley, and which of these is to get preference is a matter of dispute depending perhaps in part upon various questions of fact which will require careful determination. The claim is asserted on behalf of the Indians of the Colorado River Indian Reservation to sufficient water for their lands, irrespective of prior appropriations.

These claims in the aggregate are conflicting, but it is neither necessary nor desirable that they be now determined, nor is this possible in time for this report.

A similar difficulty arises in allocating the benefits for flood protection, although in a broad sense the older lands having the best water rights are those most in need of flood protection.

POWER DEVELOPMENT.

The development of power at the Boulder Canyon reservoir is a by-product which does not in all respects conform to the requirements of irrigation but can be made to conform thereto with some adjustment. The extremely arid and semitropic character of the lands in the Lower Colorado Basin makes it necessary to irrigate throughout the year and the irrigation requirements therefore conform more nearly to the requirements for power than do those in northern latitudes.

It is estimated that the feasible irrigation projects in the lower basin, which would divert water from the main stream, comprise 2,020,000 acres, of which about 60 per cent is in the United States and 40 per cent in Mexico. The full development of the proposed projects in the upper basin will subtract substantially from the total water supply, but there will still be left ample water to irrigate all the lands of the lower basin if it is conserved and regulated in a storage reservoir of ample capacity. The water can be used for power as drawn from the reservoir and the amount of power that can be developed with different amounts of storage capacity and with different assumptions of irrigated land below is shown by the diagram in plate VI. It shows that with 1,505,000 acres of land in the lower basin irrigated and with a total storage capacity of 31,400,000 acre-feet, of which the lower 5,000,000 is reserved for silt storage and the upper 5,000,000 is reserved for flood control, it is possible to develop over 700,000 firm horsepower. With the entire 2,020,000 acres of irrigable land developed in the lower basin the possibilities are still 600,000 firm horsepower, and besides this there is a large amount of secondary power which is not constant but will be of considerable value.

All this is on the assumption that the total area of irrigable land in the upper basin is irrigated, namely, about 4,000,000 acres, of which about three-eighths is now under ditch. The development of the upper basin will doubtless proceed steadily, but it will be a long time before the full development is reached, and the water later to be consumed by future irrigation will be available for power at Boulder Canyon until that development is realized. This will greatly increase the figures shown above for a long time to come, and in the meantime any regulation of the river above for any purpose will also tend to increase them.

The great value of this power and the wide demand for it, together with its magnitude, indicate that the power privileges of the Boulder Canyon reservoir can be made to bear the entire cost of the dam.

The markets for power are numerous and various in this part of the country, consisting in general of the mining interests in Arizona and Nevada, the pumping requirements in the Colorado River valley, and the needs of the municipalities of Arizona and southern California for municipal and commercial uses. Possible municipal customers of importance are Prescott, San Diego, Riverside, and Los Angeles.

The last-named city has indicated a desire to share in this development as shown by the letter dated December 16, 1920, on page 92. This city has already developed considerable power on the Los Angeles aqueduct, and owns a system for distributing electric current within the city limits. The demands, present and prospective, are far beyond the capacity of the city to supply with the present facilities, and this is considered the most effective and extensive of all of the power demands.

It is desirable, of course, to extend to all customers who desire to share in this development the same privileges. The use of the name of the city of Los Angeles is merely typical of such cities as may eventually elect to share in this development. Others may later apply and should have equal privileges.

TABLE No. 16.—*Status of lands in lower Colorado Basin in the United States.*

	Irrigable area, acres.						
	Private.	Entered.	Public.	Indian.	State.	Southern Pacific Railroad.	Total.
Cottonwood Island			4,000				4,000
Mohave Valley	12,800		1,600	12,600			27,000
Chemehuevis Valley			1,500	2,500			4,000
Parker project				110,000			110,000
Palo Verde Valley	72,000	6,000					78,000
Palo Verde Mesa	3,500	12,400	800		1,300		18,000
Chucawalla Valley	500	32,500	8,500		2,500		44,000
Cibola Valley	6,900	2,500	4,800		1,800		16,000
Isolated tracts	2,900		1,100				4,000
Yuma project	62,000	19,000	38,200	9,000	1,800		130,000
Imperial irrigation district	515,000						515,000
Imperial Valley extensions:							
East Side Mesa	1,200	1,200	148,100		8,300	1,200	160,000
Dos Palmas	200	1,400	700		300	2,400	5,000
Coachella Valley	12,100	3,400	3,800	11,400	4,400	36,900	72,000
West Side	1,000	9,300	14,300	100	1,600	6,700	33,000
Total in United States[1]	690,000	87,700	227,400	145,600	22,000	47,200	1,220,000

[1] Late estimates from State engineer show 30,000 acres additional in lower basin in Nevada.

CONSTRUCTION METHODS.

Borings made in 1903 and 1904 on the lower river showed that at Bulls Head, Williams Fork, Picacho, and other points tested the subterranean channel of the river had been eroded to a great depth, so that the foundation of dams at any of these points on bedrock was considered infeasible. In view of this fact and of the silt problem, some engineers were led to conclude that storage at any point in the lower basin of the Colorado River was not feasible. Further consideration, however, led to the evolution of a plan for building a high dam without excavating the river to bedrock, which, owing to the peculiar topography of Boulder Canyon, seemed to be at least worthy of consideration. At this point the canyon is about 300 feet wide at the river level, and cliffs of massive granite reach upward nearly vertical to a height of over 2,000 feet above the river. Plans were evolved for a loose-rock dam at this point constructed by the following method:

It is proposed to pierce the cliffs with large tunnels on each side of the dam site a short distance above the low level of the river at medium stages in order that the river might be diverted through these tunnels at moderate stages, if desired. These tunnels were to be equipped with controlling works. For a dam, say, 600 feet above the river level it was proposed to provide slopes for a rock-fill dam of three to one on each side when counted from bedrock to summit with a top width of 30 feet. This would mean that the thickness of the dam up and down stream at the river bed would be 3,630 feet, or nearly three-quarters of a mile. The cliffs were to be pierced with small tunnels parallel to the river at numerous points well above and outside the lines of the dam in order later to blow the rock from these tunnels into the river for forming a loose-rock dam. At a point just above where the upstream slope of the dam would intersect bedrock a tunnel on each side of the river was to be filled with powder and exploded, throwing the rock into the river bed in such manner as to form a cofferdam and divert the river into the diversion tunnels. This cofferdam was to be faced with smaller rock in order to serve its purpose and then the river turned over the cofferdam, which it would proceed to destroy by scouring the bed of the river at the lower toe and rolling the rocks of the dam into the cavity thus formed.

After such action had proceeded to a point of comparative quiescence another blast from higher tunnels on both sides of the river would blow additional quantities into the river just below the cofferdam and the river required to work upon this mass for a short time. With the high head thus formed the scouring effect of the water upon the toe of the rock fill would be very powerful and would carry away all the finer material, but the large blocks of granite that would thus be provided could not be carried by the river but being undermined would be settled deeper and deeper into the river bed.

This process would be repeated in such manner as to secure the largest possible action of the water in scouring out the foundation and settling the large rock from the cliffs as low as possible into the foundation. This proceeding from upstream to downstream would pave the foundation progressively with large rock as deeply embedded as possible. The process of blowing rock from the cliffs above by means of tunnels parallel to the river packed with black powder would be repeated at such points that the required rock fill would be built as nearly as practicable to the height desired on the required slopes, the river being used to the maximum extent in settling the rock into the foundation and all surplus waters drawn off through the tunnels. It is obvious that very much larger masses of granite could be secured in this way than could be feasibly moved by ordinary mechanism.

During the early stages of construction when the mass is of moderate height it would be necessary to take the flood waters of the river over the structure, and this action would be used to the greatest possible extent in thoroughly paving the foundation with the heaviest rock obtainable. As the structure increased in height the storage above it would increase in volume rapidly, and at moderate heights the storage capacity and the tunnel capacity combined would be adequate to prevent the overflow of the dam in times of high water after such overflow became undesirable.

When this structure had reached the designed height and slopes the entire upstream face would be brought to an even slope by depositing smaller rock until the surface was smooth enough to be paved with concrete. A concrete pavement would then be provided of considerable thickness and reinforced with steel. This would cover the entire face of the dam from the river bed to the top and would be securely sealed to the cliffs on either side to prevent percolation through the dam so far as practicable.

Prior to placing the cofferdam or any of the rock fill, it is proposed to drive a row of sheet steel piling as deeply as practicable across the upstream toe of the dam, to be later connected and sealed firmly to the toe of the concrete pavement on the water face of the dam.

The placing of the rock fill should be completed a year or more before beginning the construction of the concrete pavement. This time would be occupied in sloping up the water face preparatory to placing the pavement. The construction of the pavement would be so planned that the sealing of the pavement to the rock of the abutments would be the last finishing touch of the dam so as to give the mass the maximum time for settlement before making this junction.

The control of the river during construction and immediately after would form a pond of varying magnitude just above the dam filled with the muddy waters of the Colorado and these would deposit their sediment on the river bed and lower toe of the dam in such manner as to form something of a seal and tend to prevent water entering the foundation at any considerable velocity.

This plan of construction was discussed with Secretary Lane in obtaining authority for the extensive investigations of the Colorado River in 1914. It had previously, and has since been discussed by the author with many engineers in order to bring out, if possible, any weak points connected with the plan, and some of the details of this plan have been modified as the result of such discussions. They are of course subject to further modification by further thought, and especially by the experience obtained during construction. The plans were worked out in more detail and estimates made on the basis of such a structure as compared with a dam built of concrete under the direction of the chief engineer of the Reclamation Service by Mr. John L. Savage, designing engineer, United States Reclamation Service, and his assistants.

These investigations seemed to indicate that no material saving could be made by adopting such a plan as compared with a concrete structure carried to bedrock providing the latter proved feasible at all. A depth of 135 feet to bedrock while presenting serious difficulties in foundation work is believed to be entirely feasible if proper preparations are made and proper plans are followed.

It is not believed that in view of the cost it is desirable or necessary to divert the entire flood flow of the Colorado River, which may at times reach 200,000 cubic feet per second. The plan is to design a thin arch of such radius and dimensions as to be safe with its base upon the foundation rock and its summit about 40 feet above the low-water level of the river. Within this limit the canyon is quite narrow, being at all points less than 350 feet in width, and therefore a structure of short radius and light section would be safe. After the construction of a cofferdam and of diversion tunnels of sufficient capacity to carry the ordinary flow and moderate floods of the river, excavation would be undertaken of only sufficient width to secure foundation for this thin arch, and this would be completed and the arch poured during the nine months or so in which it would be possible to unwater the foundation by means of the tunnels and cofferdam.

This thin arch could serve as a subsequent cofferdam and also for the heel of the masonry structure to be built. If this were overtopped by floods they would fill the pit with water only, which could be quickly pumped out when the flood had passed and the excavation of the additional foundation and placing of foundation concrete could proceed at all times when the river flow is below the capacity of the tunnels; and this would mean without serious or expensive interruptions except during the brief season of high water in May and June.

The method just described for meeting foundation conditions in Boulder Canyon has been successfully carried out in placing the foundations for the Shoshone and the Arrowrock dams, the highest yet built by the Reclamation Service. The depth to foundation at Arrowrock was about 100 feet, and on the Shoshone about 90 feet. At Boulder Canyon the depth is greater and the quantities are larger, but it is practicable to assemble a much larger construction outfit and to make more strenuous speed than was found necessary at either of the two locations mentioned. These experiences have led those familiar with them to conclude that the placing of the foundation in Boulder Canyon for a concrete dam by the above method is entirely feasible and not unduly expensive.

If this is true, the plan of blowing the cliffs into place for a rock-fill dam is not necessary to solve the problem. It might, however, have advantages of economy, but this is difficult to predict on account of the unprecedented character of the operations.

A structure necessary to solve the problem of the Colorado River by a dam in Boulder Canyon is so high and so far beyond the precedents that it seems advisable, with due care for engineering safety and economy, to avoid going outside of such precedents so far as possible. For this reason it seems to be desirable to build the structure of concrete in accordance with well-established theory confirmed by numerous and varied precedents. A rock-fill structure might be cheaper, but our experience is so limited that we can not be sure that this will be the case, and if some unforeseen difficulties, such as blow-outs under the rock fill, should be encountered, its expense might even be greater than that of a concrete structure, and we can not be sure that it would be entirely safe.

COMPARISON OF BOULDER CANYON RESERVOIR WITH OTHER POSSIBLE SITES.

The demand for a large regulating reservoir on the Lower Colorado is urgent and imperative—first, for regulating floods; second, for providing storage water for irrigation; and third, for power. Without the power the reservoir is not feasible at all, as the expense would be too great to be borne by the other interests alone.

The reservoir site provided by a dam in Boulder Canyon, or its continuation, Black Canyon, is the lowest point on the Colorado River where a site of sufficient capacity can be found. Above this site the Grand Canyon occurs, and no reservoir of capacity sufficient to control the entire flow of the river occurs until we reach a point above the Grand Canyon National Park. A site has been proposed above the mouth of the Paria River in Glen Canyon, and it has been urged that a reservoir formed here would, for a given height of dam, provide greater storage capacity and would so regulate the floods as to facilitate the construction of other dams farther down. These are valid arguments, so far as they go, but such a reservoir would not answer present purposes for several reasons.

Between the Glen Canyon and Boulder Canyon sites about 50,000 square miles of drainage flows into the Colorado, including the Little Colorado, the Virgin, the Paria, the Kanab, and many smaller tributaries. This region furnishes about 8 per cent of the water supply passing Boulder Canyon, and most of it is subject to torrential summer rains and to floods at other times, and the Glen Canyon site would not, therefore, give satisfactory control of the floods, which is the most urgent of the problems presented. A satisfactory solution of this problem could not be accomplished at any point above Boulder Canyon.

Any large reservoir on the Colorado must depend for its financial feasibility upon the availability of an adequate market for not less than half a million horsepower of electric energy within economical transmission distance. The principal available markets are—

1. The Pacific slope of California, including the cities of Los Angeles, San Diego, Riverside, etc.
2. Irrigation pumping in all directions.
3. The mining regions of the mountains of Arizona, extending in a broad way from the northwestern to the southeastern corner of that State and including the cities of Prescott, Phoenix, and Tucson.
4. The electrification of the Southern Pacific, the Santa Fe, and the Salt Lake railways and their branches.
5. The cities of Nevada, Utah, Colorado, and New Mexico, and the mining regions adjacent to them.

All of the more important markets above listed are more convenient to Boulder Canyon than to Glen Canyon. This is especially true of the most important market, the cities and irrigation districts of southern California. To reach these the most feasible routes for transmission lines, considering the importance of transportation in their construction and maintenance, is approximately along the railroad routes. These compare about as follows, taking Los Angeles as typical and deducting 20 per cent as the distance that might be saved by cut-offs:

Transmission distance, Boulder Canyon to Los Angeles.

	Miles.
Los Angeles to Las Vegas, by rail	334
Las Vegas to Boulder Canyon, by rail	40
Total	374
Less 20 per cent	75
Net transmission distance	299

Transmission distance, Glen Canyon to Los Angeles.

	Miles.
Los Angeles to Flagstaff, by rail	544
Flagstaff to Junction, by rail	30
Junction to Glen Canyon, by rail	130
Total	704
Less 20 per cent	141
Net transmission distance	563
Transmission distance, Boulder Canyon to Los Angeles	299
Difference in favor of Boulder Canyon	264

Considering the population and industrial importance of the Pacific coast region, this market is the largest of all the prospective markets, and neither development could at present be justified financially without it. The advantage in transmission distance of 260 miles is of course decisive. In fact, the transmission of so much power a distance of 560 miles, though physically possible, can hardly be considered to-day commercially feasible under the conditions surrounding this problem.

It would be hard to find a power site in the United States more remote from adequate markets than the Glen Canyon site, and nearly all its markets are or can be more cheaply served from nearer points.

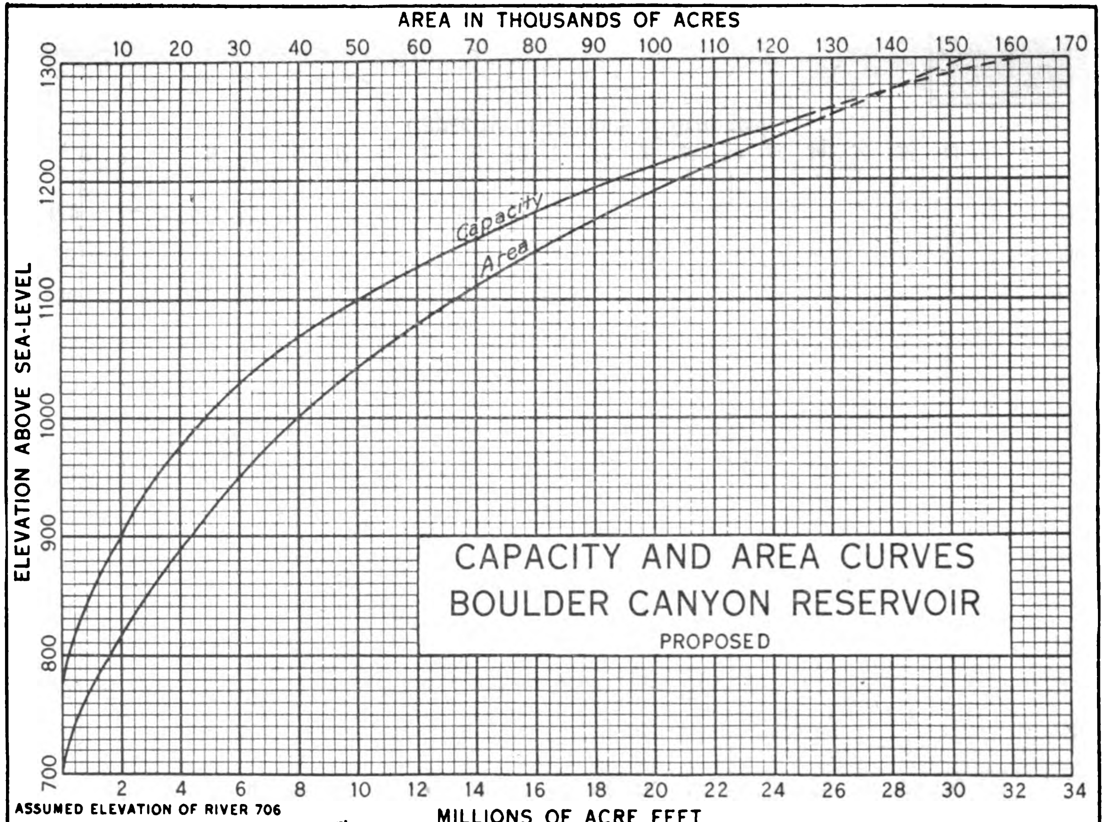
These facts are so obvious that some of the proponents of Glen Canyon reservoir tacitly admit its present inavailability as a power site and extol its virtues as a regulator for power sites to be developed below. The best located of these is that at Boulder Canyon, which, as we have seen, can be made to furnish its own regulation, so that *two* such great undertakings are at present unnecessary, and are in fact financially at present not only very uneconomical but probably infeasible. In the present state of development of the Southwest, the construction of a large reservoir at Glen Canyon under either plan would encumber the power development with such a heavy charge for construction and maintenance as to be a serious public misfortune.

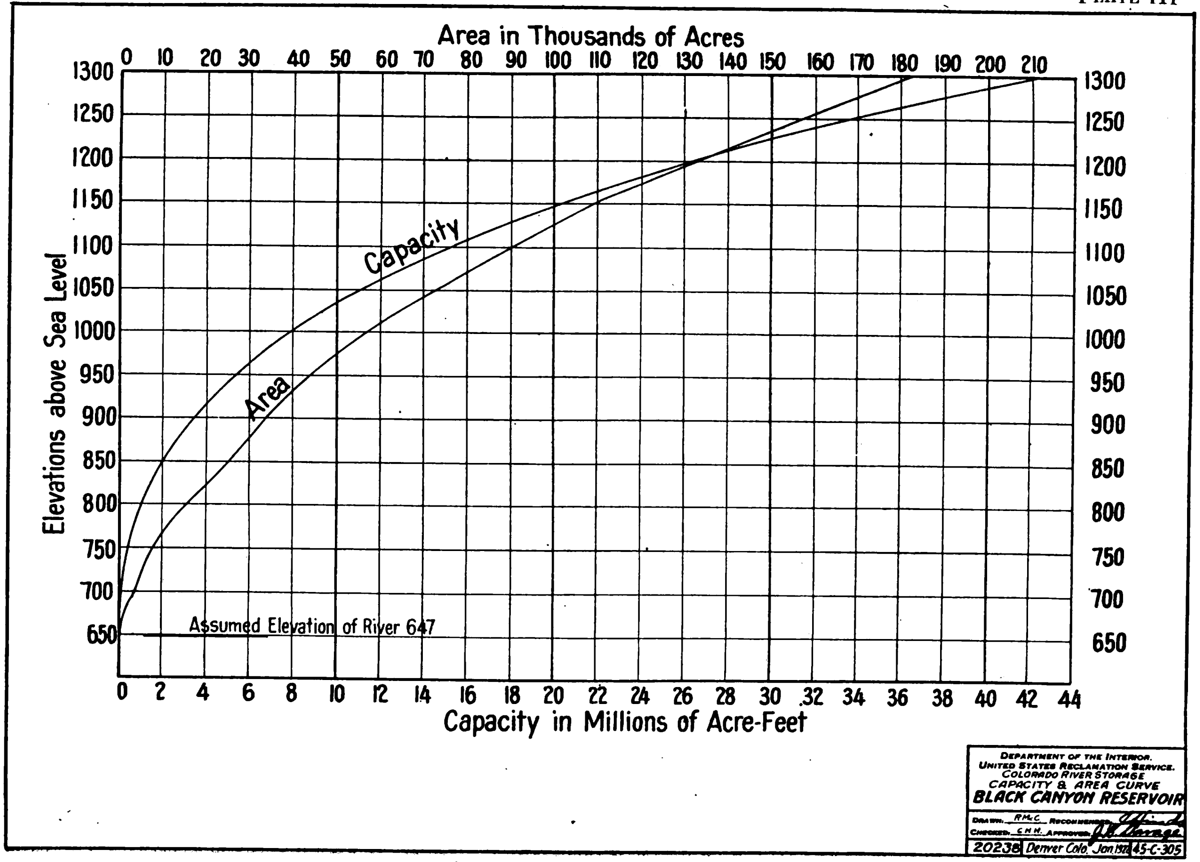
The disadvantages from an irrigation standpoint of locating a storage reservoir 650 miles by river from the point of diversion when a site is available at one-half the distance are readily appreciated.

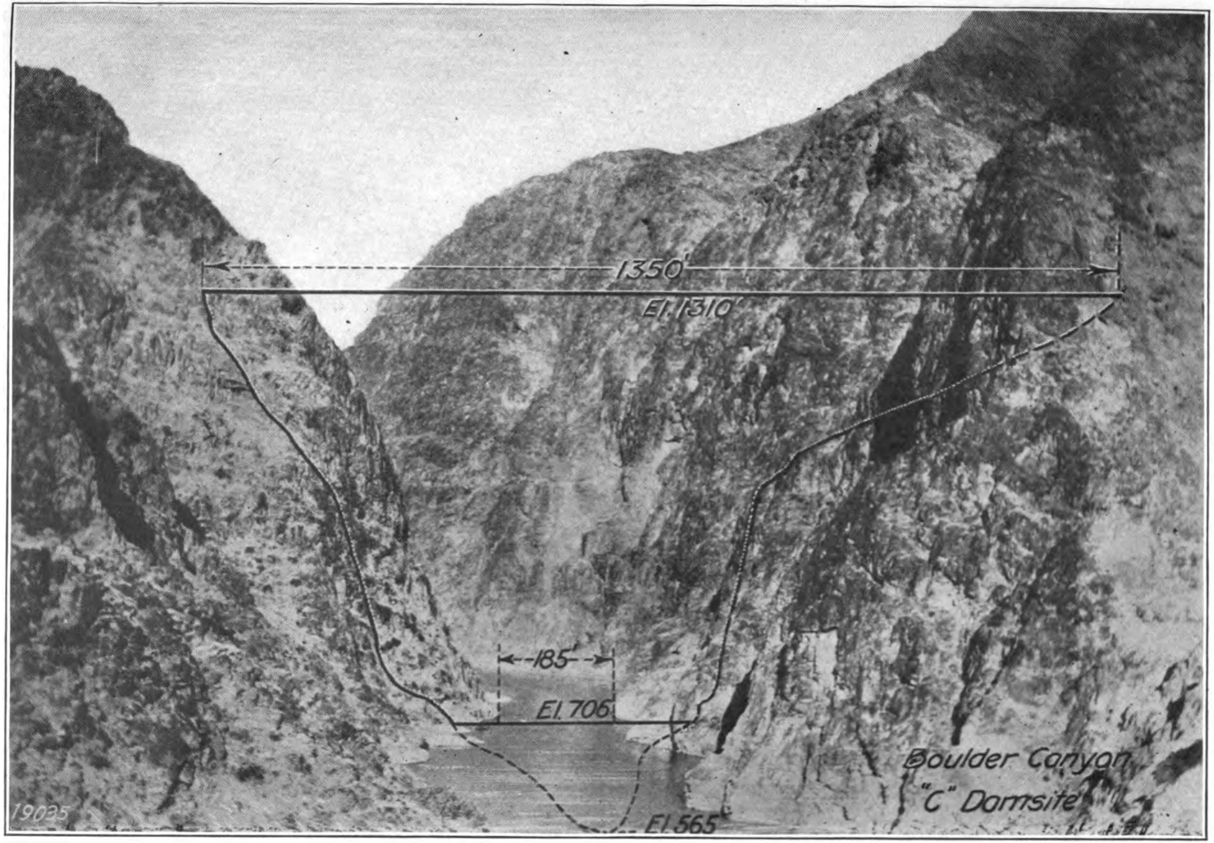
One of the great problems concerning the Colorado is that of silt. The Boulder Canyon dam as planned would store the silt for over three centuries, if all were caught and held, and for nearly a century before greatly impairing its water-storage function. It is hoped before that time that other developments above will so regulate the flow that not all of its storage capacity will be needed, but it will always be desirable to control the floods of the region between Boulder Canyon and Glen Canyon, and before the capacity of the Boulder Canyon is entirely destroyed the Glen Canyon regulator can be built to take its place. It will then be fresh and empty of silt and will last to as much later date as the age of the Boulder Canyon reservoir at that time and will, therefore, solve the silt problem for a period of two or three hundred years further into the future than if it is built first, and can, if desired, be employed as a sluicing agency for sluicing out the Boulder Canyon reservoir.

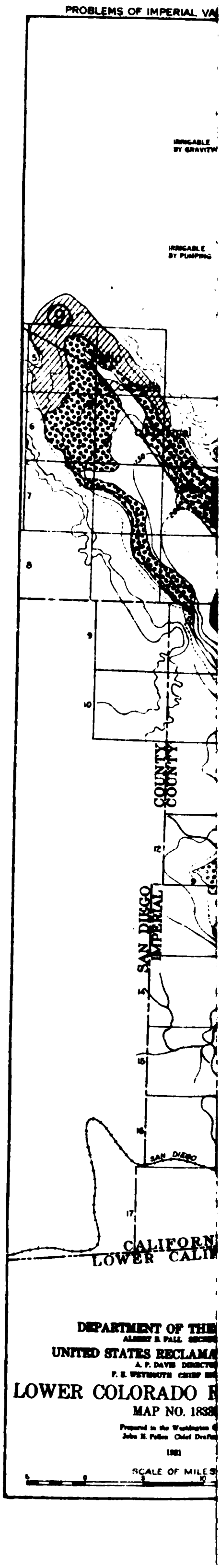
If built first the Glen Canyon reservoir would immediately begin silting up and if sluiced in the future will discharge its sediment into the reservoir later provided below and thus require sluicing of the same sediment two or more times. This multiple sluicing will not be possible without shutting down the storage and other functions of all the reservoirs below while they are being sluiced out.

By the time silt deposits have begun to encroach upon the storage capacity of the Boulder Canyon reservoir sufficient power earnings will have accrued to amortize its cost, and the full height of the dam will still be available for the development of power. The engineers


AREA IN THOUSANDS OF ACRES
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
ELEVATION ABOVE SEA-LEVEL
700 800 900 1000 1100 1200 1300
Capacity
Area
CAPACITY AND AREA CURVES
BOULDER CANYON RESERVOIR
PROPOSED
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
ASSUMED ELEVATION OF RIVER 706
MILLIONS OF ACRE FEET


Area in Thousands of Acres
Elevations above Sea Level
Capacity in Millions of Acre-Feet
Capacity
Area
Assumed Elevation of River 647
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
1300 1250 1200 1150 1100 1050 1000 950 900 850 800 750 700 650
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
COLORADO RIVER STORAGE
CAPACITY & AREA CURVE
BLACK CANYON RESERVOIR
DRAWN R.M.C.
RECOMMENDED
CHECKED C.H.H.
APPROVED
20238
Denver Colo.
45-C-305


1350'
El. 1310'
185'
El. 706
El. 565
Boulder Canyon
"C" Damsite
19035


PROBLEMS OF IMPERIAL VA
IRRIGABLE BY GRAVITY
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SAN DIEGO
IMPERIAL
COUNTY
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CALIFORN
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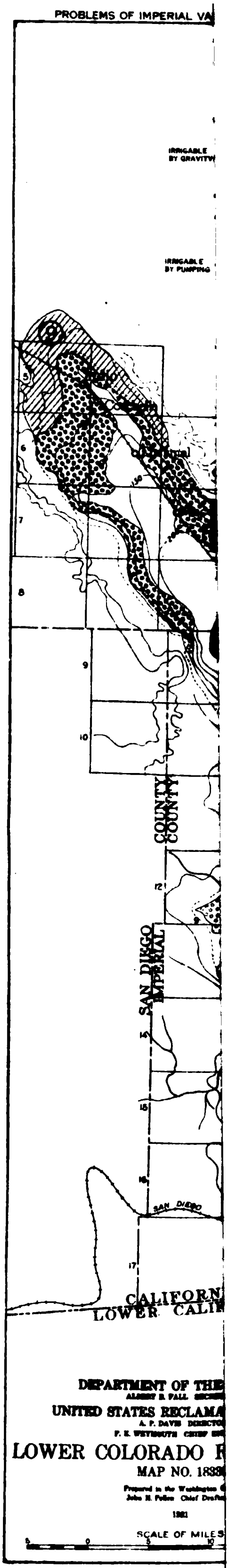
DEPARTMENT OF THE
UNITED STATES RECLAMA
LOWER COLORADO R
MAP NO. 1833
1921
SCALE OF MILES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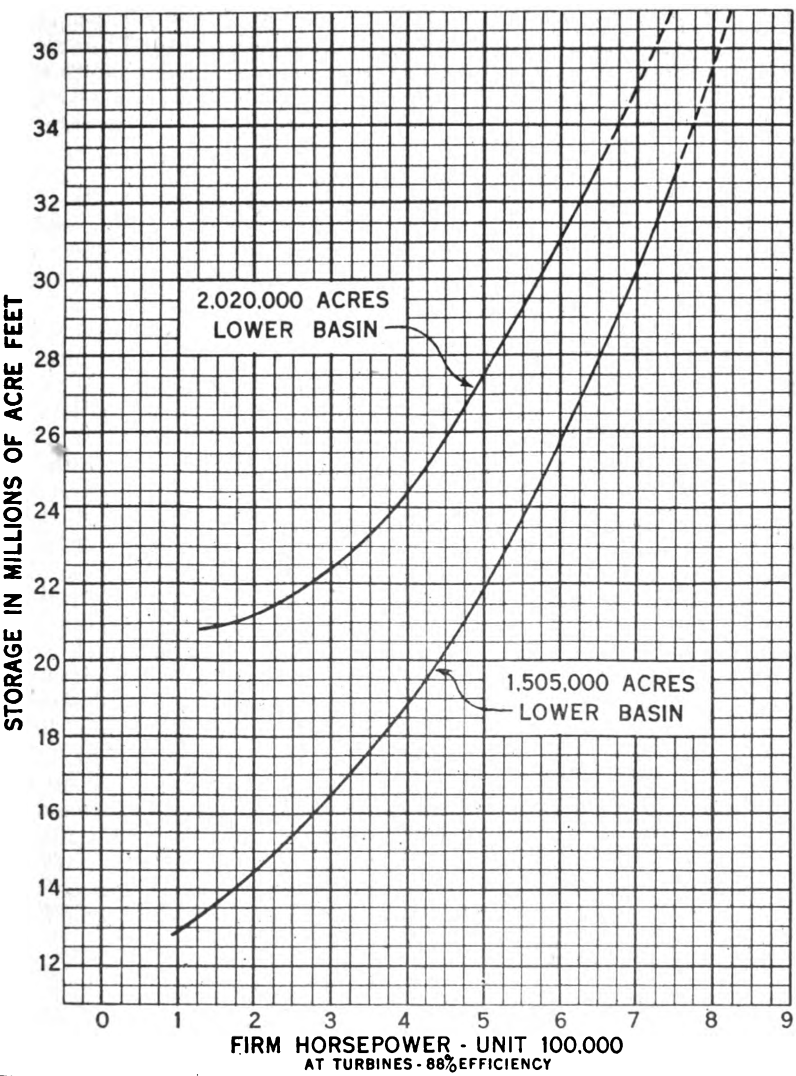
DEPARTMENT OF THE
UNITED STATES RECLAMA
LOWER COLORADO R
MAP NO. 1833
SCALE OF MILES



FIGURES ON LEFT HAND MARGIN INCLUDE 5,000,000 ACRE FEET SILT STORAGE AND 5,000,000 ACRE FEET FLOOD STORAGE.

FIRM HORSEPOWER AT BOULDER CANYON DAM SITE

U. S. R. S. NO. 19014

JHP

of that future date will then not only be in a better position to build the Glen Canyon dam than we are now but will be relieved of the expense of a power dam at Boulder Canyon we would now be saddled with and have in addition the advantage of being then free to operate the upper reservoir to best advantage for power alone, the Boulder Canyon reservoir still affording ample capacity for regulation for irrigation.

RECOMMENDATIONS.

1. It is recommended that through suitable legislation the United States undertake the construction with Government funds of a high-line canal from Laguna dam to the Imperial Valley, to be reimbursed by the lands benefited.
2. It is recommended that the public lands that can be reclaimed by such works be reserved for settlement by ex-service men under conditions securing actual settlement and cultivation.
3. It is recommended that through suitable legislation the United States undertake the construction with Government funds of a reservoir at or near Boulder Canyon on the lower Colorado River to be reimbursed by the revenues from leasing the power privileges incident thereto.
4. It is recommended that any State interested in this development shall have the right at its election to contribute an equitable part of the cost of the construction of the reservoir and receive for its contribution a proportionate share of power at cost to be determined by the Secretary of the Interior.
5. It is recommended that the Secretary of the Interior be empowered after full hearing of all concerned to allot the various applicants their due proportion of the power privileges and to allocate the cost and benefits of a high-line canal.
6. It is recommended that every development hereafter authorized to be undertaken on the Colorado River by Federal Government or otherwise be required in both construction and operation to give priority of right and use:

First. To river regulation and flood control.
Second. To use of storage water for irrigation.
Third. To development of power.

APPENDIX A.

REPORT OF BOARD OF ENGINEERS ON DESIGNS AND COST ESTIMATES OF BOULDER CANYON DAM.

WITH SUPPLEMENTARY REPORT OF OCTOBER 26, 1921.

MAY 26, 1921.

From: Board of Engineers.
To: Chief Engineer, Denver, Colo.
Subject: Report on Boulder Canyon Dam, Colorado River.

1. The undersigned board of engineers met at Boulder Canyon dam site on May 13, 14, and 15, 1921, to consider preliminary investigations, tentative designs, and cost estimates of the Boulder Canyon Dam.

EXHIBITS.

2. Attached hereto you will find plates showing topography, profiles, and a preliminary design of dam, as follows:

Plate VII: Boulder Canyon Dam sites, topography and profiles.

Plate VIII: Boulder Canyon Reservoir, river-bed section, A dam site.

Plate IX: Boulder Canyon Dam Reservoir, river-bed section, C dam site, line C–1.

Plate X: Boulder Canyon Reservoir, C dam site, line C–2.

Plate XI: Boulder Canyon Reservoir, preliminary design, curved gravity dam.

DAM SITES INVESTIGATED.

3. Two dam sites have been investigated and explored in a preliminary way with diamond-drill equipment. The two sites are about 2,900 feet apart, the upper one being some 3,500 feet downstream from the head of the canyon as determined by Boulder Wash. The lower site is known as the A site, while the upper one has been designated the C site.

4. The rock in the canyon walls is a fine-grained granite of excellent quality although jointed to a considerable extent. The walls rise precipitously from river elevation to heights of from 1,200 to 1,500 feet and then continue upward on a flatter slope and more irregularly to the higher peaks of the mountain range.

5. The river through the canyon varies in width at low-water stage from about 200 to 500 feet, the narrowest point being at the C dam site. At low stage the water is about 10 feet deep.

6. The results of the investigations made thus far indicate that bedrock will be found at depths not exceeding 140 feet below low-water surface. At the A site the greatest depth at which bedrock was reached is 137 feet, while at the C site it was reached at 130 feet. In general the river trench is filled with about 50 feet of boulders overlaid by 70 feet of sand. The largest boulder encountered in drilling was 10 feet through.

7. Both sites have been pronounced geologically feasible for the construction of a high dam by Geologist F. L. Ransome, of the United States Geological Survey. The A site has the appearance of being the better dam site, as it is located in the more confined part of the canyon, where the abutments are very massive. The C site, however, has many practicable advantages which offset any advantages which the A site may have. It offers a better solution for river diversion during construction. It is more accessible, which will simplify construction and result in a smaller unit cost of concrete. It is less confined and offers greater possibilities for construction plant. It offers a better location for the power house, outlet works, and spillway. The abutments are naturally adapted to the type of dam recommended and are so shaped as to offer the greatest possible resistance to failure. The volume of concrete in the dam is less for the type recommended than at the A site, which taken into consideration with accessibility should result in a considerably less expensive structure.

TYPES OF DAMS.

8. Two general types of concrete masonry dams have been investigated—the gravity type and the arched type. On account of the shape of the canyon at the most favorable dam site comparative estimates show practically identical costs for the gravity and arch dams, with a considerably greater cost for the power development if the arch dam is used. It is considered that the gravity type is simpler and more conservative in design and better suited to a dam of such an unprecedented height. It is recommended that to give additional security the gravity type dam should be arched in plan, using the shortest radius that will fit the topography. With a 26,500,000 acre-foot reservoir the dam will have a maximum height of 700 feet, of which 570 feet will be above the original low-water surface. Its length at the base will be about 200 feet and at the top 1,130 feet. With a 31,400,000 acre-foot reservoir the dam will have a maximum height of 735 feet, of which 605 feet will be above the original low water surface. The length on top in this case will be about 1,250 feet.

DIVERSION DURING CONSTRUCTION.

9. The base of the dam in the deepest part of the river channel will be from 130 to 140 feet below low-water level. It is proposed to provide a by-pass for the river during construction with a capacity of 50,000 second-feet. This by-pass will be through tunnels around the south end of the dam connecting with the permanent spillway outlet tunnels. Cofferdams will be built above and below the dam site capable of diverting through the by-pass floods up to 50,000 second-feet and of being overtopped without serious damage by greater floods. One type of cofferdam considered is a concrete arch with its base on bedrock and its top at proper height to by-pass a 50,000 second-foot flood. It would be built in vertical sections sunk by compressed air methods. Another method would consist of the same concrete arch except that its base would be sunk as far as practicable into the gravel and boulder formation lying beneath the 70-foot thick blanket of sand in the river bed. This method would

dispense with compressed air and sink the section of the arch by open dredging from inside the vertical shafts formed by the hollow sections of the arch, which would be filled with concrete when in final position. A third method would be by adding to this main cofferdam as many lower parallel cofferdams inside the main cofferdam as the excavation showed to be necessary.

10. The determination of the best type of cofferdam can be left as a subject for further study after securing further data on the underwater conditions by additional drilling at the site of the cofferdams. The information now at hand shows that the depth to bedrock at the dam site is within practicable limits and that the diversion of the river during the construction of the foundation can be safely effected.

SPILLWAY.

11. A spillway capacity of 200,000 second-feet has been tentatively assumed and the spillway is designed to pass this quantity with a flood-water surface elevation of 1,265 with the 26,500,000 acre-foot reservoir and 1,300 with the 31,400,000 acre-foot reservoir. With an encroachment of 10 feet on the freeboard of the dam the spillway capacity increases to 300,000 second-feet. Preliminary studies indicate that these quantities can be safely passed through shafts and tunnels in the Arizona abutment where topographical conditions are favorable for a movable-crest structure. With a reservoir of either capacity proposed, it is very improbable that the spillway will ever be subjected to a flood as great as 200,000 second-feet and it is certain that flood storage and control gates can be utilized to limit the flood to a very much smaller quantity, probably to 50,000 second-feet.

IRRIGATION AND FLOOD-CONTROL OUTLET WORKS.

12. The irrigation demand will require outlet gates of about 25,000 second-foot capacity. Preliminary studies indicate that this quantity can be passed through 60–72-inch Ensign balanced valves and that these valves can be arranged at different levels so that they can be operated under a maximum head of about 150 feet for irrigation service. By utilizing the valves under higher heads a much larger discharge capacity can be obtained for flood-control purposes. In the plan tentatively adopted the balanced valves will be arranged to discharge into the spillway shafts and tunnels. Emergency show will be provided which will make the balanced valves accessible at all times. A portion of the irrigation water would at all times pass through the power plant, which leaves a large excess capacity through outlet gates for irrigation and flood-control purposes.

POWER DEVELOPMENT.

13. Preliminary studies have been made for power development based on two different reservoir capacities, viz, 26,500,000 acre-feet and 31,400,000 acre-feet.

14. The accompanying tabulation (Table No. 1) shows a comparison of the power output and other related data for the two alternative reservoirs, based on different assumptions as to lands irrigated and to equated discharges for power development.

TABLE No. 1.—*Relation between irrigated area and power development.*

	Reservoir capacity, 26,500,000 acre-feet.							Reservoir capacity, 31,400,000 acre-feet: All United States lands and Mexican lands under All-American and Imperial canals irrigated.
	All United States lands and all Mexican lands irrigated.	All United States lands and Mexican lands under All-American and Imperial canals irrigated.	Discharge equated for power.					
Minimum discharge, second-feet	10,660	13,500	14,700	14,500	14,000	13,500	13,000	14,300
Total annual useful draft, acre-feet	9,310,000	8,880,000	9,500,000	9,360,000	9,000,000	8,640,000	8,280,000	9,370,000
Regulating storage required, acre-feet	15,300,000	13,800,000	16,500,000	16,100,000	14,500,000	13,100,000	11,800,000	16,350,000
Capacity below regulating storage	6,200,000	7,700,000	5,000,000	5,400,000	7,000,000	8,400,000	9,700,000	10,050,000
Flood-control storage	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Minimum head on power plant	329	360	302	312	344	371	389	394
Maximum head on power plant	519	519	519	519	519	519	519	559
Firm turbine horsepower, 88 per cent efficient	351,000	486,000	444,000	452,400	481,600	500,800	505,700	563,000
Acres irrigable	2,020,000	1,505,000	1,410,000	1,400,000	1,340,000	1,290,000	1,240,000	1,505,000
Monthly peak irrigation demand, second-feet	19,000	14,000	13,200	13,000	12,500	12,000	11,500	14,000
Total power, 1899 to 1921, million kilowatt hours:								
Firm power	47,300	65,560	59,906	61,094	65,010	67,562	68,244	76,054
Secondary irrigation power	24,244	2,159						1,387
Secondary increased head power	20,512	23,021	32,496	30,759	26,063	21,367	18,021	24,425
Total power	92,056	90,740	92,402	91,853	91,073	88,929	86,265	101,866
Installed turbine horsepower	480,000	608,000	662,000	652,000	630,000	608,000	585,000	715,000
Installed generator, kilowatts	358,000	455,000	494,000	486,000	470,000	454,000	436,000	535,000
Number of units	12	12	12	12	12	12	12	12

formation before final plans are decided upon. The investigations so far made have located the dam within such narrow limits that further drilling can be confined to the area to be occupied by the base of the dam and the cofferdams.

26. We recommend that as a preliminary to the final plans for the dam and for the adoption of a method of river diversion during construction, the area below the river level under the dam and cofferdams should be further explored by drilling to bed rock at least 35 holes, so distributed as to cover the entire area of the river channel under the base of the dam and cofferdams and to permit of further exploration by intermediate drilling when construction has been finally determined.

A. J. Wiley.
James Munn.
J. L. Savage.
W. R. Young.

Supplementary Report on Power Development.

The foregoing report of Board of Engineers, dated May 26, 1921, contains statement of power available on certain assumptions that do not cover all possible contingencies. On request they have made a supplemental report designed to show the maximum amount of firm power that could be developed by regulating the water for this purpose only. The results and the assumptions upon which they are based are given in the following supplemental report.

Both these reports are preliminary, and are not to be understood as final commitments to the heights of dam therein treated, or to any details of design. It seems advisable at present tentatively to adopt a flow line about contour 1250, as being the highest possible without materially affecting valuable development in the valley of Muddy Creek, and yet high enough to meet the needs of storage at this point and to develop sufficient power to pay for it.

Denver, Colo., *October 26, 1921.*

From: Board of Engineers.
To: Chief engineer.
Subject: Supplementary report on Boulder Canyon Dam, Colorado River.

1. Reference is made to the following:

Board report of May 26, 1921, on Boulder Canyon Dam, Colorado River.

Letter of July 8, 1921, from director to chief engineer; subject, "Report of Board of Engineers on Boulder Canyon Dam."

Letter of July 13, 1921, from chief engineer to director, same subject.

Letter of October 21, 1921, from director to chief engineer, same subject.

2. Complying with the director's suggestion as expressed in his letter to you dated October 21, 1921, the undersigned Board of Engineers has given further consideration to the subject of power development in connection with the Boulder Canyon reservoir, and it is desired to amend certain paragraphs of the report of May 26, 1921. These paragraphs are quoted below for convenient reference:

about 35 miles to keep above the flow line of the reservoir. Another plan is to connect with the main line of the Salt Lake route further west, at or near Las Vegas, Nev., distant about 40 miles. Both of these lines reach Boulder Canyon from the north. The other possibility is to connect with the Santa Fe at Chloride, Ariz., the end of a 20-mile branch line which leaves the main line at McConnor Junction, Ariz. From Chloride to the south rim of Boulder Canyon is about 50 miles. Further investigation is needed to decide which location is most feasible.

CAMP SITES.

22. The adoption of either of the railroad lines already mentioned will in a measure affect the location of a camp site. The size of the job, the broken character of the country, and the climate, make the location of a camp an important feature. Preferably the location should be one which will not be submerged and within easy reach of the work. While an ideal location may not be available there are several feasible ways of meeting the situation for housing, shops, storehouses, and yard room.

COST.

23. A preliminary estimate of quantities shows that the following yardage of concrete will be required in the main body of the dam for the two alternative reservoirs:

	Cubic yards.
26,500,000 acre-foot reservoir	2,800,000
31,400,000 acre-foot reservoir	3,500,000

Following is the total estimated cost of the dam, including right of way, railroad, camp, construction plant, river-diversion works, spillway, outlet works, and other minor features, together with the power house and transmission lines:

With 26,500,000 acre-foot reservoir:	
Dam	$50,000,000
Power plant	22,000,000
Transmission line	18,000,000
Total	90,000,000
With 31,400,000 acre-foot reservoir:	
Dam	55,000,000
Power plant	25,000,000
Transmission line	20,000,000
Total	100,000,000

In these figures a liberal allowance has been made for contingencies. With favorable conditions during the construction period the actual cost may be somewhat less than this estimate.

CONCLUSIONS.

24. From the facts given above and from studies of probable cost and revenues, we believe that the Boulder Canyon dam for the combined purposes of flood control, irrigation storage, and power development is physically practicable and financially feasible.

25. On account of the great construction problems involved in this unprecedentedly high dam, it is advisable to secure all possible in-

formation before final plans are decided upon. The investigations so far made have located the dam within such narrow limits that further drilling can be confined to the area to be occupied by the base of the dam and the cofferdams.

26. We recommend that as a preliminary to the final plans for the dam and for the adoption of a method of river diversion during construction, the area below the river level under the dam and cofferdams should be further explored by drilling to bed rock at least 35 holes, so distributed as to cover the entire area of the river channel under the base of the dam and cofferdams and to permit of further exploration by intermediate drilling when construction has been finally determined.

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Both these reports are preliminary, and are not to be understood as final commitments to the heights of dam therein treated, or to any details of design. It seems advisable at present tentatively to adopt a flow line about contour 1250, as being the highest possible without materially affecting valuable development in the valley of Muddy Creek, and yet high enough to meet the needs of storage at this point and to develop sufficient power to pay for it.

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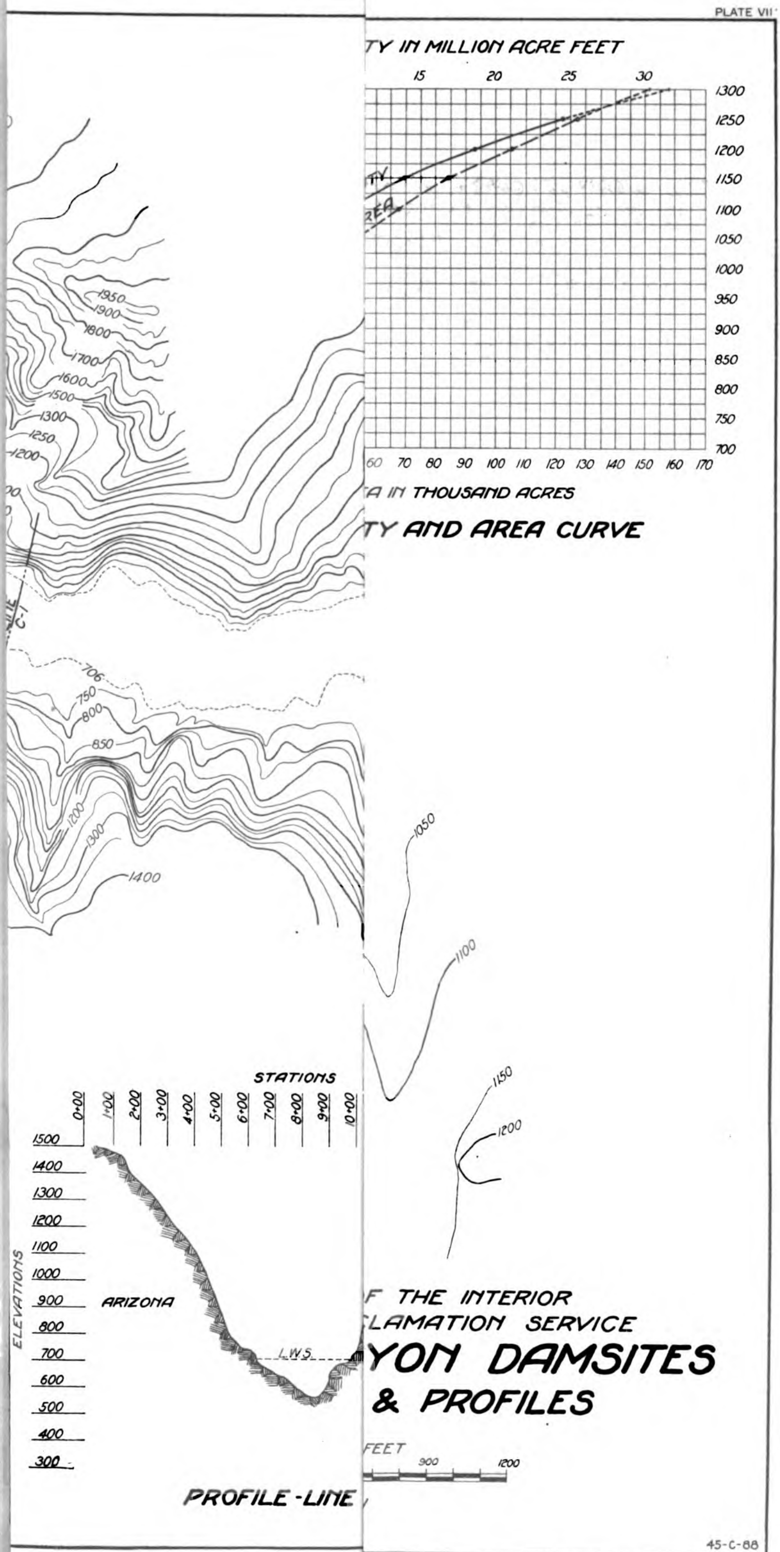
PLATE VII
TY IN MILLION ACRE FEET
15 20 25 30
1300 1250 1200 1150 1100 1050 1000 950 900 850 800 750 700
60 70 80 90 100 110 120 130 140 150 160 170
A IN THOUSAND ACRES
TY AND AREA CURVE
1950 1900 1800 1700 1600 1500 1300 1250 1200
706 750 800 850 1200 1300 1400
1050 1100 1150 1200
STATIONS
0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00
1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300
ELEVATIONS
ARIZONA
L.W.S.
PROFILE-LINE
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YON DAMSITES
& PROFILES
FEET
900 1200
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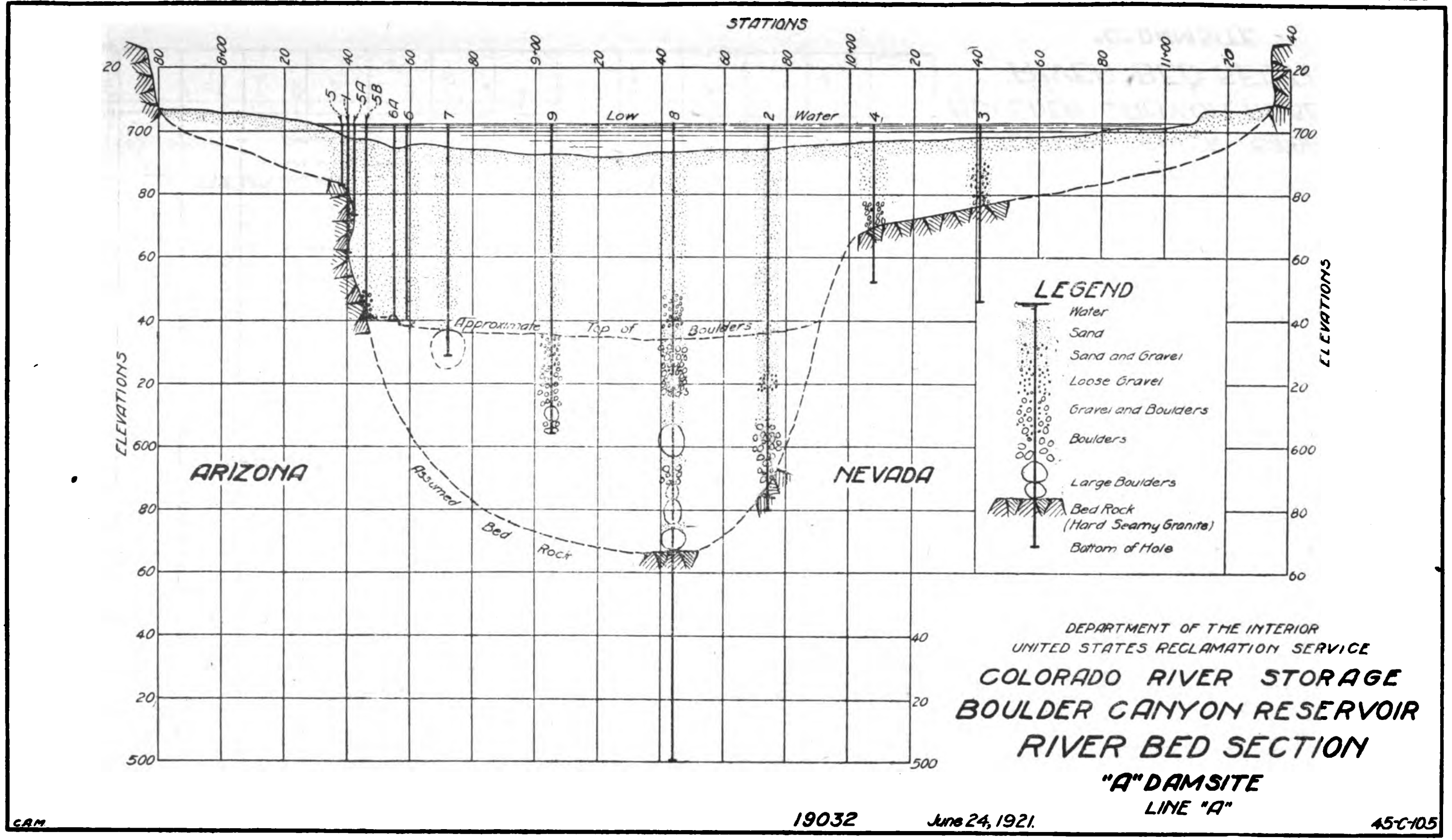
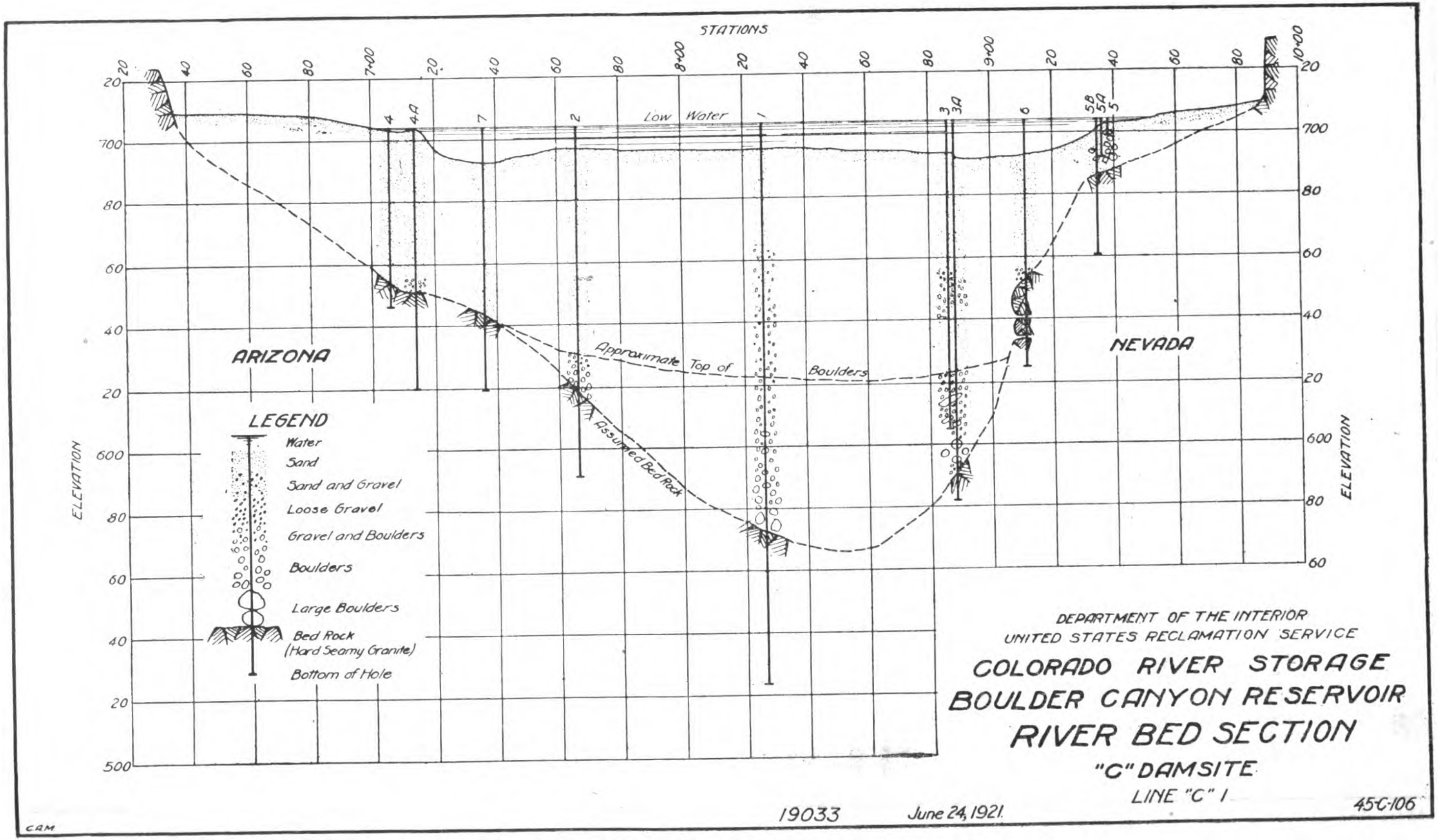
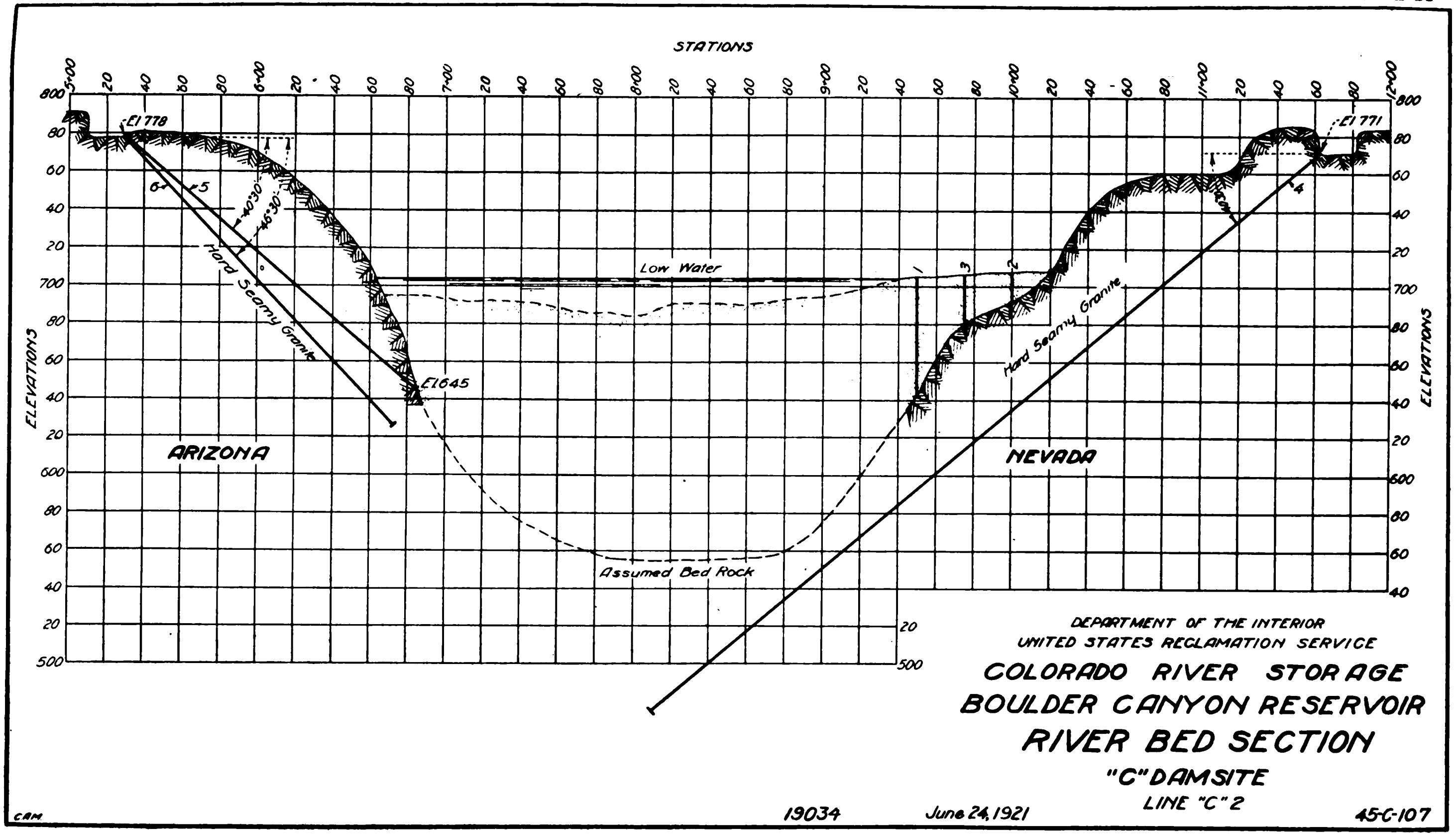
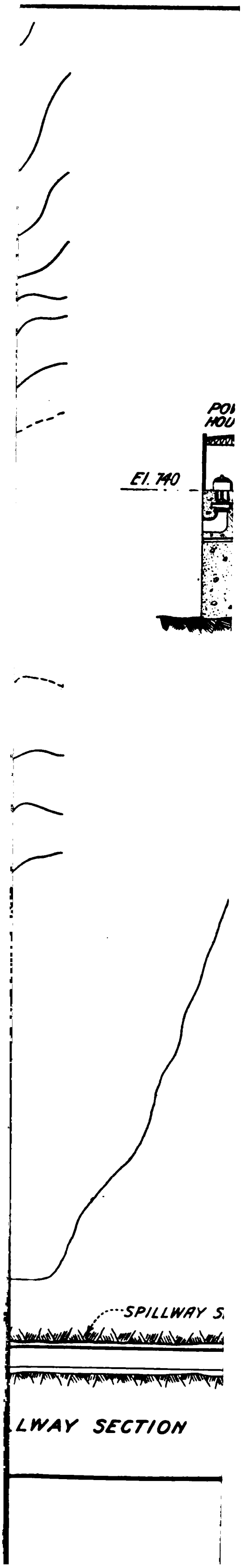

STATIONS
ELEVATIONS
Low Water
Approximate Top of Boulders
Assumed Bed Rock
ARIZONA
NEVADA
LEGEND
Water
Sand
Sand and Gravel
Loose Gravel
Gravel and Boulders
Boulders
Large Boulders
Bed Rock
(Hard Seamy Granite)
Bottom of Hole
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COLORADO RIVER STORAGE
BOULDER CANYON RESERVOIR
RIVER BED SECTION
"A" DAMSITE
LINE "A"
19032
June 24, 1921.
45-C-105
C.A.M.


STATIONS
ELEVATION
Low Water
ARIZONA
NEVADA
Approximate Top of Boulders
Assumed Bed Rock
LEGEND
Water
Sand
Sand and Gravel
Loose Gravel
Gravel and Boulders
Boulders
Large Boulders
Bed Rock
(Hard Seamy Granite)
Bottom of Hole
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COLORADO RIVER STORAGE
BOULDER CANYON RESERVOIR
RIVER BED SECTION
"C" DAMSITE
LINE "C" 1
19033
June 24, 1921.
45-C-106
C.A.M.


STATIONS
ELEVATIONS
El 778
El 645
El 771
Low Water
Hard Seamy Granite
Assumed Bed Rock
ARIZONA
NEVADA
40°30'
46°30'
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COLORADO RIVER STORAGE
BOULDER CANYON RESERVOIR
RIVER BED SECTION
"C" DAMSITE
LINE "C" 2
19034
June 24, 1921
45-C-107
CAM


POW
HOU
El. 740
SPILLWAY S
LWAY SECTION

POWER DEVELOPMENT.

13. Preliminary studies have been made for power development based on two different reservoir capacities, viz, 26,500,000 acre-feet and 31,400,000 acre-feet.

14. The accompanying tabulation (Table No. 1) shows a comparison of the power output and other related data for the two alternative reservoirs, based on different assumptions as to lands irrigated and to equated discharges for power development.

15. A comparison of the amount of firm power and irrigated acreage resulting from the various assumptions tabulated in connection with the 26,500,000 acre-foot reservoir leads to the conclusion that all lands in the United States and the lands under the All-American and Imperial canals in Mexico should be irrigated and that the power development should be based on the minimum irrigation discharge of 13,500 second-feet. This discharge with a minimum head of 360 feet will develop 486,000 turbine horsepower of firm power. If a 31,400,000 acre-foot reservoir is provided and the same lands irrigated the minimum discharge will be 14,300 second-feet, which, under a minimum head of 394 feet, will develop 563,000 horsepower of firm power.

3. The statements made in the paragraphs quoted above were based on a preliminary study of the Colorado River water supply by Engineer Harold Conkling in which it was assumed that a constant flow would be released from the reservoir for power development. A summary of Mr. Conkling's preliminary study is shown in Table No. 1 of the May 26 report.

4. Subsequent to the preparation of board report of May 26, 1921, further studies were made by Mr. Conkling which indicated that materially greater firm horsepower could be developed by a different reservoir operation whereby the amount of water released for power is varied inversely with the head. Under such operation of the reservoir, power water would be conserved at times of full reservoir and high head for use at times of low reservoir and small head.

5. Attached hereto you will find two plates prepared by Mr. Conkling showing the operation of Boulder Canyon reservoir of 31,400,000 acre-foot capacity as follows:

Plate XII. Operation of Boulder Canyon Reservoir based on the development of 700,000 firm horsepower in connection with the irrigation of 1,505,000 acres in the lower valley.

Plate XII-A. Operation of Boulder Canyon Reservoir based on the development of 600,000 firm horsepower in connection with the irrigation of 2,020,000 acres in the lower valley.

Both plates are based upon the assumption that the efficiency at the turbmes is 88 per cent and that the discharge at Boulder Canyon is 1,500 second-feet more than the recorded flow at Laguna Dam.

6. A review by members of this board of Mr. Conkling's later studies, including the plates attached hereto, leads to the following conclusions:

(*a*) The diagram, Plate VI shown at page 20 of the director's report, correctly represents the available firm horsepower at the Boulder Canyon dam site.

(*b*) This board concurs in the statements made on page 14 of the director's report relative to power development, as follows:

It is estimated that the feasible irrigation projects in the lower basin comprise 2,020,000 acres, of which about 60 per cent is in the United States and 40 per cent in Mexico. The full development of the proposed projects in the upper basin will subtract substantially from the total water supply, but there will still be left ample water to irrigate all the lands of the lower basin if it is conserved and regulated in a storage reservoir of ample capacity. The water can be used for power as drawn from the reservoir and the amount of power that can be developed with different amounts of storage capacity and with different assumptions of irrigated land below is shown by the diagram in Plate VI. It shows that with 1,505,000 acres of land in the lower basin irrigated and with a total storage capacity of 31,400,000 acre-feet of which the lower 5,000,000 is reserved for silt storage and the upper 5,000,000 is reserved for flood control, it is possible to develop over 700,000 firm horsepower. With the entire 2,020,000 acres of irrigable land developed in the lower basin the possibilities are still 600,000 firm horsepower, and besides this there is a large amount of secondary power which is not constant but will be of considerable value.

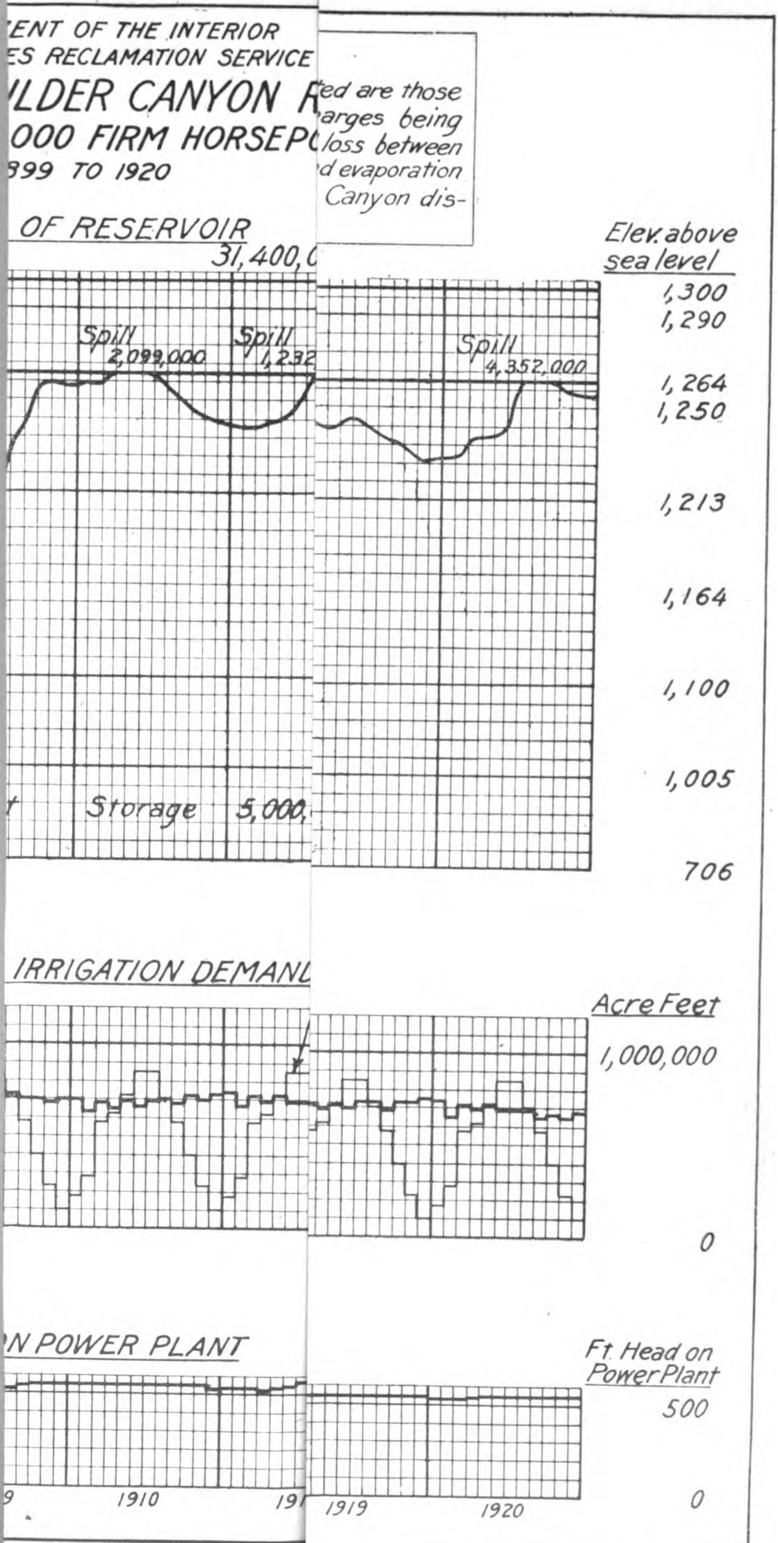
7. In paragraph 23 of the board report of May 26, 1921, the cost of Boulder Canyon reservoir of 31,400,000 acre-foot capacity is shown as follows:

Dam	$55, 000, 000
Power plant	25, 000, 000
Transmission line	20, 000, 000
Total	100, 000, 000

The estimates for the power plant and transmission line were based upon a development of 563,000 firm horsepower. No detail estimates have been prepared for the development and transmission of a larger amount of power, but it may be assumed that additional power can be developed and transmitted at the same cost per horsepower as in case of the 563,000 horsepower development. The resulting estimated cost of a 31,400,000 acre-foot reservoir in connection with the two power developments indicated in paragraph 6 above is, therefore, as follows:

700,000 firm horsepower development:	
Dam	$55, 000, 000
Power plant	31, 000, 000
Transmission line	25, 000, 000
Total	111, 000, 000
600,000 firm horsepower development:	
Dam	55, 000, 000
Power plant	27, 000, 000
Transmission line	22, 000, 000
Total	104, 000, 000

A. J. Wiley.
James Munn.
J. L. Savage.
Walker R. Young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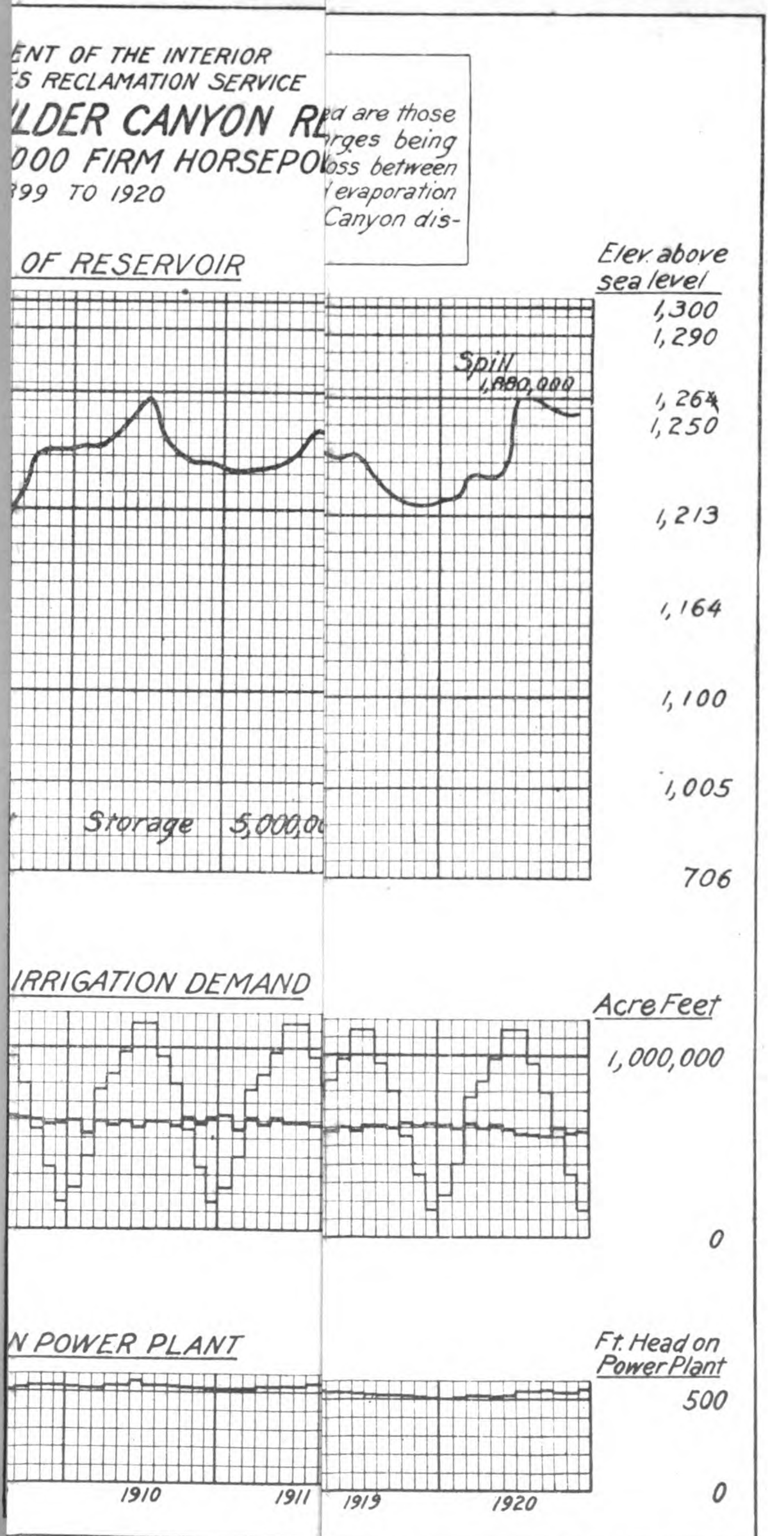
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Appendix B.

WATER SUPPLY AND DEVELOPMENT.

Colorado Basin contains over 6,000,000 acres of irrigable land for which water supply is sufficient; about 38 per cent was irrigated in 1920.

STATISTICS.

Table No. 1.—*Political (State) divisions of Colorado Basin.*

	Square miles.
Wyoming	19,000
Colorado	39,000
New Mexico	23,000
Arizona	103,000
Utah	40,000
Nevada	12,000
California	6,000
Total, United States	242,000
Total, Mexico	2,000
	244,000

Table No. 2.—*Upper basin—Acreage irrigated and irrigable in future.*

SUMMARY BY RIVER BASINS.

	Irrigated, 1920.	Additional possible to irrigate.	Total.
Green River Basin, Wyoming, Utah, and Colorado	643,000	1,212,000	1,855,000
Grand River Basin, Colorado and Utah	542,000	412,000	954,000
San Juan River Basin, Colorado and New Mexico	157,000	729,000	886,000
Price River Basin, Utah	30,000	50,000	80,000
San Rafael River Basin, Utah	80,000	20,000	100,000
Fremont River Basin, Utah	16,000	30,000	46,000
Little Colorado River Basin, Arizona	19,000	45,000	64,000
Virgin River Basin, Utah, Arizona, and Nevada	26,000	40,000	66,000
Escalanti River Basin, Utah	2,000	2,000	4,000
Kanab Creek, Utah and Arizona	2,000	2,000	4,000
Paria River, Utah	2,000	2,000	4,000
Other tributaries	7,000	3,000	10,000
Total	1,526,000	2,547,000	4,073,000

SUMMARY BY STATES.

States.	Irrigated 1920.[1]	Additional possible to irrigate.	Total.
Wyoming	367,000	543,000	910,000
Colorado	740,000	1,018,000	1,758,000
Utah	359,000	456,000	815,000
New Mexico	34,000	483,000	517,000
Arizona	21,000	47,000	68,000
Nevada	5,000	....	5,000
Total	1,526,000	2,547,000	4,073,000

[1] From United States census, modified by data from State engineers.

TABLE No. 3.—*Lower basin—Acreage irrigated and irrigable in future.*

SUMMARY BY AREAS.

	Irrigated, 1920; gravity.	Future additional possible.		Total ultimate.
		Gravity.	Pump.	
United States:				
Above Laguna Dam—				
Cottonwood Island	....	1,000	3,000	4,000
Mohave Valley	....	24,000	3,000	27,000
Chemehuevis Valley	....	4,000	....	4,000
Parker project [1]	4,000	100,000	6,000	110,000
Palo Verde Valley [1]	35,000	43,000	....	78,000
Palo Verde Mesa	....	....	18,000	18,000
Chucawalla Valley	....	....	44,000	44,000
Cibola Valley [1]	....	16,000	....	16,000
Isolated tracts [1]	....	1,000	3,000	4,000
Total above Laguna Dam	39,000	189,000	77,000	305,000
Below Laguna Dam—				
Yuma project [1]	54,000	15,000	61,000	130,000
Imperial district [1]	415,000	100,000	....	515,000
Imperial extensions [1]—				
East Mesa	....	124,000	36,000	160,000
Dos Palmas	....	5,000	....	5,000
Coachella Valley	....	72,000	....	72,000
West Side	....	10,000	23,000	33,000
Total below Laguna Dam	469,000	326,000	120,000	915,000
Total, United States	508,000	515,000	197,000	1,220,000
Mexico:				
Under Imperial Canal [1]	190,000	65,000	....	255,000
Under All-American Canal [1]	....	22,000	8,000	30,000
Delta south of Volcano Lake and Bee River	....	250,000	....	250,000
Sonora	....	210,000	55,000	265,000
Total, Mexico	190,000	547,000	63,000	800,000
Grand total, lower basin	698,000	1,062,000	260,000	2,020,000

SUMMARY BY STATES AND POLITICAL DIVISIONS.

United States:				
Nevada [2]	....	**1,000**	**1,000**	**2,000**
Arizona	**50,000**	**156,000**	**73,000**	**279,000**
California	**458,000**	**358,000**	**123,000**	**939,000**
Total, United States	**508,000**	**515,000**	**197,000**	**1,220,000**
Total, Mexico	**190,000**	**547,000**	**63,000**	**800,000**
	698,000	**1,062,000**	**260,000**	**2,020,000**
Gila Basin, Ariz. [3]	**430,000**	**400,000**	....	**830,000**

[1] Items are feasible now.
[2] Recently the State engineer has reported 80,000 acres additional possible irrigation in Nevada, of which 30,000 are in lower basin.
[3] From information furnished by State water commissioner and has been given no study since it does not affect the general problem.

TABLE No. 4.—*Summary of irrigation, entire basin, by political boundaries.*

	Irrigated, 1920.[1]	Additional possible.	Total.
United States:			
Wyoming	367,000	543,000	910,000
Colorado	740,000	1,018,000	1,758,000
Utah	359,000	456,000	815,000
New Mexico	34,000	483,000	517,000
Arizona	501,000	676,000	1,177,000
Nevada	5,000	[2] 2,000	7,000
California	458,000	481,000	939,000
Total, United States	2,464,000	3,659,000	6,123,000
Mexico	190,000	610,000	800,000
Total	2,654,000	4,269,000	6,923,000
Total:			
Upper basin	1,530,000	2,550,000	4,080,000
Lower basin	700,000	1,320,000	2,020,000
Gila Basin	430,000	400,000	830,000
Total	[1] 2,660,000	4,270,000	6,930,000

[1] From United States census, modified by data from State engineers.
[2] Recently the State engineer has reported 80,000 acres additional possible irrigation in Nevada, of which 50,000 acres are in the upper basin.

TABLE No. 5.—*Estimated additional acreage which will be irrigated in near future except Gila.*

	Acreage under present projects.	Class A.	Class X.	Total.
Upper basin	200,000	287,000	521,000	1,008,000
Lower basin	232,000	474,000	4,000	710,000
Total	432,000	761,000	525,000	1,718,000

DRAFT ON WATER SUPPLY.

The discharge of the Colorado at Yuma has been reliably recorded since and including 1903. Before that the meager records are faulty and can not be used. However, a period of low run-off preceded 1903, and it has been necessary to estimate back to 1899 to include the low period. Estimates have been made by various authorities and those of John T. Whistler are used here. What is really wanted is the discharge at Boulder Canyon, and from the record at Yuma this can be determined approximately by the following steps:

(*a*) The discharge of the Gila, which enters the Colorado just above the gaging station at Yuma, must be subtracted.

(*b*) The diversion for Yuma project, which is made at Laguna Dam, also above the gaging station, must be added.

(*c*) The water consumed by irrigation of the 39,000 acres irrigated below Boulder Canyon must be added.

(*d*) The loss by evaporation from the river bed and from the 200,000 acres below Boulder Canyon, which is perennially submerged, must be added.

Items (*a*) and (*b*) are recorded and the adjustment can be made. Item (*c*) is very small on the average, since this acreage has not always been irrigated but has been gradually increasing to the present figure. This may be neglected. Item (*d*) will vary with the annual flow and must be very large in the high years. But as the years which determine the size of the reservoir are the low years, the error will be the minimum. A part of this land will be reclaimed and irrigated, and the floods, if Boulder Canyon is built, will cease to exist, so that a considerable error is introduced in the conservative direction by neglecting this indeterminate amount.

The discharge at Boulder Canyon having been calculated, the next step estimates what it would be were this same cycle of years to recur after the development of the upper basin has been completed. The following items must be subtracted:

(1) The average amount of water which has been consumed by increased irrigation above during the life of the record.

(2) The average increase in diversions from the basin during the period.

(3) The future estimated consumption of water which increased irrigation above will bring about.

(4) The estimated increase in water diverted from the basin.

(5) The increased evaporation from the surface of reservoirs in the canyon region for power regulation and from the backwater caused by dams built to create power head.

Increased development above—Items 1 and 2.—Various dependable estimates of irrigation above are as follows: 1902, 665,000 acres; 1915, 1,127,000 acres; 1920, 1,526,000 acres; increase, 1902 to 1920, 861,000 acres. A large amount of this is in wild hay, the water consumption of which is small, but the increase in the lower Grand and Gunnison valleys was also large and here the land has been allowed to become seeped, making a heavy consumption. It is assumed that the consumption has averaged 1 to 3 feet in depth per acre and that the increase in irrigable land has been gradual since 1902. It is also assumed that this same gradual increase extended back to 1899.

In 1902, diversions out of the basin were 7,000 acre-feet. In 1920, they were 127,000 acre-feet, an increase of 120,000. Placing these two items together, if the same cycle repeated itself, it is estimated that the mean annual discharge would be 730,000 acre-feet less than recorded.

Future estimated consumption of water—Items 3 and 4.—Future consumption of water for irrigation will vary from 1 foot in depth for wild hay to probably 2 feet in such areas as the San Juan in New Mexico and 2.5 feet in the warmer climate of the Virgin Basin. It is believed that the figures used for consumption in the following table are sufficient to include evaporation from local reservoirs which will be used for irrigation. They are not large enough to include an excessive evaporation from seeped lands. However, the upper basin, as a rule, has good natural drainage and it is assumed that if it becomes feasible to irrigate the expensive projects included in the list of ultimate acreage, drainage of any seeped lands which may exist will precede such development, since it would be less costly to reclaim such lands by drainage.

The estimated depletion of the stream by development above considers storage in reservoirs and draft from them as compared to local stream flow. It also considers return flow in the annual régime observed on Reclamation Service projects. The effect of irrigation in the upper basin on discharge in the lower river will be a smoothing out of seasonal and annual irregularities, both by storage in hold-over reservoirs and storage in the ground beneath irrigation projects. In the years 1902, 1903, and 1904, the run-off was so small that in the upper basin the average project would hardly have had half its supply and this would have reduced consumptive use in those years by possibly 25 per cent. This has been taken account of in calculations.

The acreages estimated as irrigable include a few duplications; the most conspicuous example is that of the water supply of the Virgin River. This river rises in Utah and receives most of its water supply in that State. It is possible to use this water in Utah, Arizona, or Nevada. All three States propose such use to an extent that in the aggregate will greatly exceed the available water supply The acreages in all are included, but only of course the actual water supply of the Virgin River.

TABLE No. 6.—*Estimated future depletion by development—Upper basin.*

Month.	Irrigation.	Diversion out of basin.	Total.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
January	20,000		− 20,000
February	30,000		− 30,000
March	50,000		− 50,000
April	340,000		− 340,000
May	1,118,000	22,000	−1,140,000
June	1,592,000	148,000	−1,740,000
July	635,000	75,000	− 710,000
August	178,000	32,000	− 210,000
September	41,000	19,000	− 60,000
October	+36,000	16,000	+ 20,000
November	+47,000	7,000	+ 40,000
December	+10,000		+ 10,000
	3,913,000	317,000	4,230,000

Consumption per acre, 1.54 acre-feet. Estimated depletion for 1902, 1903, and 1904, 3,180,000 acre-feet.

INCREASED EVAPORATION FROM POSSIBLE RESERVOIRS FOR POWER IN CANYON REGION.

At first thought it would seem that power development above would not decrease average water supply below, but with conditions for power development on the Colorado as they are the toll of water will be large. Head for power will be developed mostly by constructing dams in the river channel, and these will create large areas of water surface to be exposed to the evaporation of this intensely arid region. Large reservoirs also must be built to equate the discharge for these dams.

TABLE No. 7.—*Possible reservoirs.*

Reservoir or dam site.	Raise in water surface.	Area of water surface.
	Feet.	*Acres.*
Yampa Basin:		
Juniper	225	25,000
Other sites [1]	580	65,000
White River Basin, Rangely	200	17,000
Main stem Green River:		
Flaming Gorge	240	40,000
Browns Park	100	13,000
Swallow Canyon,[1] Echo Park, Island Park, and Split Mountain		12,000
Ouray	100	10,000
Rattlesnake [1] and Rock Creek	340	15,000
Total, Green River		197,000
Grand River, Dewey	225	28,000
Colorado River:		
Junction	175	28,000
Lees Ferry [1]	650	140,000
Other sites between Lees Ferry and Boulder Canyon, except in Grand Canyon [1]		20,000
Boulder Canyon	332	140,000
Bulls Head	155	22,000
Williams	75	50,000
Total, Colorado River		400,000

[1] Area is only roughly approximated by comparison with other sites.

SUMMARY IN ROUND FIGURES.

	cres
Green River	200,000
Grand River	30,000
Colorado River	400,000

These are either power sites or power sites combined with large regulating reservoirs. In the power sites water will always be held at the top level and in the regulating reservoirs near the top, so that water will be in the reservoir for the low year.

A part of this area is already occupied by the stream, so that additional evaporation needs only to be considered.

Assuming, roughly, that additional evaporation will take place on 75 per cent of the above maximum areas and assigning values, the following table results:

TABLE No. 8.—*Estimated future depletion by evaporation from reservoirs.*

River.	Area.	Annual depth of evaporation.	Total amount.
	Acres.	*Feet.*	*Acre-feet.*
Green River	15,000	3	450,000
Grand	30,000	4	120,000
Colorado	300,000	5	1,500,000
Total			2,070,000

TABLE NO. 9.—*Averages 1903–1920.*

		Acre-feet.
Average discharge of Colorado at Yuma, 1903–1920		17,400,000
Diverted above by Yuma project		150,000
Total discharge		17,550,000
Discharge of Gila		1,080,000
Estimated at Boulder Canyon		16,470,000
Past depletion [1]		560,000
Remainder at Boulder Canyon		15,910,000
Future depletion:		
Development, upper basin	4,230,000	
Reservoirs in canyon section	2,070,000	
		6,300,000
Remaining water		9,610,000

The above table is for the years 1903 to 1920, which leaves out the low cycle preceding. However, it is probable that no reduction in average amount of water would result if that period were taken into the cycle because consumption would be less in the upper basin and evaporation less in the regulating reservoirs along the river. At Boulder Canyon, for instance, the reservoir contents would be so depleted that the average submerged area would be about 60 to 70 per cent of that normally submerged.

DEMANDS ON WATER SUPPLY.

The demands on water supply at Boulder Canyon will be for irrigation of the entire irrigable area below, both now irrigated and estimated additional, plus evaporation from reservoirs at Boulder Canyon and below. This last item has been already used in estimating the water supply in the previous computation so that only irrigation demands remain to be considered.

Data at hand indicate that water consumed annually in Imperial Valley for crop growth averages somewhat less than 3 feet in depth. Hence, if conditions were favorable for reuse of return flow, there is enough water for approximately 3,000,000 acres. But conditions are not favorable for reuse of return flow at least by diversion from the river as, after Laguna Dam is passed, most of the irrigable land does not slope toward the river.

In the Imperial Valley there should be some dependable seepage or return water in the drainage channels and perhaps some surface water which can be reused, but because of the peculiar topographical features of the region this will be comparatively small.

The following assumptions are made: Annual gross demand for irrigation, gravity, 4.40 acre-feet per acre; pump, 3.50 acre-feet per acre. Annual net demand above Laguna Dam, consumptive use, 3 acre-feet per acre.

[1] Less than given in previous estimates, because embracing a shorter period of time.

TABLE No. 10.—*Diversion duty.*

[Acre-feet per acre.]

Month.	Pumping.	Gravity.	Lands above Laguna Dam, net.	Month.	Pumping.	Gravity.	Lands above Laguna Dam, net.
January	0.10	0.12	0.10	August	0.40	0.50	0.35
February	.18	.22	.10	September	.33	.42	.30
March	.32	.40	.35	October	.24	.30	.15
April	.35	.44	.35	November	.14	.18	.10
May	.40	.52	.35	December	.08	.10	.05
June	.48	.60	.45				
July	.48	.60	.45	Total	3.50	4.40	3.00

TABLE No. 11.—*Estimated future demand.*

		Acres.
United States, all lands		1,220,000
Mexico:		
Imperial Canal	255,000	
All-American Canal	30,000	
		285,000
Total		1,505,000

ACRE FEET.

	Above Laguna Dam.	Below Laguna Dam.		Total (round figures).
		Gravity.	Pumping.	
Acres	305,000	1,072,000	128,000	1,505,000
Demand (acre-feet per acre)	[1] 3.00	4.40	3.50	4.04
January	30,000	129,000	12,000	170,000
February	30,000	236,000	22,000	290,000
March	107,000	429,000	41,000	580,000
April	107,000	472,000	45,000	620,000
May	108,000	558,000	53,000	720,000
June	138,000	643,000	61,000	840,000
July	138,000	643,000	61,000	840,000
August	108,000	536,000	51,000	700,000
September	90,000	450,000	43,000	580,000
October	45,000	322,000	31,000	400,000
November	30,000	192,000	18,000	240,000
December	16,000	107,000	10,000	100,000
Total	915,000	4,717,000	448,000	6,080,000

[1] Net.

TABLE No. 12.—*Estimated ultimate demand.*[1]

	Acres.
United States	1,220,000
Mexico	800,000
Total	2,020,000

[1] All lands below Boulder Canyon.

TABLE No. 12.—*Estimated ultimate demand*—Continued.

ACRE FEET.

	Above Laguna Dam.	Below Laguna Dam.		Total (round figures).
		Gravity.	Pumping.	
Acres	305,000	1,532,000	183,000	2,020,000
Demand (acre-feet per acre)	[2] 3.00	4.40	3.50	4.10
January	30,000	182,000	18,000	230,000
February	30,000	337,000	32,000	400,000
March	107,000	612,000	58,000	780,000
April	107,000	674,000	64,000	850,000
May	108,000	797,000	75,000	980,000
June	138,000	920,000	86,000	1,140,000
July	138,000	920,000	86,000	1,140,000
August	108,000	766,000	73,000	950,000
September	90,000	644,000	65,000	800,000
October	45,000	460,000	44,000	550,000
November	30,000	276,000	25,000	330,000
December	16,000	152,000	15,000	150,000
Total	915,000	6,740,000	641,000	8,300,000

[2] Net.

Although all of the foregoing estimates and assumptions rest on many uncertainties, the general conclusion may be drawn in the light of present knowledge that the water supply of the Colorado is equal to all the demands which will be made on it.

STORAGE REQUIRED.

Should the upper basin and power in the canyon region develop as has been outlined, consideration of the matter leads to the conclusion that storage will be needed only of sufficient amount to regulate the river for irrigation after it has passed through the large regulating reservoir which may be possible at Lees Ferry just below the San Juan, and also to regulate the 1,330,000 acre-feet of inflow below the reservoir.

It is, however, apparent, as was stated previously, that a reservoir primarily for irrigation will be needed at Boulder Canyon, otherwise there will arise a continued series of troubles from conflicts between the lower basin and the power developments or between the lower basin and upper basin irrigationists.

It is necessary to adopt a working hypothesis for a basis in considering what is necessary to be done with the river. Accordingly, the problem has been worked out for three plans.

(1) To provide storage which will be necessary when the most feasible irrigation developments in both the upper and lower basins have been made. This is the minimum storage which should be provided. In the last five years the average increase of irrigated land in the upper basin has been 80,000 acres yearly. This took place under the impetus of war prices, and it is unlikely that it will exceed that average for some time to come. At the same rate the 1,000,000 acres of most likely land would be irrigated in less than 15 years. In the lower basin there are 710,000 acres of land which are known to be feasible at the present time if the necessary works on which they are mutually dependent can be financed. The time for reclamation of these lands may not exceed 15 years at the present

rate of increase of 50,000 acres per year, so that storage which might be developed under this plan may take care of the situation for only 15 years.

(2) To provide the maximum storage which will be needed for ultimate irrigation development if no power reservoirs are built in the canyon region.

(3) To provide for complete regulation of the river with the idea that surplus water be used to develop power at Boulder Canyon and that later as development above decreases the discharge available, release for power will be decreased. To compensate for decrease in release for power there will be less capacity in the reservoir which must be reserved for storage and consequently more head available for power. This works out satisfactorily, especially if the Boulder Canyon plant is tied in with one above where discharge can be regulated according to power needs.

PLAN 1. MINIMUM STORAGE DEVELOPMENT.

		Acres.
Upper basin—additional acreage		1,008,000
Lower basin:[1]		
Present acreage	698,000	
Additional acreage	710,000	
		1,408,000
Total		2,416,000

TABLE No. 13.—*Estimated demand for most feasible acreage.*

[Acre-feet. Based on 5 feet duty for lower basin because of no necessity for economy.]

	Lower basin, 1,408,000 acres.	Upper basin, 1,008,000 acres total.[2]	Total.		Lower basin, 1,408,000 acres.	Upper basin, 1,008,000 acres total.[2]	Total.
January	260,000		260,000	August	800,000	160,000	960,000
February	200,000		200,000	September	730,000	160,000	890,000
March	610,000		610,000	October	450,000	80,000	530,000
April	670,000	80,000	750,000	November	380,000		380,000
May	680,000	380,000	1,060,000	December	110,000		110,000
June	870,000	400,000	1,270,000				
July	870,000	320,000	1,190,000	Total	6,630,000	1,580,000	8,210,000

TABLE No. 14.—*Storage required for most feasible acreage neglecting evaporation from reservoir.*

	Acre-feet.		Acre-feet.
1899	460,000	1910	410,000
1900	1,660,000	1911	380,000
1901	1,410,000	1912	330,000
1902	2,340,000	1913	810,000
1903	1,010,000	1914	320,000
1904	440,000	1915	1,000,000
1905	980,000	1916	200,000
1906	250,000	1917	370,000
1907		1918	770,000
1908	290,000	1919	1,030,000
1909		1920	460,000

[1] Consists of those items shown as "feasible now" in Table 3, p. 32.
[2] Assumed that withdrawals for storage balance return flow out of irrigation season.

PLAN 2. MAXIMUM STORAGE NEEDED FOR IRRIGATION DEVELOPMENT.

		Acres.
Upper basin, additional acreage		2,547,000
Lower basin:		
Present acreage	698,000	
Additional acreage	1,322,000	
		2,020,000
Total		4,567,000

TABLE No. 15.—*Estimated demand for ultimate acreage.*

[Acre-feet.]

	Upper basin.	Lower basin.	Total.		Upper basin.	Lower basin.	Total.
Acres	2,547,000	2,020,000	4,567,000	June	1,740,000	1,140,000	2,880,000
Demand (acre-feet per acre).	1.54	4.10	2.68	July	710,000	1,140,000	1,850,000
				August	210,000	950,000	1,160,000
				September	60,000	800,000	860,000
January	20,000	230,000	250,000	October	+20,000	550,000	530,000
February	30,000	400,000	430,000	November	+40,000	330,000	290,000
March	50,000	780,000	830,000	December	+10,000	150,000	140,000
April	340,000	850,000	1,190,000				
May	1,140,000	980,000	2,120,000	Total	[1] 4,230,000	8,300,000	12,530,000

[1] Of this total, 317,000 acre-feet is for diversion outside the basin.

TABLE No. 16.—*Storage required for full irrigation development, evaporation neglected.*

	Acre-feet.		Acre-feet.
1899	530,000	1910	2,630,000
1900	2,510,000	1911	460,000
1901	2,510,000	1912	300,000
1902	[1] 3,540,000	1913	1,850,000
1903	[1] 1,380,000	1914	290,000
1904	[1] 2,710,000	1915	1,260,000
1905	1,340,000	1916	170,000
1906	380,000	1917	340,000
1907	0	1918	940,000
1908	1,790,000	1919	2,850,000
1909	0	1920	470,000

PLAN 3. COMPLETE CONTROL OF THE RIVER.

	Acre-feet.
Average annual discharge at Boulder Canyon after allowance for past depletion above	15,700,000
Average future depletion from upper basin	4,030,000
Ultimate discharge	11,670,000

Mass computations give the following results:

	Acre-feet.
Average annual draft	11,670,000
Storage required for complete control	25,000,000
Average annual evaporation (5-foot depth)	520,000
Average useful annual draft	11,150,000
Ultimate irrigation needs lower basin	8,300,000
Used for power	2,850,000

[1] In the years marked thus, the entire run-off is short by the amounts shown. To supply this it is necessary to carry over water from previous years which detail calculations, including evaporation of 5 feet in depth, show will require 11,000,000 acre-feet of storage

POSSIBLE RESERVOIR SITES.

Two major plans have been proposed for the regulation of waters of the Colorado:

(1) A series of reservoirs on the major tributaries below irrigation development.

(2) A large reservoir at Boulder Canyon.

There are many obvious reasons why a reservoir at Boulder Canyon has the best strategic location. The most striking of these are:

(1) It is nearer to the areas which will use the water and therefore irrigation supply can be better controlled.

(2) It will control the floods which menace the Lower Basin (discussed later).

(3) It will not impose restrictions on any power development on the upper basin as would a reservoir for Imperial Valley located on one of the tributaries.

Although it is apparent that the solution of the ultimate development of the Colorado lies in a reservoir on the lower river rather than on the tributaries, the possibilities in use of upper reservoirs is here discussed in order to bring out their inadequacy and because as a temporary expedient it may be necessary to have recourse to one of these reservoirs.

TABLE No. 17.—*Major storage sites in Colorado Basin for use of lower basin.*

Reservoir site.	Stream.	Height of water storage above river.	Acre-feet capacity.	Greatest depth to bedrock.
On tributaries:				
Flaming Gorge	Green River	240	4,000,000	73 feet.
Browns Park	do	200	2,500,000	Unsatisfactory bedrock.
Ouray	do	210	16,000,000	121 feet.
Juniper	Yampa River	200	1,500,000	24 feet.
Kremling	Grand River	230	2,200,000	104 feet.
Dewey	do	215	2,270,000	44 feet.
Bedrock	Dolores River	210	800,000	Not drilled.
Bluff	San Juan River	206	1,350,000	Do.
On main stream:				
Junction	Colorado River	250	7,450,000	None at 120 feet.
Boulder Canyon—				
Dam at Boulder Canyon	do	(1)	(1)	Now exploring.
Dam at Black Canyon	do	(2)		

[1] Any capacity. [2] Not yet determined.

Of the foregoing the following are of doubtful availability:

Browns Park.—Because it is only a short distance below Flaming Gorge, would control the same water, and has unsatisfactory foundation.

Ouray.—Because of large cost in getting to bedrock, and also because it would flood the location of the Moffatt Railroad, which is now partially built and which is expected at some time to be built into this region.

Kremling.—Because it is now occupied by the Moffatt Railroad, which has built through the reservoir dam site and would be costly to remove.

Bluff.—Site would not be satisfactory for irrigation because of large silt discharge compared to size. Furthermore, the entire flow of the San Juan, except in extremely high floods, can be used for irrigation in the lower basin. The Bluff could be used as a detention reservoir.

Junction.—Because of lack of foundation.

Bedrock.—Because irrigation above will exhaust the tributary flow.

Summing up, the following reservoirs have been found to be suitable:

	Capacity in acre-feet.
Explored:	
Flaming Gorge-Green	4,000,000
Juniper-Yampa	1,500,000
Dewey-Grand	2,270,000

The sum total of the known feasible capacity is 7,770,000 acre-feet, but silt storage is required at Dewey to take care of the 10,000 acre-feet passing that site yearly, and if 770,000 acre-feet is reserved for this purpose there remains only 7,000,000 acre-feet of water capacity.

For plan 1, which is only a temporary expedient, any one of these reservoirs would be approximately sufficient. However, the amounts of storage necessary as calculated for that plan should be increased by about 20 per cent to provide for increased difficulty of regulation from a reservoir so distant and to provide for evaporation loss from the reservoir surface, so that if Dewey or Juniper were used, there would be shortage in 1900 and 1902.

A serious objection to the use of Juniper or Flaming Gorge is the interference with potential power at the sites and below. There exists a necessity for early addition of power development in that vicinity, and the value of the sites would be largely impaired if the flow of those rivers were regulated for irrigation.

The potential power on the Yampa at the present time is 245,000 horsepower and on the Green to the mouth of the Yampa 260,000 horsepower. Reconnaissance has indicated that there are possible sites on the Yampa below Juniper, whereby 730 feet of head can be developed and on the Green 800 feet.

This objection does not apply to the Dewey, since the flow is large and it is probable that a reservoir for irrigation would so regulate the flow as to make a valuable power site at that point. The conclusion is, therefore, that if a partial development should be found necessary, Dewey reservoir would answer the purpose with material benefit to all interests.

For plan 2, about 3,000,000 acre-feet capacity will provide the necessary storage except in the low cycle 1902–1904. This capacity exists at Flaming Gorge, but the stream flow available, which averages 1,920,000 acre-feet annually now and which estimated irrigation above will reduce to about 1,100,000, makes it useless for so large a storage, except as a holdover reservoir which would retain all the discharge until full and remain full until needed for a low cycle of years. A plan of operation for a combination of the three reservoirs—Dewey, Juniper, and Flaming Gorge—is as follows: Dewey emptied first would provide for 14 years of the 22 without draft on other reservoirs. Draft on Juniper next would provide for four more, and Flaming Gorge, acting as a holdover reservoir, could provide approximately for all the rest except 1903 and 1904, when shortages to the full amount shown would be felt, of 17 per cent and 33 per cent, respectively.

What has been said as to power under plan 1 applies more cogently to this because the value of all power sites on the entire Yampa, while not destroyed, would be seriously impaired because they could use only Little Snake River water. On the Green, until the Yampa is reached, they would be totally destroyed and seriously impaired below that.

In addition, the upper reservoirs will provide insufficient flood control of the Lower River.

FLOOD CONTROL ON THE COLORADO.

Floods in the lower Colorado come from three sources: (*a*) The Gila Basin; (*b*) the intermediate area between the San Juan and the Gila; (*c*) the headwaters of the Green, Grand, and San Juan.

The first gives floods in January and February, as a rule, but they are very erratic. They are also heavier than floods from other sources, but are of short duration. The second area gives floods of similar nature and they are possibly as severe as from the Gila, and they are likely to come at times when they might coincide with the Gila and thus be especially destructive. In the period of record there was one flood of about 70,000 second-feet in February, 1920, most of which probably came from this source, but to date records are not available from the upper streams by which the source can be determined. Floods from the third area, the upper tributaries, occur practically every spring and are of long duration. They start with the melting snow on the slopes of the Continental Divide and its spurs in Colorado, Utah, and Wyoming.

Floods from the first source can be controlled only by a reservoir near the mouth of the Gila, from the second by a reservoir below Virgin River, and from the third by reservoirs either on the major tributaries or lower down on the main river. A reservoir below the Virgin would control floods from both areas 2 and 3.

Flood control by storage will have to be supplemented by levees. It is estimated that if the floods could be controlled to a maximum of 50,000 second-feet a satisfactory levee system could easily be maintained. When ultimate development takes place the floods will be reduced by storage for irrigation in the upper basin, and by storage in canyon area for power. In round figures the flood control necessary under present conditions is 8,000,000 acre-feet.

There is likelihood that more severe floods occur. So far as gage records give information, exceptionally high water occurred in 1884, 1905, 1906, 1907, and 1909, with 1909 the highest during the spring floods. Gage heights at Yuma are not entirely conclusive, as there is some evidence that the river bed raised 3 feet at Yuma between 1884 and 1909, which, if true, would indicate a very heavy flood in 1884. This would corroborate other evidence bearing on 1884, which is as follows:

(*a*) Grand River (principal tributary to Colorado): Gage in 1884 read at peak was 18.5; highest since, in 1909, was 15, indicating a flood with possibly twice as high a peak as the 1909.

(*b*) Cache La Poudre River (heading on opposite side of Rockies from the Grand): 1884 was highest year ever recorded. The next highest was 1909. In May and June of 1884 total discharge was 68 per cent greater than in 1909.

(*c*) Columbia River was higher in 1884 than in 1909, although the difference for entire year was only 7 per cent.

The inference from the foregoing is that there was surely a high flood on the Grand, that it may have continued through May and June, and that probably heavy discharge occurred throughout the West, making it possible that the Green and San Juan both were in heavy flood at the time.

A 50 per cent greater flood continued as long as that of 1909 would require for control to 50,000 second-feet storage capacity of 12,000,000 acre-feet for present conditions on the river and 7,000,000 acre-feet for ultimate conditions.

A baffling feature of estimate of flood control necessary is the great variation in discharge with the same gage. It would be conservative, however, to estimate that a 9,000,000 acre-foot capacity always reserved for flood control would bring the largest flood down to 50,000 second-feet and a 5,500,000 acre-foot capacity would reduce the largest flood to 75,000 second-feet.

Necessity for building capacity specifically for flood control decreases as reservoirs approach that capacity necessary for complete control of the discharge, and if development takes place as outlined, floods on the Colorado will be taken care of without reservation of much capacity in Boulder Canyon reservoir for this purpose.

FLOOD CONTROL ON THE GILA.

Control of the Gila for floods can be completely accomplished only at Sentinel reservoir site. The worst flood of record occurred from January 20 to February 3, 1916, during which time the peak reached almost 200,000 second-feet and the entire discharge was 2,373,000 acre-feet.

The following shows the storage necessary to reduce the discharge to various figures:

Discharge (in second-feet):	Storage necessary.
10,000	2,100,000
20,000	1,800,000
30,000	1,500,000
40,000	1,200,000
50,000	900,000

With control of the Colorado River by reservoirs on the tributaries and with floods from the Gila probably occurring at the same time that floods occur from the intermediate basin below the San Juan, there would be necessity for reducing the floods of the Gila perhaps to as low as 10,000 second-feet in order to avoid simultaneous floods. But with the Colorado River reservoir at Boulder Canyon such necessity would not exist, and the discharge could be permitted to average during the filling period probably 40,000 second-feet with safety, reducing the necessary size of the reservoir by 900,000 acre-feet for the year 1916.

The possibility of financing the Sentinel reservoir seems remote, and its feasibility is doubtful from an engineering standpoint. Without it to control the Gila, control of the Colorado River alone will not be fully effective, although necessary. That is, if the Sentinel reservoir is not built, large expenditure for levees to protect against extraordinary floods below the Gila must still continue, whether the Colorado River itself is controlled or not.

APPENDIX C.

IRRIGATION AND DEVELOPMENT, LOWER BASIN.

As used here the term "lower basin" indicates the portion of the Colorado Basin below Boulder Canyon, but excludes the Gila, the waters of which are not available for the development of the lower basin.

The lower basin in its characteristics is entirely different from the upper basin. Its valleys are arid and nearly frostless, with irrigation necessary the year through. The mean annual temperature is 74° F., and the mean annual precipitation is 3 inches.

Its soils are recent unconsolidated silts, mostly very fertile and easily eroded.

Its transportation needs are well served by the Santa Fe and Southern Pacific railroads.

As a whole, also, reclamation of the lands of the lower basin by irrigation must be accompanied by flood protection.

For discussion, the lower basin conveniently divides into two parts: That above Laguna dam, the head of the Yuma project canal, and that below Laguna dam.

ABOVE LAGUNA DAM.

Below Black Canyon, which is a continuation of Boulder Canyon, the river leaves the plateau and canyon region, where it has flowed in the immense canyons which characterize its whole middle course. It then enters a region of irregular mountain chains and valleys which continues until Laguna dam is reached. Long, narrow valleys alternate with canyons. The irrigable lands which can be reached by gravity lie in the flood plains of the river, from which the generally rough and broken valley sides rise steeply to confining mountains or hills. The fall of the river below Boulder Canyon averages 1.75 feet per mile, so that it is not possible to reach by gravity any land other than that in the flood plains unless a high diversion dam is constructed, and such a diversion could be made only at immense cost. Throughout most of its course irrigable lands can not be reached by practicable pumping lifts, but at one place, the Chucawalla Valley and Palo Verde mesa, a lift of 230 feet will reach a considerable area of land.

A part of these flood plains is subject to periodical overflow, for protection against which levees are required.

BELOW LAGUNA DAM.

This comprises Imperial Valley, the Yuma project, and the delta lands in Mexico. The major part of that on the west side of the river lies below sea level. On the east side the irrigable lands lie either on the river's flood plains or on mesas which can be reached by pumping. The area as a whole is very compact.

The outstanding feature is Imperial Valley and the possible extensions therein are described fully in the following pages.

Lower basin.

[Acres.]

	Gross area.	Net area.			Irrigated, 1920.	Additional possible.	Total ultimate.
		Gravity.	Pump.	Total.			
UNITED STATES.							
Above Laguna Dam:							
Cottonwood Island, Nev. and Calif.	7,000	1,000	3,000	4,000	....	4,000	4,000
Mohave Valley, Ariz.	48,000	24,000	3,000	27,000	....	27,000	27,000
Chemehuevis Valley, Calif.	5,000	4,000	....	4,000	....	4,000	4,000
Parker project, Arizona	121,000	104,000	6,000	110,000	4,000	106,000	110,000
Palo Verde Valley, Calif.	95,000	78,000	....	78,000	35,000	43,000	78,000
Palo Verde Mesa, Calif.	45,000	....	18,000	18,000	....	18,000	18,000
Chucawalla Valley, Calif.	136,000	....	44,000	44,000	....	44,000	44,000
Cibola Valley, Ariz.	19,000	16,000	....	16,000	....	16,000	16,000
Isolated tracts, Arizona	4,000	1,000	3,000	4,000	....	4,000	4,000
Total	480,000	228,000	77,000	305,000	39,000	266,000	305,000
Below Laguna Dam:							
Yuma project, Arizona and California	130,000	69,000	61,000	130,000	54,000	76,000	130,000
Imperial Irrigation district, California	604,000	515,000	....	515,000	415,000	100,000	515,000
Imperial Valley extension, California—							
East Mesa	206,000	124,000	36,000	160,000	....	160,000	160,000
Dos Palmas	81,000	5,000	....	5,000	....	5,000	5,000
Coachella Valley	121,000	72,000	....	72,000	....	72,000	72,000
West side	123,000	10,000	23,000	33,000	....	33,000	33,000
Total	1,265,000	795,000	120,000	915,000	469,000	446,000	915,000
Total United States.	1,744,000	1,023,000	197,000	1,220,000	508,000	712,000	1,220,000
MEXICO.							
Under Imperial Canal	340,000	255,000	....	255,000	190,000	65,000	255,000
Under All-American Canal	43,000	22,000	8,000	30,000	....	30,000	30,000
Delta South of Volcano Lake and Bee River	....	250,000	....	250,000	....	250,000	250,000
Sonora	....	210,000	55,000	265,000	....	265,000	265,000
Total Mexico	....	737,000	63,000	800,000	190,000	610,000	800,000
Grand total	....	1,760,000	260,000	2,020,000	698,000	1,322,000	2,020,000

CLASSIFICATION OF FUTURE IRRIGATION.

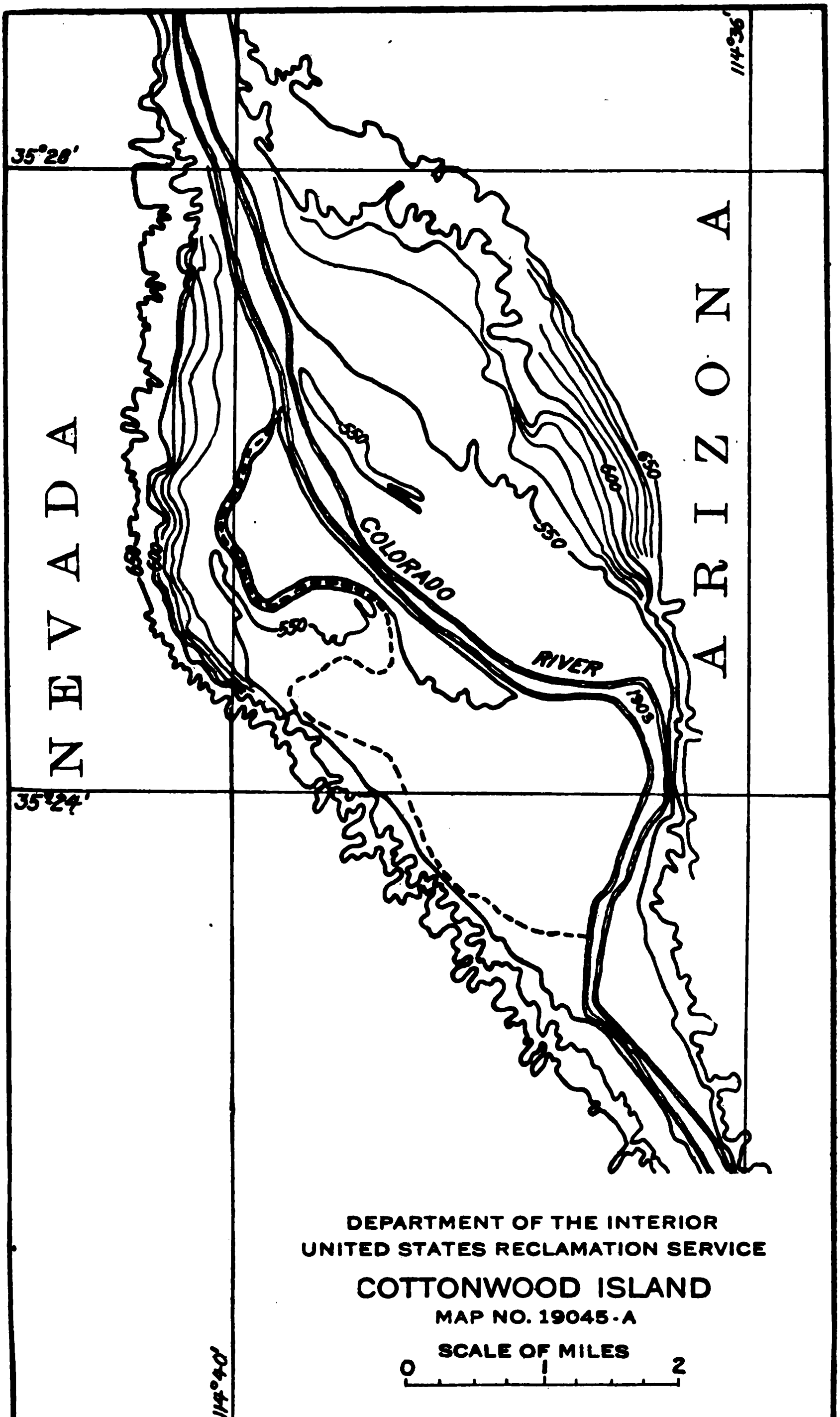
A rough classification of the different areas has been made from the standpoint of feasibility.

Class A: Feasible projects now.

Class B: Projects which for various reasons can not be expected to be constructed for some time.

Class C: Projects the construction of which is expected to take place in the distant future.

Class X: Small individual extensions.


35°28'
35°24'
114°36'
114°40'
NEVADA
ARIZONA
COLORADO
RIVER
1905
550
600
650
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COTTONWOOD ISLAND
MAP NO. 19045-A
SCALE OF MILES
0
1
2

Classification of future irrigation, lower basin.

[Acres.]

	Under present project but not yet irrigated.	A.	B.	C.	X.	Total.
UNITED STATES.						
Above Laguna Dam:						
Cottonwood Island			4,000			4,000
Mohave Valley			27,000			27,000
Chemehuevis Valley			4,000			4,000
Parker project		106,000				106,000
Palo Verde Valley	43,000					43,000
Palo Verde mesa				18,000		18,000
Chucawalla Valley				44,000		44,000
Cibola Valley		16,000				16,000
Isolated tracts					4,000	4,000
Total	43,000	122,000	35,000	62,000	4,000	266,000
Below Laguna Dam:						
Yuma project	24,000	52,000				76,000
Imperial irrigation district	100,000					100,000
Imperial Valley extension		270,000				270,000
Total	124,000	322,000				446,000
Total United States	167,000	444,000	35,000	62,000	4,000	712,000
MEXICO.						
Under Imperial Canal	65,000					65,000
Under All-American Canal		30,000				30,000
Delta				250,000		250,000
Sonora				265,000		265,000
Total Mexico	65,000	30,000		515,000		610,000
Grand Total	232,000	474,000	35,000	577,000	4,000	1,322,000

DIVISION BY STATES.

[Acres.]

	Under present project but not yet irrigated.	A.	B.	C.	X.	Total.
United States:						
Nevada			2,000			2,000
Arizona	24,000	174,000	27,000		4,000	229,000
California	143,000	270,000	6,000	62,000		481,000
Total	167,000	444,000	35,000	62,000	4,000	712,000
Mexico	65,000	30,000		515,000		610,000
Grand total	232,000	474,000	35,000	577,000	4,000	1,322,000

COTTONWOOD ISLAND PROJECT.

The Cottonwood Valley project, or what is generally known as Cottonwood Island, is located on both sides of the Colorado River in Clark County, Nevada, and Mohave County, Arizona. The nearest railroad point is Chloride, which is about 30 miles east.

This tract is a small valley of river-bottom land through which the river meanders, changing its channel from time to time. There are generally two principal channels, which form the island, but the river is now all in the west channel. This tract will be submerged in case the Bulls Head reservoir is constructed.

Ownership.—There are no patented lands in the valley. The area was withdrawn under the reclamation act in 1903 for the proposed Bulls Head reservoir.

Area:	Acres.
Gross	6,600
Irrigable—	
Gravity	1,600
Pumping (40-foot lift)	2,800
Total	4,400

MOHAVE VALLEY PROJECT.

Location and general description.—Mohave Valley is located principally in Mohave County, Arizona, with a small area on the west side of the river, in Clark County, Nevada, and in San Bernardino County, California.

The principal town, Needles, with a population of 2,500, is located on the west bank of the river. The Atchison, Topeka & Santa Fe Railroad crosses the Colorado River at the lower end of the valley.

The main valley extends from Fort Mohave on the north to Topock on the south, a distance of about 25 miles, with a maximum width of about 5 miles.

Regarding this valley, Mr. Homer Hamlin, in his diary of April 13, 1920, states:

> The bottom lands in Needles Valley are very low, and a small rise in the river will cause extensive overflow. The river is evidently changing its course at many points. The low bottom lands and rapidly changing river channel will make the irrigation of these lands extremely difficult, if not impossible.

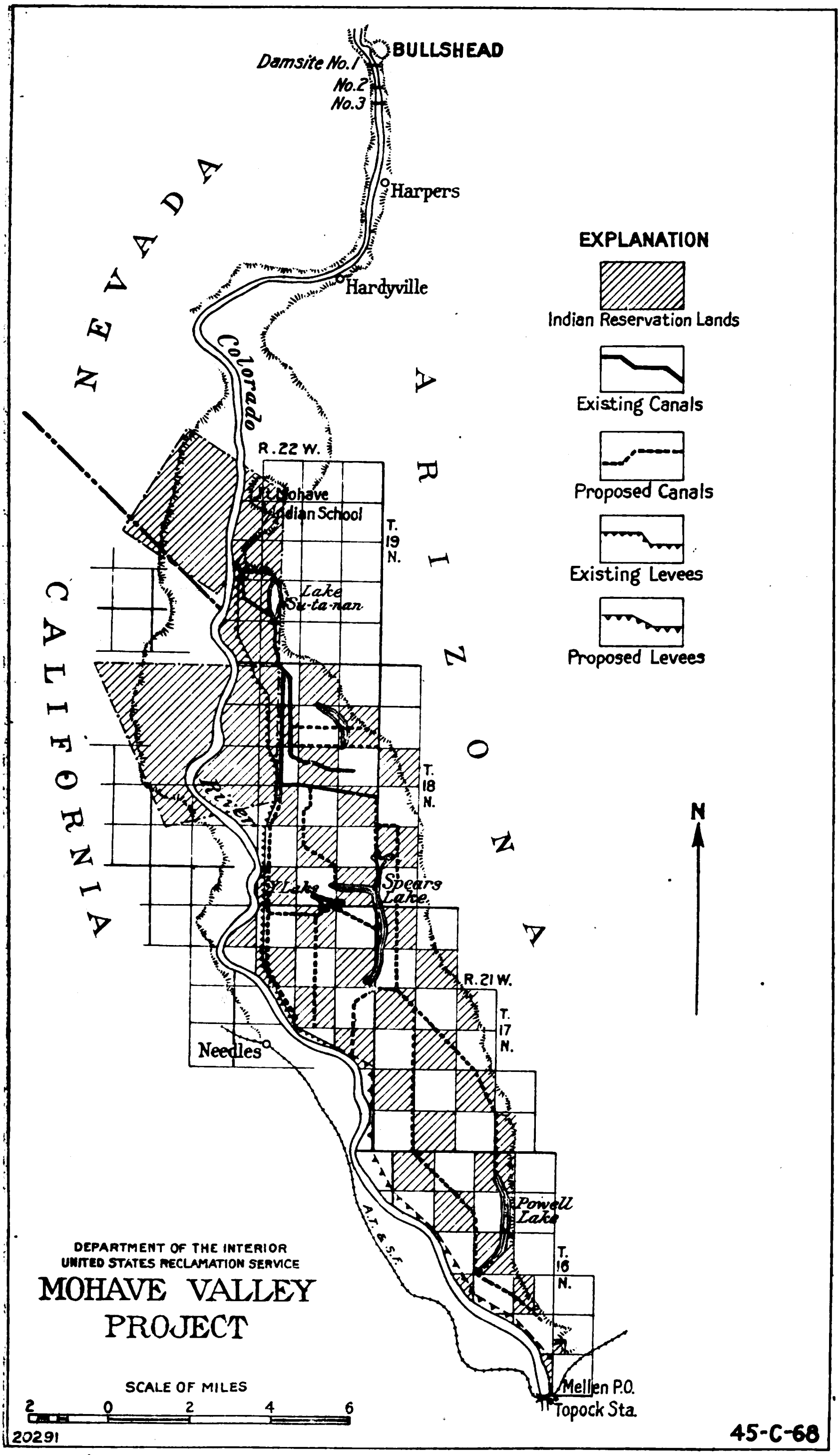
The valley is subject to overflow, at least to some extent, for floods of 25,000 second-feet. It would appear, therefore, that even with storage for flood control a levee system will be required in order to reclaim these lands.

All odd-numbered sections in the Mohave Valley on the east side of the river and outside of the reservation were granted by the United States to the Atlantic & Pacific Railroad, now the Atchison, Topeka & Santa Fe. In 1904 these lands were sold and are now held by the Cotton Land Co., which planned to reclaim 30,000 acres.

All even-numbered sections in Mohave Valley east of the river—about 18,000 acres—were made a part of the Indian reservation by Executive order of February 2, 1911.

In 1912 and 1913 the Indian Service constructed 5 miles of levee. This levee failed in 1914, as also did the levee of the Cotton Land Co. Since that date neither of these levees has been repaired.

Land classification and topographic surveys were made of the Mohave Valley in 1903.


BULLSHEAD
Damsite No. 1
No. 2
No. 3
Harpers
Hardyville
NEVADA
ARIZONA
CALIFORNIA
Colorado River
EXPLANATION
Indian Reservation Lands
Existing Canals
Proposed Canals
Existing Levees
Proposed Levees
R. 22 W.
Ft. Mohave Indian School
T. 19 N.
Lake Su-ta-nan
T. 18 N.
Spears Lake
R. 21 W.
T. 17 N.
Needles
A.T. & S.F.
Powell Lake
T. 16 N.
Mellen P.O.
Topock Sta.
N
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
MOHAVE VALLEY PROJECT
SCALE OF MILES
2 0 2 4 6
20291
45-C-68

Classification of lands, Mohave Valley project.

Tract.	Ownership.				Area.			
	Indian lands.	Public lands.	Private lands.	Total.	Gross.	Irrigable.		
						Gravity.	Pumping.	Total.
Mohave Valley, east side	20,000		19,000	39,000	39,000	22,500	2,400	24,900
North of Fort Mohave:								
East side		1,000	2,000	3,000	3,000		800	800
West side	2,500	1,700	1,800	6,000	6,000	1,000		1,000
Total, gross	22,500	2,700	22,800	48,000	48,000	23,500	3,200	26,700
Total, net irrigable	12,500	1,500	12,700	26,700				

Present status.—The only irrigation development in the Mohave Valley has been done by the Cotton Land Co. and the United States Indian Service. The Cotton Land Co. system comprises about 19½ miles of canal, with a capacity of about 100 second-feet. A concrete intake is installed about 2 miles below Fort Mohave which is at a point well protected from river action by a jutting point of mesa. No silting works or diversion structure other than an intake have been provided.

The Cotton Land Co. has also constructed about 10 miles of levee, with a crown width of about 6 feet and an average height of 4 feet. No riprap or slope protection has been done. This levee, as previously stated, was partly destroyed in 1914.

The United States Indian Service afterwards constructed a levee running south from near the headgate of the Cotton Land Co.'s canal. This levee was also partly destroyed in 1914 and has not since been repaired.

CHEMEHUEVIS VALLEY PROJECT.

Location and description.—The Chemehuevis Valley is located on both sides of the Colorado River, with the larger area on the west side. The portion on the east side is in Mohave County, Arizona. The portion on the west side of the river is in San Bernardino County, California.

The nearest town and railroad station is the station of Powell, on the Atchison, Topeka & Santa Fe Railroad, about 10 miles from the valley.

The length of the valley north and south is about 6 miles and the maximum width 2 miles. The elevation is about 400 feet above sea level. The valley is all subject to overflow during normal high water. For this reason it is not feasible for irrigation development without the construction of levees on both sides of the river. Such levee construction may be reduced in cost by a partial flood control, and possibly could be eliminated with complete flood control by storage. The valley is small and is not attractive as an irrigation project.

The valley on the west side of the river is in the Chemehuevis Indian Reservation. A few Indians (approximately 200) live on the reservation. Tentative allotments of 10 acres each have been made to these Indians, aggregating a total of about 2,000 acres.

There is no irrigation at the present time nor has there been in the valley. The Indians living here do some farming on a small scale on the overflow lands, the crops being planted after the receding of the high water.

Land classification and a topographic survey on a scale of 2 inches to the mile were made in 1902 and 1903.

Ownership.—There are no private lands in the valley. The lands were all withdrawn under the reclamation act in 1903. The west side of the river is Indian reservation lands and the east side is public lands.

Classification of lands, Chemehuevis Valley project.

	Area.	
	Gross.	Net.
Indian lands	2,900	2,300
Public lands	1,700	1,400
Total	4,600	3,700

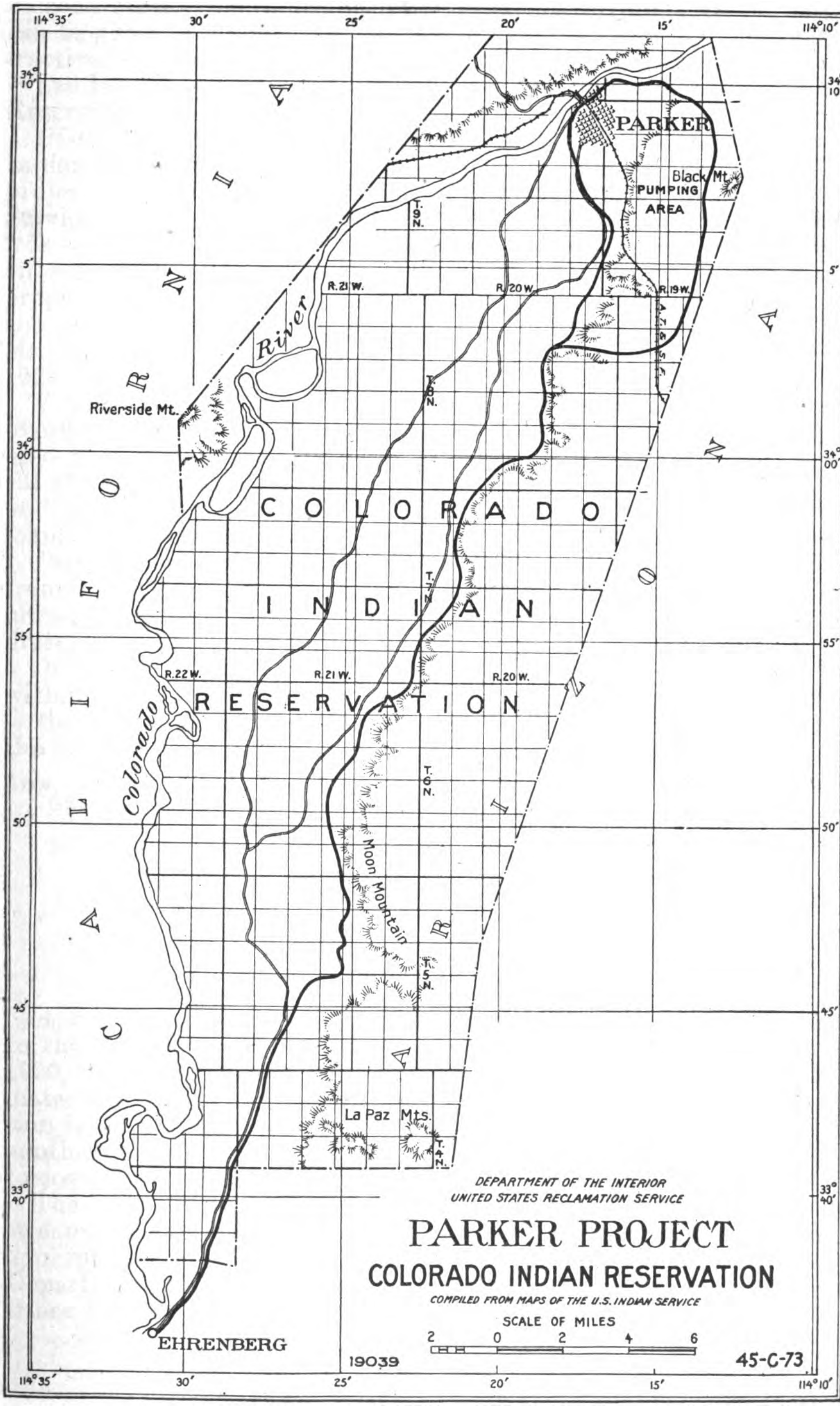
PARKER PROJECT, COLORADO RIVER INDIAN RESERVATION.

Location and description.—The Parker Valley, or Colorado River Indian Reservation project, lies on the east side of the Colorado River in Yuma County, Arizona. A small portion of the valley is on the west side of the river, in Riverside County, California. The principal town, Parker, at the head of the valley, with a population of 500, is located on the Atchison, Topeka & Sante Fe Railroad.

The Parker Valley has a total length of about 37 miles, extending from Parker on the north to near Ehrenburg on the south. The maximum width of the valley is about 7 miles on the east side of the river. The river channel in this valley is somewhat more stable than in the Mohave Valley, though it is also subject to erosion and to shifting of its bed. The river is said to overflow the lower bottom lands with a flood exceeding 40,000 second-feet, and 95,000 acres are said to be subject to overflow during periods of maximum flood. It would appear, therefore, that for anything less than complete flood control by storage a levee system will be necessary, although with partial control the section of the levee and the riprapping could probably be reduced accordingly.

On the west side of the river there are several separate small areas of bottom land aggregating about 4,000 acres; but, owing to the small area and to the narrowness of the valley, this land could not be protected from overflow within reasonable cost by levees, and it will, therefore, not be considered as a part of the project. With complete flood control by storage, it would probably become attractive to individuals, either by irrigation through direct diversion or low-lift pumps.

The bench lands considered as a part of the project consist of the Parker Mesa, at the head of the valley, surrounding the town of Parker. This is an attractive stretch of land, being quite smooth and level, with a gravelly and sandy soil. The bench is from 75 to 150 feet above the bottom lands.


114°35′
30′
25′
20′
15′
114°10′
34° 10′
5′
34° 00′
55′
50′
45′
33° 40′
PARKER
Black Mt.
PUMPING AREA
T. 9 N.
R.21 W.
R.20 W.
R.19 W.
A.T.&S.F.
River
Riverside Mt.
T. 8 N.
COLORADO
INDIAN
RESERVATION
T. 7 N.
R.22 W.
R.21 W.
R.20 W.
Colorado
T. 6 N.
Moon Mountain
T. 5 N.
La Paz Mts.
T. 4 N.
CALIFORNIA
ARIZONA
EHRENBERG
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
PARKER PROJECT
COLORADO INDIAN RESERVATION
COMPILED FROM MAPS OF THE U.S. INDIAN SERVICE
SCALE OF MILES
2 0 2 4 6
19039
45-C-73

There is also a mesa on the west side of the river, namely, the Calzona Mesa. There has been no survey of this mesa, so no detail can be given of it. It is said, however, to be rather rough and unattractive. It is not here considered as a part of the project.

Lands of the Parker project are all in the Colorado River Indian Reservation.

Historical.—A detailed survey and estimate of the Colorado River Indian Reservation project, consisting of the gravity system of the project proposed herein, was made by the United States Indian Service in 1918 and 1919. Topography was taken on a scale of 400 feet to 1 inch covering the entire reservation, with a contour interval on the bottom lands of from 1 to 2 feet. Detailed estimates were prepared and the final report written by Mr. C. A. Engle, engineer in charge, under date of June 30, 1920. A soil report was also made by Mr. A. T. Strahorn, United States Department of Agriculture, dated 1920, which report is made a part of the Engle report.

Topography and soil.—The bottom lands are flat and subject to overflow and are considerably cut with sloughs and very heavily covered with mesquite, arrow weed, and other brush. The soil is river silt and sandy loam and is very fertile. The Parker bench is smooth and gently sloping toward the river. The soil is gravelly and sandy loam.

Drainage.—The bottom lands are lowest next to the mesa, or away from the river, and are subject to seepage from the river during normal high water and by backing up from the sloughs. Artificial drainage will be necessary.

Ownership.—All the lands in the proposed Parker project lie within the United States Indian reservation. Fifteen thousand acres is the maximum that will be needed for allotment to the Indians; the balance may be thrown open to settlement.

Area:	Acres.
Gross	121,000
Irrigable—	
Gravity	104,000
Pumping, lift approximately 135 feet	6,000
Total irrigable	110,000

WATER SUPPLY.

Appropriations.—No water filings have been made for this project to the knowledge of the engineer in charge. The area irrigated in 1920, which is the maximum to date, is 4,100 acres, and it is estimated by the engineer in charge that 7,000 acres will be in cultivation in 1921. The present pumping plant, with the installation of another boiler which is planned in the near future, will be sufficient to cover about 7,500 acres.

The right to divert water from the Colorado River (a navigable stream) was authorized by act of Congress entitled "An act making appropriations for the current and contingent expenses of the Indian Department and for fulfilling treaty stipulations with various Indian tribes for the fiscal year ending June 30, 1905, and for other purposes" (act Apr. 21, 1904, ch. 1402, 33 Stat., 189). The portion authorizing the diversion of water reads as follows:

That in carrying out any irrigation enterprise which may be undertaken under the provisions of the reclamation act of June 17, 1902, and which may make possible and provide for, in connection with the reclamation of other lands, the reclamation of all or any portion of the irrigable lands on the Yuma and Colorado River Indian Reservations in California and Arizona, the Secretary of the Interior is hereby authorized to divert the waters of the Colorado River and to reclaim, utilize, and dispose of any lands in said reservations which may be irrigable by such works in like manner as though the same were a part of the public domain.

Storage required.—On the assumption of complete development of lower Colorado River lands storage will be required for the use of the Parker project for the undeveloped area of, say, 103,000 acres.

PRESENT STATUS.

There is a pumping plant installed by the United States Indian Service, as above described, with a capacity for the irrigation of about 7,500 acres. This pump is located on the bank of the river at the head of the valley. The water is pumped from a sump, into which the water enters from the river through five 7-foot gateways equipped with flashboards to keep out all but the top water. The lift of this plant is about 21 feet. Near the pumphouse a large settling basin has recently been constructed, with provision for sluicing the silt back into the river by means of a by-pass.

The canal system consists of about 10 miles of canal of more than 50 second-feet capacity and 43 miles of laterals. The area under the present canal system is about 6,000 acres.

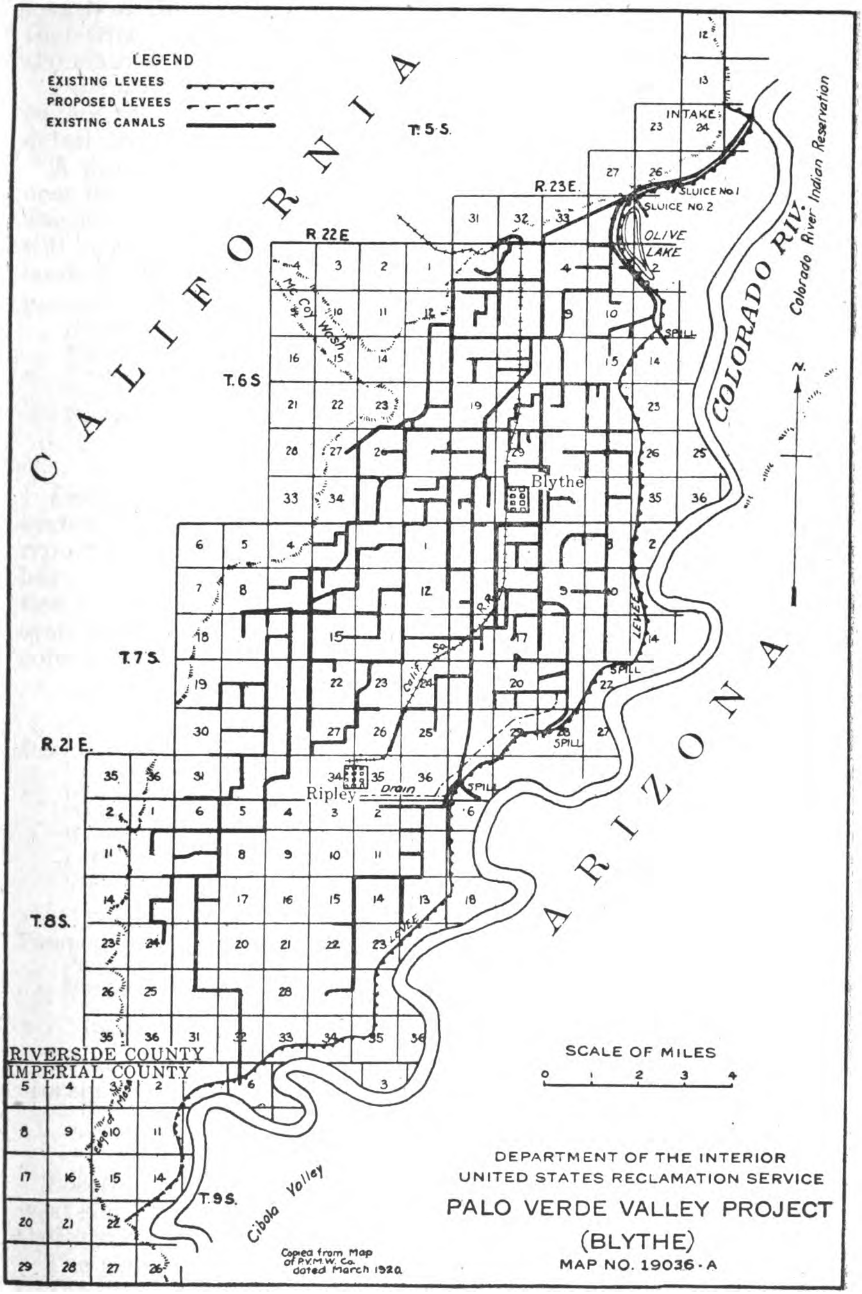
Nine miles of drainage canals have also been constructed.

IRRIGATION PLAN.

Plan of C. A. Engle, engineer in charge, for gravity system (Report of June 30, 1920).—A diversion weir is planned at a point locally known as Headgate Rock, which is a short distance above the railroad crossing of the river. This weir is of the floating type on a sand foundation. The length is 1,600 feet, with a height of 14 feet above mean low water. At the end of the weir a by-pass or diversion channel is planned, to have a clear width of 200 feet and a depth of 22 feet below the weir crest. There will be five by-pass gates (Stoney type), 23 by 41½ feet. A desilting basin and sluiceway similar to the one at Laguna Dam is planned on the land side of the by-pass structure. The clear width of this basin is 160 feet, and depth 14 feet.

The main canal to the head of the valley where the first division is made is 2¼ miles in length. This will be mainly in a rather porous gravel, and it is planned to be concrete lined. It has a capacity of 1,600 second-feet. The total length of canals, including the principal branches, is 46 miles, and the total length of distributaries is 184 miles.

A protective levee is provided. This is planned to be constructed near the bank of the river, with a section consisting of a 12-foot crown and a height of 5 to 6 feet above mean high water. A coarse gravel blanket 12 inches thick is to be placed on the entire surface of the levee, and the river slope is to be provided with a rock revetment containing an average of 7½ cubic yards per linear foot. The total length of levee planned is 45 miles.


LEGEND
EXISTING LEVEES
PROPOSED LEVEES
EXISTING CANALS
CALIFORNIA
ARIZONA
COLORADO RIV.
Colorado River Indian Reservation
T. 5 S.
T. 6 S
T. 7 S.
T. 8 S.
T. 9 S.
R. 21 E.
R 22 E
R. 23 E.
INTAKE
SLUICE No. 1
SLUICE NO. 2
OLIVE LAKE
SPILL
LEVEE
Mc Coy Wash
Blythe
Ripley
Drain
Calif.
RIVERSIDE COUNTY
IMPERIAL COUNTY
Cibola Valley
Edge of Mesa
SCALE OF MILES
0 1 2 3 4
N.
Copied from Map of P.V.M.W. Co. dated March 1920
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
PALO VERDE VALLEY PROJECT
(BLYTHE)
MAP NO. 19036-A

A drainage system is provided with a main drain running the length of the valley and with a system of lateral drains connecting therewith. A pumping plant will be required at the lower end of the main drain.

Pumping system.—The pumping portion of the project, which covers the area of the Parker bench, has not been worked out in detail and therefore the plan and estimate herein are very rough.

A pumping plant will be required to pump from the main canal near its head, and, as the bench slopes toward the river, a long pipe line will be required with probably a second lift. The average lift will be approximately 135 feet. The distribution system of the mesa lands is to be concrete lined.

Power requirement:	
Irrigable area ..... acres..	6,000
Pump capacity ..... second-feet..	60
Mean lift ..... feet..	135
Theoretic horsepower	920
Requirement, horsepower (60 per cent efficiency)	1,500

COSTS.

Cost to date.—The cost of the present pumping plant and canal system of the United States Indian Service, according to the Engle report of 1920, is approximately $140,000. The pumping plant will have no value as a part of the larger project, though the distribution system can be incorporated by an enlargement into the new system and will probably have a value equal to the cost of its construction.

Estimated cost to complete (exclusive of storage or flood control).

Gravity project data from Engle, report of June 30, 1920:	
Diversion weir	$753,300
By-pass or diversion channel	601,590
Desilting basin and sluiceway	698,410
Main canal and distributary system	2,059,400
Levee system and river improvement	2,271,500
Drainage system	849,400
Total (Engle estimate)	7,233,600
Pumping system (no detailed estimate available):	
Pumping plant, 1,500 horsepower, at $100	150,000
Distribution system (concrete lined), 6,000 acres, at $70	420,000
Grand total	7,803,600

Total estimated cost for a project of 100,000 acres, exclusive of storage, flood control, and power, $78 per acre.

PALO VERDE VALLEY (BLYTHE PROJECT).

Location and description.—The Palo Verde Valley is located on the west side of the Colorado River, in Riverside and Imperial Counties, California.

The principal town is Blythe, with a population of 2,000, situated in the north-central part of the valley. Ripley is a new town and is at the terminus of the California Southern Railroad, a branch of the Atchison, Topeka & Santa Fe from Blythe Junction. The distance from Blythe Junction to Blythe is 42 miles.

The valley is 25 miles in length with an average width of about 6 miles. It lies in a compact body and is well adapted to irrigation development. The river skirts the east side of the valley except near the north end, where the Palo Verde Valley overlaps the Parker Valley, and at the south end, where it overlaps the Cibola Valley. These three valleys in fact constitute one large valley, being broken only by the river channel at the two points where it crosses the valley. The Palo Verde mesa lies adjacent to and west of the valley and the Chucawalla Valley lies west of this, over a small divide.

The general elevation of the valley is 250 feet above sea level. The engineer in charge of the project, Mr. C. E. Yost, states that it will overflow with a flood of from 50,000 to 60,000 second-feet without levees, and that bank protection would be necessary with a flood of 35,000 second-feet.

There is a rock point on the west river bank at the head of the valley known as Blythe Heading, which is the point where the main canal diverts. The river strikes the west bank about this rock point, which diverts it to the east bank across the valley. The river has always hugged this rock, though there is no natural barrier on the east bank to prevent the river from leaving the heading and going to the east.

HISTORICAL.

About the year 1856 * * * Thomas H. Blythe came into the Palo Verde Valley and acquired about 40,000 acres under the swamp and overflow act. This tract became known as the Blythe rancho. Blythe then proceeded to make certain water filings. * * * He built the gravity intake now in use and known as Blythe intake, a main canal and laterals, and irrigated a considerable area. In 1905 or 1906 a corporation known as the Palo Verde Land & Water Co. was organized and acquired the Blythe rancho and all the water rights appertaining thereto. This corporation immediately proceeded to repair, enlarge, and extend the irrigation system, and to develop and colonize the rancho.

In 1908 the present company was organized in the valley and bought all of the water right filings from the Palo Verde Land & Water Co., together with all the rights of way for the canal system extensions. The present company is a mutual one, each farmer taking water from the canal system being a shareholder. It is called the Palo Verde Mutual Water Co., and has operated and extended the canal and levee systems. This company also attended to the perfecting of the water rights.

In 1918 the Palo Verde joint levee district was organized for the purpose that its name implies. This organization is separate from the water company, though at the present time there are three men who hold the position of director in both companies. For a time the management of the two companies was separate, but at the present time it is all handled in the office of the water company, and is under the direction of one engineer, Mr. C. E. Yost.

LAND.

Topography and soils.—The valley is flat river-bottom land, all subject to overflow without protection. It is generally quite smooth and free from small sloughs as compared with other valleys along the Colorado, though there are a few large sloughs extending through the tract. As is characteristic of the valleys of the Colorado, it is lowest on the farthest side from the river or near the mesa, the fall being about 15 feet.

The lower end of the valley is a fine, rather heavy silt. The middle and upper portion is a light sandy silt. The soil is very fertile, as is evidenced by the land in cultivation, and generally it seems quite free from alkali, except in some of the lower portions in the old irrigated sections, where it has become alkalied by the rise of the ground water.

Drainage.—There is fairly good surface drainage throughout the valley except during the high-water period, the water being carried off through the large sloughs above mentioned, which empty into the river near the lower end of the valley, but due to irrigation it was found that during a period of about 10 years prior to 1918 the ground water had risen about 7 feet, and at that time was also within about 7 feet of the surface. Since that time the water table has remained about the same, though it fluctuates to some extent, due to the rise and fall of the river. The need of artificial drainage has been felt for some years in the irrigated portion of the valley, and a drainage estimate and plan of work were made in report by D. W. Murphy, drainage engineer, under date of November 18, 1918. Since that time some progress has been made in the way of drainage construction.

Ownership and area.—Practically all of the land in the Palo Verde Valley is in private ownership. The Blythe rancho has been sold off in small tracts averaging about 60 acres. The area of the project and the status of land as of October, 1920, as shown by the records of the United States Land Office, are as follows:

	Acres.
Gross area of valley	95,000
Irrigable area—	
Private	72,000
Entered	6,600
Total	78,600

It is the opinion of the engineer in charge of the project that the water rights of the company are sufficient for the irrigation of the entire valley, and that no storage will be required. The question of the water rights of the company is a matter to be eventually determined by adjudication.

PRESENT STATUS.

The present works of the Palo Verde Mutual Water Co. consist of 181 miles of irrigation canals and laterals, of which approximately 8 miles are main canals, 26 miles of submains, and 147 miles of laterals. The company has also constructed 28½ miles of main levee, 6 miles of auxiliary levee, 7½ miles of wasteway canals, and 5½ miles of drainage canals, in addition to the borrow-pit drain which extends the full length of the levee. The intake of the main canal is constructed in a granite rock cut at the Blythe heading, above mentioned. A new concrete structure has been installed at this point sufficient in capacity to irrigate the entire valley. The structure is controlled by wooden emergency gates, with steel stem screw-lifting devices. Ordinarily it is controlled by flashboards, over which the water enters the canal, permitting the skimming process. As the main current of the river strikes the Blythe heading it is free from silting up above the intake.

Two and one-half miles below the intake is sluiceway No. 1, and at mile 4 is sluiceway No. 2, which are large wooden structures. The skimming process is repeated at these points over flashboard into the canal, and the silt is sluiced out into the river. Excess water is run to these points for this purpose.

At 7¾ miles below the intake are located the controlling gates of the three submains, at the lower end of the main canal proper.

The engineer in charge, Mr. Yost, states that the canals are sufficient in capacity for the irrigation of the entire valley on condition of proper cleaning.

The main levee as constructed at present extends from the head of the valley to the county line near the lower end of the valley, a length of 28½ miles. The section of the levee is: Crown 12 feet, river slope 3:1, land slope 2:1, average height 10 feet. A borrow pit has been constructed continuously on the land side, with a berm of 50 feet between the pit and the levee. This borrow pit is intended as a shallow drain and has been fairly successful for this purpose, though deep drains are planned some distance back from the levee; 3,500 feet only of the levee have been riprapped. Two miles of railroad are constructed on the levee and 3 miles leading from the levee to the quarry. There are several cross levees extending from the main levee out into the valley. The area protected by levees at present is said by the engineer in charge to be 70,000 acres, which is also the area under the present constructed canal system.

The area irrigated in the present season (1920) is approximately 35,000 acres.

The shares of water stock issued by the company represent water sufficient for 1 acre to the share. To the present date, October 20, 1920, 40,700 shares have been sold. These shares are valued at $35 per share.

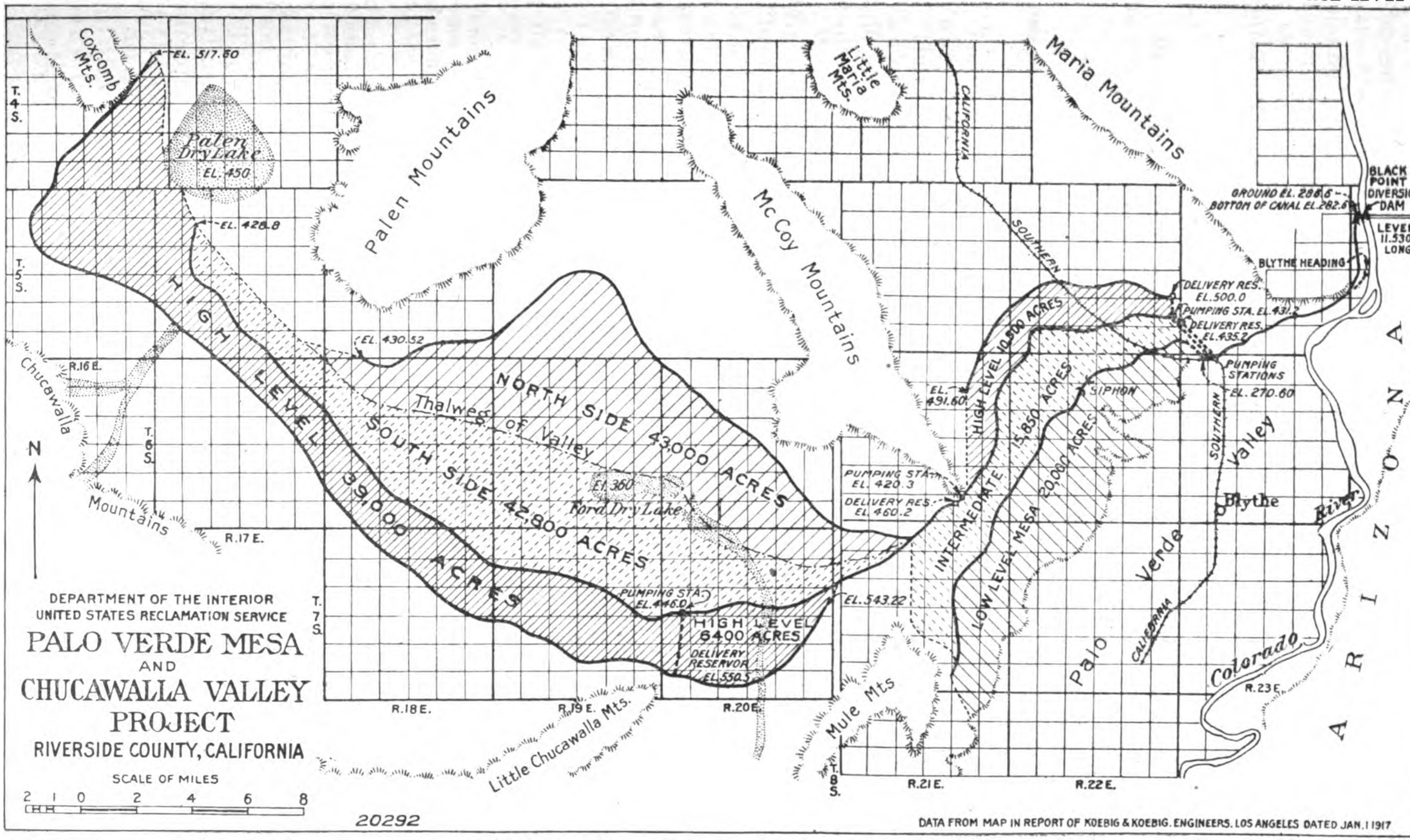
IRRIGATION PLAN.

The Palo Verde project is entirely a gravity system. The water is diverted direct from the river at the Blythe intake, as above described, without a diversion dam. There is no plan on the part of the management for the construction of a dam at this point, first, for the reason that it is not needed, as at practically all times there is sufficient head against the intake for the required diversion, and in the second place for the reason that there is no dam site at the head of the Palo Verde Valley. As stated previously, there is no physical reason why the river should not leave the Blythe heading and go to the east, as there is a wide, flat valley at this point. This, however, has never occurred in the history of the project, though it does not necessarily follow that it will not occur in the future. Such a possibility is realized by the present management, and plans are made to riprap the opposite bank in case it should become necessary.

The desilting question is handled fairly well at the present time, considering that there is no diversion dam with sluiceway, as at Laguna. This is probably the best natural intake on the lower Colorado River, and the project is thus fortunate in being able to enjoy the benefit of reasonably well desilted water without the cost of diversion dam.

The lateral system is now constructed for all but about 9,000 acres in the valley, and the present plan is to extend these laterals as water stock is purchased by new lands and water is called for. The sale of the stock pays for the construction of the new laterals.

It is planned to extend the main levee to the lower end of the valley for a distance of 6 miles. A railroad is planned to be constructed on



DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
PALO VERDE MESA
AND
CHUCAWALLA VALLEY
PROJECT
RIVERSIDE COUNTY, CALIFORNIA
SCALE OF MILES
2 1 0 2 4 6 8
20292
DATA FROM MAP IN REPORT OF KOEBIG & KOEBIG, ENGINEERS, LOS ANGELES DATED JAN. 1 1917
Coxcomb Mts.
Palen Dry Lake
EL. 450
EL. 517.60
EL. 428.8
EL. 430.52
Palen Mountains
McCoy Mountains
Little Maria Mts.
Maria Mountains
Chucawalla Mountains
Little Chucawalla Mts.
Mule Mts
HIGH LEVEL 39,000 ACRES
NORTH SIDE 43,000 ACRES
SOUTH SIDE 42,800 ACRES
Thalweg of Valley
EL. 360
Ford Dry Lake
PUMPING STA. EL. 446.0
HIGH LEVEL 6400 ACRES
DELIVERY RESERVOIR EL. 550.5
EL. 543.22
PUMPING STA. EL. 420.3
DELIVERY RES. EL. 460.2
EL. 491.60
INTERMEDIATE 15,850 ACRES
HIGH LEVEL 10,500 ACRES
LOW LEVEL MESA 20,000 ACRES
SIPHON
DELIVERY RES. EL. 500.0
PUMPING STA. EL. 431.2
DELIVERY RES. EL. 435.2
PUMPING STATIONS EL. 270.60
BLYTHE HEADING
GROUND EL. 288.6
BOTTOM OF CANAL EL. 282.6
BLACK POINT DIVERSION DAM
LEVEE 11,530' LONG
CALIFORNIA
SOUTHERN
Palo Verde Valley
Blythe
Colorado River
ARIZONA
N
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
R. 16 E.
R. 17 E.
R. 18 E.
R. 19 E.
R. 20 E.
R. 21 E.
R. 22 E.
R. 23 E.

the entire length of the main levee for the purpose of protection in case the river threatens at any point. Riprap, generally, is not planned, except at threatened points, though without flood control the entire length will probably eventually require riprap.

A complete drainage system will be required and is planned, as outlined in the D. W. Murphy report of January 1, 1918.

POWER REQUIREMENT.

As the Palo Verde project is under a gravity system, no power will be required.

PALO VERDE MESA AND CHUCAWALLA VALLEY PROJECT.

[Data mainly from report of Koebig & Koebig, consulting hydraulic engineers, Los Angeles, Calif., dated Jan. 1, 1917.]

Location and description.—The Palo Verde Mesa and Chucawalla Valley project is located in Riverside County, California.

The Palo Verde Mesa lies adjacent to and west of the Palo Verde Valley or Blythe project. The elevation of the mesa is from 320 to 450 feet above sea level and from 70 to 200 feet above the adjacent valley.

West of the Palo Verde Mesa is a low pass between Mule and McCoy mountains, at an elevation of 460 feet above sea level. Through this pass is the Chucawalla Valley, extending northwesterly for a distance of about 30 miles and with a maximum width of about 12 miles. The valley is a large inland basin or sink, with no surface drainage outlet. There are two dry lake beds in the bottom of the basin: Pelan Lake, elevation 450 feet, near the west end of the basin, and Ford Lake, the lower point of the basin, elevation 360 feet, near the east end.

HISTORICAL.

On November 9, 1908, the Chucawalla Development Co. was organized for the purpose of supplying water from the Colorado River to an extensive area of desert land. * * * The lands to be covered by this irrigation project are known as the Palo Verde Mesa and the Chucawalla Valley and embrace an area of, collectively, 177,550 acres. * * * The land has been filed upon in the United States Land Office under the desert-land act, these filings having been made under the encouragement offered by the Chucawalla Development Co. * * *

* * * The company made preliminary surveys of the canal lines. Investigations of and borings at the dam sites, situated 8 miles above Parker, Ariz., below Bill Williams Fork and at Pyramid Canyon, 30 miles above Needles, Calif., also surveys of the reservoir sites, were made in connection with the dam sites herein mentioned. * * * Further preliminary surveys were made for a transmission line for conveying electric power to the pumping plants near the diversion dam and reservoir at Black Point.

The report of Koebig & Koebig, from which the above is quoted, outlines a general plan of the project, including a diversion dam, pumping plants, and canal systems, and includes estimates of cost of the same.

An act of Congress was passed and approved February 15, 1911, entitled "An act to authorize the Chucawalla Development Company to build a dam across the Colorado River at or near the mouth of Pyramid Canyon, Arizona, also a diversion intake dam at or near Black Point, Arizona, and Blythe, California." (Public, No. 374, H. R. 31859.) The following provisions are made in this act:

Provided, That the actual construction of said dams shall be begun within two years and completed within five years from the date of the passage of this act. *And provided further*, That the actual construction of said dams shall not be commenced until the plans and specifications therefor shall have been presented to and approved by the Secretary of the Interior in addition to the requirements of the act approved June 23, 1910, entitled "An act to amend an act entitled 'An act to regulate the construction of dams across navigable waters' approved June 21, 1906," and in approving the plans and specifications the Secretary of the Interior may impose such conditions as to him shall seem proper for the protection of the public interests of Indians and the United States.

Ownership and area.—The status of the project lands as of October, 1920, as determined from the records of the United States Land Office, is as follows:

Classification of lands, Palo Verde Mesa and Chucawalla Valley project.

Tract.	Gross acreage.				Total.	
	Public.	Entered.	Private.	State.	Revised area.	Koebig & Koebig report.
Palo Verde Mesa:						
Low level	600	12,700	5,000	1,400	19,700	20,000
Intermediate level	1,200	12,100	2,000	1,200	16,500	15,850
High level	600	7,200	500	700	9,000	10,500
Chucawalla Valley:						
North side	13,000	28,000	300	1,700	43,000	43,000
South side	4,000	37,000	500	2,500	44,000	42,800
High level	8,000	38,500	350	2,150	49,000	45,400
Total	27,400	135,500	8,650	9,650	181,200	177,550

Net irrigable area, assuming 50 per cent waste on account of poor soil (see soil report), also omitting the two high lifts as advised by Koebig & Koebig in letter of October 27, 1920:

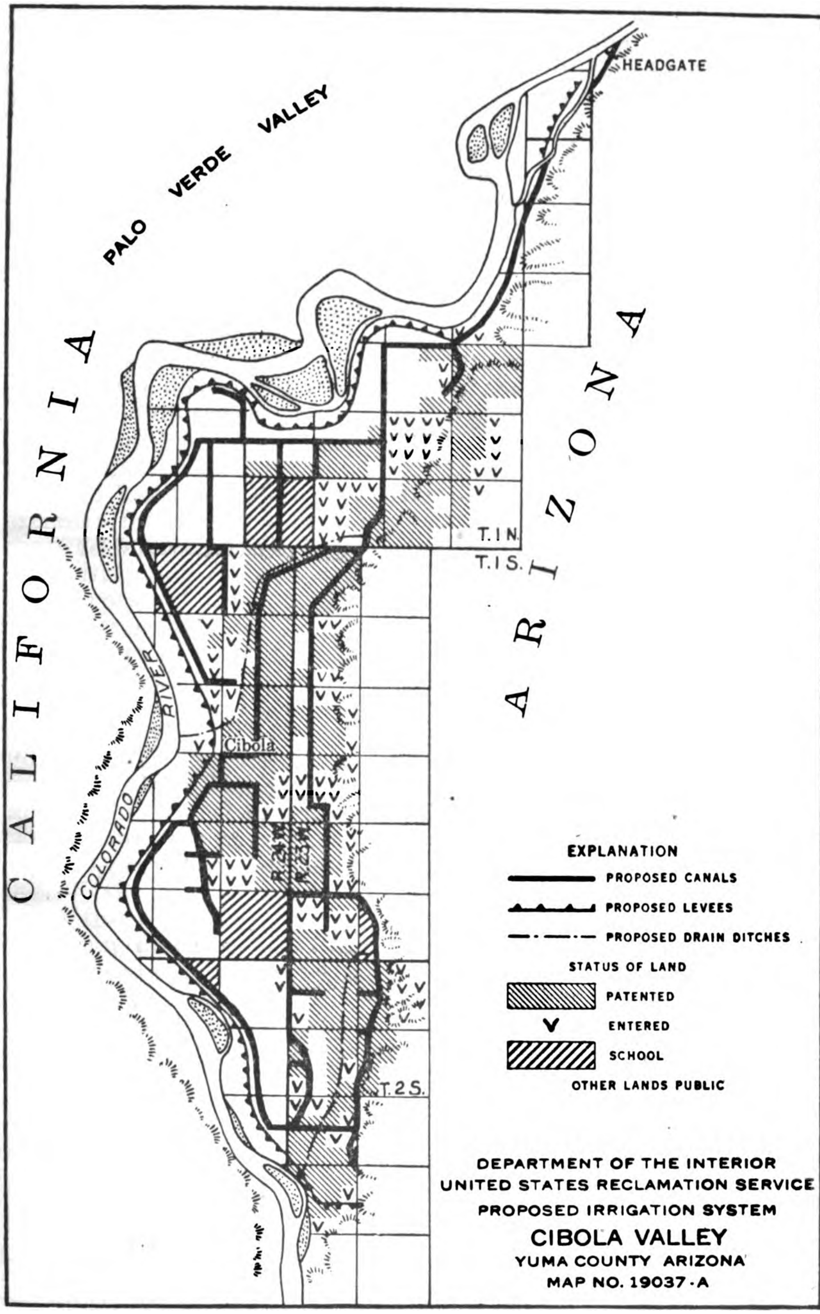
	Acres.
Public	9,500
Entered	45,000
Private	4,000
State	3,500
Total	62,000

Present status.—No construction has been undertaken to date on this project, and no plan has been presented for financing its construction.

There are no improvements on the project except a few wells.

Most of the land is held under desert entry and is unpatented. The status of these entries is defined in the act of Congress entitled "An act to exempt from cancellation certain desert-land entries in Riverside County, California (Public, No. 49), approved April 11, 1916," which reads in part as follows:

That no desert-land entry heretofore made in good faith under the public-land laws for lands, townships * * * in Riverside County, State of California, shall be canceled prior to May 1, 1919, because of failure on the part of the entrymen to make any annual or final proof falling due upon any such entry prior to said date. * * * If the said entrymen are unable to procure water to irrigate the said lands above described through no fault of theirs, * * * the Secretary of the Interior is hereby authorized to grant a further extension for an additional period of not exceeding two years.


HEADGATE
PALO VERDE VALLEY
CALIFORNIA
ARIZONA
COLORADO RIVER
Cibola
T.1 N.
T.1 S.
T.2 S.
EXPLANATION
PROPOSED CANALS
PROPOSED LEVEES
PROPOSED DRAIN DITCHES
STATUS OF LAND
PATENTED
ENTERED
SCHOOL
OTHER LANDS PUBLIC
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
PROPOSED IRRIGATION SYSTEM
CIBOLA VALLEY
YUMA COUNTY ARIZONA
MAP NO. 19037-A

CIBOLA VALLEY PROJECT.

Location and description.—The Cibola Valley lies on the east side of the Colorado River in Yuma County, Arizona. It is about 20 miles south of the lower end of the Parker Valley and is adjacent to the lower end of the Palo Verde Valley, being separated from the latter only by the river.

The nearest railroad point is the new town site of Ripley in the Palo Verde Valley, about 12 miles north.

The general elevation of the valley is about 230 feet above sea level.

The valley lies north and south, with a length of 12 miles and a mean width of 3 miles.

The Cibola Valley is but little above the bed of the stream, and the entire area is subject to overflow during normal high water. The valley could not be developed without complete storage control or without a levee for the full length of the river bordering the valley. There is no diversion dam site in the vicinity of the Cibola Valley.

A topographic survey was made on the scale of 2 inches per mile in 1902 and 1903.

There has never been any irrigation development in this valley except a few attempts on a very small scale of individual pumping. Some farming on a small scale has been practiced on overflow lands.

An irrigation district was formed by the landowners in 1913 for the purpose of developing an irrigation project. Detailed surveys of an irrigation and levee system were made for the district by R. L. Morton in 1914. From these surveys a complete system of canals, levees, and drains was designed and quantities computed, and a report and estimate were made covering the same by C. K. Clarke in 1914. The plan as laid out by Mr. Clarke is shown on Plate XVIII, which was copied from a large-scale map prepared by him. The irrigation district voted bonds for the construction of the project as outlined and estimated by Mr. Clarke, but to the present date no market has been found for them.

Drainage.—The sloughs above mentioned are sufficient for carrying off the surplus water, except during high water of the river when the valley is subject to overflow. With the development of irrigation, however, artificial drains will be necessary. These sloughs can be used to a large extent in the construction of a drainage system.

Ownership and area.—The area of the project and the status of the lands, as of October, 1920, as shown by the records of the United States land office, are as follows:

Classification of lands, Cibola Valley project.

	Gross.	Net.
Entered	3,000	2,550
Patented	8,000	6,800
Public	5,500	4,650
State	2,000	1,700
Total	18,500	15,700

YUMA PROJECT.

Location and description.—The Yuma project is located in Yuma County, Arizona, and in Imperial County, California. The principal town of the project is Yuma, with a population of 5,000. It is located on the Colorado River, at the point of crossing of the Southern Pacific Railroad. The other principal towns of the project are Somerton and Gadsden, in Arizona, and the town of Winterhaven, in California.

The railroads of the project are the main line of the Southern Pacific; the San Diego & Arizona Railroad, recently completed, from Yuma to San Diego, Calif.; and the Yuma Valley (Government) Railroad, which runs south from Yuma to the Mexican border, a distance of 24 miles.

The present constructed portion of the Yuma project comprises the valley lands of the Yuma Indian Reservation on the California side, extending from Yuma northeast about 10 miles to near the Laguna Dam, at which point the river flows between two rock hills. On the Arizona side the present constructed project comprises the Yuma Valley lands, extending from Yuma to the Mexican border, a distance of about 17 miles. The average width of the Yuma Valley is about 6 miles, and that of the reservation about 3 miles.

The valley lands of the project were practically all subject to overflow in extreme high water, and it has been necessary to construct levees for their protection.

The pumping unit of the project, or what is known as the Yuma auxiliary project, comprises the bench lands lying adjacent to and east of the Yuma Valley, at a general elevation of about 190 feet above sea level and about 80 feet above the valley lands. The first unit of this project is now under construction.

Historical.—Reconnaissance made and preliminary surveys begun in 1902.

Construction recommended by board of engineers April 8, 1904.

Construction authorized by Secretary, May 10, 1904.

First irrigation by Reclamation Service, season of 1907.

Laguna Dam completed March, 1909.

Colorado River siphon completed June 29, 1912.

Gravity water from Laguna Dam furnished to Yuma Valley through siphon June 29, 1912.

Yuma Mesa auxiliary reclamation project act passed January 25, 1917.

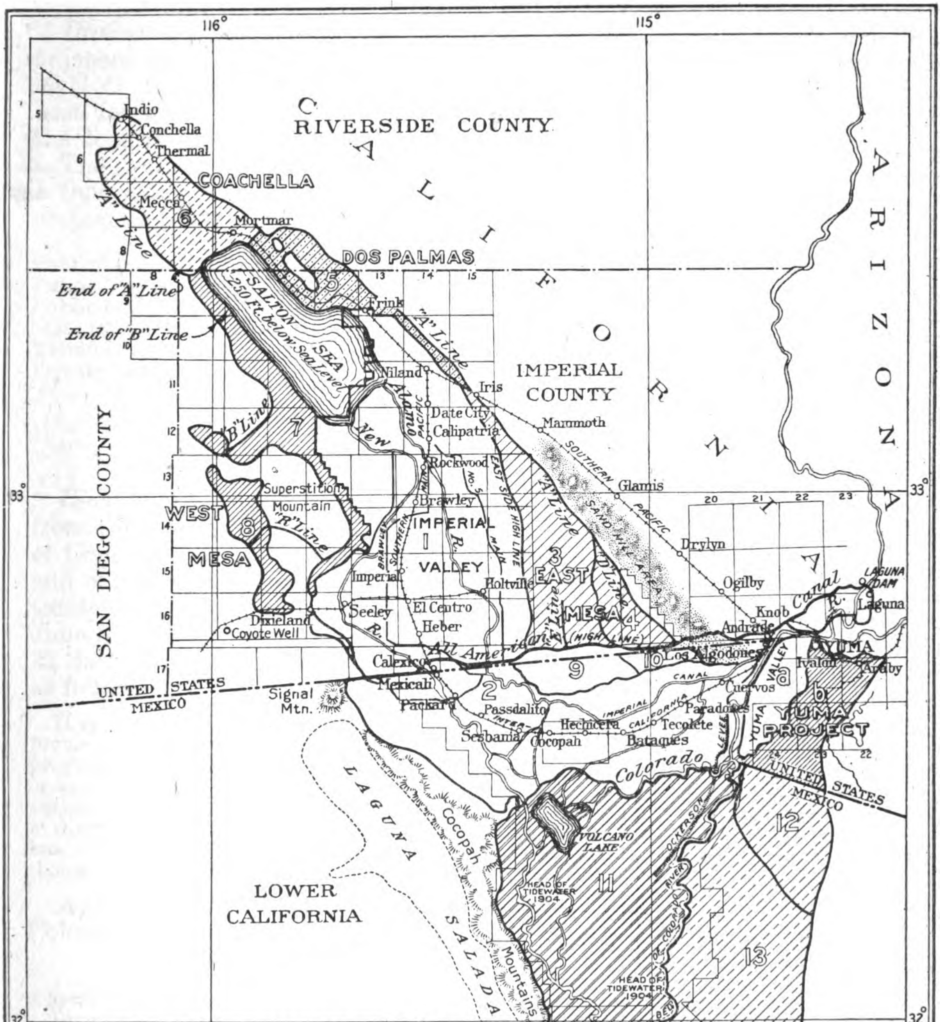
Construction of first mesa unit approved June 8, 1920.

Yuma project 95 per cent completed and first mesa unit of auxiliary project 20 per cent completed June 30, 1920.

LAND.

Topography and soil.—The valley lands of the project are flat river-bottom lands, formerly covered with brush, and cut to some extent with sloughs, as is characteristic of other valleys of the Colorado River. There are also some sand dunes in portions of the project. The soil is alluvium, or river silt, and especially near the river is quite sandy.

The mesa lands are uniformly smooth, with a gentle slope to the southwest. The soil is sandy loam.



IRRIGABLE AREAS BELOW LAGUNA DAM				
Index No.	Gross Areas	Irrigable Areas		
		Gravity	Pumping	Total
IN UNITED STATES	Acres	Acres	Acres	Acres
Salton Sea	179,000			
a and b : Yuma Project	170,000	69,000	61,000	130,000
Under present Canal				
1: Imperial Irrigation District	604,000	515,000		515,000
Proposed extensions				
3: East Mesa	165,000	124,000		124,000
4: East Mesa	42,000		36,000	36,000
5: Dos Palmas	81,000	50,000		50,000
6: Coachella	121,000	72,000		72,000
7: West Side	95,000	10,000		10,000
8: West Mesa	27,000	23,000		23,000
Total in United States	1,305,000	818,000	97,000	915,000
IN MEXICO				
2: Under present Imperial Canal	370,000	275,000		275,000
Under All American				
9: Mexican Gravity	32,000	22,000		22,000
10: Mexican Pumping	11,000		8,000	8,000
11: Lower California Delta	510,000	250,000		250,000
12-13 : Sonora	550,000	210,000	55,000	265,000
Total in Mexico	1,473,000	757,000	63,000	820,000
Grand Total	2,778,000	1,575,000	160,000	1,735,000

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
IRRIGABLE AREAS
BELOW
LAGUNA DAM
COLORADO RIVER
Map No. 20293

SCALE OF MILES
10 5 0 10 20 30

45-C-75

Drainage.—The valley lands are generally lower near the mesa than adjacent to the river, and in general are lower than the high-water level of the river. Due to these conditions artificial drainage has been found necessary for the greater portion of the valley lands, and the construction of open drains is actively under way.

The drainage conditions of the mesa lands are good.

Ownership and area.—The status of the irrigable lands of the project as of June 30, 1920, is as follows:

	Acres.
Public land entered	19,000
Public land open	300
Public land withdrawn	37,900
State land unsold	1,800
Indian land	9,000
Private land	62,000
Total irrigable area	130,000

WATER SUPPLY.

Right to divert water from Colorado River.—The right to divert water from the Colorado River (a navigable stream) was authorized by act of Congress entitled "An act making appropriations for the current and contingent expenses of the Indian Department and for fulfilling treaty stipulations with various Indian tribes for the fiscal year ending June 30, 1905, and for other purposes" (act Apr. 21, 1904, ch. 1402, 33 Stat., 189). The portion authorizing the diversion of water reads as follows:

> That in carrying out any irrigation enterprise which may be undertaken under the provisions of the reclamation act of June 17, 1902, and which may make possible and provide for, in connection with the reclamation of other lands, the reclamation of all or any portion of the irrigable lands on the Yuma and Colorado River Indian Reservations in California and Arizona, the Secretary of the Interior is hereby authorized to divert the waters of the Colorado River and to reclaim, utilize, and dispose of any lands in said reservations which may be irrigable by such works in like manner as though the same were a part of the public domain.

Appropriations.—Appropriations of water for diversion from the Colorado River to be used on the Yuma project are listed as follows:

	Second-feet.
Appropriated July 8, 1905, to be diverted from the left side of Colorado River at Laguna Dam, to be used on lands in Yuma County, Ariz., recorded July 10, 1905, at Yuma County recorder's office, Yuma, Ariz. (book 5, miscellaneous, p. 99)	3,000
Appropriated July 8, 1905, to be diverted from right bank of Colorado River at Laguna Dam, to be used on lands in Imperial County, Calif., recorded July 13, 1905, at Imperial County recorder's office at El Centro, Calif. (book 1, p. 106)	6,000

Also in 1907 and 1908 the United States purchased for the benefit of the Yuma project the property and rights of the following old canals in the Yuma Valley:

Farmers' pump canal.—Purchased from the Colorado Valley Pumping & Irrigation Co., March 15, 1907. This company was incorporated March 4, 1901. There was under irrigation in 1907 from 2,000 to 3,000 acres from this system.

Farmers' gravity canal.—Purchased from the Yuma Valley Union Land & Water Co., February 3, 1908. This company (originally the Yuma Canal Co.) was incorporated June 26, 1897. Its plans involved practically all lands in the Yuma Valley.

Rollins Ditch (including Ives heading, pumps, and ditches).—Purchased from the Greene Land & Cattle Co., July 23, 1908. This system was constructed in 1892, and on January 20, 1893, an act of Congress was approved granting right of way for two ditch lines for the company.

Storage required.—It is assumed that the water rights of the Yuma project, as stated above, are of sufficient priority to furnish an ample supply from the natural flow of the Colorado River for the completed project, and therefore it is not estimated that any storage will be required.

IRRIGATION PLAN.

The irrigation plan of the Yuma project provides for the diversion of water from the Colorado River at the Laguna Dam, 10 miles northeast of Yuma, Ariz., into a canal system heading on the California side, conveying water to the irrigable lands on that side of the river, including those in the Yuma Indian Reservation, crossing the river at Yuma through an inverted siphon and serving lands in the Yuma Valley below the town of Yuma. The plan also provides for large pumping plants below Yuma on the east main canal for raising water to irrigate 45,000 acres of mesa land. The lands adjacent to the Colorado River are protected from overflow by means of levees. In addition, a drainage system is under construction and is being extended to areas in which the ground water is rising to such an extent as to threaten the lands with seepage. At the lower end of the project a large pumping plant is provided for pumping the drainage waters across the levee.

Power requirement, Yuma project.

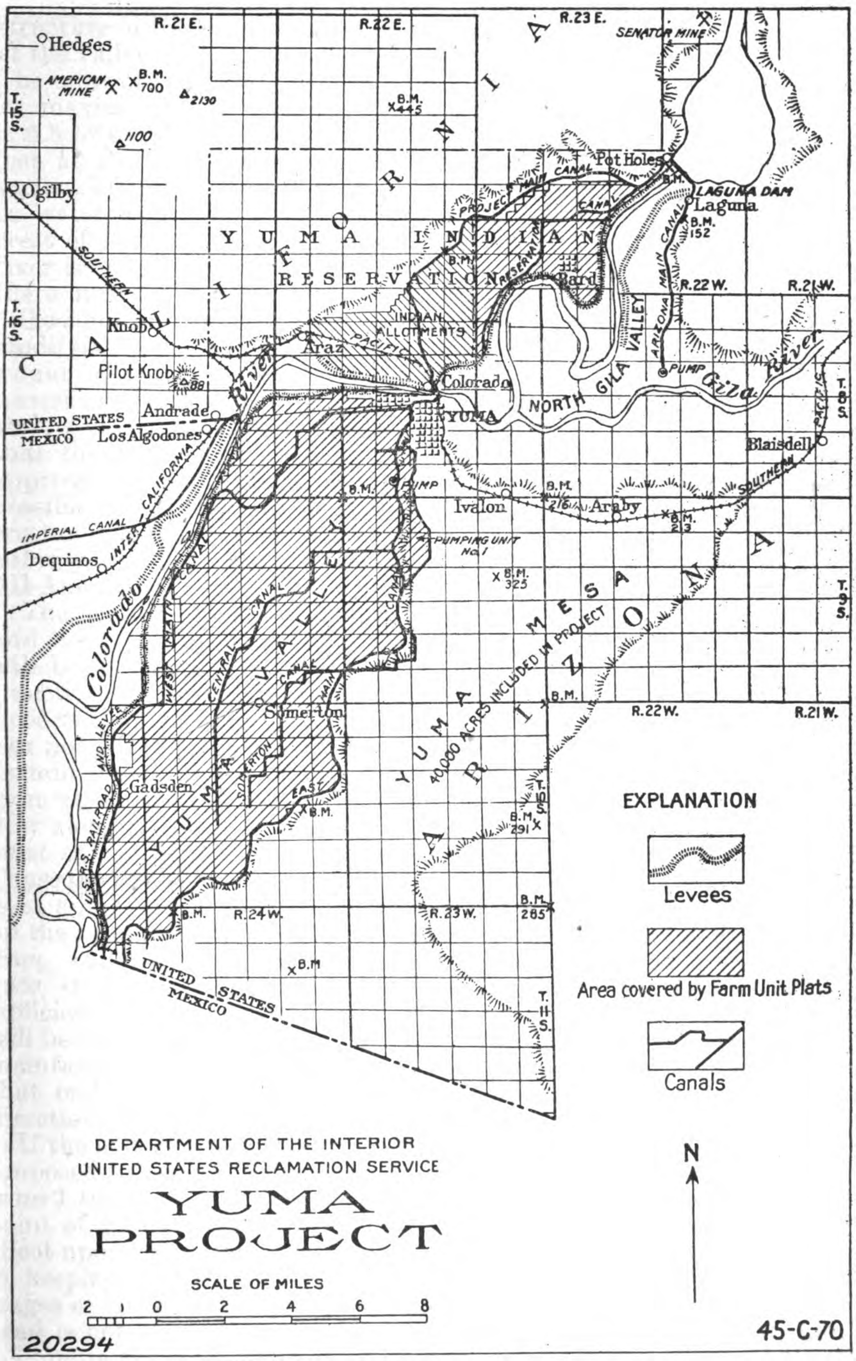
	Theoretic horsepower.
Yuma mesa pumping:	
162 second-feet, lift 80 feet	1,473
185 second-feet, lift 68½ feet	1,440
103 second-feet, lift 54.6 feet	640
50 second-feet, lift 10 feet	57
Total mesa pumping	3,610
Drainage pumping	300
Total for project	3,910
Required horsepower (40 per cent loss in pump and motor)	6,500

It is planned to develop part of the power required for the Yuma project on the project, a small plant to be developed at the siphon drop on the main canal, where there is a head of about 12 feet, and a larger plant near Araz, or as an alternative power will be secured from the power plants which it is proposed to construct at the drops of the All-American High Line Canal.

THE CANAL HEADWORKS AT LAGUNA DAM.

[Extract from Report of All-American Canal Board, July 22, 1919.]

The headworks of the Yuma project canal are to be so modified that the diversion into a common canal will be adequate to supply the irrigation demand of both this project and the Imperial Valley. At the point of diversion on the Colorado River, about 10 miles northeasterly from Yuma, the elevation of the water surface in the river is


R.21 E.
R.22 E.
R.23 E.
Hedges
AMERICAN MINE
B.M. 700
2130
1100
B.M. 445
SENATOR MINE
T. 15 S.
Ogilby
Pot Holes
LAGUNA DAM
Laguna
B.M. 152
PROJECT MAIN CANAL
CALIFORNIA
YUMA INDIAN RESERVATION
RESERVATION
Bard
R.22 W.
R.21 W.
SOUTHERN
T. 16 S.
Knob
INDIAN ALLOTMENTS
Araz
PACIFIC
ARIZONA MAIN CANAL
NORTH GILA VALLEY
PUMP
Gila River
Pilot Knob
Colorado
T. 8 S.
UNITED STATES
MEXICO
Andrade
Los Algodones
YUMA
Blaisdell
PACIFIC
INTER-CALIFORNIA
IMPERIAL CANAL
Dequinos
PUMP
B.M.
B.M. 216
Ivalon
Araby
B.M. 213
SOUTHERN
PUMPING UNIT No. 1
B.M. 325
T. 9 S.
Colorado River
WEST MAIN CANAL
CENTRAL CANAL
CANAL
MAIN CANAL
YUMA VALLEY
YUMA MESA
ARIZONA
40,000 ACRES INCLUDED IN PROJECT
Somerton
B.M.
R.22 W.
R.21 W.
U.S. R.S. RAILROAD AND LEVEE
Gadsden
SOMERTON
EAST
B.M.
T. 10 S.
B.M. 291
B.M.
R.24 W.
R.23 W.
B.M. 285
UNITED STATES
MEXICO
B.M.
T. 11 S.
EXPLANATION
Levees
Area covered by Farm Unit Plats
Canals
N
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
YUMA PROJECT
SCALE OF MILES
2 1 0 2 4 6 8
20294
45-C-70

brought under control by the Laguna Dam. This is a broad, low structure of the weir type, which extends from solid rock on one side of the valley of the Colorado 4,750 feet to solid rock on the other side. The crest of the structure is at a uniform height (elevation 151 feet). At maximum flood stage the depth of water on the crest of the dam is 5.5 feet. This dam raises the water surface of the river about 10 feet at the river's low stage. At high water the fall of the water surface at the structure—that is, the fall from water above the dam to water below the dam—is only about 5 feet. The shape of the crest of the dam is such that some of the large drift carried by the river is caught by the dam at certain stages of the water and hangs there until the water of a higher stage pushes it over.

To some extent checking of drift in this way could be prevented by modifying the shape of the crest. As this is desirable and as there would be material advantage to both the Yuma project and the All-American Canal project in holding the water above the Laguna Dam at low stages somewhat higher than heretofore, the board suggests that the crest of the dam be raised 2 feet and rounded, with short approach from upstream on a gentle slope, so as to offer the least possible obstruction to drift. The advantage of thus raising the crest of Laguna Dam is represented by the saving of about 1,000,000 cubic yards of excavation for each foot that the grade line of the All-American Canal is raised.

The board realizes that due to the great length of the Laguna Dam and the broad expanse of the submerged area above the dam there will be a deposit of material to and above the full height of the structure over some areas, and a growth of willows and brush is to be expected which may so encroach upon the structure that the dam can not function uniformly from end to end. There will always be certain points at which there will be freer approach for the water from above than at others, and from these points there will be some flow along the dam to the right and left. The water going over the crest of the dam will not, in other words, be at a uniform depth. Consequently the height to which the water will rise when the river is at a high stage will be somewhat above what would be calculated on the assumption that the overflow is uniform from end to end of the dam. Allowance for this fact has been made in planning the headgate structures, bulkheads, and training walls, which are to be sufficiently high to avoid overtopping. The point at which there will be the greatest concentration of overflow over the dam should be maintained near its California end. The large diversion of water at that end of the structure will aid in drawing the stream in this direction.

If the suggestion to modify the crest of the dam is approved, it is proposed to depress a section of the crest, possibly 800 feet thereof, from 1 to 2 feet below the general level, thereby definitely fixing the point of greatest water concentration, which will have more or less effect upon the course on which most of the drift runs and may assist in keeping the same out of the canal. Furthermore, during high stages of the river when, due to the flow over the dam, an increased head is not required, such a depression would reduce somewhat the maximum water elevation above the structure.

At the California end of the dam, where the water is taken into the Yuma Canal, there are three large Stoney gates, closing openings

33 feet 4 inches wide, whose sills are about 13 feet lower than the crest of the dam. When these gates are raised, water from above the dam, flowing at high velocity, cuts out the sand and silt which have lodged in the desilting channel at whose lower end the gates are located. This desilting channel is separated from the river just above the dam by a rockfill spur or training wall. On the land side of this channel close above the Stoney gates is the headgate of the Yuma project canal. This is a simple structure with 35 openings, each 7.5 feet in the clear, between concrete piers which carry a concrete footbridge from which the flashboards, with which the flow of water is regulated, can readily be manipulated. The water drops into the canal over the top of these flashboards. By thus admitting water to the canal from the surface of the sluggish stream in the desilting channel much less silt is taken into the canal than would be the case if underflow gates were used. Once a week the sluice gates are opened and the sand and silt which have been deposited in the desilting channel are washed out, passing through the gates to the river below the dam. While no precise statement can be made of the amount of suspended material which is taken out of the water by this desilting process, it is generally estimated by representatives of the United States Reclamation Service to average about 50 per cent. In addition, it is to be noted that practically none of the bed load of the river gets into the canal. All of this, together with the coarsest portion of the suspended load as above shown, is kept out of the canal by the desilting operation.

At the present stage of development in the Yuma project, with about 45,000 acres under cultivation and with a maximum canal flow of about 1,200 second-feet, the time required per week to free the desilting channel of deposits is three to four hours. During this time the sluice gates are open and the diversion of water into the canal ceases. This is of no inconvenience to the irrigators, who readily adjust their requirements to such a schedule. They have in fact thus far adjusted their demands to a shutdown of much longer duration than required for sluicing. The canal is being operated from early Monday morning to Saturday evening. Throughout Sunday the sluice gates are open and the canal bed is dry.

Under a full development of the Yuma project the desilting operation will have to be extended to a much larger flow of water. The maximum diversion for the irrigation of project lands will then be about 1,600 second-feet, and, on the assumption that there should be no cooperation with Imperial Valley, there would have to be added to this flow about 4,000 second-feet to be used at some point near Araz for the generation of power. The power would be necessary to lift the water to the Yuma Mesa, on which are located about 50,000 acres of project lands. The desilting channel would then be conveying from the river to the canal about five times as much water as heretofore, and there will have to be suitable enlargement of the diverting works and more frequent operation of the sluice gates.

Under the cooperation with Imperial Valley the maximum diversion, as planned for the All-American Canal, will reach about 10,600 second-feet. The present desilting channel has not been dimensioned either for this amount of water nor yet for that ultimately required for the Yuma project alone. It must be enlarged and extended. But the general plan of operation will remain the same. Periodically the sluice gates will be opened and the sand which has been deposited in the desilting chamber will be scoured out.

It is proposed as a part of the All-American Canal work to allow space for a fourth Stoney gate inshore from those now in use. The desilting basin will be widened and extended farther upstream. It will be confined between two rock-fill training walls, which, while gradually spreading apart, will curve out toward the river so as to leave a wide, open mouth for the inflow of the canal water.

The present headgate will be replaced by a new structure similar in type, having a length of about 1,374 feet. The upstream portion of this headgate will be constructed while the present one remains in service, and later the upper end of the new gate will be put into use during reconstruction of its lower end.

Based on the experience thus far at the Laguna Dam, it is estimated that for desilting operations an amount of water not in excess of eight hours per week of the canal's flow will be required. Whether the desilting operation will be undertaken once a week or more frequently will depend not alone on the rate at which sand accumulates in the desilting channel, but also upon the effect which the resulting irregular flow in the canal will have upon the development of power and on the demands of the irrigators.

THE CANAL FROM LAGUNA DAM TO THE SIPHON DROP.

For 10.2 miles from Laguna Dam the canal will carry 10,600 second-feet of water, for both the Yuma project and the Imperial Valley, in the enlarged Yuma Canal. At the lower end of this 10-mile stretch on the present canal is a structure known as the siphon drop, through which the Yuma project water drops about 10 feet to the lower level, at which it flows across the submersible river lands to the bank of the river opposite Yuma. The 6-foot superelevation of the canal banks will be such that with perfect safety the ordinary water-surface elevation could be increased. Furthermore, the operation of the system will probably require that dredges be kept in operation at certain points of the canal, and these can at any time when the necessity therefor is apparent be used to enlarge the canal prism and increase its capacity. The canal is to have a bed width of 162 feet. Its side slopes are planned at 1 to 1½ on the land side and 1 to 2 on the river side. When flowing full, the depth of water will be 16 feet. Its gradient will be 0.000079, or a little over 5 inches per mile. It has been so dimensioned that when flowing at capacity the mean velocity will be about 3.5 feet per second and that when its flow falls to one-half of the rated capacity the velocity will be at least 2.5 feet per second.

The enlargement of the Yuma project canal from its present dimensions is to be accomplished chiefly by raising the water surface and excavating in the bottom and on the land side of the present canal and placing the excavated material for the most part on the river side of the canal A high, broad bank of earth will thus be provided, on which there should be both road and railroad track.

Within about 1¼ miles downstream from the Laguna Dam there will be three Stoney gates placed in this canal embankment, which are to serve as sluice gates and as waste gates whenever occasion may arise. They will discharge back into the river and, together with a similar set which will be placed near Araz, will not alone serve their prime purpose as sluice gates but will also facilitate the discharge of storm water when there is large inflow from the hill region.

This provision for handling the storm water is suggested by the large reservoir capacity represented by the 17 miles of canal from the Laguna Dam to the proposed power station at Pilot Knob. All along this portion of the canal the left or river bank thereof will be a high embankment, as already described. Against this embankment water could rise 3 or possibly even 4 feet above the ordinary high-water line without serious menace. If a storm should occur near the head of the canal with a large delivery of water into the canal, such a rise might turn some water upstream, back into the desilting channel, and thence into Colorado River.

While this is occurring, preparation would be made at all the sluice gates to open the same when necessary. The opening of those at the Luguna Dam would stop the inflow of river water into the canal; those near the 1¼-mile point and those near Araz would be opened to relieve the canal of storm water.

To prevent damage to the canal by the deposit in it of the coarse material which a cloudburst may sweep along in the beds of the sand washes which this part of the canal crosses, the canal will be closed where feasible against these by means of substantial embankments or barriers above which the flood occasioned by such a cloudburst will be pocketed. Interconnection will be provided so far as practicable from one sand wash to the next, and at selected points the barriers will be provided with concrete crests and protected slopes or drops to the canal, so that when the basin behind them is full they will discharge over the barriers into the canal. In this way a number of pockets will be provided for the interception of sand, gravel, and cobbles, and these can hereafter be increased in extent by adding to the height of the overfall barriers.

THE CANAL FROM SIPHON DROP TO PILOT KNOB.

At the Siphon Drop the water from the Yuma project will be dropped, as explained, to a lower level, while the water for Imperial Valley will be held at grade. The All-American Canal, strictly speaking, will begin at this point. It will follow rather difficult ground, generally near and finally well in among the outlying hills and knolls which are features of the higher ground between a number of sand washes. An agreement will be necessary with the Southern Pacific Co. in order to secure permission to encroach on its right of way. In addition a bridge will have to be provided for the main line on the Southern Pacific Railroad, and one for the Inter-California Railroad. In this section, too, the canal is to have a freeboard of at least 6 feet. At the lower end of this section there will be a rock cut or tunnel through a spur of Pilot Knob. Adjacent to and either above or below this spur the Pilot Knob power station will be located. At a convenient point below the power house offtake there will be a controling gate in the canal. By means of this the flow in the canal to the westward will be regulated. Any surplus water will be discharged either through the waste gates at Araz or through the power house offtake canal and a by-pass, which is here to be provided.

CANAL LOCATION AT PLOT KNOB AND THENCE WESTERLY.

The range of hills which parallels Colorado River on its right or west bank in California terminates at Pilot Knob, which lies in the extreme southeasterly corner of California. While not very high nor of large surface exent, Pilot Knob is nevertheless a conspicuous topographic feature. This is due in a measure to its isolation. It is separated from the chain of hills and mountains to the north by a somewhat broken section of the mesa which forms the flat eastern slope of Imperial Valley, extending from the base of this mountain range to the lower-lying Imperial Valley lands.

Pilot Knob is surrounded by this mesa formation on three sides, to the north, to the west, and to the south. On its remaining easterly side its base has at times been washed by the waters of the Colorado River, and a spur of the mountain has been cut away to provide suitable foundation for the Hanlon gate with which since 1906 the flow of water into the Imperial Canal has been controlled. Southward from Pilot Knob the mesa formation is much broken up by washes which have been cut deep and wide to an outfall upon the lower delta land of the river. The mesa elevation around the base of Pilot Knob is generally at or above 200 feet in elevation. The bottoms of the sand washes on the proposed canal line are generally at about 130 to 140 feet in elevation. Between them the remnants of the mesa, in long narrow ridges, with tops more or less broken, extend off toward the south into Mexico. The boundary line is just far enough south of Pilot Knob to leave space for a canal which, at the elevation attainable under use of Laguna Dam as the point of diversion, will cut through these mesa ridges and cross the intervening washes, with water grade practically at or slightly below the surface of the sand in the larger washes. At a point a little less than 2 miles from Hanlon's the canal will be out of this broken ground and the deep cut into the mesa will be continuous and uniform for about a mile and a quarter to the easterly edge of the sand hills.

Entering the sand area the course of the canal for another mile and a quarter will continue parallel with the boundary, being here located across an area over which low dunes are drifting. These dunes are irregularly distributed. Any course through them is as good as any other course. There was, therefore, no object in departing from a direct course westerly. But a continuation of this course would send the canal through a broad area of high sand ridges. It was found that by deflecting the course of the canal toward the northwest it could be kept for a mile in a location on which the surface of the sand was but little above the surface of the mesa and that one of the main sand ridges could then be pierced in a cut only a little over one-half mile in length westerly to a long, narrow, bare stretch of mesa surface which has been designated on the maps as Government Gap. The adopted canal location will follow this gap for 1½ miles to its westerly extremity. For three-fourths of a mile thence, still on a westerly course, the canal will cut through a mass of sand with a number of summits at elevations approximately 50 feet above the surface of the mesa. It is on this stretch of canal that the drifting sand is most likely to prove troublesome.

Upon leaving this three-quarter-mile stretch the canal will be cut for about one-half mile through the westernmost ridge of sand, which crests on the canal line about 80 feet above the surface of the mesa and about 105 feet above the water surface of the canal.

On the entire canal stretch of about 10½ miles through the sand-hill area the canal will have to be cut deep into the mesa formation. This mesa formation underlies the sand everywhere. Its surface is smooth, with definite moderate slope from northeast to southwest. The canal, where it leaves the sand-hill area a few hundred yards to the northward of the watering station at the west end of the plank road, will be in a cut about 40 feet in depth. Its water surface will be 25 feet below the surface of the mesa. Its course will be slightly south of west from this point, with gradual approach to the international boundary.

As an alternative proposition, consideration has been given to a canal through the sand-hill area of smaller cross section, with higher velocity and with bottom and sides lined with concrete. The disadvantage of this alternative lies in the fact that the ultimate area to be irrigated by the canal must be taken into account at the time of construction, because when once constructed there can not well be any enlargement of a concrete-lined canal which must be kept in operation without interruption of service. The advantage of the lined canal lies mainly in the high velocity at which the water will be carried, thereby making sure that any sand and silt which get into the canal will lodge elsewhere than in that portion of the canal in the sand-hill area, where the canal is deepest in the ground and where the removal of the sand would therefore be more difficult than from other portions of the canal.

A lined canal would be only about 70 feet wide on the bottom, its gradient would be about 0.00017, the velocity when flowing full would be about 6 feet per second, and its bottom would be from nothing to 6 feet lower than that of an unlined canal. Less excavation by about 6,000,000 cubic yards would be required in its construction, but the saving in cost from this reduction in yardage would be about offset by the cost of the concrete lining.

For further information on this subject reference should be had to the report of Mr. Preston, the engineer in charge of surveys.

At about 6 miles to the westward of the sand hills the canal will be out of deep cut and a proposed mesa canal can there be supplied with water. At this point it is proposed to turn out for use on the mesa and lands to the northward 3,000 second-feet of the canal flow. The remainder, or about 6,000 second-feet, will be dropped 24 feet through a near-by power-house at mesa power station No. 1, located about 4 miles west.

About 3 miles westerly from this power station a low-level mesa canal, with a capacity of 500 second-feet, will be taken off and the remaining 5,500 second-feet will be held available for use in Imperial irrigation district and on the west-side lands.

On this canal stretch, at about 5 miles westerly from the mesa power station No. 1, there will be a second power station. A fall of 47 feet can here be made available.

Beyond this point the construction of the canal offers no difficulties, but there will be several expensive structures required to carry the water across the deep Alamo and New River barrancas and to provide for the wastage of surplus waters.

At Calexico the canal will be located 1 mile to the northward of the boundary line. It can be held at an elevation sufficient to reach the west side canal at a point about one-half mile northward from the international boundary. A few thousand acres of ground along the boundary line on the west side will be too high to be commanded by gravity flow. For the irrigation of these lands a pumping plant will be required.

IMPERIAL IRRIGATION DISTRICT, CALIFORNIA, AND IMPERIAL VALLEY, MEXICO.

Location and description.—The Imperial irrigation district is located in Imperial County, California, in townships 9 to 17 south, ranges 12 to 16 east. The district comprises the bottom of the south portion of what is known as Salton Basin, the district extending from the center of the east side of Salton Sea on the north to the Mexican border on the south, a distance of about 48 miles, and with a maximum width of 30 miles.

The Imperial Valley of Mexico lies south of and adjacent to the Imperial district in California, extending a maximum distance south of the boundary line of about 20 miles and having a length parallel to the boundary of about 50 miles.

The Imperial Valley, both of California and Mexico, comprises the north slope of the Colorado River delta, which has been built across the north end of the Gulf of California during past ages. The crest of the delta is in Mexico, about 20 miles south of the border in the vicinity of Volcano Lake and along the line of Bee River, which is the present channel of the Colorado River. The valley ranges in elevation from about 100 feet above sea level in the eastern portion of the Mexican lands to about sea level on the California-Mexican border and to 250 feet below sea level at Salton Sea.

The principal towns of the project in California are Calexico, near the boundary; El Centro, in the south-center; Brawley, in the north-center; and Niland, near the north end. The principal Mexican town is Mexicali, near the west end of the Mexican tract and just south of the border, and other important railroad stations are Hechicera, near the center, and Paradones, near the east end.

The railroads of the project are the main line of the Southern Pacific, touching the north end of the Imperial district in California, a branch of the Southern Pacific extending south from Niland through the center of the district to Calexico on the border line, and the San Diego & Arizona (in Mexico called the Inter-California) Railway, running west from Yuma through the Mexican lands and north into the Imperial district at Calexico and to El Centro and west to San Diego.

HISTORICAL.

* * * Dr. O. M. Wozencraft, as principal promoter, with Ebenezer Hadley, the county surveyor of San Diego County, as his engineer, worked out a project some 60 years ago for the colonization and development of lands in California under irrigation with Colorado River water. Their proposition involved a diversion of water from the river toward the west into the region drained by the Alamo River, which would then carry it, substantially as under the later scheme, to the points in California from which it could be distributed by a canal system.

This project involved a grant of Government land to California amounting to about 3,000,000 acres. It was approved by the Legislature of California, but the necessary bill failed to pass Congress. Subsequently an examination was made under Government direction to determine whether or not it would be feasible to reach the Imperial Valley without following a route through Mexico. This examination was made in 1876 by Lieut. Eric Bergland, Corps of Engineers, United States Army, who acted under the direction of Lieut. George M. Wheeler. He reported unfavorably upon a canal location entirely in the United States, but again called attention to the natural route across Mexican territory.

Despite this report, which was discouraging to those who desired to have water supplied to the desert in a canal located throughout its entire length on United States territory, the efforts to get water into Imperial Valley did not cease. But no proposition gave promise of success until Mr. C. R. Rockwood and his associates organized the Colorado River Irrigation Co. in 1892. Surveys were made and works were planned to deliver water from Colorado River in California across the boundary into a short canal in Mexico, which would discharge into the Alamo River, down which it would then flow to a reentry into California. This company failed, however, and was succeeded in 1896 by the California Development Co. At the head of this company, except for two years, 1900–1902, was the late Mr. A. H. Heber. Mr. Rockwood remained in charge of engineering and construction. A reorganization of the company in 1905 put the control of its affairs into the hands of the Southern Pacific Co. From 1910 until 1916 the property of the canal company was in the hands of a receiver. In 1914 the Imperial irrigation district was organized and two years later took over the canal properties, which included all the shares of stock of the Mexican corporation through which the properties in Mexico are managed.

The canal of the California Development Co., as originally constructed, had its head in California at Hanlons or Hanlons Crossing, about 100 yards north of the international boundary. The canal was cut from the river at an oblique angle, and its flow was controlled by a timber structure. On a falling river the head of the canal and the headgate were obstructed by silt deposit, and it became difficult to keep the water flowing from the river into the canal. The water shortages due to this cause in 1903 and 1904 and the failure of various remedial measures prompted the application to Mexico for a concession under which a diversion would be allowed on Mexican territory. This concession was granted in 1904, and operating thereunder the dredger cut was made about 4 miles below the boundary line in Mexico, which caused the river a year later to turn for a time inland away from its course to the Gulf.

The concrete headgate of the Imperial Canal at Hanlon, which was constructed in 1906, has a sill at elevation 100.7 feet above mean sea level. (U. S. Geol. Survey datum.) This was at that time believed to be low enough to accomplish diversion of the desired amount of water at any stage of the river. The large amount of sand which has annually been carried into the canal and the depression of the water surface in the river below the assumed minimum elevation have combined to make the diversion of an adequate quantity of water at the river's low stages impossible. This is true despite the fact that a few years ago a 25-foot section of the headgate sill was lowered 5 feet. Imperial irrigation district has, therefore, found it necessary to construct temporary weirs across the river of rock and brush. Such a weir was constructed in 1910 and annually since 1915.

There is some water obtained for the irrigation of lands in the Imperial irrigation district and in Mexico from Volcano Lake through the Cerro Prieto Canal. This is only a temporary expedient. The connection of the Cerro Prieto Canal with Volcano Lake was made in 1916. Water has thus been made obtainable from the Volcano Lake region while the river is high. As this water is drawn from an extensive ponded area it is comparatively clear, and its use has materially reduced the difficulty with silt in the west-side canal system. The maximum amount of water obtained from this source has exceeded 800 second-feet. This source of supply will be available only so long as the river is allowed to send its flood waters against the Volcano Lake Levee. The time will come when the river is put back upon a direct course to the Gulf, and thereupon this source of supply will no longer be available. (All-American Canal report.)

Regarding flood-protection problems of the Imperial Valley, the following is from report of Mead, Henny, and Jacobs on "Irrigation and flood-protection problems of Imperial Valley, Calif., March, 1917:

* * * In 1891 so much water flowed over the western bank that it found its way through the dense bordering growth of brush and weeds and reached the lowest part of the Salton Sink; not, however, for a long enough time or in sufficient volume to effect a permanent channel change.

Concentrated flow, carrying the entire Colorado River, occurred, however, in 1905 and again in 1906, when the river left its normal course by breaking through the lower Mexican heading of the Imperial Canal, gathered in the Alamo and New River Channels, and flowed then to the Salton Sink, which it transformed into a great inland sea. The cost of closing these breaks and restoring the river to its old channel was in excess of $2,000,000.

No doubt many diversions of the Colorado River to the Salton Sink mark the past history of that stream, but in recent times we have only the record of 1891, when a lake of 100,000 acres, and of 1905 and 1906, when a lake of 285,000 acres was formed.

In order to insure against a recurrence of such a channel change in the Colorado River, levees have been constructed as shown on Exhibit B. These levees are necessary for the protection of Imperial Valley lands both in Mexico and in the United States, although their location is entirely on Mexican soil. They include the following:

(*a*) The C. D. Levee, built by the California Development Co., extending from the present Imperial Canal intake, southerly along the right bank of the Colorado River a distance of 10 miles; thence southwesterly an additional distance of 17 miles.

(*b*) The Volcano Lake Levee, extending from Cerro Prieto, a rock mountain at the northwesterly corner of Volcano Lake, a distance of 16½ miles to a connection with the Inter-California Railroad embankment; thence north 1½ miles to a connection with the south embankment of the Imperial Main Canal.

(*c*) The Ockerson Levee, constructed in 1911 by the United States for the primary purpose of returning the flow of the Colorado from the Bee River Channel, which it had assumed two years before, back into its previous and more easterly channel along the base of the Sonora Mesa. During the summer flood of 1911 it was breached at numerous points, the largest breach occurring at the Bee River Channel, which widened until the entire river flowed down this channel to Volcano Lake, which continues to be its course to the present time. Due to the lack of maintenance a few additional breaches have occurred, but the major part of the levee is intact.

The total expenditure incurred to date in the above levee construction, including closures, has been estimated at about $5,000,000. (See Exhibit F.) Aside from the Ockerson Levee, these levees have thus far fairly accomplished their object, but not without actual and threatened breaks that might have precipitated a calamity at any time.

The political obstacles encountered in constructing and operating the system have been almost as serious as the physical difficulties and have at times jeopardized the integrity of the enterprise. From its inception the project has been financed by American capital and built with American equipment, although practically all of the main canal and the flood-protection works and about one-third of the irrigable area are in Mexican territory. The customs and other regulations of Mexico governing movement of persons and materials across the border often cause serious and costly delays which, in cases of emergency, might be disastrous. The situation is at times so critical and the ability to act promptly is so vital to the safety of the enterprise that these restrictions should be abolished. The present Mexican concession is unsatisfactory because inadequate in several respects. It does not establish equality of irrigation charges on the two sides of the boundary; it does not authorize enlargement of the main canal or construction of any higher canal; it does not provide for any flood-protection works. The unstable political conditions in Mexico add to the gravity of this situation.

Drainage.—As the district stands to-day, there is very little provision made for drainage. The need of proper drainage facilities is being felt in different sections where the underground water is bringing the salt to the surface. In these sections it is impossible to raise a crop to-day on land that was giving a heavy yield five years ago.

Imperial Mutual Water Co. No. 3 has a few surface drainage ditches. The usual method is to run a double system of canals with a road between.

Imperial Mutual Water Co. No. 8 has a few surface drainage ditches, but they are for the most part owned by private individuals and are not kept in very good condition.

Imperial Mutual Water Co. No. 5 has an elaborate system of surface drainage ditches. Practically every feed canal in the system is paralleled by a drainage ditch. The usual method of placing a road between every feed and drainage ditch is followed. In the other companies little or no provision has been made for surface drainage.

The New, the Alamo, and the Greeson River channels are ideally located for the main drainage channels of the district. At the present time they are used for wasteways by the several water companies. A dam has been thrown across the Alamo River channel at a point opposite Calipatria, and the Imperial Northend and Northside Mutual water companies divert the waste water for irrigation purposes.

Ownership and area, Imperial Valley projects.

Tract and ownership.	Gross area.	Irrigable area.
Imperial irrigation district, California (practically all private lands)	603,800	515,000
Mexican lands:		
Lower California Land & Water Co	72,000	54,000
Small tracts, private owners	10,000	8,000
International Co	12,000	9,000
Imperial Development Co	15,000	11,000
E. Easton (owner)	15,000	11,000
Colorado River Land Co	208,000	156,000
Government land	8,000	6,000
Total, Mexican	340,000	255,000
Grand total	943,800	770,000

Appropriations—Water supply.

[Joseph Jacobs's report, April, 1917.]

Claimant.	Date of filing.	Amount claimed.	Remarks.
		Sec. ft.	
E. I. Rockwell	May 16, 1895	10,000	Diversion point 1¼ miles north of boundary.
California Development Co	Dec. 15, 1895	10,000	Do.
E. I. Rockwell to the California Development Co.	Aug. 15, 1911	10,000	Rockwell conveys to California Development Co. all his interests in his original filing of May 16, 1895.
W. T. Gonder	July 15, 1895	10,000	Diversion point 1½ miles north of boundary.
W. T. Heffernen	Sept. 13, 1895	10,000	Do.
W. T. Gonder	Nov. 12, 1895	10,000	Do.
Do	Jan. 14, 1896	10,000	Diversion point 1¼ miles north of boundary.
W. T. Heffernen	Mar. 18, 1896	10,000	Do.
Do	do	10,000	Do.
Do	Jan. 23, 1897	10,000	Do.
W. T. Gonder	Mar. 27, 1897	10,000	Do.
W. T. Heffernen	July 24, 1897	10,000	Do.
California Development Co	Dec. 15, 1898	10,000	Do.
C. N. Perry, for himself and California Development Co.	Dec. 21, 1898	10,000	Do.
W. T. Heffernen	Jan. 18, 1899	....	Assigns all his claims to California Development Co.
W. T. Gonder	Jan. 25, 1899	....	Do.
Do	Apr. 25, 1899	10,000	Diversion point 1¼ miles north of boundary.
C. N. Perry, for himself and California Development Co.	Feb. 20, 1899	10,000	Do.
Do	Apr. 25, 1899	10,000	Do.
Do	do	10,000	Diversion point 3,000 feet north of boundary.

Mexican use of water.—A concession was granted by Mexico in 1904 for rights of way for the Imperial Canal. Regarding water for Mexican lands, this concession provides as follows:

The Sociedad de Reigo y Terrenos de la Baja California, S. A., is authorized to carry through the canal which it has built in Mexican territory, and through other canals that it may build, if convenient, water to an amount of 284 cubic meters per second from the waters taken from the Colorado River in territory of the United States by the California Development Co., and which waters this company has ceded to the Sociedad de Riego y Terrenos de la Baja California, S. A. It is also authorized to carry to the lands of the United States the water, with the exception of that mentioned in the following article.

From the water mentioned in the foregoing article, enough shall be used to irrigate the lands susceptible of irrigation in Lower California with the water carried through the canal or canals, without in any case the amount of water used exceeding one-half of the volume of water passing through said canals. (All-American Canal Board report, p. 20.)

Storage required.—It is expected that some storage will be required for full development of the lands under the Imperial Canal in California and Mexico. The question of water supply and storage requirements of this project must be considered in conjunction with the subject as a whole on the Colorado River, and it is being so considered in the general water-supply report being prepared on the Lower Colorado River in connection with the investigations required under the Kinkaid Act.

Present status.—The present constructed works of the Imperial Project are briefly as follows:

There is a new heading about 6,000 feet above the old or Hanlon heading, constructed in 1918. This is a concrete structure, with its face parallel to the river bank. It consists of 75 gates 8 feet center to center, 27 of which have a sill elevation of 98.6 feet above sea level and 48 have a sill elevation of 106.7 feet. The height of the structure above the higher sill gates is 21 feet. The piers are 18 inches thick, and there is a 24-foot pier between the high and the low sill gates.

The main canal from the Rockwood heading through Mexico is about 55 miles long and mainly follows an old channel of the river known as Alamo River. Portions of the channel have been straightened by constructing cut-offs, and these portions especially will require enlarging for the carrying of sufficient water for the entire project. Also the old channel, due to silting, has in places spread out over considerable areas and will require dredging or reconstruction for full development of the project. The maximum amount carried in the canal to date has been about 6,000 second feet. There are about 70 miles of distributaries operated by the district in Mexico and about 61 miles constructed and operated by the district in the United States. Other distributing canals and laterals in the United States were built, and are operated by 14 separate water companies, the distributaries of these companies aggregating approximately 2,300 miles in length. The total canals and laterals of the Imperial project in both California and Mexico aggregate approximately 2,570 miles. The distribution system of the project is estimated to be 75 per cent completed. The area irrigated in the Imperial district in 1920 was 415,000 acres, or 80 per cent of the net irrigable area, and in Mexico there were irrigated, in 1920, 190,000 acres, or 75 per cent of the net irrigable area.

Levees constructed.—C. D. Co. and Saiz Levee, built by C. D. Co., 1906 to 1909, length 27 miles, with 10 miles enrocked.

Volcano Lake levee, built by C. D. Co. and United States, 1908 to 1912, and later raised 3½ feet and extended to connect with the Inter-California Railroad and with the bank of the main Imperial Canal, length 18 miles, with 8 miles enrocked.

Ockerson levee, built by United States in 1911, length 24½ miles. This was partly destroyed shortly after its construction and has not since been repaired.

Operation difficulties.—A great deal of difficulty is being experienced by the Imperial project in its operation, due to the fact that there is no permanent diversion dam and sluicing basin at the inlet, which condition requires the construction of a temporary diversion dam, which is needed to enable the diversion of sufficient water through the low period; and on account of the insufficient desilting at the diversion point a large expense is incurred in dredging canals. The present course of the river is following the Bee River channel to the southwest into Volcano Lake and it is silting up the lake to such an extent as to endanger the Volcano Lake levee. Plans are now being considered by the district to divert the river to the south and thus keep it out of Volcano Lake.

Irrigation plan.—The present plan of the project provides for diversion from the west side of the Colorado River at the Rockwood heading, about 7,000 feet above the Mexican line, and the control of the low-water diversion by temporary rock-and-brush weirs; a main canal through the Imperial Valley of Mexico following mainly the old Alamo River channel; the diversion of water into submains and laterals for irrigation of lands in Mexico; the division of the main canal, a short distance south of where it reenters the United States, into the east-side high line, east-side low line, central main and west-side main canals for the irrigation of the lands of the Imperial irrigation district. A diversion from Volcano Lake is also made to supplement the irrigation on the west side in Mexico and the United States.

The present plan of flood control is by a levee extending from Hanlon heading southwesterly to near Volcano Lake and the Volcano Lake levee, extending from the west mesa, just north of the lake, northeasterly to the Inter-California Railroad embankment and to the bank of the main canal. This forms a double defense except near the west side of the valley. It is planned to strengthen these levees as required and also to repair the Ockerson levee near its crossing of Bee River and to extend it westerly on the north side of Bee River, a distance of about 5 miles, and at this point to cut a new river channel southwesterly from Bee River for a distance of about 4 miles, where it will discharge into an arroyo and onto lower ground and thus to keep it away from Volcano Lake and from threatening the Volcano Lake levee.

Alternate plan.—It is proposed to divert at Laguna Dam of the United States Reclamation Service, to enlarge the Yuma project main canal to the siphon drop, and to construct an All-American canal from this point to near the border line of Mexico and thence west on the American side to the Imperial Valley. A contract has been entered into to this effect dated October 23, 1918, between the United States and the Imperial irrigation district. Details of this plan, including estimate, are outlined in the section devoted to Imperial Valley, this report.

Power requirement.—The present Imperial project is all a gravity system and no power is required for irrigation pumping.

IMPERIAL VALLEY INVESTIGATIONS—PRELIMINARY ESTIMATE.

Surveys, reports, and estimates.—Surveys for the Imperial Valley extensions were made under the field direction of Engineer H. J. Gault during the period of August to December, 1920, covering a gross area of approximately 600,000 acres, exclusive of the Imperial irrigation district and the Salton Sea. The total line run was 292 miles of transit and 400 miles of levels, at a field cost of about $21 per mile for the total. The survey was very preliminary in character, consisting of an angle transit line followed by levels taken usually at 100-foot stations. The profiles generally did not follow very closely the selected grade lines, so they are not of much value for estimating yardage. No topography was taken, though at each transit point the approximate slope of the ground was recorded. From these data and from inspection of the ground, appropriate percentages were selected to be added to the economic cut for estimating the yardages of excavation. The locations and profiles of the several canal lines surveyed are shown on the attached drawings.

Two preliminary reports and estimates of the proposed extension project were prepared by Mr. Gault under dates of November 9 and November 16, 1920. The surveys were not completed till later (about Dec. 1) and Mr. Gault was then assigned to other work before completing his report.

A soil reconnaissance was also made during the same period and covering the same area, under the field direction of Mr. A. T. Strahorn, United States Department of Agriculture, assisted by Mr. S. W. Cosby, of the University of California, and a preliminary soil report was prepared under date of November 12, 1920. A more complete soil report covering this area has since been compiled by Mr. Strahorn, a summary of which appears on pages 95 to 98 of this volume.

Under date of November 27, 1920, Mr. A. P. Davis, Director, United States Reclamation Service, transmitted to the Secretary of the Interior a report on "Problems of Imperial Valley and vicinity," in which is briefly outlined the plan of the proposed Imperial Valley extension system, including a summary of Mr. Gault's preliminary estimate.

Detail surveys were made in 1918–19 under the field direction of Engineer Porter J. Preston, of an All-American canal extending from Laguna Dam to the west main canal of the Imperial irrigation district, for the irrigation of the Imperial irrigation district lands and also the proposed Imperial Valley extensions. A report and estimate was prepared by Mr. Preston under date of June 17, 1919, which report has been published as Part Two of the All-American Canal Board report of July 22, 1919, by Messrs. Mead, Schlecht, and Grunsky.

Irrigation plan.—The plan of the Imperial Valley project is briefly as follows:

To raise the crest of the Laguna Dam 2 feet and to enlarge the sluiceway and reconstruct the headworks and to enlarge the Yuma project main canal to the siphon drop sufficient to carry the Imperial Valley water. To construct a canal from this point on a grade contour to the Mexican boundary at Pilot Knob, and thence west on the American side to the west main canal of the Imperial irrigation district. Outlets will be provided at points where this (the All-

American) canal intercepts the canals of the Imperial district. Two large drops (24 feet and 47 feet) will be required where the canal emerges from the mesa on the east side of the valley; at these drops power plants will be installed for irrigation pumping for Imperial mesa lands, for the Yuma project, and also for commercial power. Detail plans of this canal may be found in the All-American Canal report above mentioned.

For the Imperial Valley extensions the following is planned:

A principal canal (line A) to divert on grade at mile 39 of the All-American Canal, and to extend on a grade contour along the east side of the Imperial and Coachella valleys, swinging around the north end of the latter and returning on the west side of the valley, terminating at the county line, a distance of approximately 140 miles. One long flume will be required on the east side, and two drops on the west side. Numerous washes will be crossed with concrete siphons, and smaller washes will be flumed over the canal. This canal will irrigate about 177,000 acres, net, by gravity.

A pump canal (line D), lift 30 feet, will divert on the east mesa at mile 31 of the All-American Canal. This canal will run northwesterly near the edge of the sand hills for a distance of 17.5 miles to a junction with the A canal. It will irrigate 36,000 acres net in the United States and will also siphon across the All-American Canal to irrigate 8,000 acres in Mexico.

A gravity diversion on the south side of the All-American Canal opposite the heading of the A canal will irrigate 8,800 acres net in the United States and also 22,000 acres in Mexico, which are above the reach of the Imperial Canal.

A gravity canal (line E) will divert at mile 46 of the All-American Canal and will extend northerly for a distance of 6 miles for the irrigation of 15,700 acres net on the east mesa.

On the west side, at the point where the All-American Canal intercepts the old west main canal, there will be a gravity diversion (line B), which will extend northerly to the east end of Superstition Mountain, a distance of 21 miles. This canal will be run on a lighter grade than the old one, and will thereby gain an elevation of 23 feet and will also irrigate by gravity about 10,000 acres net above the old canal. On condition that the lands under the present west-side canal are willing to pay their proportion of the cost, the old canal will be abandoned and the B canal constructed with sufficient capacity for both old and new lands; if not, only sufficient capacity for the new lands will be constructed.

At the end of the B canal a pumping plant will be installed, lift 125 feet, for pumping into the R canal, which will extend along the south side of Superstition Mountain for a distance of 8 miles. At the end of the R canal there will be diversions both to the north and south for the irrigation of 23,000 acres net. The R canal will require three flumes, aggregating about 1,200 feet in length.

Power for the Superstition pumping plant and also for the east mesa plant will be secured from the drops in the All-American Canal. A small pumping plant may also be installed near Indio for lifting from the A canal to a height of 50 feet to cover a small area in the north end of the Coachella Valley. Surveys were not made covering this area, but it is believed of doubtful feasibility on account of the limited area of good land and to the further fact that part of the tract is now irrigated from artesian wells.

On the west side, above the B line and below the ancient beach line, there is a strip of land about 1½ miles wide extending from the Mexican boundary north to Superstition Mountain, which appears from the Strahorn soil survey to be arable land. This tract contains about 14,000 acres net, and it could be reached with a comparatively low lift (about 50 feet). This area is not included in this estimate as it was not included in the Gault surveys; however, it should be investigated before the final conclusions are reached as to the area under the All-American Canal.

Data for estimates.—The estimate of the cost of the All-American Canal as outlined in the board report of July 22, 1919, is adopted in this report with appropriate revisions occasioned by the change in canal capacity due to the revision of the irrigable area as determined by the Gault and Strahorn surveys.

For the extension canal estimates the data, including unit costs, prepared by Mr. Gault and appearing in his preliminary reports of November 9 and 16 and also in his field computation books, are generally adopted, with appropriate changes for the revision of acreage as determined by the recently completed soil survey. These data are as follows:

Canal capacities.—For long canals a capacity of 1 second-foot to 100 acres, net, is figured at the lower end or at the heads of laterals and an allowance for loss is made at the rate of 0.5 foot in depth per day over the wetted area. Short canals are figured at a capacity of 1 second-foot to 85 acres, net, at the head of the canal.

Velocities.—A nonsilting velocity is planned, ranging from 2.5 to 3 feet per second.

Canal side slopes.—For canal construction, side slopes are planned at 2 horizontal to 1 vertical. For canal capacity, on account of the tendency of the silty water to build a berm against the constructed slope, one-half horizontal to 1 vertical is figured.

Coefficient of friction.—$n = 0.0225$.

Canal sections.

Capacity.	Base width.	Depth water.	Free-board.	Top width banks.
	Feet.	*Feet.*	*Feet.*	*Feet.*
100 to 500 second-feet	12- 30	3- 5	2.0	12
500 to 1,000 second-feet	30- 45	5- 7	2.5	12
1,000 to 2,000 second-feet	45- 80	7- 8	3.0	15
2,000 to 3,000 second-feet	80-100	8-10	4.0	20

Siphons.—The principal canal structures are reinforced concrete siphons crossing the many large washes. A 9.6-foot diameter barrel is planned, with a capacity of 434 second-feet, and one or more barrels are used, as required. An entrance head of 0.25 foot is allowed in the canal profile for each siphon, with a fall of 0.1 foot per 100 feet through the structure.

Districts.—The project is divided into several districts or divisions, as indicated on the accompanying map, Plate XXI, as follows:

(*a*) Imperial irrigation district, comprising the old water-right lands.

(*b*) East mesa gravity, extending from the Mexican boundary on the east side north to the Southern Pacific Railroad.

(c) East mesa pumping, comprising the area under the D line.

(d) Dos Palmas, the tract on the east side from the Southern Pacific Railroad at Iris, north to range line between ranges 10 and 11 east.

(e) Coachella Valley, the north end of the project to the end of the A line.

(f) West side gravity, the area between the B line and the Imperial irrigation district west boundary, extending north to the north line of T. 14 S.

(g) West mesa pumping, the pumping areas on the west side.

(h) Mexican gravity and pumping, the mesa lands in Mexico adjacent to the border on the east side.

Areas and status of lands.—The gross, net, or irrigable areas and the approximate status of lands in the above districts are shown by the following table. The net areas are the arable lands under the proposed canals as determined by the Strahorn soil survey and as shown by the hatched areas on the accompanying map. The status of lands was determined by Mr. Gault from the land office records at El Centro, and areas are here adjusted by proportion to conform to the corrected total net areas. The results may be considered approximate only.

Areas and approximate status of lands, Imperial Valley.

[Acres.]

District.	Gross area.	Net area.	Status of lands.					
			Public.	Private.	State.[1]	Southern Pacific Railroad.[1]	Entered.	Indian.
Imperial irrigation district	603,800	515,000		515,000				
East mesa gravity	164,500	124,300	114,000	1,200	6,700	1,200	1,200	
East mesa pumping	41,800	36,000	34,300		1,700			
Dos Palmas	81,000	5,300	700	200	300	2,600	1,500	
Coachella Valley gravity	121,000	71,800	3,800	12,100	4,400	36,800	3,300	11,400
West side gravity	95,200	10,000	3,600		600	4,400	1,300	100
West mesa pumping	27,400	23,000	10,700	1,000	1,000	2,300	8,000	
Total in United States	1,134,700	785,400	167,100	529,500	14,700	47,300	15,300	11,500
Mexican gravity	32,000	22,000	20,000	2,000				
Mexican pumping	11,000	8,000	4,300	3,700				
Total under All-American canal	1,177,700	815,400	191,400	535,200	14,700	47,300	15,300	11,500
Salton Sea	179,000							

[1] Original State and railroad lands, sales to individuals not shown.

COST ESTIMATES.

Unit prices.

Canal excavation, earth, per cubic yard	$0.25
Canal excavation, loose rock, per cubic yard	.60
Structure excavation, earth, per cubic yard	.75
Backfill, per cubic yard	.25
Reinforced concrete, small structures, per cubic yard	30.00
Reinforced concrete, large structures, per cubic yard	20.00–25.00
Lateral system, per acre	16.00
Right of way, improved land, per acre	125.00
Telephone line, on main canals, per mile	250.00
Telephone line, on laterals, per mile	200.00

Administration, engineering, and contingencies, add 25 per cent to all of the above items.

"A" LINE CANAL SYSTEM.

Design of canals.

[Canal capacity at heads of laterals, 1 second-foot to 100 acres. Loss in canals, 0.5 foot in depth per day over wetted area. n=0.0225. Side slopes, ½ to 1 for capacity and 2 to 1 for excavation and for figuring wetted area.]

Station.	Total acreage.	Diversion.	Loss.	Required capacity.	S.	V.	Base.	Depth of water.
		Sec.-ft.	Sec.-ft.	Sec.-ft.		Ft. per sec.	Feet.	Feet.
7300 [1]	13,200	132	15	147	0.0003	2.3	12	4.4
6500	40,400	272	24	443	.0003	2.9	28	5.0
5740	52,200	118	28	589	.000175	2.5	40	5.6
5000	71,800	196	29	814	.000175	2.7	45	6.4
4300	77,100	53	92	959	.00015	2.7	45	7.4
2200	103,100	260	56	1,275	.00015	2.8	55	7.8
1120	123,000	199	22	1,496	.000125	2.7	60	8.5
730	156,000	330	21	1,897	.000125	2.8	70	8.7
400	176,900	209	27	2,083	.000125	2.9	80	8.7

[1] Increase length 10 per cent between stations 7300 and 5740 on account of change of line.

Canal excavation.

Station.	Economic cut per 100 feet.	Per cent added.	Excavation per 100 feet.	Total excavation.
	Cubic yards.		Cubic yards.	Cubic yards.
0-400	1,940	30	2,520	1,008,000
400-730	1,520	30	1,970	650,000
730-1120	1,400	23	1,720	671,000
1120-2200	1,230	90	2,340	2,714,000
1120-2200				[1] 10,000
2200-4300	960	67	1,600	3,232,000
2200-4300				[1] 230,000
4300-5000	830	57	1,300	910,000
5000-5740	700	40	980	725,000
5740-6500	500	37	680	517,000
6500-7300	310	44	450	360,000
Total				11,027,000
Loose rock				347,000
Earth				10,680,000

[1] Added for deep cuts or fills.

NOTE.—10 per cent of excavation from stations 2200 to 4300 is estimated as loose rock.

Estimate of cost.

From head to railroad crossing at Iris:	
Excavation, 5,053,000 cubic yards, at 25 cents	$1,263,200
8 bridges, at $8,000	64,000
4 bridges, at $6,000	24,000
4 checks with turnouts, at $28,000	112,000
3 checks with turnouts, at $19,500	58,500
7 siphons, 1,800 feet (3 tubes), at $20,245 per 100 feet	364,400
2 arroyo crossings	18,000
1 wasteway	30,000
Telephone line, 42 miles, at $250	10,500
Telephone line, 160 miles, at $200	32,000
Lateral system, 99,800 acres, at $16	1,596,800
Total	3,573,400
Administration, engineering, etc., 25 per cent	893,400
Total above railroad	4,466,800

Ninety-nine thousand eight hundred acres, at $44.70.

From railroad crossing at Iris to end:

Excavation, 5,627,000 cubic yards, at 25 cents	$1,406,800
Excavation, 347,000 cubic yards, at 60 cents	208,200
5 bridges, at $4,800	24,000
6 bridges, at $4,500	27,000
10 bridges, at $3,000	30,000
3 checks and turnouts, at $13,700	41,100
6 checks and turnouts, at $11,700	70,200
14 checks and turnouts, at $6,600	92,400
47 siphons, 10,000 feet (2 tubes), at $13,435 per 100 feet	1,343,500
18 siphons, 3,000 feet (1 tube), at $6,625 per 100 feet	198,800
30 arroyo crossings, at $7,000	210,000
10 arroyo crossings, at $5,800	58,000
10 arroyo crossings, at $3,700	37,000
3,000 feet sidehill concrete flume (capacity 960 second-feet), at $40	120,000
2 concrete drops	25,000
3 wasteways	30,000
Telephone line, 100 miles, at $250	25,000
Lateral system, 77,000 acres, at $16	1,232,000
Total	5,179,000
Administration, engineering, etc., 25 per cent	1,295,000
Total below Iris	6,474,000

Seventy-seven thousand one hundred acres, at $84.

Summary of "A" line:

Total above Iris	4,467,000
Total below Iris	6,474,000
Total "A" line	10,941,000

One hundred and seventy-seven thousand acres, at $61.50.

South side of All-American Canal (gravity): Eight thousand eight hundred acres in the United States and 22,000 acres in Mexico. Capacity required in All-American Canal, 308 second-feet.

Estimate of cost.

Lateral system, 30,800 acres, at $16	$492,800
Administration, engineering, etc., 25 per cent	123,200
Total (30,800 acres, at $20)	616,000

"E" LINE CANAL SYSTEM.

Net area, 15,700 acres. Length of canal, 6 miles. Canal capacity at head, 180 second-feet; base, 17 feet; depth, water, 4 feet; V=2.4; S=0.0003. For excavation add 50 per cent to economic cut.

Estimate of cost.

Excavation, 127,200 cubic yards, at 25 cents	$31,800
3 bridges, at $1,425	4,300
2 checks with turnouts, at $3,130	6,300
Lateral system, 15,700 acres, at $16	251,200
Telephone system, 6 miles, at $250	1,500
Total	295,100
Administration, engineering, and contingencies, 25 per cent	73,900
Total "E" line system	369,000

Fifteen thousand seven hundred acres, at $23.50.

"D" LINE CANAL (PUMPING) SYSTEM.

Net area, 36,000 acres in United States and 8,000 acres in Mexico. Canal capacity at head for United States lands, 1 second-foot to 85 acres, or 425 second-feet; base, 25 feet; depth, water, 5 feet; V=3.1. Capacity at end, 25 second-feet; base, 7 feet; depth, 2 feet. S=0.00035. Length, 17.5 miles. For excavation add 50 per cent to economic cut; average, 460 cubic yards per 100 feet, or 24,290 cubic yards per mile.

Estimate of cost.

Excavation, 425,000 cubic yards, at 25 cents	$106,200
3 bridges	9,000
5 checks with drops and turnouts	37,600
Pumping plant,[1] capacity, 500 second-feet; static lift, 30 feet; total horsepower required, 2,250, at $88	198,000
Transmission line (No. 6 wire), 11.5 miles, at $1,330	15,300
Lateral system, 44,000 acres, at $16	704,000
Telephone system, 17.5 miles, at $250	4,400
Total	1,074,500
Administration, engineering, and contingencies, 25 per cent	268,500
Total "D" line system	1,343,000

Forty-four thousand acres, at $30.60.

"B" LINE CANAL (FOR NEW LANDS ONLY).

Net area 33,000 acres, 10,000 under proposed gravity and 23,000 under proposed pumping (lift 125 feet). Length of canal, 20.6 miles. For excavation add 50 per cent to economic cut.

Station.	Total acreage.	Diversion.	Loss.	Required capacity.	S.	V.	Base.	Depth of water.	Economic cut per 100-foot station.
		Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*		*Ft. per sec.*	*Feet.*	*Feet.*	*Cubic yards.*
1088	26,000	270	....	270	....	....	....	....	....
790-1088	30,500	45	10	325	0.00012	1.87	32	5	532
0-790	33,000	25	25	375	.00012	1.9	37	5	565

Excavation 910,000 cubic yards, at 25 cents	$227,500
6 bridges, at $3,000	18,000
10 siphons, 1,400 feet (1 tube), at $6,625 per 100 feet	92,800
3 arroyo crossings, at $2,700	8,100
4 checks and turnouts, at $6,600	26,400
1 wasteway	7,000
Telephone line, 20.6 miles, at $250	5,200
Total	385,000
Administration, engineering, and contingencies, 25 per cent	96,000
Total	481,000

"B" LINE CANAL (FOR OLD AND NEW LANDS).

Net area, 123,000 acres; including 90,000 under present canal, 10,000 under proposed gravity, and 23,000 under proposed pumping (lift, 125 feet). Length of canal, 20.6 miles. For excavation add 50 per cent to economic cut.

[1] For details see table "Pumping plants, Imperial Valley investigations," in Exhibit A following.

Station.	Total acreage.	Diversion.	Loss.	Required capacity.	S.	V.	Base.	Depth of water.	Economic cut per 100-foot station.
		Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*		*Ft. per sec.*	*Feet.*	*Feet.*	*Cubic yards.*
1110	75,000	882	0	882					
760–1110	103,000	290	18	1,190	0.00012	2.6	53	8	1,240
300–760	118,000	150	24	1,364	.00012	2.65	60	8	1,310
0–300	123,000	50	16	1,430	.00012	2.65	63	8	1,350

Excavation, 2,162,000 cubic yards, at 25 cents	$540,500
6 bridges, at $6,000	36,000
2 siphons, 350 feet (4 tubes), at $27,025 per 100 feet	94,600
8 siphons, 1,050 feet (3 tubes), at $20,245 per 100 feet	212,600
3 arroyo crossings, at $9,000	27,000
4 checks and turnouts, at $19,500	78,000
1 wasteway	20,000
Telephone line, 21 miles, at $250	5,300
Total	1,014,000
Administration, engineering, and contingencies, 25 per cent	253,000
Total "B" line canal	1,267,000
Charge to new lands (see preceding table)	481,000
Charge to Imperial district lands	786,000

WEST SIDE PUMPING SYSTEM.

Net area, 23,000 acres. Static lift, 125 feet. Total lift, 132 feet. Pump capacity, 240 second-feet. "R" canal, length, 8.15 miles; capacity 240 second-feet at head; 230 feet at end. "S" canal, length, 7 miles; capacity, 200 second-feet.

Estimate of cost.

Pumping plant: [1]	
Required horsepower, 4,750, at $50	$237,500
1,600 feet discharge pipe, 5.9 feet diameter, at $20.50	32,800
Excavation, 56,700 cubic yards, at 25 cents (branch forebay)	14,200
Transmission line (No. 6 wire) 42 miles, at $1,330	55,900
Total	340,400
Administration, engineering, etc., 25 per cent	85,100
Total pumping plant and transmission	425,500

"R" canal: Base, 21 feet; depth of water, 4 feet; S=0.00035; V=2.6. Add 100 per cent to economic cut for yardage.

Excavation, 310,000 cubic yards, at 25 cents	$77,500
3 metal flumes, total length 1,200 feet, at $15	18,000
3 bridges, at $3,000	9,000
3 checks with turnouts, at $66	19,800
5 arroyo crossings, at $2,700	13,500
Subtotal, "R" canal	137,800

"S" canal: Base 18 feet; depth of water, 4 feet; S=0.00035; V=2.5. Add 100 per cent to economic cut for yardage..

Excavation, 260,000 cubic yards, at 25 cents	$65,000
3 checks with turnouts, at $3,000	9,000
3 bridges, at $1,750	5,300
Subtotal "S" canal	79,300

[1] For details see table, "Pumping plants, Imperial Valley investigations," in Exhibit A following.

Telephone line, 15 miles, at $250	$3,800
Lateral system, 23,000 acres, at $16	368,000
Total	588,900
Administration, engineering, etc., 25 per cent	147,100
Total "R" and "S" canals and lateral system	736,000
Pumping plant	425,500
Total west side pumping system	1,161,500

Twenty-three thousand acres, at $50.50.

Summary "B" line and west side pumping system.

"B" line canal (chargeable to new lands)	$481,000
Lateral system (gravity) 10,000 acres, at $20	200,000
Pumping system	1,161,500
Total	1,842,500

Thirty-three thousand acres, at $56.

Summary of distribution system.

[Estimate, including all-American canal.]

"A" line canal system	$10,941,000
South side gravity area, including Mexican lands	616,000
"E" line canal system	369,000
"D" line canal pumping system, including Mexican lands	1,343,000
"B" line canal and west side pumping system	1,842,000
Total	15,111,000

Three hundred thousand four hundred acres new lands, at $50.

ALL-AMERICAN CANAL.

For details of plans and estimates, see All-American Canal board report of July 22, 1919.

Net area, 815,400 acres, as follows: Imperial irrigation district, 515,000; west side, gravity, 10,000; west mesa, pumping, 23,000; east mesa, gravity, 124,200; east mesa, pumping, 36,000; Dos Palmas, 5,300; Coachella Valley, gravity, 71,800; Mexican, gravity, 22,000; Mexican, pumping, 8,000.

Hydraulic functions.

Stations.	Total acreage.	Diversions.	Loss.[1]	Required capacity.	S.	V.	Base.	Depth of water.	Side slopes.
		Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*					
3450 (end)	123,000	1,430	....	1,430	....	....	....	....	....
2760-3450	141,000	212	33	1,675	0.0002	3.3	54	8	1½:1
2425-2760	335,000	2,282	26	3,983	.00016	3.5	100	10	1½:1
2250-2425	393,000	682	15	4,680	.00014	3.5	108	11	1½:1
1919-2250	548,000	1,824	32	6,536	.00012	3.5	125	13	1½:1
1555-1919	563,700	185	36	6,757	.00011	3.5	130	13	1½:1
1117-1555	771,400	2,391	52	9,200	.00009	3.5	145	15	2 :1
465-1117	815,400	505	84	9,789	.00009	3.5	157	15	2 :1
0-465 [2]	....	0	60	9,849	.00009	3.5	162	15	2:1; 1½:1
0-540 [3]	....	1,600	75	11,524	.00008	3.5	177	16	2:1; 1½:1

[1] Loss figured at 0.5 foot depth per day over wetted area.
[2] Station 0 at siphon drop=station 540 approximately from dam.
[3] Station 0 is at Laguna Dam.

ESTIMATE OF COST OF ALL-AMERICAN CANAL.

Canal of capacity to serve 815,400 acres in Imperial Valley and to carry 1,600 second-feet additional down to siphon drop for the Yuma project:

Item.	Board estimate of July 22, 1919.	Revised estimate due to change in canal capacity and acreage.	
		Per cent of board estimate.	Total.
To connect with Laguna Dam	$1,900,000	97	$1,843,000
Canal:			
Laguna Dam to siphon drop	3,109,000	108	3,358,000
Siphon drop to Araz	1,359,000	109	1,481,000
Araz to power site	811,000	109	884,000
Power site to Pilot Knob	1,470,000	109	1,602,000
Pilot Knob to "A" canal heading	17,067,000	101	17,238,000
"A" heading to "E" heading	600,000	112½	675,000
"E" heading to west main	3,239,000	114	3,692,000
Total, dam and canal	29,555,000		30,773,000
Power plant No. 1: Canal capacity, 6,757 second-feet; fall, 24 feet; water horsepower, 18,400; delivery capacity, 11,000 horsepower	1,232,000	112	1,380,000
Power plant No. 2: Canal capacity, 6,536 second-feet; fall, 47 feet; water horsepower, 34,800; delivery capacity, 21,000 horsepower	1,633,000	118	1,927,000
Total power	2,865,000		3,307,000

Summary of cost of canal and distribution system and division according to benefits.

Item.	Cost estimate.	Division of cost.			Mexican lands.
		Yuma project.	Imperial irrigation district.	New United States lands.	
To connect with dam	[1] **$1,843,000**		**$1,165,000**	**$610,000**	**$68,000**
All-American Canal:					
Dam to Araz	**4,839,000**	[1] **$980,000**	**2,439,000**	**1,278,000**	**142,000**
Araz to end	**24,091,000**		**15,222,000**	**7,982,000**	**887,000**
Total dam and canal	**30,773,000**	**980,000**	**18,826,000**	**9,870,000**	**1,097,000**
Power plant No. 1	**1,380,000**				
Power plant No. 2	**1,927,000**				
Total power	**3,307,000**	[2] **528,000**	[3] **2,051,000**	[4] **596,000**	[4] **132,000**
Distribution system:					
"A" line system	**10,941,000**			**10,941,000**	
South side gravity	**616,000**			**176,000**	[5] **440,000**
"E" line system	**369,000**			**369,000**	
"D" line system, including pump	**1,343,000**			**1,133,000**	[6] **210,000**
"B" line system, including pump	**1,842,000**			**1,842,000**	
Total distribution system	**15,111,000**			**14,461,000**	**650,000**
Grand total	**49,191,000**	**1,508,000**	**20,877,000**	**24,927,000**	**1,879,000**

[1] Determined under contract with Imperial irrigation district dated Oct. 23, 1918. Dam and balance of All-American Canal proportioned according to acreage.
[2] Determined by ratio of cost of 8,500 water horsepower to total water horsepower.
[3] Commercial power (33,000 water horsepower) all charged to Imperial irrigation district.
[4] Power required for pumping (20,200 water horsepower) charged at cost of power plant.
[5] Lateral system only.
[6] Lateral system and proportion of pumping plant only.

Cost per acre.

Imperial irrigation district, 515,000 acres	$40.50
New United States lands, 274,400 acres	90.90
Mexican lands, 30,000 acres	62.10

EXHIBIT A.

DEPARTMENT OF THE INTERIOR,
UNITED STATES RECLAMATION SERVICE,
Denver, Colo., January 14, 1921.

From: Chief Engineer.
To: Project manager, Yuma, Ariz.
Subject: Pumping station, Imperial Valley—Imperial Valley investigations.

1. There is given herewith the estimated construction cost of three pumping plants in connection with the Imperial Valley investigations, as requested in your letter of December 22, 1920. The data on which these estimates were based are given in the following table.

2. These estimates are based on the following assumptions:

Location, plants placed on the banks of canals, similar to the design of the B lift pumping plant for the Yuma auxiliary project. Buildings, reinforced concrete, plain walls. Transformers, 33,000/22,000 volts. Motors, 2,200-volt, 3-phase, 60-cycle synchronous motors. Pumps, vertical centrifugal.

3. The cost of discharge pipes and transmission lines is not included in this estimate.

F. E. WEYMOUTH.

NOTE.—The Indio plant shown in the following table was first considered, but it developed from the survey that there is so little arable land above the gravity line the plan was abandoned. It is possible, however, to install several small pumping plants in the Coachella Valley.—*C. C. F., 3-4-21.*

Pumping plants—Imperial Valley investigations.

Plant.	Capacity.	Static lift.	Total lift assumed.	Total horsepower required.	Number units.	Size motors (horsepower).	Size pumps.	Specific speed.	Pump speed.	Pump capacity.
	Sec.-ft.						Inches.			Sec.-ft.
East Mesa	388	30	31.0	1,750	3	600	54	261	360	130
West Mesa	270	132	136.0	5,350	4	1,400	36	126	600	69
Indio	118	55	57.0	980	2	500	30	169	450	58

Estimated cost.

	East Mesa.		West Mesa.		Indio.	
	Size.	Cost.	Size.	Cost.	Size.	Cost.
Preparatory work		$3,000		$4,000		$20,000
Building and foundations		40,000		60,000		25,000
Machinery:						
Motors	3-600 h. p.	24,000	4-1,400 h. p.	60,000	2-500 h. p.	15,000
Pumps	3-54"	24,000	4-36"	36,000	2-30"	9,600
Transformers	7-333 Kv-a.	15,000	7-900 Kv-a.	45,000	7-200 Kv-a.	9,200
Switching apparatus		7,000		10,000		4,000
Motor generator exciter sets	2-37½ Kv-a.	4,000	2-15-Kv-a.	7,000	2-25 Kv-a.	3,000
Miscellaneous machinery		5,000		7,000		4,000
Miscellaneous material		5,000		6,000		3,000
Gate valves		6,300		7,000		3,500
Manifold		2,400		3,000		1,200
Intake gates		1,800		2,400		1,000
Freight and hauling		4,000		5,000		2,700
Labor installing		9,000		12,000		6,000
Testing plant		500		600		300
Switch yard		2,700		3,000		1,800
Total estimated field cost		153,700		268,000		91,300
Contingencies, 10 per cent		15,300		26,800		9,100
Administration and engineering, 15 per cent.		22,000		40,200		13,600
Grand total estimated cost		191,000		335,000		114,000

PARTICIPATION BY CONTRIBUTING AGENCIES.

In order to comply with section 4 of the act, the following letter was addressed to the Imperial irrigation district and similar letters to the other interests involved. (For act, see p. 196.)

WASHINGTON, D. C., *November 11, 1920.*

IMPERIAL IRRIGATION DISTRICT,
El Centro, Calif.

GENTLEMEN: In connection with the investigations required by the Kinkaid Act we have now under way the making of the necessary surveys, borings, examinations, and studies required for the report, and so far as these are available they will be reported to Congress in accordance with the above act on the 6th of December. The one question that has not yet been covered is required by section 4, as follows:

"What assurances he (the Secretary of the Interior) has been able to secure as to the approval of, participation in, and contribution to the plan or plans proposed by the various contributing agencies."

In general, the character of report which I expect to make and which I hope the Secretary and Congress will approve is that we should undertake to irrigate all of the American lands that can be feasibly irrigated by gravity and reasonable pumping lifts, and that this should be the primary use of the waters of the Colorado. Secondarily, we should develop as much power as can be done without seriously interfering with the primary use of the water above stated.

The principles to be followed in the distribution of the power are as I take it, that each shall have preference in the following order: First, the pumping of Colorado River water for irrigation; second, the local needs of the municipalities irrigated from Colorado River water; third, use by other municipalities; and fourth, disposal to private interests for pumping or other uses. This means that the various irrigation districts should have first preference for such power as they need for pumping and municipal use; second, that municipalities like the cities of Los Angeles, San Diego, or any other towns that can be reached by the lines of the sytem should be served to the extent that they desire, and anything that is left over after this should be disposed of to railroads or any other customer that can be reached.

The general principle I doubt not will be that all interests will contribute in proportion to benefits as nearly as these can be determined, the United States standing the proper proportion for the public lands served and each of the districts standing the requisite assessment in proportion to benefits rendered it. This will involve some difficult determinations of relative benefits, such as the relative values of water for power and for irrigation and the benefits of flood control, and these problems will not be easy to solve.

The general discussion of the subject held in San Diego, I believe you will recall, was to the effect that the Secretary of the Interior was to be designated as the arbiter concerning such matters, and his opinion as to the proportion the United States should bear is required by the Kinkaid Act.

The general application of this principle is not insisted upon and should not be, if any better method can be suggested. On these points we would like to have the opinion of your district and eventually have something in writing which I can quote in my report expressing the desire of your district for participation in the power development, if you have such desire, of course, accompanied by the expression of your willingness to participate in the expense of construction.

I am starting West and will spend some weeks in the study of the Colorado River problem, preparing the report required by Congress on the 6th of December. My address will be Yuma, Ariz., and I should like to hear from you at that point as to whether the above principles are satisfactory and whether or not your district will contribute its proportion on this basis.

Very truly, yours,

A. P. DAVIS, *Director.*

Several replies to the above have been received, as follows:

IMPERIAL IRRIGATION DISTRICT,
El Centro, Calif., November 23, 1920.

MR. ARTHUR P. DAVIS,
Director United States Reclamation Service, Washington, D. C.

DEAR SIR: We have your favor of November 11, 1920, advising that the Secretary of the Interior will, in accordance with the terms of the Kinkaid Act, report to Congress on December 6 next the result of the investigations required by that act and will recommend a definite plan of construction procedure adequate to meet the needs of Imperial Valley.

We are gratified, indeed, by the progress made by your department in the prosecution of necessary surveys and investigations required to be made in order that Congress may be fully advised as to the scope, feasibility, and immediate necessity for the construction of works on the lower Colorado River outlined in the bill introduced at the last session of Congress as H. R. 11553, and we have the greatest confidence that the effect of your work in this connection and your report on existing conditions will result in the present formulation of a feasible plan for the safeguarding and proper development of the Imperial Valley and adjacent lands, which will be authorized by necessary congressional action.

You state: "In general, the character of report which I expect to make and which I hope the Secretary and Congress will approve is that we should undertake to irrigate all of the American lands that can be feasibly irrigated by gravity and reasonable pumping lifts, and that this should be the primary use of the waters of the Colorado. Secondarily, we should develop as much power as can be done without seriously interfering with the primary use of the water above stated."

With this general statement of plan to be advocated we heartily concur.

Your letter points out that the report to Congress must disclose "What assurances he (the Secretary of the Interior) has been able to secure as to the approval of, participation in, and contribution to the plan or plans proposed by the various contributing agencies."

We feel that the general plan covered in the report and recommendations soon to be submitted by you to the Secretary of the Interior and by him to Congress very largely results from the long-continued efforts of the people of Imperial Valley, acting through the Imperial irrigation district, to safeguard our property and improve and stabilize conditions affecting the right of our people to continued and sufficient use of the waters of the Colorado for irrigation purposes. We therefore state unreservedly that we approve of the plan of work and policy to be adopted, as stated in paragraph 3 of your letter, and will, when lawfully authorized so to do, participate ratably and equitably in the cost thereof, as the same may be hereafter properly determined.

At the meeting held in San Diego, Calif., August 2 last, which was called primarily for the purpose of securing an expression of views of owners of lands tributary to the flow of the Colorado River in order to determine how large an area would participate in the investigations contemplated and in the cost of works found to be feasible, a discussion of "power development" and an offer of "participation in cost and interest in proportion to benefits received" was developed, by some of those present who were not landowners adjacent to the Colorado River, along lines in which we do not concur.

We hold that it is necessary to build a storage dam at Boulder Canyon site for the purpose, fundamentally, of impounding and controlling a sufficient amount of water to permanently and adequately irrigate all lands below that point, both public and private, which are susceptible of economic reclamation by the use of such waters. The storage of such waters and their daily discharge under control will very largely decrease the element of danger of loss to lands resulting from flood and overflow waters of the Colorado River, and hence is to be reckoned as an additional benefit accruing to lands irrigated from storage.

Some lands, by reason of location with respect to the channel of the Colorado River, will be benefited more than others by the lessening of the danger of flood and overflow, just as other lands which are not now irrigated may be more greatly benefited by storage and the development of a supply of water for irrigation purposes. These and similar questions which should determine the cost per acre to be paid by lands benefiting by works to be undertaken on the lower Colorado River should be arbitrated and acreage charges fixed by the Secretary of the Interior. The Government of the United States should contribute in proportion to benefits so derived to the extent of its public lands served by such works.

If it is found to be possible and expedient to develop hydroelectric power at the storage-dam site without seriously interfering with the primary use of the structure for storage and flood-control purposes, such power should be regarded as a by-product belonging to the lands which pay for the construction of the works, and the proceeds derived from the sale of such by-product should be applied to the reduction of cost charges to be paid by the owners of the lands contributing thereto. We believe that all matters relative to the sale and disposition of power may under this theory be properly left for determination to the Secretary of the Interior or other governmental department or agency which shall have the administrative charge of the property.

However, since the investigation of the Boulder Canyon storage-dam site has not yet been completed, and it can not now be determined whether such site will be found to be feasible, nor to what extent it can be utilized for the development of hydro-electric power, it seems to us that it would be extremely difficult at this time to consider or determine the relative proportions of the total cost which might properly be assigned to storage, flood-control, and power development.

Until the investigations are completed and cost estimates based thereon submitted to the different irrigation districts now cooperating under the terms of the Kinkaid Act, so that they be examined and an approximation made of the acreage charges necessary to cover the cost of the proposed works, it would be impossible for us to decide whether or not we can cooperate in power development.

We would prefer, then, that the investigations be continued to completion at the expense of the irrigation districts now contributing, and that the matter of the nature and extent of participation to be guaranteed by the several districts affected be thereafter considered and determined.

In our judgment, Mr. Davis, it is more vitally necessary now than ever before that a definite plan for development of the lower Colorado River Basin must be decided upon, and that Congress must assist by appropriate legislative action in the accomplishment of the work if disaster to our valley is to be averted. You know personally and officially the elements of hazard, uncertainty, and extreme danger in our situation, which will not permit of longer delay in dealing with the situation in a broad and permanent way.

We trust that the work now in progress will be prosecuted as rapidly as possible, and that you will soon be able to report definitely upon the feasibility of the Boulder Canyon Dam, and that a bill may be framed to give full force and effect to the recommendations contained in the Secretary's report to Congress.

Respectfully submitted.

By order of the board of directors.

J. S. Nickerson, *President.*

Department of Public Service,
Los Angeles, November 22, 1920.

Hon. Arthur P. Davis,
United States Reclamation Service, Yuma, Ariz.

My Dear Mr. Davis: I have your letter of the 11th instant in reference to proposed developments on the Colorado River and in reply beg to say:

The principles outlined by you to govern participation and order of preference appear to me sound and reasonable.

The city of Los Angeles, I am convinced, would be willing to participate in the expenses of power development.

Furthermore, I am equally confident that the city of Los Angeles would undertake special financing on a large scale for the power project under conditions prescribed by the Government, protecting the Government, the city, and other participants. This plan would probably be in the interest of an early commencement and completion of the work.

Later, when you shall require it, a formal statement will doubtless be issued by the proper authorities defining the attitude of Los Angeles upon such power project.

I should add that Mr. W. B. Mathews, special counsel of the Los Angeles department of public service, with whom I have been conferring on the above matters, fully concurs in the views here expressed.

Very truly yours,

Wm. Mulholland, *Chief Engineer.*

Coachella Valley County Water District of Riverside County,
Coachella, Calif., November 23, 1920.

Hon. Arthur P. Davis,
Director United States Reclamation Service, Yuma, Ariz.

Dear Sir: Your favor of November 11, in which you outline the general principles under which you propose to distribute the costs and benefits in carrying out the project to be considered in your report to Congress under the Kinkaid Act, has been received, and has been under discussion by this board upon several occasions.

This district board is in accord with and indorses the general principles as therein outlined by you and wishes to state that it is desirous of participating in the project as a whole; provided, however—

First. That the final report shows that it will be practical from an engineering and economic standpoint to this district.

Second. That there be a fair, just, and equitable distribution of the costs of the entire project.

This district board wishes to express itself as being in harmony with the idea that has been expressed by numerous organizations and bodies relative to having the Secretary of the Interior act as a final arbiter when the question of the distribution of costs and benefits will be considered.

Thanking you for your courtesy in this matter, and assuring you of our sincere desire to cooperate in working out the problems under consideration, we are,

Very truly yours,

COACHELLA VALLEY COUNTY WATER DISTRICT,
By S. S. M. JENNINGS, *President.*

PALO VERDE JOINT LEVEE DISTRICT,
Blythe, Calif., November 27, 1920.

Mr. ARTHUR P. DAVIS,
Director United States Reclamation Service, Yuma, Ariz.

DEAR SIR: Replying to your letter of November 11, I respectfully submit the following:

I have ascertained the opinion of the people of the Palo Verde Valley to an extent that enables me to assure you that if the investigations and surveys now being made at Boulder Canyon prove the feasibility of the construction of a reservoir at that place of sufficient capacity to control the flood waters of the Colorado River and to furnish water to all irrigable lands lying below that point, at a cost consistent to the benefits that should be derived by the construction of said reservoir, that the district will participate in the cost thereof to an extent compatible to the benefits that should be derived therefrom.

We feel that the primal motive for the dam's construction should be the reclamation of all lands that can be profitably irrigated below the Boulder Canyon site, both by gravity flow and where practicable by pump lift, and that, provided Mexico desires to participate in the costs of the undertaking, provisions be made to meet her requirements.

We believe that the development of hydroelectric power at the proposed reservoir is essential to the economical consummation of the great undertaking; that the revenue derived from the sale of this electric power should greatly lessen the burden that must be carried by the various districts participating in the work.

We believe that this power should be owned by and operated for the benefit of the districts, and we favor your plan of distribution as outlined in paragraph 4 of your letter.

We feel that in the development of hydroelectric power the fundamental object of the proposed reservoir's construction should never be lost sight of; that regardless of the desirability of maximum power production the water level in the reservoir should be held at such levels as will at all times control the flood water and will provide adequate irrigation water during years of low-water run-off.

Paragraph 5 of your letter meets with our hearty approval.

We are greatly pleased by the progress that has been made by your department in the great undertaking, and deeply appreciate your personal interest and untiring efforts in the work.

Yours very respectfully,

ED F. WILLIAMS, *President.*
W. J. BURTON,
President of the Palo Verde Mutual Water Co.

YUMA COUNTY WATER USERS' ASSOCIATION,
Yuma, Ariz., May 16, 1921.

Hon. A. P. DAVIS,
Director United States Reclamation Service.

DEAR SIR: Replying to your letter of the 10th instant, addressed to the president of this association, upon unanimous approval of our board of governors, expressed at an adjourned meeting held this day, we respectfully submit the following supplemental statement to our resolution of November 29, 1920:

After having obtained the opinions of many of our shareholders with reference to the storage and power propositions purposed at Boulder Canyon, we believe the sentiment of a great majority of our constituent members to be such that if the Boulder Canyon project is declared to be feasible to the extent of controlling the flood waters of the Colorado River and of furnishing irrigating water to all of the irrigable lands lying below said point, as well as for sufficient hydroelectric power for the lands and adjacent territories, at a cost consistent with the benefits to be derived from the construction of the reservoir, that the Yuma Valley water users will participate in the cost thereof to an extent compatible with the benefits the valley should derive therefrom.

We believe that the development of hydroelectric power at the proposed reservoir is essential to the complete welfare of the project, and that the revenue to be derived from the sale of this electric power should greatly reduce the ultimate cost of the undertaking to the various districts participating in the construction of the project.

We believe that said power should be owned by and operated for the benefit of the various cooperating districts, and we favor your plan as outlined in paragraph 4 of your letter of November 12, 1920.

Your scheme of contribution in proportion to the benefits to be derived by each district seems to us to be proper, and we believe the colossal scheme of conservation as undertaken by you and your associates to be the only reliable solution for controlling the flood waters of the Colorado, supplying a bountiful and dependable supply of water to the greatest number of settlers and furnishing incomparable hydroelectric energy.

Very respectfully yours,

WM. WISENER, *President.*
H. L. BELTZHOOVER, *Secretary.*

DEPARTMENT OF PUBLIC SERVICE,
Los Angeles, Calif., December 16, 1920.

HON. ARTHUR P. DAVIS,
Director United States Reclamation Service, Washington, D. C.

SIR: The city of Los Angeles is deeply interested in your investigation of the subject of water and power development on the Colorado River, regarding it as a matter directly and vitally affecting, in its possibilities, the prosperity and welfare of California and the whole Southwest.

The officials and the people of Los Angeles will, we are confident, specially welcome the opportunity to participate with other cities, districts, and communities in the cost of power development on the Colorado under a plan or policy established by the United States Government.

Moreover, we firmly believe that the people of Los Angeles would authorize the city to undertake the financing of a major power project on that river, under conditions prescribed by the Government, assuring the city of a share in the power commensurate with its investment, and, at the same time, reserving the privilege for other communities to become participants in the benefits of such development.

Very truly yours,

MEREDITH P. SNYDER, *Mayor.*
HOWARD ROBERTSON,
President of Board of Public Service Commissioners.
WM. MULHOLLAND,
Chief Engineer of Water Works.
E. F. SCATTERGOOD,
Chief Electrical Engineer.

SOIL SURVEYS.

CLASSIFICATION OF SOILS BORDERING THE IMPERIAL VALLEY.

By Charles F. Shaw, Professor of Soil Technology, University of California.

April 22, 1921.

The following report on the character of the soils of the regions bordering the Imperial Valley is based largely on the very careful and thorough examination of these soils that was made by Mr. A. T. Strahorn, of the Bureau of Soils, and Mr. S. W. Cosby, of the University of California. The writer went over the area with these men, discussing the classifications that they had made and examined and studied the definite bodies of soils as delineated on their maps. Earlier investigations of portions of this area had been made in the course of other surveys in the Imperial Valley and some supplemental examinations were made of lands within the general region but outside of the area included in this survey. All of this information is drawn upon in the preparation of this report.

The soils of the east mesa are prevailingly sandy, ranging from a light sandy loam to a gravelly sand, with by far the larger part of a light fine sandy loam texture. The subsoils are likewise sandy, and quite uniform in character. These sandy soils rest upon a substratum of compact, stratified clays, at depths of 25 feet, more or less, below the surface. In a few places these compact clays are within 6 feet of the surface and a few outcrops of this material give some small areas of clay soils, usually containing alkali. These soils, together with a few areas of steep or rough land along the mesa margin, with the areas of wind-eroded "blow-outs" and the areas of dune sand, constitute the nonagricultural lands of the east mesa. A study of the soil maps shows that, excluding the dunes which border the mesa on the east, there are about 54,000 acres of nonagricultural land within the area of the east mesa.

The survey shows that this mesa includes 169,739 acres of agricultural land, of which 125,227 acres are relatively smooth and level and of good quality, while 44,512 acres are more irregular, with scattered low mounds, ridges, or dunes that would need considerable work in leveling in order to prepare them for irrigation. While of a sandy texture, the agricultural lands of the east mesa are of good quality and should give good results with the crops suited to that region.

North of the east mesa, from Niland to the Coachella Valley the soils are of a poor quality. Here compact stratified clays, carrying large quantities of alkali, are exposed on the surface or are covered by a veneer of recent wash from the mountains on the east. Some extensive deposits of this recent alluvium occur, but for the most part they are considered nonagricultural because of the ever-present danger of brief but locally severe floods which cause such serious erosion that in spite of extensive control measures the railway roadbed is not infrequently washed out. Of the 107,435 acres in this section (Dos Palmos unit) only 7,550 are classed as agriculturally possible, and these are of questionable value.

The west side area, comprising all the lands west of the Imperial irrigation district and the Salton Sea, has a widely divergent topography, ranging from uniform alluvial slopes or smooth mesas of considerable extent to areas of typical bad lands, eroded ridges, and low mountains. A large area of good land lies west and southwest of the Superstition Mountains, in a broad belt extending from the El Centro-San Diego highway north to San Felipe Creek. These soils consist of sands and sandy loams, with some small occurrences of heavier-textured soils. This area occupies sloping alluvial plains and smooth to gently-undulating low mesas, and a total of over 55,000 acres is of good quality and well suited to agriculture if water can be supplied. Probably much of it lies at such elevation that it will prove impracticable to pump water to irrigate it.

A considerable area of land of agricultural value lies just above the present irrigated lands of the Imperial Valley in a belt from 1 to 4 miles wide, extending from the international boundary north to the Superstition Mountains. This belt of soil is more or less broken by areas of sand dunes and in a minor way has a rather irregular topography, but includes over 20,000 acres that can be classed as agricultural land of fair to good quality. There are other areas of agricultural land on the west side, usually of small extent and more or less isolated in bodies of poor lands. A total of about 120,000 acres of the west side lands were classed as agricultural.

Much of the land classed as nonagricultural (totaling over 250,000 acres) is of low value, because of either irregular to rough topography, unfavorable soil texture and subsoil conditions, or the presence of alkali. Large areas of land with favorable topography and good surface appearance have a subsoil composed of old, partially-indurated, stratified clays, usually containing considerable alkali. If irrigated, these soils would develop alkali in the surface and would soon become worthless. There are also broad areas of alluvial soils on the delta of San Felipe Creek which are strongly impregnated with alkali and which are of little or no agricultural value. The development of the west side will depend largely on the possibilities of lifting water high enough to cover a sufficient area of the good land lying west of the Superstition Mountains.

The Coachella Valley, comprising a unit of considerable extent and importance, lies to the northwest of the Salton Sea, in the lower portion of a long, desert valley. The soils of the valley consist mainly of the sediments deposited by the flood waters of the Whitewater River and range from light sandy soils to silt loams and clay loams. A considerable portion of the heavier soils has heavy accumulations of alkali and is of little or no present value, although its ultimate reclamation by drainage and leaching is quite possible. About 39,000 acres of this valley are strongly impregnated by alkali.

There are nearly 7,200 acres of agricultural land, lying below the line of the canal survey in this valley, of fair to excellent quality suited to the production of any of the crops adapted to the climate of the region. The extension of irrigation from gravity canals may cause a rising water table and an extension of the area injured by alkali, but if the utilization of the ground water keeps the water level down, the area of good soil can slowly be increased.

The east mesa offers the largest area of good soil, in compact bodies well situated for irrigation. The Coachella Valley also offers extensive areas of good soil, well located, while the west side, though including large areas of good soil, has, through unfavorable location and high elevation, less favorable conditions for development.

Most of the land in this survey that is classed as agricultural is of good quality, and with adequate water for irrigation should give satisfactory yields of crops suited to the climate. Alfalfa, sorghums, barley, cotton, and truck crops should do well, while tomatoes, lettuce, cantaloupes, and other vegetables grown for the early markets should prove successful. Table grapes, and possibly other fruits, may prove profitable if grown in sufficient quantity to develop adequate marketing facilities.

I consider this region, and particularly the east mesa, as an area of great possibilities, where the investment of funds to supply water for irrigation will make possible a material extension of our agricultural lands, the development of new rural communities, and the establishment of a large number of settlers on farm units of high potential value.

SUMMARY OF SOIL SURVEY OF IMPERIAL VALLEY.

By A. T. Strahorn.

East mesa.—The east mesa occupies a roughly triangular area east of the Imperial irrigation district and north of the international boundary line. The gross area of the mesa is 223,878 acres.

The soils are predominantly sands, fine sands, sandy and fine sandy loams, that are friable and porous to a depth of many feet. Wind-blown sands and fine sands form extensive deposits on the floor of the mesa, and over 40,000 acres of the mesa are rendered nonagricultural by this material. The soils, except for a few very limited areas, are free of alkali and possess excellent drainage features.

The wind-blown sands have a very broken topography, and an uneven surface is formed by the old beach line and its adjacent slopes. These districts comprise about 24 per cent of the area of the mesa, and the balance (76 per cent) has a very uniform to slightly-hummocky surface, none of which is too uneven to be utilized for irrigation and cultivation.

With the exception of limited areas along the western margin of the mesa, no injuriously high ground water or accumulations of alkali are expected to develop.

The soils of the mesa have been placed into three units, depending upon their apparent value for agricultural development.

The following table gives a summary of the acreage of the lands on the mesa:

	Acres.	Per cent.
Agricultural:		
First unit	125,227	
Second unit	44,512	
Total	169,739	76
Nonagricultural lands	54,139	24
Total	223,878	100

Dos Palmas unit.—The Dos Palmas unit includes all the land lying between the Imperial irrigation district and Salton Sea on the south and the rough, broken lands below the base of the Chocolate Mountains on the north, and extending for a distance of some 35 miles in a northwesterly direction from the northern end of the East Mesa unit. The gross area of the Dos Palmas unit is 107,435 acres.

A large part of the soils consist of faulted, folded, compacted, heavy-textured alkaline clays, and the balance are light-textured sandy and gravelly alluvial materials that form an extensive series of moderately to steeply-sloping alluvial fans lying between the base of the Chocolate Mountains and lower-lying clays. Wind-blown materials are confined to a very few small areas of dune sand.

The unit is crossed by hundreds of washes and arroyos of varying size that serve to carry the storm waters from the higher lands north of the area surveyed. Owing to the violence of many of the storms the channels are often of not sufficient capacity and the storm waters frequently cover extensive areas of land, as short but violent floods.

A large part of the soils carries excessive amounts of alkali, and as this material is associated with clays that are too compact and impervious to be drained, its removal is not a feasible undertaking.

There is no settlement within the unit.

Only about 7,000 acres of land possess favorable soil and drainage features that would permit of their successful agricultural development.

Dos Palmas unit.	Acres.	Per cent.
Agricultural land	7,550	7
Nonagricultural land	99,885	93
Total	107,435	100

Coachella Valley.—The Coachella Valley is an oblong area lying to the northwest of Salton Sea, and lies at the northwestern extremity of the area covered by this reconnaissance. The gross area is 187,023 acres. Of this area there is a net agricultural area of 98,479 acres. There are 39,515 acres of heavily alkaline lands, which can not be handled under present conditions. If these lands were reclaimed, the total agricultural area would be 137,994 acres. About 64 per cent of the area lies below the recently surveyed canal line.

The valley is a long, relatively narrow valley, extending northwesterly from Salton Sea, and which is inclosed by the Santa Rosa and Chocolate ranges of mountains. The floor of the valley is very uniform, excepting for minor areas of dune sand, and the surface rises by gradual slopes to the adjacent mountains. The lower valley lands range from about 249 feet below sea level to about 100 feet above. Along the bases of the mountains the surface rises to a maximum elevation of about 400 feet above sea level.

The main line of the Southern Pacific Railroad passes through the valley, and the several stations constitute the only towns. The valley is well supplied with roads.

The agricultural development of the valley began about 20 years ago, after the existence of artesian water was discovered. It is estiated that there were about 9,000 acres of land under cultivation during the season of 1920. Alfalfa, maize, cotton, small grains, vegetables, and a small but steadily increasing acreage of dates and grapes are the principal crops.

The soils consist largely of alluvial sediments deposited by streams draining toward Salton Sea. Along the margins of the valley they are predominantly coarse textured and often gravelly. Throughout the central portion of the valley the soils are predominantly silt loams underlain by fine sandy subsoils. Wind-blown sands occupy a considerable acreage in the upper end of the valley, and where the topography is not too broken they may be brought under cultivation. Throughout a large part of the central portion of the valley the soils are heavily alkaline. Under present economic conditions these lands are practically worthless but they are not impossible of reclamation, and may be handled at some future time.

Land classification, Coachella Valley.

	Acres.
Gross agricultural land	137,994
Land with an excess of alkali	39,515
Net agricultural land	98,479
Nonagricultural land	49,029
Total area	187,023

West mesa unit.—The west mesa unit includes all of the desert region lying west of Salton Sea and the Imperial irrigation district and extending to the bases of the mountains or to adjacent areas of rough, broken lands. From San Felipe Creek northward and along the eastern side of the Superstition Mountains the surface is a series of sloping alluvial fans that are traversed by hundreds of small intermittent drainage channels. South of San Felipe Creek the surface is more of a uniform mesa-like plain that extends southerly to the international boundary. South of the Superstition Mountains this plain is limited on the east by an irregular area of rough, broken land, below which the surface is gently undulating, and is the western extent of the Imperial Valley region. The Superstition Mountains are a low uplift of eroded clays and sandstones in the east-central portion of the unit. This unit ranges from about 249 feet below sea level to about 400 feet above. Two branches of the State highway between this region and western California points cross the unit, and a number of roads and trails afford access to various districts and to settlements to the east and west of the unit. The San Diego & Arizona Railroad crosses the southern portion of the unit.

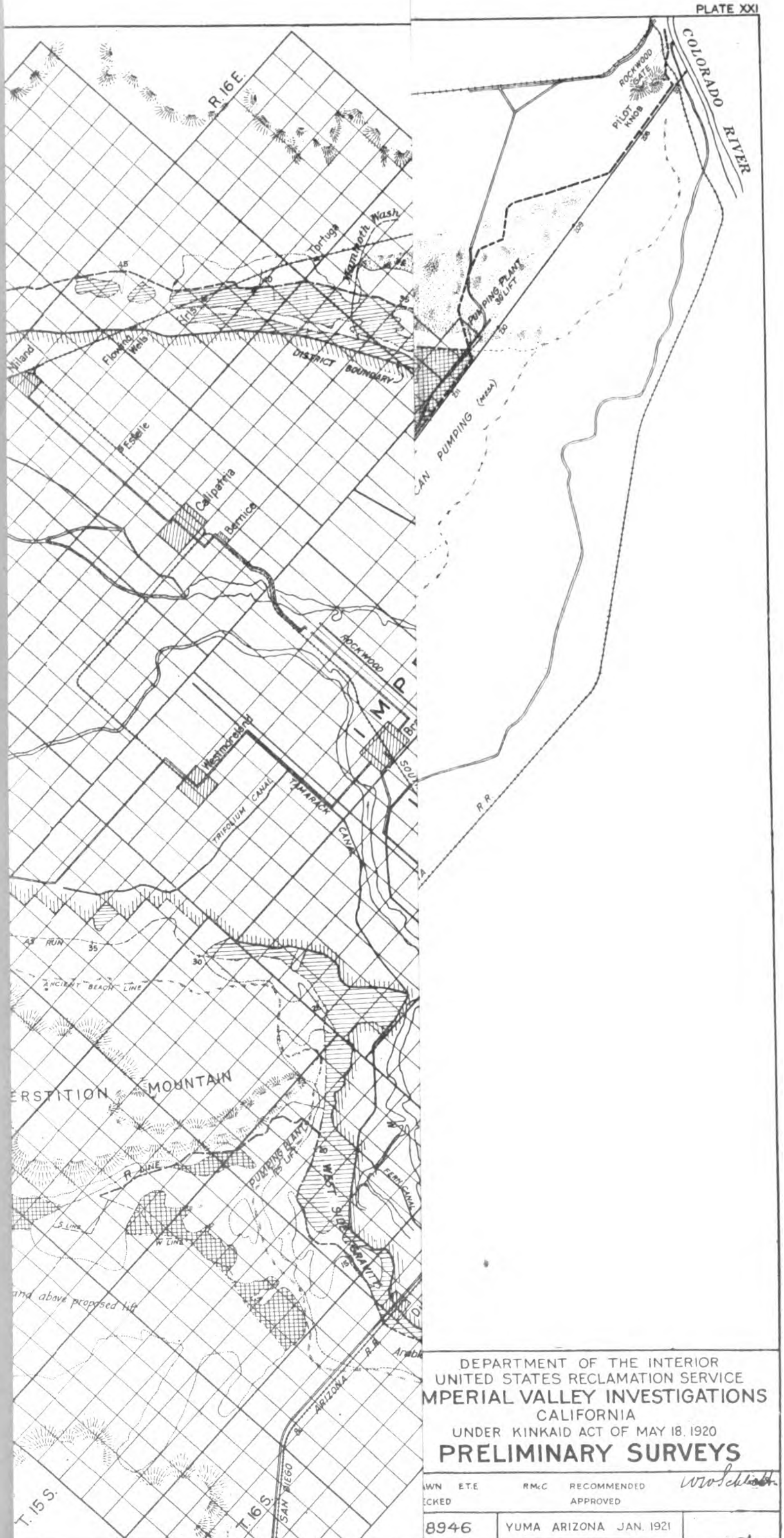
The soils are largely recent alluvial materials derived from the mountain slopes west of the area and range from sands to clay loams in texture. They are prevailingly light in texture, light brown in color, and often carry considerable quantities of water-worn gravel. Very old alluvial materials, now in the form of compacted, indurated, and alkaline clays, form the larger part of the rough, broken lands in the unit and underlie considerable areas of recent alluvial materials. Æolian materials are widely scattered over the surface of the other soils, but usually occur as small, isolated dunes. The very much larger part of this unit is subject to occasional overflows, as the stream channels are seldom sufficient to carry the volume o[illegible] storm waters. Alkali is always present in excessive amounts in the older alluvial materials and in many of the more recent soils where drainage conditions have not been or are not now favorable.

The land classification map, Plate XXI, indicates the areas of the agricultural lands.

West mesa unit.

	Acres.	Per cent.
Agricultural lands	122, 697	[illegible]
Nonagricultural lands	270, 965	[illegible]
Total	393, 662	[illegible]

PLATE XXI



S. Doc. 142, 67–2. (Face p. 98.)

Appendix D.

IRRIGATION AND DEVELOPMENT—UPPER BASIN.

In preparing this portion of the report, many sources of information have been drawn upon. Fortunately, the different States have begun compiling information on possibilities in that portion of the Colorado Basin within the respective States. Many thanks are due to the State engineers of Wyoming, Colorado, Utah, and New Mexico for making a large part of the preliminary information being compiled for the Colorado River Commission available in time for this report.

Especial acknowledgments are due to Mr. A. J. McCune, State engineer of Colorado, and to Mr. R. I. Meeker, special deputy State engineer in direct charge of work on the Colorado River for the State of Colorado. Information on Colorado possibilities is given in considerable detail in this section of the report because of the hearty cooperation given by Mr. Meeker in the onerous task of compiling the large amount of data concerning Colorado. Reclamation Service engineers have also made extensive reconnaissance of projects in Colorado.

In Wyoming possibilities were outlined in 1915 by the Wyoming cooperative report participated in by the State of Wyoming and the Federal Government through the Reclamation Service. A later reconnaisance in 1918 by an engineer of the Reclamation Service was made and these two, together with the many Carey Act segregations made in the Green River Basin, are believed to furnish very complete information on possibilities. The filing system of Wyoming is such that information on present and near future development is readily accessible.

In Utah, the Uinta Basin possibilities have been well outlined by reconnaissance by Reclamation Service engineers. One detailed survey of the proposed Castle Peak project has also been made there. In the remainder of the Colorado Basin in Utah the aggregate of possible irrigation extension is not large, as compared to the other upper States, and has been rather roughly approximated for this report.

In New Mexico the possibilities have been outlined by various reconnaissances made by Reclamation Service engineers. State Engineer Gillette has also made studies of water supply for the projects in that State and furnished data for the Colorado commission which have been used herein.

In Nevada possibilities, as estimated by the State engineer, aggregate 82,000 acres, of which 50,000 acres are in the upper basin. Details of these proposed projects were not furnished in time for this report.

CLASSIFICATION OF PROJECTS.

A rough attempt has been made to classify the projects as to relative feasibility. Obviously such a classification must be very rough. That adopted is as follows:

Class A.—Projects concerning which no serious difficulties are mentioned in the various reports considered and for which water supply seems ample. Perhaps feasible at present time.

Class B.—Projects which appear to be expensive.

Class C.—Extremely expensive projects which are obviously out of the question to build at the present time.

Class X.—Small individual extensions and new ditches. These are constantly being built and there is no way of forecasting when. Class X may be regarded as feasible. The acreage placed in Class X is based largely on topography of the basin and is estimated larger where diversion is easier and water supply large.

This classification is based partly on apparent physical feasibility as nearly as can be determined from reading of reports and on sufficiency of water supply in accordance with standards used in this report which are not the present standards of the Reclamation Service, as determined by rough analyses of existing stream discharge records made for this report. The location of the project and present transportation service also have a bearing. There is also another class of lands, those under existing ditches but not yet reclaimed by settlers. It may be assumed that this class will be irrigated in the near future.

Feasibility of a project can be determined definitely only by a detailed and exhaustive field survey, and so far as the Reclamation Service is concerned, this would have to be made by Reclamation Service engineers before indorsement. Nor can the analyses of water supply be regarded as anything more than very preliminary in nature. Many projects included would have a much scantier supply of water than considered desirable by the Reclamation Service. They are included, however, because it is known that large irrigated areas have been built up successfully on a comparatively small amount of water. These are the growth of years, and it is not too much to hope that the same efficiency will come on these possible projects with the lapse of time.

The estimates of water consumed are based on existence of efficient natural or artificial drainage. Without artificial drainage many of these projects will consume more water than has been estimated. In general, lands in the upper basin have good natural drainage, but this is not true in parts of Wyoming, in Utah particularly along the Duchesne, and in the present large projects in the Grand River Basin. It is to be expected that the lower lands in the Yampa Basin will require some artificial drainage if the upper benches are irrigated.

In every project that is built provision should be made for drainage, whether of lands in the project or of lands outside which may become swamped by irrigation of the project.

Feasibility of a project depends on whether enough value is added to the land to make it a profitable investment to the landowner. It goes without saying that in a favorable climate, such as the lower valleys of the Upper Basin have, more value will be added to the land by bringing water to it than will be the case in the higher and colder altitudes and that, therefore, more money can profitably be spent in such locations.

Precipitation and the time of year it occurs also enter into the question. In parts of the Yampa, Dolores, and San Juan basins it is possible to raise crops by dry farming, and bringing water to that land will not enhance its value so much as would water on the deserts.

Transportation facilities have a major influence. The history of the West shows that large development of natural resources has always followed and never preceded the building of railroads.

The Upper Basin is inadequately served by railroads. The Santa Fe touches the extreme south end, but the Union Pacific and the Denver & Rio Grande are its only major roads, while the Denver & Salt Lake, an ill-equipped independent, enters a small portion of the Yampa Basin.

In Wyoming the Union Pacific crosses the southern part of Green River Basin, and while some is adjacent, most of the irrigable land lies north from 10 to 80 miles without a branch line. In Colorado the Yampa and the White River basins lie with only the eastern end served by the Denver & Salt Lake and a large part of the irrigable land at considerable distance. The Grand River main stem and the Gunnison are both well served by the Denver & Rio Grande. In the Dolores Basin the southern end is traversed and inadequately served by a narrow-gage branch of the same road. The entire San Juan Basin has suffered much and been held back by the insufficient narrow-gage branch of the Denver & Rio Grande which serves it. Much of the irrigable land in the last two basins lies 10 to 70 miles from even the present railroad. In Utah the Uinta Basin lies about 80 miles from the nearest accessible railroad station, but recent plans may result in a railroad to that locality at an early date. Aside from the Uinta Basin, other irrigable areas of size in eastern Utah are well served by the Denver & Rio Grande. In the south of Utah irrigable lands lie about 80 miles from the Salt Lake route.

So the feasibility of a project may lie with something entirely outside the physical aspect of the project itself and this has to an extent influenced the class under which a project is placed. It is not at all probable that every project is placed in its proper class.

In the following table are summarized the data which are developed in detail in the pages following:

Irrigation, in acres—Upper Basin.

BY STREAMS AND STATES.

	Irrigated, 1920.	Possible future.					Total ultimate.
		Under constructed project but not yet irrigated.	Class A.	Class B.	Class C.	Class X.	
Green River Basin, Wyoming	357,000	92,000	96,000	98,000	146,000	101,000	890,000
Green River (direct), Utah	5,000			150,000			155,000
Yampa Basin:							
Wyoming	10,000			7,000	3,000		20,000
Colorado	65,000		152,000	93,000	62,000	53,000	425,000
White Basin, Colorado	35,000		14,000			16,000	65,000
Uinta Basin, Utah	171,000	27,000			48,000	54,000	300,000

Irrigation, in acres—Upper Basin—Continued.

BY STREAMS AND STATES—Continued.

	Irrigated, 1920.	Possible future. Under constructed project but not yet irrigated.	Possible future. Class A.	Possible future. Class B.	Possible future. Class C.	Possible future. Class X.	Total ultimate.
Grand River Basin:							
Main stem—							
Colorado	251,000	46,000	10,000			117,000	424,000
Utah	13,000						13,000
Gunnison, Colo	245,000	35,000		20,000		45,000	345,000
Dolores, Colo	33,000		15,000	114,000		10,000	172,000
San Juan Basin:							
Colorado	111,000			180,000		36,000	327,000
New Mexico	34,000			208,000	275,000		517,000
Utah	12,000			30,000			42,000
Price River Basin, Utah[1]	30,000			30,000		20,000	80,000
San Rafael Basin, Utah[1]	80,000					20,000	100,000
Fremont Basin, Utah[1]	16,000					30,000	46,000
Escalante, Paria, and Kanab:[1]							
Utah	4,000					4,000	8,000
Arizona	2,000					2,000	4,000
Little Colorado Basin, Arizona[1]	19,000			40,000		5,000	64,000
Virgin River Basin:[1]							
Utah	21,000			35,000		5,000	61,000
Nevada	5,000						5,000
Other tributaries, Utah[1]	7,000					3,000	10,000

BY STREAM BASINS.

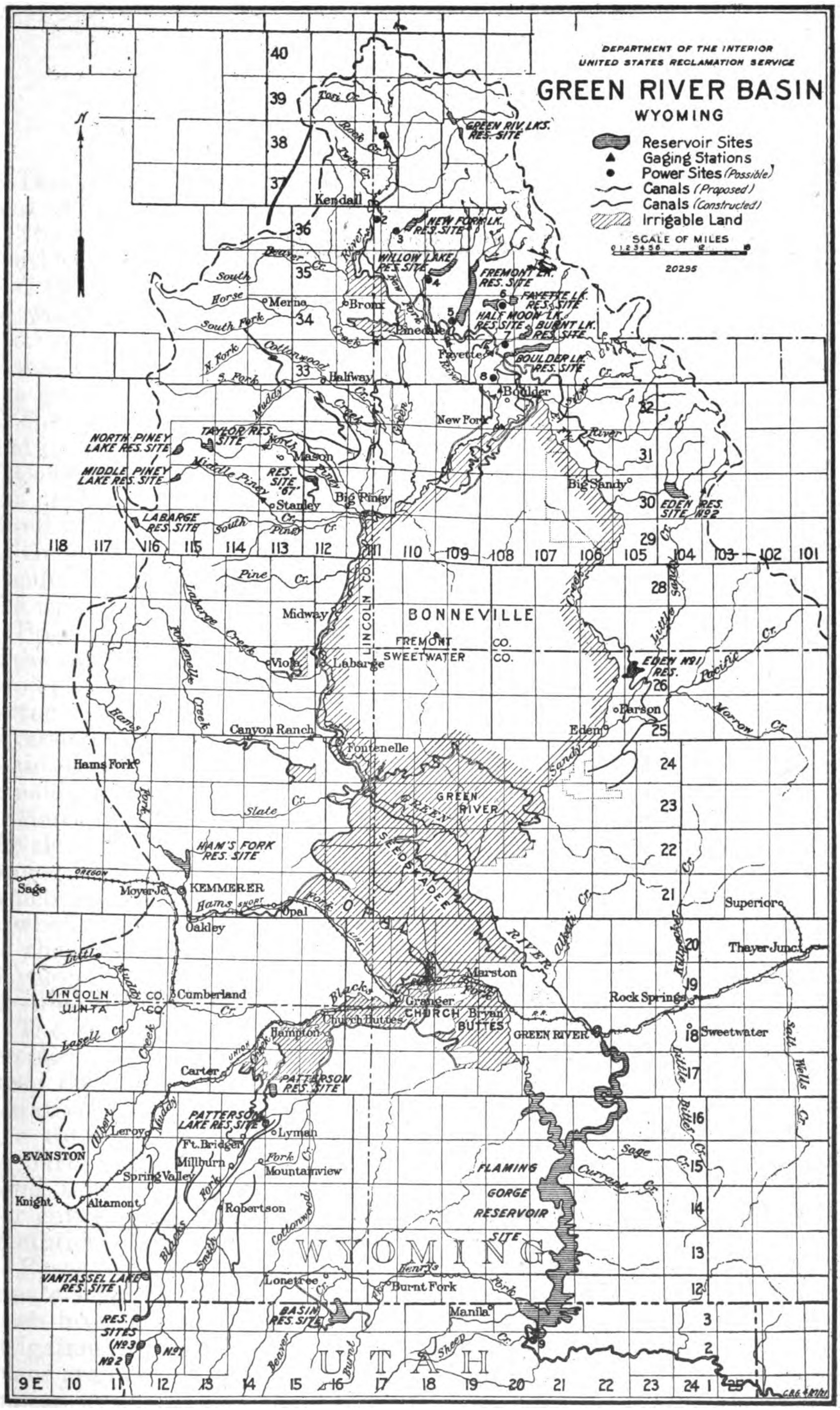
Green River Basin	643,000	119,000	262,000	343,000	259,000	224,000	1,855,000
Grand River Basin	542,000	81,000	25,000	134,000		172,000	954,000
San Juan River Basin	157,000			418,000	275,000	36,000	886,000
Price River Basin	30,000			30,000		20,000	80,000
San Rafael Basin	80,000					20,000	100,000
Fremont Basin	16,000					30,000	46,000
Little Colorado River Basin	19,000			40,000		5,000	64,000
Virgin River Basin	26,000			35,000		5,000	66,000
Escalante	2,000					2,000	4,000
Kanab	2,000					2,000	4,000
Paria	2,000					2,000	4,000
Other tributaries	7,000					3,000	10,000
Total	1,526,000	200,000	287,000	1,005,000	534,000	521,000	4,073,000

BY STATES.

Wyoming	367,000	92,000	96,000	105,000	149,000	101,000	910,000
Colorado	740,000	81,000	191,000	407,000	62,000	277,000	1,758,000
Utah	359,000	27,000		245,000	48,000	136,000	815,000
New Mexico	34,000			208,000	275,000		517,000
Arizona	21,000			40,000		7,000	68,000
Nevada	5,000						5,000
Total	1,526,000	200,000	287,000	1,005,000	534,000	521,000	4,073,000

[1] Information is very poor. It is taken from 1920 United States Census as to present irrigated acreage. This is divided by counties which sometimes include several drainage areas. On the Virgin and Price some data are at hand as to definite projects. The amounts placed in class X are arbitrarily assumed without as good working knowledge of conditions as is at hand for other main tributaries.

Plate XXII


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
GREEN RIVER BASIN
WYOMING
Reservoir Sites
Gaging Stations
Power Sites (Possible)
Canals (Proposed)
Canals (Constructed)
Irrigable Land
SCALE OF MILES
20295
GREEN RIV. LKS. RES. SITE
NEW FORK LK. RES. SITE
WILLOW LAKE RES. SITE
FREMONT LK. RES. SITE
FAYETTE LK. RES. SITE
HALF MOON LK. RES. SITE
BURNT LK. RES. SITE
BOULDER LK. RES. SITE
NORTH PINEY LAKE RES. SITE
TAYLOR RES. SITE
MIDDLE PINEY LAKE RES. SITE
LABARGE RES. SITE
EDEN RES. SITE Nº2
EDEN Nº1 RES.
HAM'S FORK RES. SITE
PATTERSON RES. SITE
PATTERSON LAKE RES. SITE
VANTASSEL LAKE RES. SITE
BASIN RES. SITE
FLAMING GORGE RESERVOIR SITE
Kendall
Merna
Bronx
Pinedale
Fayette
Boulder
Halfway
New Fork
Mason
Stanley
Big Piney
Big Sandy
Midway
BONNEVILLE
LINCOLN CO.
FREMONT CO.
SWEETWATER CO.
Viola
Labarge
Farson
Eden
Canyon Ranch
Fontenelle
Hams Fork
GREEN RIVER
SEEDSKADEE
Sage
Moyer Jc.
KEMMERER
Oakley
Opal
Superior
Thayer Junc.
Marston
Rock Springs
Granger
CHURCH BUTTES
Bryan
Church Buttes
GREEN RIVER
Sweetwater
LINCOLN CO.
UINTA CO.
Cumberland
Hampton
Carter
Leroy
Lyman
Ft. Bridger
Millburn
Mountainview
EVANSTON
Spring Valley
Knight
Altamont
Robertson
WYOMING
Lonetree
Burnt Fork
Manila
UTAH
118 117 116 115 114 113 112 111 110 109 108 107 106 105 104 103 102 101
9E 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
40 39 38 37 36 35 34 33 32 31 30 29 28 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 3 2

GREEN RIVER BASIN, WYOMING.

This includes the entire Colorado Basin in Wyoming except that part drained by Vermillion Creek and Little Snake River.

The Green River Basin covers an area of 15,000 square miles in southwestern Wyoming. The altitude of the basin is from 5,800 feet to 14,000 feet, but most of the irrigable land lies at an elevation between 6,000 and 7,000 feet.

Average annual precipitation on the valley floor ranges from 6 inches in the south to 11 inches in the north, with 3 to 4 inches in the growing season. In the mountain ranges it is much more.

The average annual temperature varies from 34° in the northern and higher parts to 42° at Green River.

Coal mining and stock growing are the principal occupations of the 20,000 residents of the valley. Sixty-five per cent of these dwell in the coal mining towns along the Union Pacific Railroad or at Green River town which is a railroad division point for the Union Pacific. Most of the valley lies to the north of the railroad, some of the irrigable land being 100 miles north as the crow flies.

Present irrigation development is generally in small individual areas mostly along bottom lands although some few fairly large projects have been built under the Carey Act. However, on these latter actual irrigation has progressed only to a small degree. While diversion from tributaries is not difficult, land reached from the main river, especially near the southern end, requires long main canals because of the slack grade of the river.

Many projects have been outlined by surveys. Especially, much development under the Carey Act has been proposed and several projects have been built. The total acreage under those permits, which also embrace Carey Act lands, is 403,000 acres. The area as a whole is not well developed. Present irrigation is supplementary to the stock industry, the crop being largely wild hay. Its future development will be also a supplement to stock raising but it is possible to raise grain and various root crops.

The small precipitation and inability to spend large amounts in preparing the land because of the short growing season will always keep the amount of land watered per second-foot of diversion comparatively low. On the other hand, the short irrigation season keeps the total seasonal diversion down. Natural drainage is not good in parts and this with lack of precipitation and intense aridity will tend toward a rather high consumptive use of water. Diversion for entire basin is estimated 2.5 acre-feet annually and actual consumption of water 1.5 acre-feet.

Power developments will always be small unless it is feasible to create head by dams on the main river. This possibility has not been investigated. On the tributaries possibilities are small. The irrigation, as noted herein, will use all known reservoirs and if these plans are ever carried out, it must be at the sacrifice of some possible power.

GENERAL DATA.

Irrigation development.

	Present.[1]	Estimated additional possible.	Total ultimate.
	Acres.	*Acres.*	*Acres.*
Above Green River city	250,000	420,000	670,000
Blacks Fork	79,000	51,000	130,000
Hams Fork	14,000	50,000	64,000
Henrys Fork	14,000	12,000	26,000
Total	357,000	533,000	890,000

[1] State engineer reports.

Stream discharge, Green River.

	Present annual discharge out of basin.[1]	Estimated decrease.	Ultimate after full irrigation development.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
At Bridgeport, Utah	1,920,000	800,000	1,120,000
Green River, Wyoming	1,380,000	630,000	750,000

[1] After allowing for depletion through increased irrigation during period of record.

FUTURE IRRIGATION POSSIBILITIES.

Rather extensive systems can be built covering large acreages, much more than there is water for. These have been outlined by surveys both by private enterprise under the Carey Act, by the Wyoming cooperative report between the State of Wyoming and the Federal Government, and by a reconnaissance made by Garfield Stubblefield in 1918.[1] Lack of reservoirs will prohibit development to use the entire run-off of the basin, even if land were sufficient.

In the following list of projects the acreage only is given for which the water supply at point of diversion is estimated to be sufficient in most years. While most strategic points on every stream have records started in the past few years, yet no winter records can be kept, the period of record is not long, and estimates must be made by comparison with Green River, Wyo., station, which is at a lower altitude than the source of supply. It has been necessary also in some cases to estimate by comparison of drainage areas.

Possible future projects in Green River Basin, Wyoming.

	Acres.
Above Green River town:	
Fontanelle	4,000
La Barge (Carey Act list 93)	3,000
Apex	4,000
Green River (Carey Act list 49)	94,000
Uinta-Fremont (Carey Act list 88)	11,000
Seedskadee	[2] 146,000
Big Piney—La Barge	6,000
Individual efforts	60,000
Total	328,000
Hams Fork: Opal project	50,000

[1] Unpublished "Report on Green River Basin in Wyoming, U. S. R. S., March, 1919.
[2] Considerable doubt as to whether so much irrigable acreage is found in project; see later discussion.

	Acres.
Blacks Fork:	
Uinta Nos. 2 and 3 (Carey Act list 10–70)	22,000
Individual efforts	29,000
Total	51,000
Henrys Fork: Individual efforts	12,000
Grand total	441,000

The total irrigable acreage not now irrigated is much larger but is included in unfinished projects. In the above the last item, "Individual efforts," is an arbitrary assumption. There is a constant increase in irrigated land through individual effort in building additional small ditches, but there is no way of arriving at the total of this in advance, particularly on the tributaries of Blacks Fork and on Henrys Fork, where there are no known reservoirs, and such extensions can expect water only in the first half of the irrigation season.

Classification of projects.

	Class A.	Class B.	Class C.	Class X.
Above Green River city:				
Fontanelle		4,000		
La Barge	3,000			
Uinta-Fremont	11,000			
Apex	4,000			
Seedskadee			146,000	
Big Piney-La Barge	6,000			
Green River		94,000		
Individual efforts				60,000
Hams Fork, Opal	50,000			
Blacks Fork:				
Uinta Nos. 2 and 3	22,000			
Individual efforts				29,000
Henrys Fork, individual efforts				12,000
	96,000	98,000	146,000	101,000

NOTE.—All proposed Carey act projects above Green River city, except Green River, are placed in class A because assumed that tracts most easily irrigated were first surveyed under this act. There is no definite information at hand. Green River Carey act is placed in B because of difficult canal and shallow soil. Seedskadee placed in class C because if Green River Carey act built first storage must be provided at reservoirs of uncertain feasibility and because canal construction difficult.

IRRIGATION POSSIBILITIES.

In considering irrigation possibilities it was found that the areas covered by surveys exceed the water supply. Therefore, it was necessary to—

(1) Estimate the depletion in water supply caused by development above gaging station during the period of run-off record because if the same cycle repeated the water passing would be less.

(2) Estimate the acreage not yet irrigated and the water supply for partially developed Carey Act projects to get future demands in supply by existing rights partially developed.

(3) Estimate the acreage in Carey Act projects having a water right but not constructed.

(4) Assume an acreage which will be developed under individual filings probably before some of the larger projects outlined.

These four items are assumed to constitute a prior demand on the water supply. If the assumptions are wrong as to acreage of these items it makes no difference in the ultimate total because more or less, as the case may be, can be irrigated in the larger projects outlined, the building of which will be in the distant future.

For convenience of discussion, the basin is divided into four parts: Above Green River city, Hams Fork, Blacks Fork, and Henrys Fork.

CAREY ACT PROJECTS ABOVE GREEN RIVER CITY.

FONTANELLE CREEK.

A possible project of 4,000 acres has been surveyed from this creek. In the average year the natural run-off is almost sufficient for such a project, but in the low years practically no water is available after June 15. The total run-off is always sufficient for this acreage, but no reservoir sites are known to exist.

LA BARGE PROJECT.

Acreage, gross, 4,100; net, 3,000.

Carey Act segregation list No. 93 was requested in 1912, but refused because in petroleum reserve. Nothing is known concerning the irrigation plan except that diversion is from La Barge Creek in section 19, township 26 north, range 113 west.

Water supply.

	Estimated average discharge La Barge Creek.	Demand 4,000 acres, 3,000 in project plus 1,000 acres recent rights.
	Acre-feet.	*Acre-feet*
April	20,000	
May	12,000	1,000
June	10,000	3,700
July	4,000	3,700
August	3,000	1,600
	49,000	10,000

In the average year the supply is sufficient. In a dry year storage required to fill the demand is 4,000 acre-feet.

Reservoir.—La Barge reservoir near headwaters, capacity 4,050 acre-feet.

TEPEE PROJECT.

Carey Act segregation list No. 87 was requested in 1911, but time of withdrawal has now expired. Acreage 15,600.

Water supply.

	Acre-feet.
Estimated average discharge Middle Piney Creek:	
September–April inclusive	3,500
May	1,400
June	4,100
July	3,300
August	1,500
Total	13,800

Present rights below gaging station are estimated to total 3,000 acres leaving practically no water for extensions of any sort. Extension of small rights is at a standstill now.

NORTH PINEY—COTTONWOOD—GREEN RIVFR PROJECT.

Carey Act segregation No. 57 for 42,000 acres was made in 1909 and the system constructed. At the close of 1920, only 600 acres were irrigated, the results being due partially to inadequate water supply. Most of the land can be covered by canal from Green River heading in section 3, township 33 north, range 110 west. Carey Act segregation No. 106 covering a part of the original lands plus some additional has been made. This system is now under construction and will be complete in 1921. The irrigable acreage is 25,000.

There remains 4,600 acres in the project to be watered from North Piney Creek, the discharge of which at a point above the diversions of the original segregations is estimated to average 32,000 acre-feet. There are almost 21,000 acres having rights on the creek and knowledge is not sufficient to determine their location with respect to the gaging station.

State officials state that by building reservoirs water supply can be made sufficient for the 4,600 acres and therefore assumption is made herein that this area will eventually have a water supply.

Reservoir sites available:	Acre-feet.
Taylor Park	5,180
North Piney	1,570
Total	6,750

The supply for the 25,000 acres is measured at Daniel on the Green River and natural flow is in excess of requirements at all periods even in the driest years.

	Estimated average discharge, Green River at Daniel.	Demands 25,000 acres.
	Acre-feet.	*Acre-feet.*
May	95,000	6,250
June	163,000	23,000
July	105,000	23,000
August	45,000	10,000

UINTA-FREMONT.

Carey Act segregation No. 88 requested in 1911 with permit covering 14,000 acres. Time of withdrawal expired and no construction commenced. Canal heads in Green River in section 3, township 35 north, range 111 west. Supply has been measured only in part of 1918 and is more than ample.

APEX PROJECT.

Adjacent to Uinta-Fremont and covering 4,000 acres with canal heading in section 11, township 35 north, range 111 west also has ample water supply.

NEW FORK RIVER AND TRIBUTARIES.

The following projects have been constructed but are only partially irrigated now:

Name.	Stream.	Acres irrigated, 1920.	Total irrigable.
Boulder	Boulder Creek	5,400	8,600
Fremont Lake	Pine Creek	1,000	7,000
East Fork	East Fork River	1,000	4,900
Paradise [1]	New Fork River		4,100
Total		7,400	24,600

[1] To be completed 1921.

Water supply is ample for these.

EDEN PROJECT.

Carey Act lists 35 and 37 secured in 1906 and 1907. Permits cover 70,200 acres, of which 60,000 are estimated irrigable and of which 7,000 were irrigated in 1920.

Irrigation plan.—Diversion from Big Sandy Creek in sections 17 and 27 north, range 106 west to east side of river. This is constructed. Diversion in section 3, township 26 north, range 106 west to west side of river, not constructed.

Irrigable acreage, east side	40,000
Irrigable acreage, west side	20,000

East side canal feeds Eden Reservoir of 18,300 acre-foot capacity now built and also picks up the waters of Little Sandy Creek. Additional storage of 105,000 acre-feet is contemplated in Eden Reservoir No. 2 at the headwaters.

Water supply.—Big Sandy Creek was gaged only in 1915–16 and Little Sandy Creek only in 1911 and 1912, both for only a part of the year.

Based on this meager data, the run-off above the diversion is estimated to average as follows:

	Big Sandy.	Little Sandy.	Total.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
November to March, inclusive	[1] 9,000	[1] 2,000	
October and April	14,000	[1] 3,000	14,000
May	12,000	2,000	14,000
June	31,000	7,000	38,000
July	13,000	4,000	17,000
August	4,000	1,000	5,000
Usable	74,000	14,000	88,000

[1] Lost because undivertible.

Based on the above estimate of discharge, the present irrigation system is sufficient in the average year for 30,000 acres, as shown by the following:

	Supply.	Demand, 2,500 feet per acre.	Surplus and deficits.
October and April	14,000	....	+14,000
May	14,000	7,500	+ 6,500
June	38,000	27,600	+10,400+30,900
July	17,000	27,600	−10,600
August	5,000	12,000	− 7,000−17,600
	88,000	74,700	

In dry years the supply will be short because of lack of reservoir capacity.

The run-off tributary to Eden Reservoir No. 2 is estimated to be 60,000 acre-feet annually, based on fragmentary measurements made in 1911, but about 30,000 acre-feet of this is required to fill old rights between this reservoir site and the diversion. The remainder should be sufficient for 10,000 acres at 2.5 feet per acre because of large reservoir capacity to hold years of heavy run-off. The project will eventually total 40,000 acres, and it is probable the west side will never be built.

SUMMARY, GREEN RIVER BASIN, WYOMING.

1. Present irrigation above town of Green River:			
Territorial rights		30,000	
Adjudicated rights		195,000	
Carey Act lands irrigated but not adjudicated:[1]			
Fremont Lake project	1,000		
East Fork	1,000		
Bertram	700		
Cottonwood	600		
Eden	7,000		
Total	10,300		
Say		10,000	
Miscellaneous lands under permit, irrigated but not adjudicated—an arbitrary figure		15,000	
			250,000
2. Near-future irrigation: Carey Act lands under constructed or partially-constructed systems but not yet irrigated:[1]			
Boulder	3,200		
Fremont Lake	6,000		
East Fork	3,900		
Paradise	4,100		
Green River-Cottonwood-Big Piney—			
From Green River	25,000		
From Cottonwood	4,000		
"67" Reservoir	2,100		
Eden	33,000		
		81,000	
Big Piney-La Barge to be constructed in 1921		6,000	
Permits issued since 1918, total 19,200 acres, part eventually irrigated, estimated will be		15,000	
			102,000

[1] State Carey Act engineer's estimate of irrigable acreage.

3. Additional lands under projects on which no construction work has been done and for which local water supply is sufficient:		
Green River Carey Act	94,000	
Uinta-Fremont Carey Act	11,000	
La Barge	3,000	
Fontanelle	4,000	
Total	112,000	
Without Green River Carey Act, project of 94,000 acres		18,000
4. Miscellaneous individual rights		60,000
Total		430,000

As the Green River project is large and as analysis for its water supply fits in well with the Seedskadee, it is omitted from the foregoing and placed in the following list:

Additional projects outlined by Wyoming cooperative survey, 1918, and Stubblefield survey, 1918:

	Gross acreage.
Bonneville project	610,000
Small Seedskadee	50,000
Large Seedskadee	190,000
Big Piney-La Barge	15,000
Green River (see previous list)	117,000
Total	982,000

The above list outlines the gross acreage covered by surveys. It vastly exceeds the net irrigable acreage.

WATER SUPPLY.

The diversion for all projects past and future is taken at 2.5 acre-feet per acre. As the climate is very dry, consumption of water is taken at 1.5 acre-feet per acre, with a return flow of 1 foot. As the irrigation season is only 105 days, the amount of return flow which can be used again is small, as there are no reservoir sites for storing it.

The change which will take place in discharge of the stream at Green River by irrigation above is estimated to be as follows per acre of land irrigated. The demand or diversion is in accordance with present practice and the percentage of return flow each month the same as on the Shoshone project, Wyoming, which project has a climate somewhat similar to Green River Basin, although warmer.

	Acre-feet per acre.		
	Diversion.	Return.	Change.
Sept.-May 15		0.60	+0.60
May 15-31	0.25	.08	−.17
June	.92	.11	−.81
July	.92	.14	−.78
August	.40	.07	−.33
Total	2.50	1.00	1.50

	Acre-feet.
Discharge Green River at town of Green River, Wyo., average (1895–1906; 1915–1920)	1,466,000
Estimated increase of irrigation during period 1895–1920 is 110,000 acres; if cycle were repeated, discharge would be less; 55,000 acres average at 1.5 acre-feet	83,000
Present average discharge	1,383,000
Assumed near future irrigation (items 2, 3, and 4 in foregoing summary) 180,000 acres at 1.5	270,000
Total	1,113,000

To determine the water available for new projects it will be necessary to estimate the probable monthly change in discharge caused by the extension of irrigation as noted above.

	Average discharge, Green River.	Estimated change by past and expected future diversions 235,000 acres.	Discharge partly available for new projects.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
Aug. 20–May 15	470,000	+141,000	611,000
May 15–31	139,000	− 40,000	99,000
June	476,000	−190,000	286,000
July	292,000	−183,000	109,000
Aug. 1–20	89,000	− 77,000	12,000
Total	1,466,000		1,117,000

However, only that part of the winter discharge which can be retained in reservoirs will be available for new projects. There are no reservoir sites known on the main stream by which the return flow can be caught and all reservoirs on small tributaries are assumed to be and will be used for irrigation on those tributaries, if it develops as herein outlined, leaving only reservoirs on New Fork River and at headwaters of Green River available.

There are a number of lakes on the above headwaters listed in Wyoming cooperative report which can be used as reservoirs.

Nothing is known of dam foundations. Such lakes are often of glacial origin which makes the possibility of using them as reservoirs very doubtful. If they are found infeasible, future irrigation possibilities will be reduced from the figures used here.

The following are listed:

Capacity in acre-feet.

On Green River:	
Green River Lake	10,000
On New Fork River:	
New Fork Lake	22,000
Willow Lake	19,000
Fremont Lake	100,000
On New Fork River—Continued.	
Half Moon Lake	95,000
Burnt Lake	23,000
Boulder Lake	130,000
Total	499,000

The discharge of New Fork River and Green River at the gaging stations nearest below these lakes is estimated by comparison with Green River at Green River, Wyo., to be 139,000 acre-feet out of the irrigation season, but this is probably too high because in the lower altitude of Green River town the winter run-off should be comparatively larger. Also the discharge at the lakes should be less than at the nearest gaging station because of higher altitude. Therefore the winter run-off at these lakes is estimated to total 100,000 acre-feet.

This will give a supply for extension to new projects as follows:

Average supply for new projects.

	Acre-feet.
August 20–May 15	100,000
May 15–31	99,000
June	286,000
July	109,000
August 1–20	12,000
Total	606,000

Disregarding return flow, this is enough for 240,000 acres at 2.5 acre-feet per acre diversion, for which 200,000 acre-feet of storage will be needed in the average year. For hold-over, all the reservoir sites noted should be constructed.

If the Bonneville project is built, some use can be made of return flow. If the other projects—Seedskadee and Green River—are built, there will be little opportunity to use return flow because it is to be expected that all bottom land below Green River town will eventually be submerged by Flaming Gorge reservoir. However, water available to Bonneville project is less than the estimated amount available at Green River and estimates made from reconnaissance show that main canal would be expensive. It is therefore assumed that the lower projects will be irrigated in preference to the Bonneville.

The Big Piney-La Barge project has been placed in the list of lands expected to be irrigated in the near future, and its demands subtracted from the total water supply. The remaining projects are as follows:

	Gross area, acres.
Small Seedskadee	50,000
Large Seedskadee	190,000
Green River	117,000
Total	357,000

After reconnaissance of the first two the net irrigable acreage is placed by Stubblefield as follows:

	Acres.
Small Seedskadee	28,000
Large Seedskadee	65,000

But this figure can be increased by artificial drainage. Nothing is known of the Green River project, but it is estimated by Mr. Lloyd, Wyoming Carey Act engineer, to be 80 per cent irrigable—94,000 acres, making a total of 187,000 acres before drainage.

If a total of 240,000 acres does not exist in these projects with drainage, there are other possibilities along the river without recourse to the Bonneville project in full. In townships 31, 32, and 33 north and ranges 108 and 109 west are shown canals diverting from Boulder Creek and Silver Creek, for which surveys have been run. Also, the easier part of the Bonneville project could be built.

SEEDSKADEE PROJECT.

The Small and Large Seedskadee can be covered by the same canal, and hence are described together.

Precipitation, 6.5 inches.

Temperature, 42°.

Between frosts (summer), 85 days.

Transportation, 10 to 30 mile hauls to stations on the Union Pacific.

Irrigation plan.—Diversion from Green River on west bank 2 miles above mouth of La Barge Creek. Thence skirting the river about 30 miles to the project, picking up creeks en route. About 5 miles is rough going which must be flumed. Some stretches of canal must be lined and there are two siphons crossing creeks.

Discussion as to other items concerning the project is in the general discussion preceding, which shows that water supply is sufficient if reservoirs are feasible, and that after the irrigable acreage has been determined it remains only to determine how many of the reservoirs at headwaters are necessary.

GREEN RIVER PROJECT.

Statistics are the same as for the Seedskadee. It is on the opposite side of the river and is segregated under Carey Act list No. 49. It is said to be a very smooth body of land with shallow soil. Diversion can be accomplished by heading on west side of river on Anderson Island, Section 20, township 25 north, range 112 west; thence about 15 miles along river to a siphon crossing to east side in section 25, township 24 north, range 112 west; thence about 3 miles to main body of land.

Taking the Green River project by itself, the average estimated supply, as compared to demand, is as follows:

	Supply.	Demand.
	Acre-feet.	*Acre-feet.*
Aug. 20–May 15	100,000	....
May 15–31	99,000	24,000
June	286,000	86,000
July	109,000	86,000
Aug. 1–20	12,000	38,000

That is, storage at any one of the lakes is practically sufficient for the average year, but for dry years like 1919 storage sufficient for all of July and August and part of June is required to give a full supply, or about 170,000 acre-feet.

BONNEVILLE PROJECT.

Irrigation plan.—Diversion from Green River in section 14, township 28 north, range 11 east, thence to New Fork River across much side drainage for 16 miles to a tributary of New Fork River. Diverts from New Fork River in section 11 and township 34 north, range 110 west, thence by canal 62 miles long to Big Sandy Creek. Of this, 38 miles should be lined because in glacial material. The line contains five tunnels, one siphon, and eight flumes.

From Big Sandy Creek diversion is made immediately to the project which covers a gross acreage of 610,000, of which a large part is non-irrigable because of roughness.

BLACKS FORK, SMITHS FORK, AND BIG MUDDY.

Irrigation development from these streams and particularly from Blacks Fork is proportionately greater than from any other tributary of the Green in Wyoming. In an average year present rights take all the water from Blacks Fork from July 1 until the end of the season. On Smiths Fork and Big Muddy development has not gone so far and present rights do not exhaust the water until about July 15.

Without reservoirs, extension of irrigation from these streams will be limited, but at present new permits for water are being taken out rapidly and many adjudications have been made in the last two years.

No reservoir sites have been found in Smiths Fork and Big Muddy and no new projects have been outlined, therefore the probable extension of irrigated land is not separately treated but is part of the grand total of miscellaneous extensions given in the general summary.

On Blacks Fork reservoir sites exist as follows, nothing being known as to foundation conditions:

	Acre-feet.
On stream headwaters:	
No. 1	900
No. 2	6,300
No. 3	4,600
Offstream in irrigated area, Peterson	18,000
Total	29,800

Water supply.—The estimated average flow below most irrigation is as follows:

	Acre-feet.
September–April	17,000
May	22,000
June	29,000
July	2,000
August	......
Total	70,000

Duty of water per acre—New extensions.

	Acre-feet.
May	0.25
June	.92
From storage:	
July	.92
August	.40

Storage must provide 1.32 acre-feet for each acre, which gives, if all the reservoirs are feasible, 22,000 acres which can be irrigated in addition to the present. This will not give a full supply to the land each year, as some water will be lost and in low years there will not be sufficient to fill the reservoirs.

Possible projects.

	Area in acres.
Reclamation Service, Stubblefield report, Churchs Butte	25,000
Carey Act:	
Uinta No. 2, Carey Act, list 10	15,000
Uinta No. 3, Carey Act, list 70	33,000

Nothing is known of the comparative difficulties of these projects because there are few data on the two Carey Act projects, but it is presumed the two latter are the easier, since they were surveyed in 1900 and 1910, respectively, while the Churchs Butte project was not outlined until 1915.

CHURCHS BUTTE PROJECT.

Acreage, 22,000 net,[1] 70,000 gross.
Precipitation, 65 inches.
Annual temperature, 42°.
Between frosts (summer), 85 days, average.
Transportation, Union Pacific Railroad.

Irrigation plan.—Diversion from Blacks Fork section 28, township 17 north, range 16 east; thence along left side of river to irrigable lands lying on both sides of Blacks Fork.

HENRYS FORK.

Nothing is known of possible extension of irrigation. The discharge of the river based on the record for 1916, which is the only year measured, will average as follows:

	Acre-feet
September–April (inclusive)	9,000
May	6,500
June	6,500
July	1,200
August	1,800
Total	25,000

This shows that present rights above the station exhaust the flow after June. One off-stream reservoir, basin site, has been surveyed, but indications are that it will not hold water. Possible extension of irrigation is limited and is placed in the grand total in the summary of irrigated acreage for entire Green River in Wyoming.

HAMS FORK, OPAL PROJECT.

Acreage: Gross, 70,000; net, 50,000.
Other statistics same as for Churchs Butte project.

Irrigation plan.—Diversion from Hams Fork in section 31, township 21 north, range 114 west; thence along right bank of river 10 miles to siphon crossing the river where it reaches the project.

Reservoir.—On the river above Kemmerer. Capacity, 100,000 acre-feet. The site is occupied now by a branch railroad. Construction of this reservoir may interfere with coal mining in the vicinity.

Average estimated water supply.—Measured just below reservoir:

	Acre-feet.
September–April (inclusive)	35,000
May	65,000
June	33,000
July	6,000
August	1,000
Total	140,000

[1] 22,000 acres used because of lack of water supply.

Demand.

	Per acre.	50,000 acres.
	Acre-feet.	*Acre-feet.*
May	0.25	13,000
June	.92	46,000
July	.92	46,000
August	.40	20,000
Total	2.50	125,000

Assuming a use below the measuring point for old rights of 10,000 acre-feet leaves 130,000 acre-feet for a new project, which if built to 50,000 acres will require 80,000 acre-feet of storage in the average year. Probably 125,000 acre-feet should be built to provide reasonable hold over. The project can expect severe shortages in dry years. The irrigable acreage given by Stubblefield is 30,000 acres of the gross of 70,000, but it is possible to extend to cover the lower end of the Seedskadee and it is assumed that 50,000 irrigable acres can be found.

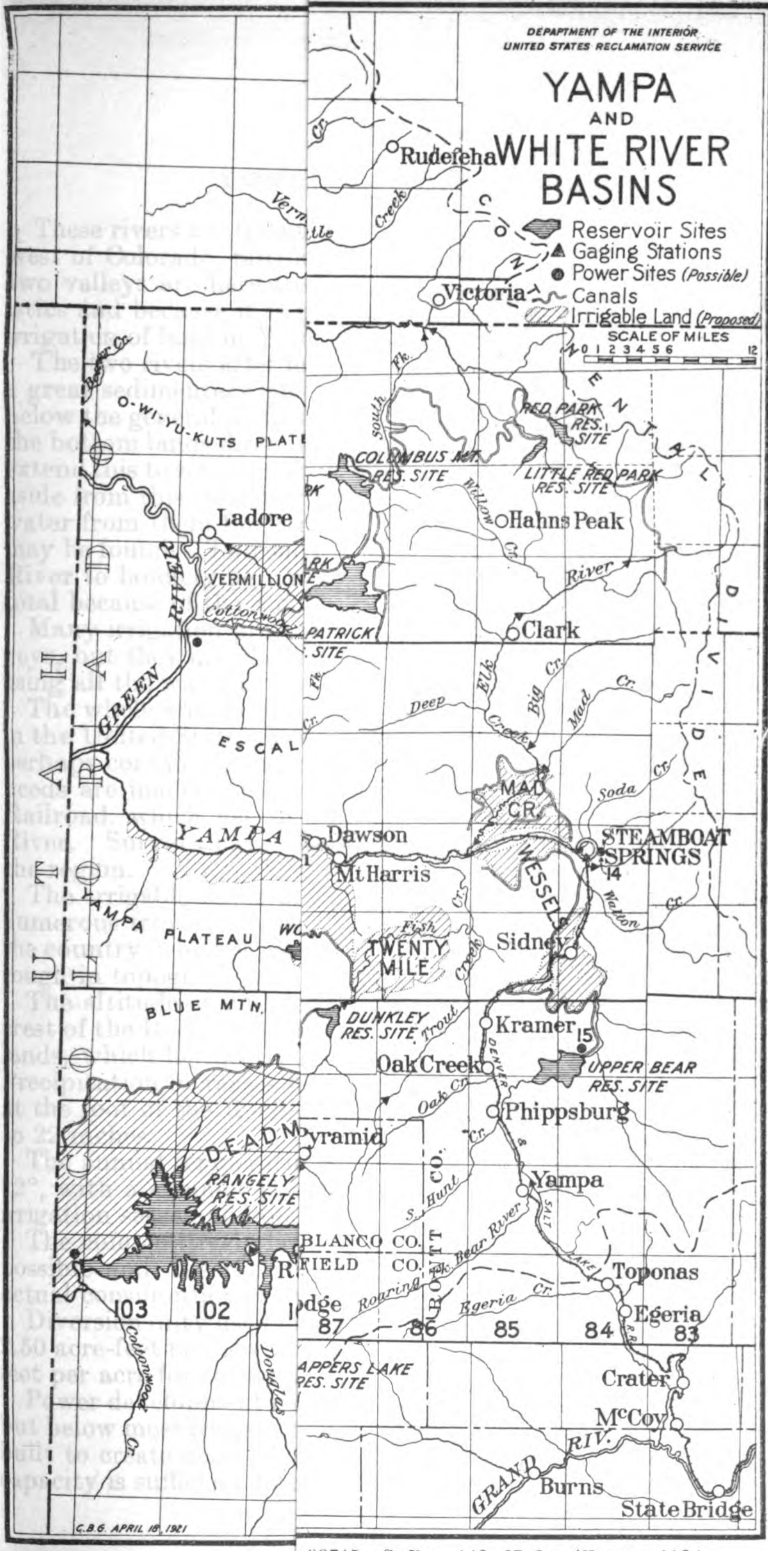
DIVERSIONS OUTSIDE THE BASIN.

No diversions have been proposed.

Possible power sites, Green River, Wyoming.

[Additional investigated possibilities derived from United States Geological Survey data.]

Index number on map.	Stream.	Discharge, cubic feet per second.	Available head.	Horsepower.	Remarks.
1	Green River			3,130	Kendall, 150-foot dam.
2	.....do		120	5,340	Kendall.
3	New Fork River		110	450	New Fork Lake.
4	Willow Creek		110	420	Willow Lake.
5	Pine Creek	110	310	3,100	Fremont Lake.
6	Pole Creek		280	1,780	Half Moon and Fayette lakes.
7	Fall Creek		225	860	Burnt Lake.
8	Boulder Creek		200	1,750	Boulder Lake.
	Total horsepower			16,830	


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
YAMPA
AND
WHITE RIVER
BASINS
Reservoir Sites
Gaging Stations
Power Sites (Possible)
Canals
Irrigable Land (Proposed)
SCALE OF MILES
0 1 2 3 4 5 6 12
Rudefeha
Victoria
Ladore
VERMILLION
GREEN RIVER
YAMPA
Dawson
Mt Harris
STEAMBOAT SPRINGS
Clark
Hahns Peak
COLUMBUS MT. RES. SITE
RED PARK RES. SITE
LITTLE RED PARK RES. SITE
MAD CR.
TWENTY MILE
Sidney
Kramer
Oak Creek
Phippsburg
UPPER BEAR RES. SITE
DUNKLEY RES. SITE
RANGELY RES. SITE
Yampa
Toponas
Egeria
Crater
McCoy
Burns
State Bridge
GRAND RIV.
BLANCO CO.
ROUTT CO.
103
102
87
86
85
84
83
C.B.G. APRIL 18, 1921

YAMPA AND WHITE RIVER BASINS.

These rivers are tributary to the Green and drain the entire northwest of Colorado, plus a small portion of southern Wyoming. The two valleys are here treated together because of similar characteristics and because it is proposed to use the waters of the White for irrigation of land in Yampa Basin.

The two rivers after leaving the mountains flow westward through a great sedimentary plateau into which they have cut channels far below the general surface of the country. There is some irrigation of the bottom lands direct from both rivers and it is believed possible to extend this to some extent, in the case of the Yampa particularly; but aside from this the flat grade of the rivers makes it difficult to divert water from them for irrigation of the mesas on which irrigable land may be found. Two such diversions have been proposed from White River to lands lying north of the river, but are not included in the total because of the reported difficulties later discussed.

Many irrigation projects have been proposed and outlined by surveys, but they are all from tributaries, and there is no possibility of using all the water in the region.

The whole area in general is one of the largest undeveloped regions in the United States, having immense coal and oil shale deposits and perhaps containing oil in commercial quantities. Its transportation needs are inadequately served by the Denver & Salt Lake (Moffat) Railroad, which has its present terminus at Craig, on the Yampa River. Surveys have been made from the Union Pacific south into the region.

The irrigable lands are fertile and generally well drained by the numerous tributary stream channels and coulees. The formation of the country, which is easily eroded, makes them as a whole rolling to rough in topography.

The altitude of the area is from 5,000 on the west to 14,000 at the crest of the Rockies, which form the eastern boundary. The irrigable lands, which lie mostly to the east, range from 6,500 to 7,000 feet. Precipitation increases from about 9 inches in the west to 22 inches at the foot of the Rockies. On the irrigable lands it varies from 12 to 22 inches.

The annual temperature in the irrigable portion varies from 37° to 42°, with a summer period between frosts of 65 to 90 days and an irrigation season of from 3.5 to 4.5 months.

The comparatively large precipitation makes a high duty of water possible and, together with the good drainage, should make a low actual consumption of water.

Diversion duty used in computing water supply varies from 1.75 to 2.50 acre-feet per acre and the consumptive use is taken at 1.25 acre-feet per acre for the average.

Power development can not be very extensive near the headwaters, but below most irrigation possibilities on the main rivers dams can be built to create head for power, and behind these dams the reservoir capacity is sufficient to completely control the streams.

AUTHORITIES.

Data on projects have been derived from State engineer's files and general information and from field examination and report by W. R. Parkhill.[1]

GENERAL DATA.

Irrigation development.

	Present.	Estimated additional possible.	Total ultimate.
	Acres.	*Acres.*	*Acres.*
White River	35,000	30,000	65,000
Yampa River:			
Colorado	65,000	360,000	425,000
Wyoming	10,000	10,000	20,000
Total	110,000	400,000	510,000

Stream discharge.

	Present annual discharge out of basin.	Estimated decrease.	Total ultimate.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
White River	470,000	190,000	280,000
Yampa River	1,880,000	320,000	1,560,000

NOTE.—Decrease in White River is relatively large because of diversion of 150,000 acre-feet to Yampa Basin.

FUTURE IRRIGATION POSSIBILITIES.

As stated, rather extensive systems can be built covering large acreages, and these have been outlined by surveys. Probably most of the possibilities have been covered. Water supply available at the point of diversion is not always sufficient for the total acreage included in the different projects by the surveys, and in the list following only the acreage is given which can be supplied in most years. The estimates of water supply are deduced, in some cases where discharge measurements are lacking, from run-off of adjacent related drainage areas, which is not a reliable basis.

	Acres.	
Yampa Basin projects:		
Wessels	12,000	
Mad Creek	5,000	
Great Northern No. 1	23,000	
Hayden Mesa	40,000	
Twenty Mile	10,000	
Elk River	140,000	
Yellow Jacket (from White River)	60,000	
Summers (pumping)	20,000	
Dolan Mesa (Wyoming)	7,000	
Individual efforts	53,000	
		370,000

[1] Unpublished "Irrigable Areas Yampa, White River, and Little Snake." U. S. Reclamation Service, 1917.

	Acres.	
White River Basin projects:		
Yellow Jacket	12,000	
Wolf Creek	2,000	
Individual efforts	16,000	
		30,000
Total		400,000

The last item in each basin, "Individual efforts," is an arbitrary assumption. There is a constant increase in irrigated land by building additional small ditches, but there is no way of arriving at the ultimate total of this. The estimate used here is furnished by State officials and is subject to modification upon completion of detailed studies now under way.

Classification of projects.

	Class A.	Class B.	Class C.	Class X.
Wessels	12,000			
Mad Creek	5,000			
Hayden Mesa		40,000		
Twenty Mile		10,000		
Elk River, unit 1	75,000			
Elk River, unit 2			65,000	
Dolan Mesa		7,000		
Great Northern, No. 1		23,000		
Yellow Jacket	72,000			
Summers		20,000		
Wolf Creek	2,000			
Total	166,000	100,000	65,000	69,000

DESCRIPTION OF PROJECTS.

WESSELS PROJECT.

Acreage, 12,000.

Temperature, mean annual, 39°.

Precipitation, mean annual, 22 inches; irrigation season, 6 inches.

Elevation, 7,000 feet.

Transportation, Denver & Salt Lake Railroad.

Between frosts (summer), 65 days, average.

Irrigation plan.—Diversion canal heads center of township 4 north, range 84 west, on Yampa River; thence 6 miles along the west side of river; thence west by means of a half-mile tunnel through a ridge to the first unit of 9,000 acres. Along this unit with half-mile siphon across Oak Creek and back to river at Steamboat Springs. Skirting river it reaches 3,000 acres formerly proposed in Mad Creek project.

Storage.—At Upper Bear site on Yampa River capacity is 125,000 acre-feet, with 200-foot raise in water surface.

Duty of water.

	Per acre.	12,000 acres.
	Acre-feet.	*Acre-feet.*
May	0.25	3,000
June	.70	8,400
July	.70	8,400
August	.35	4,200
Total	2.00	24,000

Water supply.—Stream is not measured at diversion.

	Acre-feet.
Discharge at Steamboat Springs	370,000
Discharge at Yampa	22,000
Estimated at diversion (average)	112,000
October to April	28,000
May	35,000
June	38,000
July	8,000
August	3,000
Total	112,000

Little is known of demands of old rights on this water and no storage may be necessary. If old rights should demand all water after July 15, storage required is 9,000 acre-feet.

MAD CREEK PROJECT.

Acreage, 5,000.

Statistics, same as for Wessels project.

Irrigation plan.—Diversion from Mad Creek on north line of section 12, township 7 north, range 85 west; thence down the canyon for 1 mile, where it reaches the project. Irrigable lands are rough and rolling, lying in two equal areas.

Storage.—Is not necessary, as prior rights are in wild-hay land which does not require water in August. Project will be short of water in August of low years. Possible storage site exists at Swamp Park in the headwaters.

Duty of water.

	Per acre.	5,000 acres.
	Acre-feet.	*Acre-feet.*
May	0.25	1,250
June	.70	3,500
July	.70	3,500
August	.35	1,750
Total	2.00	10,000

Water supply.

	Acre-feet.
Average discharge:	
October to April	13,000
May	25,000
June	36,000
July	16,000
August	2,200
Total	92,200

HAYDEN MESA PROJECT.

Gross area, 68,000 acres.

Net area, 40,000 to 50,000 acres (limited by water supply).

Temperature, mean annual, 42°.

Precipitation, mean annual, 17 inches; irrigation season, 5 inches.

Elevation, 6,500 feet.

Transportation, Denver & Salt Lake Railroad.

Between frosts (summer), 90 days average.

Two plans have been proposed for this project. Both divert from Williams Fork north to the project.

PLAN NO. 1.

Irrigation plan.—Supply canal diverts from Williams Fork on the north side of township 3 north, range 88 west; thence on west bank of stream to siphon crossing Williams Fork; thence by canal to tunnel 12,500 feet long onto land. Irrigable lands lie south of Hayden & Craig on bench south of Yampa River. The land is rolling mesa cut by coulees to some extent.

Duty of water.

	Per acre.	40,000 acres.
	Acre-feet.	*Acre-feet.*
May	0.25	10,000
June	.70	28,000
July	.70	28,000
August	.35	14,000
Total	2.00	80,000

Water supply.—Aside from the supply from some small creeks on the project, water will be derived from Williams Fork, the drainage area above the diversion point being 98 square miles. Records exist for most of 1910 and 1911. By comparison with the discharge record of four years at Hamilton, on Williams Fork near mouth, the average at point of diversion is estimated to be 93,000 acre-feet and in the extreme low years 55,000 acre-feet. During the period November to February, inclusive, water can not be diverted, leaving an average of 86,000 and a minimum of 48,000 available.

Estimated at diversion (average).	Acre-feet.
October to April	16,000
May	28,000
June	32,000
July	12,000
August	4,000
Total	92,000

As the stream has its peak discharge in May and early June, draft on storage must commence not later than June 15 in the average year and in low years supply must come partly from storage for practically all season.

Storage.—In an average year about 35,000 acre-feet are required, and this should be increased to 50,000 acre-feet to give a reasonable carry-over for low years.

Reservoirs.—The only reservoir known to exist is the Bunker Basin, reached by 2 miles of canal. Capacity given is 8,300 acre-feet, which it may be possible to increase. Small reservoir sites may be found on the project, and some return flow would be available to decrease demands on reservoir.

Conclusion.—The project is not feasible by this plan, because of ack of reservoir capacity.

PLAN NO. 2.

In addition to Hayden Mesa, this covers an area of 10,000 acres in Twenty Mile Park, which is more easily reached than Hayden Mesa, giving a total of 50,000 acres.

Irrigation plan.—Diversion from Williams Fork, 6 miles farther upstream than plan 1, thence 20-mile canal containing one siphon to Dunkley reservoir, on Fish Creek. From the reservoir water is taken direct to Twenty Mile Park, and through a 1-mile tunnel it reaches Hayden Mesa.

Water supply.—This is secured from Williams Fork, Fish Creek, and Trout Creek. From Williams Fork the drainage area tributary is 25 square miles less than plan 1, which at 500 acre-feet per square mile will leave an average of 80,000 acre-feet, of which 73,000 acre-feet may come during the open season. Drainage area of Fish Creek is 32 square miles, which at 500 acre-feet per square mile would yield 16,000 acre-feet. From Trout Creek a supply canal intercepting 12 square miles can be built to the reservoir, which at 400 acre-feet per square mile divertible would yield 5,000 acre-feet.

Total supply (estimated).

	Acre-feet.
Williams Fork	73,000
Fish Creek	16,000
Trout Creek	5,000
Total	94,000

Demand.—For 50,000 acres the demand is estimated to be 100,000 acre-feet. Some return flow will be available on the project and some supply will come from creeks on the project so that the supply may be approximately equal to that demand. Although this is extremely doubtful, the full 50,000 acres have been taken as an ultimate possibility.

Storage.—Storage required is estimated to be 50,000 acre-feet on the average year, but about 70,000 should be provided for hold-over.

Reservoirs.—Known capacity available is:

	Acre-feet.
Dunkley site	50,000
Bunker Basin	8,000
Total	58,000

Conclusion.—Plan No. 2, while more expensive than plan No. 1, will provide more water supply and better storage facilities.

ELK RIVER PROJECT.

Acreage, 140,000.

Temperature, mean annual, 42°.

Precipitation, mean annual, 13 inches; irrigation season, 4 inches.

Elevation, 6,500 feet.

Between frosts (summer), 85 days.

Transportation, wagon haul, 35 to 70 miles to either Craig on the Denver & Salt Lake Railroad on the south, or Wamsutter on the Union Pacific in the north.

Irrigation plan.—Gathering canal taking the headwater of Elk River to reservoirs on the headwaters of Little Snake River; thence supply canal to Columbus Mountain reservoir site on Slater Creek.

Main canal for project diverts from Slater Creek 6 miles below reservoir and reaches irrigable lands after crossing Willow Creek at thirteenth mile. Supply canals from the headwaters of Elkhead Creek are also proposed to feed the Columbus Mountain reservoir site.

Lengths of canals are as follows:

	Miles.
Feeder from Elk River to Little Snake River	27
Feeder from Little Snake River to Columbus Mountain reservoir site	30
Supply canal to project	13
Main canal on project	105

Irrigable lands.—These consist of an estimated total of 165,000 acres out of a gross area embracing 275,000 acres. The lands are fertile but rolling and eroded.

Duty of water.—Is 2.50 feet at diversion.

May	0.40
June	.85
July	.75
August	.40
September	.10
Total	2.50

WATER SUPPLY.

Elk River headwaters.—Average discharge at Hinman Park, April to October, is 128,000 acre-feet. The discharge available to the pick-up canal is larger because Hinman Creek and South Fork are not included; that is, some of the less prolific territory tributary to the gaging station lies below the canal, while more prolific territory discharging below the gaging station is reached. The April to October supply available to the feeder canal may be 150,000 acre-feet.

Diversion can hardly start before May 1 and will end about November 1, which subtracts 16,000 acre-feet from the above amount. Losses due to peak discharges greater than the economical section of the canal may amount to 24,000 acre-feet, leaving 110,000 acre-feet available for the project from this source.

Snake River headwaters.—The water from Elk River is carried to the Snake River slope and into the Red Park reservoir (proposed) of 47,000 acre-foot capacity on Middle Fork of Little Snake. Little Red Park, of 12,000 capacity on Independence Creek, can be used to regulate the supply from that creek. From these two creeks a supply canal, also tapping the South Fork of Little Snake, will carry the water to Columbus Mountain reservoir site. With the regulation provided by the reservoirs practically all of the summer run-off from the 54 square miles intercepted can be carried to Columbus Basin reservoir site. The annual discharge at the gaging station from 160 square miles is 122,000 acre-feet, or 800 per square mile.

It is believed that from the higher 54 square miles it will be 50 per cent more per square mile, or, say, 75,000 acre-feet. Because of reservoir control practically all, or, say, 70,000 acre-feet, is divertible.

Slater Creek.—The run-off is 61,000 acre-feet, of which probably 40,000 acre-feet is tributary to the project. The Columbus Mountain reservoir site is on this creek; capacity, 76,000 acre-feet, and will be used to control the entire discharge above and from the South Fork and Elk River supply canals.

Elkhead Creek.—Pick-up canals from both sides of the watershed tributary to Park reservoir site on Elkhead Creek are proposed. The run-off from this creek is 57,000 acre-feet, and 40,000 is needed for the 23,000-acre project directly adjacent to the creek, leaving a surplus of 17,000 acre-feet, of which possibly 15,000 can be diverted.

OTHER MINOR SUPPLIES.

On the project itself are small creeks which may yield 12,000 acre-feet after supplying present rights.

Summary of water supply.

	Acre-feet.
Elk River (Trans-Mt.)	110,000
Little Snake	70,000
Slater Creek	40,000
Elkhead Creek (Trans-Mt.)	15,000
Minor creeks	12,000
	247,000
Return flow possibly 50,000; because of proximity to land its efficiency should be doubled, giving	100,000
	347,000
140,000 acres, at 2.5 acre-feet	350,000

Conclusions.—Data on both the irrigable land and the water supply are very meager. While stations have been maintained at base points on all the streams, yet the yield which may be expected from intercepting canals at higher elevations is problematical. From what data are available from the estimates made, the supply of water is too small to cover all the irrigable land, and more complete knowledge may show that the acreage assumed should have been smaller.

Reservoirs.—While the total amount of water is assumed sufficient for 140,000 acres, the amount of reservoir capacity necessary to control it can be only roughly estimated.

Assuming 50,000 acre-feet of return flow available for diversion during irrigation season and assuming, further, that it will be twice as efficient as natural flow because it can be used immediately without losses from long canals, the reservoir capacity required for an average year is 100,000 acre-feet. (See following table.)

Total estimated supply (acre-feet).

	Elk River.	Little Snake.	Slater Creek.	Elkhead Creek.	Miscellaneous creeks.	Total.	Return flow.	Total.
September	5,000	2,000	1,000			8,000		8,000
October	6,000	2,000	1,000			9,000		9,000
November		2,000				2,000		2,000
December		2,000				2,000		2,000
January		2,000				2,000		2,000
February		2,000				2,000		2,000
March		2,000	1,000			3,000		3,000
April		7,000	4,000	7,000	5,000	23,000		23,000
May	20,000	33,000	16,000	8,000	7,000	84,000	20,000	104,000
June	50,000	16,000	17,000			83,000	21,000	104,000
July	22,000					22,000	27,000	49,000
August	7,000					7,000	32,000	39,000
Total	110,000	70,000	40,000	15,000	12,000	247,000	100,000	347,000

Demand, 140,000 acres; duty, 2.5 acre-feet at diversion.

	Supply.	Demand.	Deficiency.	Reservoir contents end of period.
October-April	43,000	....	+43,000	43,000
May	104,000	56,000	+48,000	[1] 91,000
June	104,000	119,000	−15,000	76,000
July	49,000	105,000	−56,000	20,000
August	39,000	56,000	−17,000	3,000
September	8,000	14,000	− 6,000	−3,000

[1] In June supply would exceed demand in early days of month, making reservoir capacity necessarily greater than shown—say, 100,000 acre-feet.

The following reservoir sites are available:

Columbus Mountain	76,000
Little Red Park	12,000
Big Red Park	47,000
Total	135,000

Other reservoirs may be found on the project and there is a small one below Columbus Mountain reservoir on Slater Creek. The capacity noted is not sufficient to give good carry-over to dry years and if more are not found the average supply will be less.

The foregoing outlines an ultimate possibility, but construction in its entirety is not feasible now and estimates of water supply may be grossly in error.

The project divides itself readily into two units, which may be constructed separately.

No. 1 contains 75,000 acres of irrigable land from Slater Creek west to the west line of range 92. The remaining 65,000 acres are covered by extending the main canal of the first unit.

UNIT NO. 1.

General statistics are same as for the entire project.

Irrigation plan.—Use of Columbus Park reservoir with such feeders as are necessary to gather the water.

Assumed duty (acre-feet per acre).

May	0.30
June	.70
July	.60
August and September	.40
Total	2.00

NOTE.—Duty assumed smaller because less extensive feeder canals are required than for the entire project. Total required, 150,000 acre-feet.

This project has almost reached the construction stage as a Carey Act project, at an estimated cost of $55 per acre, and it is considered entirely feasible by State officials. The General Land Office has reduced the project to 44,000 acres, with a duty of 1.67 acre-feet at diversion, requiring a total of 75,000 acre-feet. Based on the foregoing estimates of water crop from different areas 67,000 acre-feet could be gotten from the last three items in the table and the remainder from a short feeder to the South Fork of the Snake, neglecting all return flow.

It is evident that whether or no the duty set is sufficient more water can be obtained by extending a feeder to the South Fork of the Little Snake and that this may provide for the entire 75,000 acres. The Columbus Park reservoir site will be built as part of the first unit.

The best plan for progressive development would be to leave Elkhead Creek diversion to the last so that its water, if needed by lands in its own basin, can be used there.

DOLAN MESA PROJECT.

Statistics: Same as for Elk River project.

Irrigation plan.—Supply canal 10 miles long, heading in Savery Creek near the northeast corner of T. 14 N., R. 89 W.; thence 10 miles of difficult construction to the project. Storage to be provided in Savery reservoir.

Irrigable lands.—Consist of 7,000 acres on Dolan Mesa. The land lies well and is between Savery Creek and Cottonwood Creek in Wyoming.

Duty of water.—At diversion 2 acre-feet, distributed same as other projects.

Reservoir.—Savery reservoir site: Regardless of project needs, this should be built to full capacity of 34,000 acre-feet and surplus water supplied to prior rights on the creek. A considerable portion of the supply for the project must come from storage because of heavy present appropriation.

Water supply.—No specific data on amount available to the project but believed sufficient. Discharge of Savery Creek at mouth—80,000 acre-feet from drainage area of 354 square miles. About 200 miles of most prolific territory are tributary to Savery reservoir site.

GREAT NORTHERN PROJECT NO. 1.

Acreage: Gross, 45,000; net, 23,000.

Statistics: Same as for Hayden Mesa project.

Irrigation plan.—Diversion from Elkhead Creek near north line of township 8 north, range 88 west; thence on west side of creek to lands lying between Elkhead and Fortification creeks.

Storage.—At Park Reservoir site on Elkhead Creek; capacity 40,000 acre-feet.

Irrigable lands.—Are badly eroded and are extremely rough.

Duty of water.—1.75 acre-feet, divided as follows:

Duty of water.

	Per acre.	23,000 acres.
May	0.15	3,000
June	.65	15,000
July	.65	15,000
August	.30	7,500
Total	1.75	41,000

Water supply.—Discharge recorded during 1910 and 1920 at diversion point and at mouth for 10 years, showing average at mouth below irrigation of 87,000 acre-feet and at diversion of possibly 90,000 acre-feet. Estimated at diversion (average):

	Acre feet.
October–April	32,000
May	42,000
June	15,000
July	1,000
August	0
Total	90,000

Storage.—In the average year, practically all the supply after June 15 is taken by prior rights, making 30,000 acre-feet of storage necessary, and to give some hold-over 40,000 acre-feet should be built.

Reservoirs.—Park reservoir site on Elkhead Creek; capacity 40,000 acre-feet with estimated tributary run-off about 40,000 acre-feet.

SUMMERS PROJECT.

Proposed to irrigate 20,000 acres on the first bench above Yampa River and in the neighborhood of Juniper Mountain.

Direct diversion would require a 100-foot dam and a long canal. The project might be irrigated by pumping if Juniper reservoir is built. Water supply is sufficient.

YELLOWJACKET PROJECT.

White River slope, 12,000 acres; Yampa River slope, 60,000 acres; total, 72,000 acres.

Mean annual temperature, 42°.

Mean annual precipitation, 12 inches; irrigation season, 4 inches.

Elevation, 6,500 feet above sea level.

Transportation, Denver & Salt Lake Railroad.

Between frosts (summer), 90 days.

Irrigation plan.—Diversion from North Fork of White River in center of township 1 north, range 90 west; thence along river to Beaver Creek, where there is a unit of 12,000 acres; thence to Yellowjacket Pass, through tunnel 4,000 feet long, total length, 25 miles. After passing through the tunnel there are 2 miles of ditch to Pass Butte reservoir site; thence 10 miles to the main unit of 60,000 acres lying in Axial Basin on benches south of Yampa River.

Duty of water (2.50 acre-feet per acre).

	Per acre.	72,000 acres.
May	0.30	22,000
June	.85	61,000
July	.85	61,000
August	.50	36,000
Total	2.50	180,000

Water supply.—Derived from North Fork of White River, Milk Creek, and small creeks on project. Average discharge of the North Fork of White River:

	Acre-feet.
November to March (undivertible)	58,000
April	16,000
May	54,000
June	52,000
July	24,000
August	15,000
September	13,000
October	13,000
Total	245,000
Divertible	187,000

Milk Creek has not been measured, but the estimated diversion from it may be 14,000 acre-feet annually.

	Acre-feet.
North Fork	187,000
Milk River	14,000
Total	201,000

Storage.—Storage required in the average year is 70,000 acre-feet, if no return flow were available on the project. Assuming 0.50 acre-foot per acre of available return, probably 90,000 acre-feet of storage is sufficient to give hold-over for dry years.

Reservoirs.

	Acre-feet.
Pass Butte	68,000
Trappers Lake	15,000
Marvine Lake	10,000
Total	93,000

Replacement storage.—Present rights on the main river near Meeker will require replacement storage if all the flow of the North Fork is diverted. This can be found at Stillwater reservoir site, on the South Fork:

	Acre-feet.
Capacity	17,000
Required	13,000

WOLF CREEK PROJECT.

A small project of 2,000 to 2,500 acres on Wolf Creek in township 5 north, ranges 100 and 101 west. As given by promoter, the data are as follows:

Area	acres	2,000
Water supply	acre-feet	4,750
Elevation	feet	6,000
Precipitation	inches	13.5
Reservoir capacity	acre-feet	4,160

DEADMANS BENCH PROJECT.

An alternative plan for use of White River water is to divert near the town of Meeker, carrying water through a very difficult country to the neighborhood of Blue Mountains and beyond, on the White River slope.

A possible reservoir site at the junction of the North and South forks is filed on in the State engineer's office. Capacity is about 100,000 acre-feet, but this is not sufficient entirely to control the river. From Parkhill's report the Yellowjacket is the more feasible place to use the water; and if so, the supply available to Deadmans Bench project would be so reduced that the project is not considered in the ultimate irrigable acreage.

SAVANNAH BUTTE PROJECT.

A diversion is proposed on the north side of White River in range 103 west to lands in Utah. Gross area, 80,000 acres, of which possibly 40,000 acres are irrigable. Judging from general descriptions of the country, construction would be very difficult. If Rangely reservoir is built, this project might be constructed without other storage. It is not listed in possible projects in this report.

POWER POSSIBILITIES.

On the headwaters of the two rivers small amounts of power can be developed, but possibilities are small. Below irrigation and along the main rivers are reservoir sites where the entire flow of the river can be equated for power.

YAMPA RIVER.

Juniper Reservoir.—This site is the first proceeding downstream. The discharge at present averages 1,300,000 acre-feet annually, but extension of irrigation, it is estimated, will reduce this to 1,140,000 acre-feet.

		Acre-feet.
Discharge, Yampa at Maybell		1,300,000
Consumptive use on 90,000 acres to be irrigated above Maybell:		
90,000 acres, at 1.25 acre-feet	110,000	
Diverted to Snake River slope	125,000	
		235,000
Return flow from Yellowjacket project, which is to be watered from White River		75,000
Total		1,140,000

Storage capacity of 1,550,000 acre-feet will equate the stream to 1,600 second-feet ultimate, or 1,800 second-feet present minus evaporation, although from an economic standpoint a smaller reservoir may be better. This is based on 10 years' record and does not include the extremely low period which occurred in the period 1899–1902. A dam raising the water surface 240 feet will provide this amount of storage and give 150 feet head below the storage. A higher dam is possible. This reservoir is also a part of a storage plan for Imperial Valley, as later discussed.

Cross Mountain.—Just below Juniper site and above the Little Snake confluence, the water surface can be raised 100 feet without interfering with Juniper and will use the discharge equated at Juniper.

Other sites below exist, but data concerning them are not available.

Upper Bear reservoir.—This is on the headwaters. A capacity of about 110,000 acre-feet will equate the stream to 150 second-feet. A dam, raising the water surface 200 feet, will give this storage and also create a head of 100 feet below the storage. It is not known whether the dam can be built higher. This would provide any storage needed by the Wessels project also.

WHITE RIVER BASIN.

The only apparent power possibility in the headwaters is below Stillwater reservoir site on White River, where, if Yellowjacket project is built, the replacement storage from the reservoir for present rights near Meeker will give a good flow in low-water periods. Without doubt other small sites exist.

Rangely reservoir site.—This lies near the west line of Colorado. The discharge at present averages 550,000 acre-feet, but extension of irrigation, it is estimated, will reduce this to 360,000 acre-feet, and if the Deadmans Bench project is built there would be no water available.

		Acre-feet.
Present discharge, White River at Rangely		550,000
Consumptive use, ultimate irrigation 30,000 acres at 1.25 acre-feet	40,000	
Diverted to White River slope	150,000	
		190,000
Total		360,000

A storage capacity of 330,000 acre-feet will equate the stream to a uniform discharge of 500 second-feet (after irrigation depletion above, or 760 second-feet present), minus evaporation from the reservoir, but a smaller reservoir may be better from an economic standpoint. A dam, raising the water surface 200 feet, will give 330,000 acre-feet of storage and provide a constant head of 160 feet below that storage. As the reservoir is expensive, the desirability of this development rests largely on finding other sites below where head can be created to use the equated flow. It is to be expected that other dam sites exist above and below this point.

Yampa and White rivers known undeveloped power sites.

[Future discharges after irrigation depletion.]

Index number on map.	Stream.	Name.	Reservoir required (acre-feet).	Head.	How created.	Constant discharge (second-feet).	Horse-power output at switchboard 80 per cent efficiency.
13	Yampa	Juniper	1,550,000	150	Dam	1,600	21,800
12		Cross Mountain		100	do	1,600	14,600
11		Lily Park [1]					
15		Upper Bear		100	Dam	150	1,350
17	White	Rangely	330,000	160	do	500	7,300
		Stillwater [1]					
	Little Snake [1]						

[1] No data.

Some idea of the total power possible to generate if dam sites can be found is given by the following:

	Feet.
White River:	
Elevation outlets, Rangely reservoir	4,960
Elevation water surface at mouth	4,640
Total fall in 70 miles	320
Yampa River:	
Elevation outlets, Juniper reservoir	6,090
Elevation water surface at mouth	4,880
Total fall in 70 miles	1,210

VERMILLION CREEK.

This drains the extreme northwest corner of Colorado and a small part of Wyoming, flowing directly into the Green River. The irrigable areas are limited only by water supply. Little is known of the physical features and costs. Climatic conditions are about the same as for the Yampa Basin, except that precipitation probably does not exceed 9 inches. Altitude 5,200–6,000 feet. Soil is said to be fertile and well drained and the topography is smooth.

Water supply data are very meager. The drainage area is 1,917 square miles. Discharge records were kept for a part of 1910 and January to November of 1911. There is little mountain drainage area and discharge is very erratic. The total discharge in 1911 was 107,000 acre-feet with 65,000 occurring in March.

Large reservoir capacity will be needed because of erratic discharge. An excellent dam site has been located and a low-cost reservoir is apparently available.

Based on 1911 record, 40,000 acres could be irrigated if floods were stored. Because of uncertainty the total is placed here at 20,000 acres.

UINTA BASIN, UTAH.

The Uinta Basin lies in northeastern Utah, and the term as used here includes the area drained by the Duchesne River and Ashley Creek, both of which rise on the precipitous eastern slopes of the Uinta Range and flow eastward to the Green River. Most of the area is included in the Uinta Indian Reservation.

The irrigable lands in the basin range in altitude from 5,000 to 6,500 feet. Precipitation on the valley floor is from 8 inches to 10 inches annually, of which from 5 to 6 inches falls during irrigation season.

Stock growing is the principal industry, but coal is found and large deposits of minerals derived from asphalt exist, which would, if railroads entered the valley, form a considerable industry.

Outlet from the valley is by stage and truck southward about 100 miles to Price and Helper on the Denver & Rio Grande Railroad. The Moffatt Road, the Los Angeles and Salt Lake and lately a local line from Salt Lake called the Bamberger Railroad have all surveyed through the valley, and it is to be expected one of these will be built.

In 1920 there were 171,000 acres irrigated in the basin and estimates of irrigable land give a total ultimate of 300,000 acres.

Consumptive use of water is taken at 1.5 acre-feet per year, because with the exception of the Duchesne bottoms natural drainage is good. The 129,000 acres estimated increase will on this basis decrease the annual discharge 194,000 acre-feet.

Agriculture is pursued principally to supplement feed of the open range, so that most of the crop is hay. Climate will permit considerable diversification of crops, however. The mean annual temperature is 44°, with the irrigation season five months—May to September.

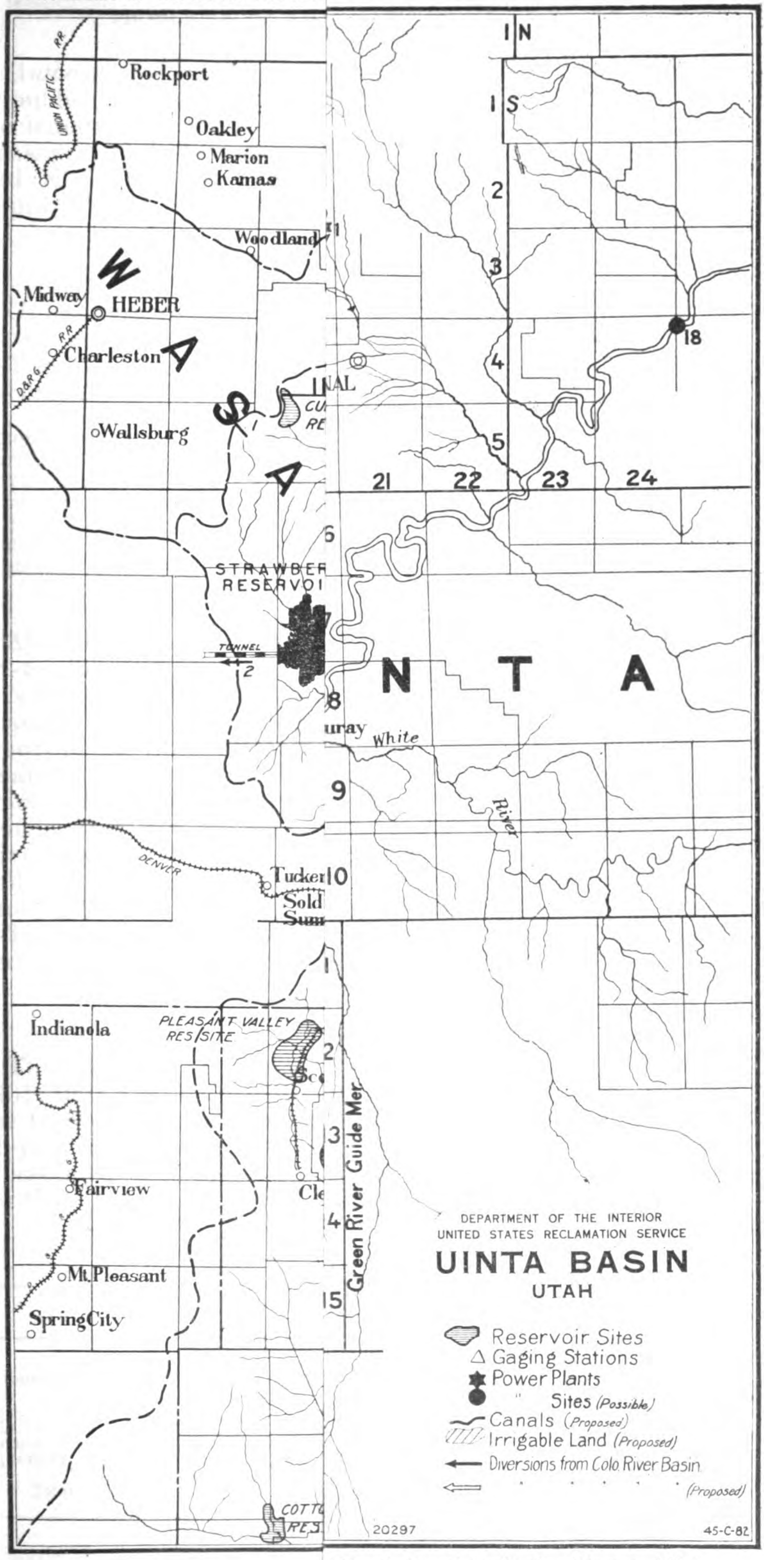
The principal town of the basin is Vernal. Other small towns are Duchesne, Myton, and Fort Duchesne.

FUTURE DEVELOPMENT.

On the map the total estimated ultimate and present irrigable areas are shown without being differentiated. Only the proposed Castle Peak project is denoted by name. It is not practicable to separate ultimate from present areas as has been done on other maps.

No attempt will be made to describe the many small extensions to the irrigated area which, added together, will make the total of 300,000 acres. A large part of this is already under ditch constructed by the United States Indian Service, which covers 79,000 acres, of which 52,000 acres were irrigated in 1920. Complete utilization of the water of the basin is not possible, because the precipitous mountains, where the streams originate, give little opportunity for reservoirs.

It is expected that future development will build what reservoirs are possible. There are many small lakes which can be used, although at great expense, and there are a few small reservoir sites. It is also expected that where lands are available for comparatively easy irrigation, ditches will be extended in full expectation of receiving no water after July 1 in any year.


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
UINTA BASIN
UTAH
Reservoir Sites
Gaging Stations
Power Plants
" Sites (Possible)
Canals (Proposed)
Irrigable Land (Proposed)
Diversions from Colo. River Basin
(Proposed)
20297
45-C-82
Rockport
Oakley
Marion
Kamas
Woodland
Midway
HEBER
Charleston
Wallsburg
STRAWBER
RESERVOI
TUNNEL
Tucker
Sold
Indianola
PLEASANT VALLEY RES SITE
Fairview
Mt. Pleasant
Spring City
Green River Guide Mer.
White River
UNION PACIFIC RR
D.&R.G. RR
DENVER
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18

Authorities.—Information is derived largely from W. R. Parkhill's unpublished report "Uinta Basin," October, 1917, United States Reclamation Service, W. R. Drager's unpublished report, "Castle Peak project," December, 1920, United States Reclamation Service, and E. C. LaRue's "Colorado River and its Utilization," Water Supply Paper 395, 1916.

ASHLEY CREEK.

Unless reservoir sites can be found, the present irrigated area of 30,000 acres represents the limit of development from Ashley Creek.

The total average annual flow of Ashley Creek is as follows, above diversions:

	Acre-feet.
October to March	17,000
April	5,800
May	32,700
June	24,000
July	8,200
August	5,500
September	4,400
Total	97,600

After July 1 the present irrigated lands receive on the average only six-tenths of an acre-foot of water aside from the return flow available.

No large reservoir sites which are feasible are known, although some possible ones in the stream bed are mentioned in the third annual report of the United States Reclamation Service; also there are many small lakes in the headwaters which can be utilized for storage reservoirs. These lakes average about 20 acres in area and evidently neither they nor the sites just mentioned are attractive. With the advent of a railroad in the valley changed conditions may result in building reservoirs to relieve the present very severe late-season shortage of water.

These reservoirs, if built, will serve present lands, and it is assumed here that no extension of irrigation will result.

UINTA AND WHITEROCKS BASINS.

The discharge of these two streams was measured for six years—1901–1903 and 1908–1910. The average flow for those six years on the Duchesne River at Myton, Utah, is practically the same as for the 21-year period during which the Duchesne has been measured, and it is assumed that the discharge of the two streams under discussion for these six years also represents a fair average.

Average recorded discharge.

	Uinta.	Whiterocks.	Total.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
October–April	69,900	29,100	99,000
May	31,200	21,300	52,500
June	46,300	28,000	74,300
July	26,200	10,400	36,600
August	19,200	8,800	28,000
September	17,000	9,700	26,700
Total	210,000	107,000	317,000

However, if the extraordinarily high year of 1909 is deducted, the average for the remaining five years is 88 per cent of the long average on the Duchesne River, and this will represent more nearly what the actual supply is. The following table gives this average, while the demand is the diversion for 57,300 acres irrigated in 1918 as given by Federal court commissioner:

Estimated average annual discharge.

	Supply.	Demand.		Surplus.
		Total.	Per acre.	
	Acre-feet.	*Acre-feet.*	*Acre-foot.*	*Acre-feet.*
October to April	98,000	....	....	98,000
May	56,000	25,000	0.44	31,000
June	59,000	50,000	.88	9,000
July	32,000	25,000	.44	7,000
August	24,000	15,000	.26	9,000
September	20,000	5,000	.09	15,000

The irrigable area is stated by Parkhill to be 66,000 acres. The draft of 1918 is probably less than for most years because there was a shortage of water. However, on Ashley Creek the average supply after July 1 is only 0.6 acre-foot per acre. If this same ratio could be ultimately attained in the Uinta and Whiterocks basins, the area irrigated would be 120,000 acres. Conditions are different in the two basins. Return flow is not all available in the latter and some of the irrigable land is bench land. It seems probable that the acreage from the river direct without storage can be increased to not more than the 66,000 acres given by Parkhill.

There is also possibility of extending by storage. One off-stream reservoir site of approximately 12,000 acre-foot capacity has been located near the center of township 6 north, range 1 east, and by use of this, replacement storage can be provided for a diversion of direct flow farther upstream. This water can be taken to 12,000 acres east of Duchesne River, called Colorado Park, although construction of such a project will be difficult.

The average supply noted in the foregoing table shows that there is ample supply for the reservoir and there is a possibility of securing some storage in small lakes at the headwaters.

Estimated acreage.

	Acres.
Present irrigated	57,000
Increase without storage	9,000
Increase with storage	12,000
Total ultimate	78,000

DRY GULCH.

From Dry Gulch there is an estimated 10,000 acres irrigated at present without possibility of increase.

LAKE FORK.

The discharge of Lake Fork at Myton, which is below practically all irrigation, has been recorded during the following periods, 1901–1903, 1908–1910, 1912–1920:

Average annual discharge.

	Acre-feet.
October to April	50,000
May	27,000
June	60,000
July	15,000
August	6,000
September	7,000
Total	165,000

In comparatively high years the discharge is all diverted by July 20, and in extremely low years there is a surplus only during the peak of the flood period, which may last for 15 to 30 days. Parkhill gives the irrigable acreage at 71,000, while the Federal court commissioner shows that 50,500 acres were irrigated in 1918.

Known reservoir sites exist as follows:

	Acre-feet.
Moon Lake	38,000
Brown Duck Lake (probably not more than)	2,000
Total	40,000

To fill these, there is the winter discharge—October to April—and the flood undivertible at present, which in the lowest year, 1919, was 19,000 acre-feet and in the next lowest was 35,000 acre-feet. In other years there is much more, so that it may be assumed that water supply is sufficient for the 20,500 acres of additional irrigable land.

In the ordinary low year the entire discharge of the river is now diverted after July 1, so that all supply for new acreage must come after that time from storage.

The demand per acre is estimated as follows:

	Acre-foot
May	0.60
June	.75
July	.75
August	.60
September	.15
Total	2.85

This means that 1.50 acre-feet per acre must come from storage, or for the 20,400 acres the total storage required is 32,000 acre-feet.

	Acres.
Present irrigated	50,500
Future extension	20,500
Total	71,000

DUCHESNE RIVER.

[Including Rock Creek and Strawberry River.]

An analysis of water supply for these streams was made in the recent Reclamation Service report noted under "Authorities" from which most of the following is summarized:

CASTLE PEAK PROJECT.

Net area, 48,000 acres.

Irrigation plan—Main canal.—The proposed diversion on the Duchesne is located 5 miles below the mouth of the Strawberry River, or about 9 miles below the Starvation reservoir. The first division of the main canal extends from the headworks to the proposed tunnel through the Myton Bench, a total length of 12 miles, and follows the contour of the hills about on the toe of slope for the greater part of the distance. The Myton Tunnel, 9,200 feet long, will deliver water in Pleasant Valley at an elevation of 5,345 feet. The second division will extend across Pleasant Valley and the South Myton Bench, a distance of 8 miles, to Tunnel No. 2, the greater part of this division being in gently sloping ground. The third division is 5 miles in length beginning with Tunnel No. 2, 1,600 feet long, and crosses the bad lands, having many structures and being in rock cut for practically its entire length. The fourth and last division of the main canal crosses the Pariette Bench lands in comparatively smooth country and has a total length of 9 miles.

Storage.—Ninety-five thousand acre-feet are to be provided at Starvation reservoir 4 miles above the town of Duchesne. Supply to the reservoir to be supplemented by a 400 second-foot canal diverting from Duchesne River above Rock Creek junction.

Water supply.—After allowing for prior rights and assuming that all old lands below Myton will be watered from return flow, it requires all of Strawberry River plus the Duchesne River above Rock Creek to supply the demands of the project.

Assumed duty.	Acre-feet per acre.
April	0.15
May	.75
June	.97
July	.98
August	.75
September	.15
Total	3.75

Total demand.—One hundred and eighty thousand acre-feet.

Conclusion.—Project not feasible now, because of high cost of reservoir. Placed in class C.

ROCK CREEK.

The irrigable area is 23,800 acres from this creek, of which 4,100 acres are now irrigated.

Average annual discharge.

	Estimated annual discharge, Rock Creek average.	Acre-feet demand (3.05 per acre).	Shortage
October to March	21,000		
April	4,000	3,000	
May	15,000	14,000	
June	32,000	19,000	
July	7,000	19,000	12,000
August	3,500	14,000	10,500
September	3,500	3,000	500
Total	86,000	72,000	23,000

	Acre-feet.
Storage required, average year	23,000
Storage which should be built	40,000

Reservoir.—Reservoir available is Stillwater site on Rock Creek of 40,000 acre-feet capacity.

Summary of Duchesne River.

	Irrigated, 1920.	Unirrigated but having rights.	Additional possible.	Total.
Duchesne River:				
Below Myton	1,300	5,400		6,700
Above Myton	6,700	11,900		18,600
Above Castle Peak diversion	11,100	2,800		13,900
Rock Creek	4,100	19,700		23,800
Castle Peak project			48,000	48,000
Total	23,200	39,800	48,000	111,000

This does not contemplate so large a development comparatively as the other streams in the basin, but easily irrigated lands are not available.

Summary of entire Uinta Basin.

	Irrigated, 1920.	Additional possible.	Total ultimate.
Ashley Creek	30,000		30,000
Uinta-Whiterocks	57,000	21,000	78,000
Dry Gulch	10,000		10,000
Lake Fork	50,500	20,500	71,000
Duchesne River and tributaries	23,200	87,800	111,000
Total	170,700	129,300	300,000

POWER.

Because reservoirs are lacking for good regulation of the streams, development of power will be very limited. Some power has been developed, but information is lacking as to possibilities. Probably the headwaters with their precipitous slope offer opportunity for small plants.

Existing power plants.

[Data from E. C. La Rue—W. S. P. 395, p. 174.]

Index number on map.	Name of plant.	Stream.	Operating head.	Installed capacity.	
				Kilowatts.[1]	Horsepower.[2]
1	Ashley Creek	Ashley Creek	84	250	400
2	Myton	Lake Fork	....	150	250

Known undeveloped power sites.

Index number on map.	Stream.	Horsepower at switchboard, 80 per cent efficiency.
22	Ashley Creek	18,900
23	Duchesne River	8,760
	Total	27,660

[1] Rated capacity of generators.
[2] Rated capacity of water wheels.

NOTE.—For discussion of Nos. 18 to 21, which are shown on Uinta Basin map but which are on Green River, see section headed "Power."

DIVERSIONS OUT OF BASIN.

Three are in operation and one proposed, which is believed infeasible because of lack of water supply.

These are shown on map described in the portion of the report devoted to a discussion of these diversions.

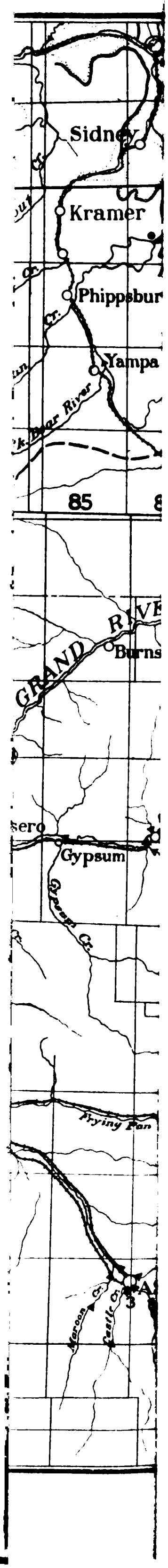
Index number on map.	Name.	Average acre-feet diverted annually.
1	Daniels Pass	4,500
2	Strawberry	78,000
3	Soldiers Summit	1,500
	Total	84,000

GRAND RIVER BASIN—MAIN STEM AND GUNNISON AND DOLORES BASINS.

GRAND RIVER BASIN, COLORADO-UTAH.

The Grand River drains 26,000 miles of area, of which 4,000 are in Utah. The remainder is in Colorado, and this area furnishes 40 per cent of the discharge of the Colorado at Yuma. Its basin has a very large, high mountain area, on the slopes of which precipitation is heavy.

For convenience of description, the basin may be divided into three areas, the main stem of the Grand, the Gunnison, and the Dolores, which are discussed in the following pages under separate headings.



Sidney
Kramer
Phippsbur
Yampa
Bear River
85
GRAND RIVE
Burns
sero
Gypsum
Gypsum Cr.
Frying Pan
Maroon Cr.
Castle Cr.
3

General data.—Summary of information contained in following pages:

Irrigation.

	Present irrigated.	Estimated future additional.	Total ultimate.
	Acres.	*Acres.*	*Acres.*
Main stream	264,000	163,000	427,000
Gunnison	245,000	100,000	345,000
Dolores [1]	46,000	139,000	185,000
Total	555,000	402,000	957,000

[1] In addition there are 105,000 acres estimated to be irrigable from the Dolores but lying in the San Juan River Basin.

Irrigation by States.

	Present irrigated.	Estimated future additional.	Total ultimate.
	Acres.	*Acres.*	*Acres.*
Utah	13,000	....	13,000
Colorado	542,000	402,000	944,000
Total	555,000	402,000	957,000

Diversions out of basin.

[Acre-feet annually.]

	Present.	Estimated future additional.	Total ultimate.
Main stream [1]	17,500	315,500	333,000
Gunnison [1]	2,500	1,500	4,000
Dolores [2]	....	210,000	210,000
Total	20,000	527,000	547,000

[1] Out of Colorado Basin.
[2] To San Juan, which is in Colorado Basin.

Average annual stream discharge at mouth of river.

	Acre-feet.	Acre-feet.	Acre-feet.
Estimated average flow since 1899			6,940,000
Decrease by development above during period:			
Increased diversions out of basins	20,000		
Increased use for irrigation	250,000		
		270,000	
Estimated future decrease:			
Diversions out of basin	527,000		
Irrigation use in basin	558,000		
		1,080,000	
			1,350,000
Estimated future discharge			5,590,000

DEWEY RESERVOIR.

Kremmling reservoir is discussed in the following section devoted to main stem of Grand River. There remains, for the purpose of this report, only the Dewey, which is below the junction of all three main streams of the Grand River basin. A dam just below the mouth of the Dolores will impound 2,270,000 acre-feet by raising the water surface 215 feet. Further raise would cover the tracks of the main line of the Denver & Rio Grande Railroad. This reservoir is part of the plan of storage on tributaries for the Imperial Valley and is the most valuable site on the tributaries for that purpose.

Silt.—It has been estimated that the river carries 10,000 acre-feet of silt annually past this site, which will necessitate some provision for silt storage.

Power.—To equate the river for power here would require roughly between 4,000,000 and 4,500,000 acre-feet of storage. It is impossible to secure so much storage because of the Denver & Rio Grande Railroad, but if, of the 215 raise, the upper 65 feet be devoted to regulating storage which will give 1,500,000 acre-feet, 770,000 acre-feet of dead or silt storage and 150 of head for power will result. Below the reservoir site the river flows 125 miles to its junction with the Green to form the Colorado, and has a total fall of 200 feet in addition to what can be created at the reservoir.

Potential continuous horsepower at turbine, 88 per cent efficiency, is as follows:

At dam site	90,000
Between dam and mouth	120,000
Total	210,000

MAIN STEM OF GRAND RIVER.

The Grand joins the Green in Utah to form the Colorado. The general course of the river is southwest from the high mountains of the Continental Divide. Irrigation diversion from the tributaries, both at the headwaters and along the river, is comparatively easy and water abundant, so that until in the vicinity of Grand Junction development to date has been by individual effort.

As it flows westward from the mountains the river has cut its way deep into the soft, sedimentary rocks which characterize the Colorado Basin. Long narrow valleys alternate with deep canyons with the result that from the main river in this region there will never be any great amount of irrigation. Lower down in the vicinity of Grand Junction the valley has been eroded into comparatively broad mesas which can be reached by long ditches from the river. Here is a compact body of irrigable land which is now covered by private ditches and by the Grand Valley project of the Reclamation Service.

Down river from this project, which is close to the Colorado-Utah line, the river flows in deep canyons from which it is impossible to divert for irrigation. One known reservoir site exists at Dewey where the Dolores River enters the Grand. This site, the Dewey, is part of the plan for developing storage on tributaries for Imperial Valley.

Precipitation ranges from 8 inches at Grand Junction on the west to 24 inches at Breckenridge on the east and much more in the mountain areas. A little over 50 per cent comes in the growing season and about 35 per cent May to August, inclusive. The average summer period between frosts ranges from 180 days at Grand Junction to 35 days at Breckenridge. Elevation of irrigable land ranges from 4,500 on the west to 9,500 on the east. Mean annual temperature ranges from 33° to 52°, increasing toward the west with decrease in elevation. The irrigation season at Grand Junction is 7 months, April to October, inclusive, but in the higher parts water is diverted only for the usual 60 to 90 days for wild hay.

Agricultural products vary from those possible with the intensive cultivation which may be maintained at Grand Junction to wild hay and timothy in the higher parts. At Grand Junction and vicinity apples and peaches comprise a considerable acreage.

Transportation is furnished by the main line of the Denver & Rio Grande Railroad, which parallels the river almost from end to end. In the eastern part the Denver & Salt Lake Railroad serves a small part of the valley.

Not enough information is at hand to estimate average diversion duty for new lands, but for the entire average of the basin a consumptive use of 1.5 feet in depth is estimated.

Power development is already extensive on the headwaters and there is opportunity for large addition to this. The steep grade of the streams and the well-sustained stream flow are favorable to power developments. Along the main stream in Colorado at several places power can be developed and at Dewey reservoir the stream can be largely equated for power. Kremmling reservoir, if built, would give considerable increase to all-year power below it.

AUTHORITIES.

Data is taken from compilations and information furnished by R. I. Meeker, special deputy State engineer, and from publications of the Reclamation Service concerning Grand Valley project.

GENERAL DATA.

Irrigation development (acres).

	Present.	Estimated additional possible.	Total ultimate.
Utah	13,000	....	13,000
Colorado	251,000	163,000	414,000
Total	264,000	163,000	427,000

Future annual decrease in stream discharge.

	Acre-feet.
Diversions from basin:	
By extension and betterments	15,000
By new projects	300,000
Consumed in irrigation, 163,000 acres, at 1.5 acre-feet per acre	244,000
Total decrease	559,000
In round figures, say	560,000

Future development.—Out of the 163,000 acres listed as possible ultimate, 39,000 acres are in the Grand Valley project; 7,000 acres in Orchard Mesa, which possibly will be taken over by the Reclamation Service; and 15,000 acres in areas large enough to warrant being termed a project. This latter is the Plateau project of 15,000 acres from Plateau Creek, concerning which no data are at hand.

The remainder of the estimated future development is in small areas which it is assumed will be reclaimed by individual efforts.

Classification of future irrigation.

	Under existing canals near Grand Junction.	Class A.	Class B.	Class C.	Class X.
Grand Valley	46,000				
Pumping extension (Government)		10,000			
All other					117,000
Total	46,000	10,000	0	0	117.000

DIVERSIONS FROM BASIN.

These are discussed fully in the part of this report devoted to "Diversions out of Colorado River Basin", p. 173, and are here listed for convenience.

Operating diversions.

[Not shown on general map.]

Name.	From.	Annual diversion.
		Acre-feet.
Grand River	North Fork of Grand	15,000
Church	Fraser	500
Boreas	Blue	800
Ewing Placer	Eagle	2,500
Total		18,800
Possible increase by enlargement and betterment		15,500
Grand total		34,300

Proposed diversions.

Index number on map.	Name.	From.	Annual diversion.
			Acre-feet.
6	Fraser River	Fraser	110,000
8	Williams Fork	Williams Fork	50,000
9	Blue River	Blue and Ten Mile	100,000
12	Eagle River	Eagle and Ten Mile	40,000
	Total		300,000

POWER.

Up to the present, horse-power development on this stream is larger than any other part of the entire basin. Doubtless opportunity exists for development at sites at present unknown.

Known power possibilities are in Gore Canyon below Kremmling reservoir site and at Dewey, where the flow can be regulated by Dewey reservoir.

GORE CANYON POWER SITE AND KREMMLING RESERVOIR.

Gore Canyon is immediately below the Kremmling reservoir site on upper Grand River, and is about 3½ miles long. The Central Colorado Power Co. investigated the feasibility of developing power in this canyon. In an 8-mile section of the river, beginning at the railroad station of Gore, the fall is 420 feet. Owing to the precipitous canyon walls, the river can not be feasibly diverted except into tunnel. By constructing a tunnel 24,000 feet long, a head of 411 feet can be obtained. By utilizing the Kremmling reservoir site a mean flow of 1,600 second-feet could be secured and about 60,000 brake horsepower could be developed.

Kremmling reservoir would be unsuitable for use in development of the lower Colorado, because it is located so far away and because such use is not compatible with the best development of the river on account of interference with power. The Denver & Salt Lake Railroad passes through the reservoir site and dam site, and large expense will be involved in the removal of this should the reservoir be built.

Existing power plants—Grand River, main stem.

[E. C. La Rue; Water Supply Paper No. 395, p. 174.]

Name.	Location.		Operating head.	Installed capacity.		Index No.
	Stream.	State and county.		Kilowatts.[1]	Horsepower.[2]	
		COLORADO.	*Feet.*			
Spruce Creek	Spruce Creek	Summit	250	450	[3] 700	10
Summit County	Snake Creek	...do	500	1,000	1,600	19
Shoshone	Grand River	Garfield	175	10,000	18,000	4
	Maroon Creek	Pitkin	356	400		
Castle Creek	Castle Creek	...do	340	400	2,900	3
	Hunter Creek	...do	876	800		
Yule Creek	Yule Creek	Gunnison	90	300	424	6
Crystal River	Crystal River	...do	390	1,300	1,750	5
Osgood	...do	Pitkin		65	85	7
Rifle	Rifle Creek	Garfield	70	150	247	8
Hinsdale	Lake Fork	Hinsdale	65	200	160	17
Hidden Treasure	Henson Creek	...do	90	128	321	16
				15,193	26,187	

[1] Figures represent rated capacity of generators.
[2] Figures represent rated capacity of water wheels.
[3] Two plants.

Known undeveloped power sites.

[E. C. La Rue, Water Supply Paper No. 395, p. 181.]

Name.	Stream.	State.	Estimate of available horsepower.	Index No.
Gore Canyon	Grand River	Colorado	60,000	25
Dewey	...do	Utah	82,000	24
Total			142,000	

GUNNISON RIVER.

The Gunnison River which is the main tributary of the Grand enters it from the south at the city of Grand Junction. It drains a roughly triangular area bounded on the east by the Continental Divide, which, also with the Uncompahgre Mountains, forms the southern boundary. On the north its boundary is the range between the main stem of the Grand and the Gunnison.

Like other streams in the Colorado Basin the valley is comparatively open in the eastern part before leaving the slopes of the Continental Divide, but with distance to the west the soft sedimentary rocks of the great plateau region are reached and here the river has cut deep canyons below the surrounding country which preclude irrigation diversion but which may give opportunity for high dams whereby hydropower can be created.

Irrigation development up to the present has been largely by individual effort, but one large project of 100,000 acres, called the Uncompahgre, has been constructed by the Reclamation Service and furnished a water supply by diverting the waters of the main Gunnison through a 6-mile tunnel to the broad valley below the surrounding mesas which has been formed by the Uncompahgre River, one of the main tributaries of the Gunnison.

Precipitation ranges from 8 inches at Delta, in the Uncompahgre Valley, which is in the western part, to about 18 inches in the eastern and higher parts, but most of the irrigable lands have precipitation running from 8 to 10 inches, of which practically 50 per cent occurs in the growing season. The average summer period between frosts ranges from 140 days at Delta to 65 days at Gunnison and is less at higher altitudes. Elevation of irrigable lands ranges from 5,000 at Delta to 7,700 at Gunnison, and of course irrigation in mountain valleys is found at much higher altitudes. Mean annual temperatures lie between the extremes of 50° on the west at Delta to 37° at Gunnison and are lower with higher altitudes.

The irrigation season on the Uncompahgre project is from the middle of April until the middle of October, but decreases from that with increase in elevation to 60 or 90 days for wild hay lands in the higher altitudes.

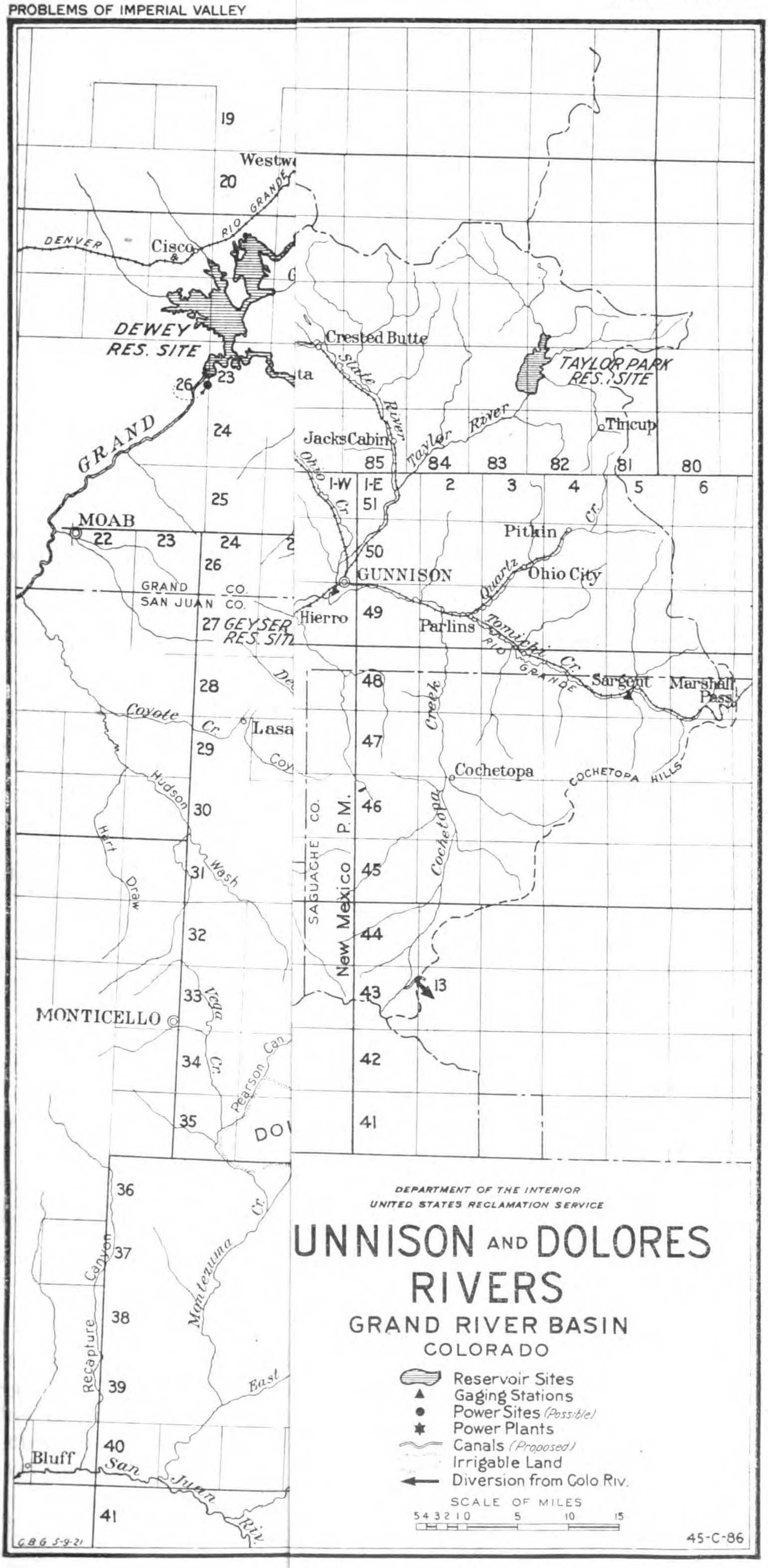
Agricultural products are those of diversified farming in the western part to wild hay, which is the main crop in the higher portions.

Transportation is furnished by a standard gage branch of the Denver & Rio Grande, which extends from Grand Junction to Montrose and from Delta up the North Fork. A narrow gage branch of the Denver & Rio Grande extends from Montrose south to Ouray and beyond, and also from Montrose east to Salida, where it connects with the standard gage. As a whole, the valley is exceptionally well provided with transportation as compared with most of the valleys of the Upper Colorado Basin.

Not enough data are at hand to estimate diversion for new lands, but for the entire average and considering the aridity of the basin the consumptive use of water is estimated at 1.5 feet in depth in spite of the short growing season.

Three small power plants on the tributaries, aggregating 3,000 horsepower, have been built to date. It is probable that other desirable sites exist on the tributaries, but no data concerning them are at hand. A possible site exists just below Montrose.

PLATE XXVI


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
UNNISON AND DOLORES
RIVERS
GRAND RIVER BASIN
COLORADO
Reservoir Sites
Gaging Stations
Power Sites (Possible)
Power Plants
Canals (Proposed)
Irrigable Land
Diversion from Colo Riv.
SCALE OF MILES
5 4 3 2 1 0
5
10
15
45-C-86
C.B.G. 5-9-21
DEWEY RES. SITE
TAYLOR PARK RES. SITE
GEYSER RES. SITE
Cisco
Crested Butte
Jacks Cabin
Tincup
MOAB
GUNNISON
Pitkin
Ohio City
Hierro
Parlins
Sargent
Marshall Pass
Lasa
Cochetopa
COCHETOPA HILLS
MONTICELLO
Bluff
GRAND
DENVER
RIO GRANDE
Slate River
Taylor River
Ohio Cr.
Quartz Cr.
Tomichi Cr.
Creek
Cochetopa
Coyote Cr.
Hudson Wash
Hart Draw
Vega Cr.
Pearson Can.
Montezuma Cr.
Recapture Canyon
East
San Juan Riv.
GRAND CO.
SAN JUAN CO.
SAGUACHE CO.
New Mexico P. M.
I-W
I-E

AUTHORITIES.

Data are taken from compilations and information furnished by R. I. Meeker, special deputy State engineer, and from publications of the Reclamation Service concerning the Uncompahgre project.

General data.

	Acres.
Irrigation development:	
Present irrigated acreage	245,000
Estimated additional	100,000
Total ultimate	345,000
Future decrease in stream discharge:	
Diverted to basin from San Miguel	15,000
Diverted out of basin to Rio Grande	2,000
Consumed in irrigation, 100,000 acres, at 1.5 acre feet per acre	150,000
Total	167,000

Future development.—Out of the 100,000 acres listed as future possibilities, 35,000 acres are in the Uncompahgre project, but at present unirrigated, and 20,000 acres in the proposed Montrose Chief project. The remainder is small areas expected to be reclaimed by individual effort.

Very meager data are at hand concerning the Montrose Chief project. The proposed irrigation plan is to divert from the San Miguel drainage 15,000 acre-feet annually and trade water now going to the Uncompahgre project which may be diverted on that project. The Uncompahgre project is contemplating storage at Taylor Park reservoir site to supplement the late water flow, which fact points to a possible error in assumptions on which plans for the Montrose Chief are based. However, if return flow is not divertible, arrangements might be made for replacement storage. The Montrose Chief project contemplates two reservoirs.

For 20,000 acres 50,000 acre-feet for diversion should be provided, and it is expected that the remainder necessary can be secured from the headwaters of the Uncompahgre.

Classification of future irrigation.

	Under Government canals.	Class A.	Class B.	Class C.	Class X.
Uncompahgre	35,000				
Montrose Chief			20,000		
Individual efforts					45,000
Total	35,000	0	20,000	0	45,000

DIVERSIONS FROM BASIN.

One is in operation diverting at Cochetopa Pass (13) from the creek of that name to the Saguache, a tributary of the Rio Grande. This is now estimated to average 2,500 acre-feet annually and expected betterments will increase this to 4,000 acre-feet. No other diversions are proposed.

Existing power plants, Gunnison River—Grand River Basin.

[E. C. La Rue, W. S. 395, p. 174.]

Name.	Location.			Operating head.	Installed capacity.	
	Stream.	County.	State.		Kilowatts.[1]	Horsepower.[2]
				Feet.		
Ames	Howards Fork	San Miguel	Colorado	580	3,600	6,200
	Lake Fork			835		
Ilium	South Fork	do	do	490	1,200	1,600

[1] Figures represent rated capacity of generators.
[2] Figures represent rated capacity of water wheels.

POWER SITES.

Only one is known, which is at Montrose. No data available.

DOLORES RIVER DRAINAGE.

The Dolores River, together with its principal tributary, the San Miguel, drains a roughly rectangular area 60 miles wide and 100 miles long between the Gunnison and San Juan watersheds, with its principal axis in a southeast-northwest direction. The area is in general a high plateau warped and eroded to a high degree. The Uncompahgre plateau, in reality a broad topped mountain range of 8,000 to 9,000 foot elevation, borders the northern side. The western tip of the San Juan Range forms the eastern tip of the area and the La Plata Range forms the southeastern boundary. The southerly boundary is a low divide on the eastern end, succeeded in the southwest corner by the La Sal mountains which cover much of the western corner of the area and reach altitudes exceeding 12,000 feet. The easterly end of the entire drainage area is roughly bisected by the low San Miguel range.

With the exception of the higher mountains the entire area is composed of relatively soft sedimentary rocks through which all living streams have readily cut canyons whose depths rapidly increase as the headwaters are left and then decrease as the central position of the main valley is approached.

The Dolores River drains the southern slope of the San Miguel range and part of the La Plata mountains along the southeastern border of the area, and after skirting the southwestern edge of the plateau for 50 miles, turns abruptly north, breaking through numerous ridges, joins the San Miguel River and resumes its northwesterly route to the Grand River. The San Miguel River drains the northern slopes of the San Miguel range, the western tip of the San Juan Range, and a part of the Uncompahgre plateau.

Irrigation development is largely confined to the central region bounded by the Dolores River on the south and west, the San Miguel range on the east, and the San Miguel River on the north. This region is a secondary plateau sloping steeply to the west and consisting of parallel ridges and valleys running northwest-southeast. Water can be supplied to this region from creeks heading in the San Miguel range or from San Miguel River but not from the Dolores River owing to the depth of its canyon. Outside this area either the topography is too rugged or the concentration of water supply insufficient for irrigation development except in small isolated tracts usually at high altitudes. Elevations range from 13,000 in the San Juan mountains to 4,000 at the mouth of the Dolores River, with the plateau region generally from 6,000 to 8,000. Precipitation ranges from 50 inches or more in the highest mountains to less than 10 inches at the lower end. In the mesa region, where irrigation development is most feasible, the rainfall is 13 to 20 inches, of which roughly one-half comes in the growing season. The mean annual temperature is 40 to 48 degrees. The growing season is comparatively long, considering mean temperatures, being frost free from 110 to 140 days. Under these conditions, an average diversion of 2 acre-feet per acre will probably prove sufficient. Practically all of the region has a "chocolate" loam soil of 5 to 30 foot depth, underlain with shale and sandstone. Natural drainage will prevent water-logging over most of the areas. A consumptive use of 1.25 acre-feet per acre of diverted water would seem ample allowance under these conditions.

The San Miguel River by reason of its high drainage area has a well-sustained summer flow, the Dolores falling off in June for lack of similar high drainage area. The combined run-off of these streams averages 730,000 acre-feet annually.

The data here given are based on information obtained from United States Geological Survey Water Supply Papers, and particularly No. 395 (E. C. La Rue), from reports by the State engineer of Colorado, from unpublished reports to the Reclamation Service by C. B. Smith and H. F. Burkhart, from information furnished by private irrigation companies, and from general information.

POWER DEVELOPMENT.

On the headwaters of the San Miguel River near Placerville, three small high head plants have been constructed with an aggregate installation of approximately 5,000 kilowatts.

While definite data are lacking, it is believed that further small developments of the same type as now installed may be feasible on the San Miguel and to a lesser degree on the Dolores watershed. The utmost development by this means would in any event be relatively small and insufficient for transmission to outside markets. On the main rivers, the relatively small flow available during most of the year combined with lack of concentrated fall preclude cheap development. Storage for equating the San Miguel run-off is not available. On the Dolores River this may be done at the Dolores and Bedrock reservoir sites. The former is the only means of utilizing Dolores water for irrigation in Colorado with diversion 173 feet above low water in a 230-foot reservoir.

Under these conditions, a power development without loss of water for irrigation purposes would be impractical. At the Bedrock site there would be no interference with irrigation interests but the development of the Dolores, Montezuma, Disappointment Valley, and West Paradox projects would reduce the present limited water supply from 357,000 acre-feet annually to an estimated 115,000 acre-feet. This flow would be reduced to a very small amount in periods of low run-off and storage sufficient to equalize annual flows would entail heavy evaporation losses and produce a continuous flow of 100 second-feet at most. On the whole, then, it may be said that power in small quantities may be developed on the headwaters of the Dolores River system without interference with irrigation and that power can not be developed on the main rivers at reasonable cost without unwarranted interference with irrigation.

IRRIGATION DEVELOPMENT TO DATE.

With all streams entering rapidly deepening narrow canyons close to their sources at high altitudes, individual development has been largely precluded, and the acreage attributable thereto is negligible. Both the Dolores and San Miguel rivers receive their supply from a large number of small streams, none of which carries sufficient water for any extensive area. Developments on the San Miguel drainage area usually have the alternative of a long canal intercepting a number of tributaries, or an equally long or longer canal through difficult country from the main river.

The former in every case requires storage as the smaller streams lack late summer water, while diversions from the main stream though expensive usually require little storage. In either case construction costs can be brought within feasible limits only by the inclusion of moderately large areas, requiring an initial investment of an amount not readily obtainable for a district so unfavorably situated. Many projects have, therefore, been initiated and in many cases considerable sums spent for construction but none has been completed.

In the Dolores River drainage the lack of cheap storage facilities in the headwaters and extremely rough topography along the main stream preclude development from the main stream except by diversion to the San Juan drainage basin, where 25,000 acres have been developed on the Montezuma project. The lack of late summer flow on tributaries of the Dolores has kept developments on them to a minimum.

The present irrigated areas are as follows:

Irrigated areas.

Canal system.	Water supply.	Reservoirs.	Area irrigated.
SAN MIGUEL DRAINAGE.			*Acres.*
Gurley and Cone	Beaver Creek	Cone, Gurley	10,000
San Miguel	do	None	1,000
Lilylands	Naturita Creek	do	1,000
Nucla Colony	San Miguel River	do	5,000
Scattered	Horsefly, Tabeguache, and Headwater tributaries.	do	7,000
			24,000
DOLORES DRAINAGE.			
Disappointment	Disappointment Creek	None	2,000
West Paradox	Paradox Creek	Buckeye, Geyser	3,000
Scattered	Various small creeks	None	4,000
			9,000
Total present irrigated area.			33,000

General data—Irrigation.

	Present irrigated area.	Estimated additional.	Total ultimate.
Colorado	58,000	214,000	272,000
Utah		30,000	30,000
Total	[1] 58,000	[2] 244,000	302,000

[1] 25,000 acres on San Juan slope.
[2] 105,000 acres on San Juan slope.

NOTE.—Of this 105,000 acres is in the San Juan Basin by diversion from the Dolores.

FUTURE IRRIGATION DEVELOPMENT.

From the conditions in the Dolores watershed heretofore described, the probable future development may be understood. Further development by individual effort will no doubt be small. For development by organized effort, all projects fall into distinct classes. One of these comprises the smaller projects requiring extension of existing canals and in most cases addition of storage which, although not cheap, can be added from time to time as demand for the irrigated land improves. This class includes the Nucla colony, West Paradox project and scattered areas with present irrigated area of 19,000 acres and additional available area of 28,000 acres. All other projects with 27,000 acres now irrigated and 197,000 additional acres irrigable, fall roughly into a class which does not permit of development by sections. The reasons for this are various and will be described for each project individually. The net result in every case is that the margin between the cost of construction and present value of irrigated land is too small to invite immediate construction. The one factor common to all projects is the lack of good transportation facilities which facilities consist at the present time of a narrow-gage line from 10 to 70 miles from the projects. The probability of the early improvement of transportation facilities was one of the factors promoting the construction of all these projects from 1904 to 1912, during which time large sums were spent for construction on all projects except the Dolores. Actual railroad construction would immediately increase the margin between construction cost for irrigation and value of irrigated lands to a point that might mean the completion of many projects. The various projects and their grouping in line with the classification adopted for projects are as follows:

Classification of projects.

Project.	Area now irrigated.	Additional irrigable areas.			
		Class A.	Class B.	Class C.	Class X.
San Miguel	1,000		60,000		
Lilylands	1,000		15,000		
Nucla colony	5,000	5,000			
Disappointment Valley			17,000		
West Paradox	3,000	10,000			
Scattered	11,000				10,000
Dolores			80,000		
Montezuma	25,000		25,000		
From return flow [1]			22,000		
Total	46,000	15,000	219,000		10,000

[1] Based on reuse of 50 per cent of return flow from projects lying within Dolores drainage area. Return flow 0.75 acre-foot per acre, from 117,000 acres in Dolores Basin. Water reused would be 44,000 acre-feet, or sufficient for 22,000 acres at 2 acre-feet per acre diversion duty. Acreage not distributed to projects.

With the exception of the last two, there are no conflicts in water supply and, in this case, ample storage for the lower diversion will insure effective utilization of available supply. Where natural flow is insufficient for the other projects, storage is usually provided for with the result that all of the above projects may be expected to average 2 acre-feet per acre diversion of which 1.25 acre-feet would be consumed.

The Dolores and Montezuma projects lying outside the Dolores drainage area will entail a total loss equal to their diversions and anticipated transmountain diversions near Ridgeway will take an amount estimated at 15,000 acre-feet annually.

Water-supply conditions for the Dolores drainage as a whole for the future are estimated as follows:

	Acre-feet.
Present outflow from Dolores River:	
Dolores at Bedrock (1918–1920)	357,000
San Miguel at Naturita (1918–1920)	272,000
Inflow below Naturita and Bedrock (estimated)	101,000
Total present outflow	730,000
Future additional diversions:	
Dolores and Montezuma projects: 105,000 acres at 2 acre-feet	210,000
Other projects within basin: 139,000 acres at 1.25 acre-feet	174,000
Transmountain diversions to Gunnison	15,000
Total future abstractions	399,000
Expected future outflow	331,000

Return flow from diversions to the Gunnison River Basin would decrease losses for the Dewey reservoir from 399,000 acre-feet annually to 395,000 acre-feet. Return flow from the Dolores and Montezuma projects would add 63,000 acre-feet annually to the San Juan above Bluff, making a net loss to the Colorado below the mouth of the San Juan of 332,000 acre-feet annually, due to operations in the Dolores drainage.

SAN MIGUEL PROJECT.

Present irrigated area, 1,000 acres; additional irrigable area 60,000 acres.

Mean annual temperature, 47°

Mean annual precipitation, 15 inches.

Mean precipitation during growing season, 8 inches.

Elevation, 6,000–6,500 feet.

Interval between killing frosts (summer), 130 days.

Transportation, Denver & Rio Grande narrow gage; nearest station, Placerville, 40 miles from heart of project.

Irrigation plan.—The project consists of two independent units. The Nelson ditch, heading in Beaver Creek, covers 10,000 acres lying west of Beaver Creek northwest to the San Miguel River. This canal has been constructed with a length of 30 miles, but the system requires storage in Beaver Park to provide the required water supply. It is being operated to provide water for old rights. The San Miguel ditch heads in San Miguel River 7 miles below Placerville, and with a length of 50 miles covers 50,000 acres south and west of Norwood. Short feeders also bring into the main canal unused waters from Beaver and Saltada creeks. The main canal includes 14 miles of flume, 1.6 miles of tunnel, and over 2 miles of siphon, with 220–580 foot head, with most of the expensive work concentrated in the 20-mile section from the head works to the point where irrigable land starts. The only work done on this unit is the benching for the flume.

Duty of water.—A diversion of 2 acre-feet per acre annually is expected to care for the needs of this project.

Water supply.—The water supply for the Nelson ditch unit is Beaver Creek, whose total estimated annual flow of 50,000 acre-feet is subject to prior rights for 7,000 acres under the Gurley ditch. The relation of irrigation demand and supply for an average year under the Nelson ditch system is as follows:

Water supply, Nelson ditch unit.

[Acre-feet.]

Month.	Beaver Creek flow.	Required for prior rights.	Available for Nelson ditch.	Demands for Nelson ditch.	Required storage.
April	11,000	1,100	9,900	1,600	....
May	18,000	2,800	15,200	4,000	....
June	12,000	4,200	7,800	6,000	....
July	3,000	2,800	200	4,000	3,800
August	1,000	2,100	....	3,000	3,000
September	500	1,000	....	1,400	1,400
October	....	....	....	....	....
March	4,500	....	....	....	....
Total	50,000	14,000	....	....	8,200

Storage capacity of 8,200 acre-feet would be required for seasonal regulation in an average year, which would be increased to 12,000 acre-feet to provide for abnormal years and for desirable hold-over. This storage is supposed to be available in Beaver Park.

For the San Miguel Canal unit the relative supply and demand are as follows:

Water supply, San Miguel Canal unit.

[Acre-feet.]

Month.	Available supply.					Prior rights Nucla colony 10,000 acres.	Residue for San Miguel project.	Demand for San Miguel project.
	San Miguel River.	Saltada Creek.	Beaver Creek.[1]	Clay and Horsefly creeks.	Total.			
April	13,800	700	3,000	6,000	23,500	2,000	21,500	8,000
May	42,000	3,500	8,000	9,000	62,500	5,000	57,500	20,000
June	50,400	1,400	4,000	3,000	58,800	7,500	51,300	30,000
July	27,900	500	1,000	1,000	30,400	5,000	25,400	20,000
August	14,300	200	500	500	15,500	3,800	11,700	15,000
September	11,800	200	500	500	13,000	1,700	11,300	7,000
Total	160,200	6,500	17,000	20,000	203,700	25,000	178,700	100,000

[1] Unused by proposed projects above.

There would apparently be some shortage in August of any average year and larger shortages than this table shows would occur in many years but the expense for necessary storage to obviate them would probably not be warranted.

Conclusion.—The Nelson ditch unit of this project requiring practically only the addition of storage for its completion would put it in the class of projects which may be completed very soon if it could be split from the balance of the project. This the controlling interests do not care to do.

The San Miguel ditch unit requires a large investment before any land may be watered, with present conditions for obtaining capital unfavorable.

LILYLANDS PROJECT.

Present irrigated area, 1,000 acres; additional irrigable area, 15,000 acres.

Mean annual temperature, 44°.

Mean annual precipitation, 18 inches.

Mean precipitation in growing season, 10 inches.

Elevation, 6,500 to 7,500 feet.

Interval between killing frosts (summer), 110 days.

Transportation, Denver & Rio Grande narrow gage; nearest station, Placerville, 45 miles from heart of project.

Irrigation plan.—A diversion canal from Naturita Creek and other small creeks at elevation 7,800 has been constructed for a length of 32 miles. Land available for this project far exceeds the available water supply. Long extensions of the feeder canal to Beaver and Fall creeks have been considered and then rejected on account of relatively small amount of water available after other projects develop. The project includes 1,000 acres of land having old rights which have been acquired for the project. Storage of 6,900 acre-feet is to be utilized for distribution of available supplies which come mostly in early summer.

Duty of water.—The duty of water for this project will be less than the average for the Dolores drainage area owing to higher altitude, greater precipitation, and shorter growing season. A diversion duty of 1.5 acre-feet per acre will probably be sufficient.

Water supply.—The supply from Naturita Creek and other streams intercepted by the proposed 32-mile canal, after deduction for prior rights of the Cone ditch, is estimated at 30,000 acre-feet annually, with a requirement of 24,000 acre-feet if a 1.5 acre-foot diversion be permitted.

The small surplus available in an average year indicates probable heavy shortages at frequent intervals, but the reduction in crop returns would not be in the same proportion owing to rainfall and temperature conditions. The project may be expected to develop to this acreage.

The promoters of this project have intended including 25,000 acres, but the lack of water supply has at all times been apparent, and the acreage adopted is probably the maximum that could be supplied.

Storage.—Storage is required for the distribution of the seasonal flow, and a site of 6,900 acre-foot capacity is available. For seasonal distribution 8,000 acre-feet may prove sufficient and fully 15,000 acre-feet would be required to provide a reasonable hold-over.

Conclusion.—This project, owing to its distance from transportation, short growing season, and doubtful water supply, if expanded as intended, will not develop readily and can at most be placed in Class B with the reduced acreage.

NUCLA COLONY.

Present irrigated area, 5,000 acres; additional irrigable area, 5,000 acres.

Mean annual temperature, 48°.

Mean annual precipitation, 14 inches.

Precipitation during growing season, 7 inches.

Elevation, 6,000 feet.

Interval between killing frosts (summer), 140 days.

Transportation, Denver & Rio Grande Railroad, narrow gage; nearest station, Placerville, 45 miles to project.

This project was started by a socialistic colony many years ago, a 16-mile canal being built from San Miguel River. The increase in acreage to the ultimate project will require increased canal capacity and extension of the main canal. The diversion for this area will average 2.5 acre-feet per acre. Having prior rights to the waters of San Miguel River, whose discharge above their headgate averages 270,000 acre-feet annually, the project will enjoy a full water supply at all times without resort to storage.

This project will be one of the first in the Dolores area to be completed, as the construction cost is less than with most projects, and an ample water supply is assured at all times.

DISAPPOINTMENT VALLEY.

Irrigable area, 17,000 acres.

Mean temperature, 46°.

Mean annual precipitation, 15 inches.

Precipitation during growing season, 8 inches.

Elevation, 6,000 feet.

Interval between killing frosts (summer), 140 days.

Transportation, Denver & Rio Grande Railroad, narrow gage; nearest station, Dolores, 50 miles away.

Irrigation plan.—Diversion from Disappointment Creek will be made to T. 42 N., R. 16 W. A feeder canal of 180 second-foot capacity and 6 miles long will deliver water to Custer Draw, where a reservoir of 17,400 acre-foot capacity is to be built. A short outlet canal will deliver stored water to the project lands. The inlet canal to the reservoir has been partially constructed.

Duty of water.—Diversions for this project of 2 acre-feet per acre are expected.

Water supply.—Diversions will be made from Disappointment and Springs creeks, with no records available. The drainage area of the two streams is approximately 200 square miles, with an average elevation of about 8,000, and the annual run-off is estimated at 35,000 acre-feet. With an annual demand of 34,000 acre-feet, the margin of water supply is too narrow to prevent many shortages.

Storage.—For seasonal storage it is estimated that a capacity of 15,000 acre-feet is required, leaving but 2,400 acre-feet of the proposed capacity for hold-over. Frequent shortages are quite certain to occur, though probably not serious enough to warrant reduction in acreage. Data regarding additional available storage are not at hand.

Conclusion.—This project can probably be constructed at less cost than most of the projects of the Dolores drainage area, but the unreliability of water supply, together with its isolated location, does not warrant placing it in the Class A projects.

WEST PARADOX VALLEY.

Present irrigated area, 3,000 acres; additional irrigable area, 10,000 acres.

Mean temperature, 48°.

Mean annual precipitation, 13 inches.

Precipitation during growing season, 6 inches.

Elevation, 5,200 feet.

Interval between killing frosts (summer), 160 days.

Transportation, Denver & Rio Grande Railroad. Placerville, on the narrow-gage line, and Delta, on standard-gage, are 70 to 75 miles away.

Irrigation plan.—Collection canals aggregating 20 miles in length will concentrate waters from West Paradox, Deep, Geyser, and Rock creeks in two reservoirs of 1,240 and 7,000 acre-foot capacity, to be released into West Paradox Creek and diverted lower down. The project has been formed by the consolidation of old ditches for the purpose of providing necessary storage and increasing the total irrigated area.

Duty of water.—Diversions are expected to average 2.5 acre-feet per acre, the longer growing season and higher temperatures demanding a greater diversion than the average over the Dolores drainage area.

Water supply.—All water is derived from Geyser, Deep, La Sal, and West Paradox creeks, which head in the La Sal mountains of Utah, in the western corner of the Dolores drainage area, and flow easterly to the Dolores River.

No records are available on these streams. Their combined drainage area of 180 square miles has an average altitude of 8,000 feet, with 25 square miles exceeding 10,000 feet. The run-off from this area is estimated at 40,000 acre-feet annually, or 3 acre-feet per acre to be irrigated. Owing to the high altitude of parts of the watershed, the spring run-off will last later in the season than on most creeks and will more nearly resemble that of the Dolores River.

Storage.—The amount of storage planned, 8,240 acre-feet, will probably suffice for the distribution of water in ordinary years, but will not do so in abnormal years nor provide hold-over for years of low total run-off. The availability of additional storage capacity is not known.

Conclusion.—This project will probably be built up reasonably soon to the acreage intended, in spite of its distance from railroads, as its crops would be in demand for feeding purposes and for the use of the uranium mining interests close by.

MONTEZUMA PROJECT.

Present irrigated area, 25,000 acres; additional irrigable area, 25,000 acres.

Mean annual temperature, 45°.

Mean annual precipitation, 15 inches.

Precipitation during growing season, 8 inches.

Elevation, 6,000 to 6,500 feet.

Interval between killing frosts (summer), 125 days.

Transportation, Denver & Rio Grande Railroad, narrow gage; nearest station, Dolores, 3 to 15 miles away.

Irrigation plan.—Water is diverted from the Dolores River a short distance below Dolores on the left bank of the river by means of a low concrete dam. Immediately below the headgate a 5,800-foot tunnel takes part of the water and delivers it to the easterly portion of the irrigated area. The remaining water is carried through an 8-mile canal to the Narraguinnep reservoir, with a present storage capacity of 5,600 acre-feet, and then fed to the distribution system covering the western and central portions of the project. The Ground Hog reservoir has been constructed on Ground Hog Creek near Dunton with a capacity of 8,000 acre-feet, but remains unused for lack of repair and because of dangerous leaks. The enlargement necessary to care for the increased area will necessitate enlarged reservoirs and canals. Two small reservoirs are also planned within the project.

Duty of water.—A diversion of 2 acre-feet per acre for this project is believed to be sufficient, considering the rainfall.

Water supply.—Aside from a small amount of surface run-off and return flow available within the project, all water is derived from the Dolores River. The relation of supply to demand at the intake is estimated to be as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Discharge of Dolores River.	Demand for irrigation.	Draft on storage.
April	44,000	8,000	
May	98,000	20,000	
June	86,000	30,000	
July	28,000	20,000	
August	12,000	15,000	3,000
September	8,000	7,000	
October-March	43,000		
Total	319,000	100,000	3,000

Storage.—From the above table there is seen to be but little storage needed in an average year. In a year like 1902, however, the discharge in Dolores River, June to September, inclusive, was but 33,000 acre-feet as against a demand of 72,000 acre-feet. Present plans provide for 18,000 acre-feet of storage which would keep the shortage even in such a year to a permissible limit.

Conclusion.—The Montezuma project may be expected to build to its full size as soon as general conditions for irrigation development improve within the Dolores Basin. While the project has been troubled with financial burdens which it has been unable to bear in the past, these may reasonably be expected to be overcome in the future.

DOLORES PROJECT.

Irrigable area, 80,000 acres or more.
Mean annual temperature, 45°.
Mean annual precipitation, 14 inches.
Precipitation during growing season, 7 inches.
Elevation, 6,000 to 6,500 feet.
Interval between killing frosts, 125 days.
Transportation, Denver & Rio Grande Railroad, narrow gage; nearest station, Dolores, 20 to 60 miles.

Irrigation plan.—The Dolores reservoir is to be built on Dolores River just below mouth of Beaver Creek, about 10 miles downstream from town of Dolores. Present water level is to be raised 230 feet and diversion to be made 173 feet above stream bed, leaving 120,000 acre-feet of active storage. The canal will follow the south side of the canyon for 14 miles and pass with a 4,800-foot tunnel to the headwaters of Montezuma Creek in the San Juan Basin. From this point the main canal branches to the south and northwest. The lands to be irrigated consist of mesas sloping toward the San Juan River and separated by deeply cut drainage channels. The canal from the reservoir to the point where the irrigable lands are reached will be built through a very difficult country, with a large amount of flume and tunnel work. After passing the San Juan divide, the canal system will not be difficult of construction.

Duty of water.—Irrigation diversions of 2 acre-feet per acre will probably prove sufficient, as much of the area has recently been successfully dry-farmed.

Water supply.—All water will be derived from the Dolores River. The average recorded discharge at Dolores is 291,000 acre-feet annually, which when adjusted for normal years by comparison with Animas River at Durango would be increased to 319,000 acre-feet. Inflow from Beaver Creek and other drainage to the dam site would add 20,000 acre-feet. On the basis of an average year, the relation of water supply and demand for an 80,000-acre development would be as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Discharge of Dolores at reservoir.	Prior rights of Montezuma project.	Balance for Dolores project.	Demand for Dolores project.	Draft on storage.
April	48,000	8,000	40,000	13,000	....
May	104,000	20,000	84,000	32,000	....
June	91,000	30,000	61,000	48,000	....
July	29,000	20,000	9,000	32,000	23,000
August	13,000	15,000	....	24,000	24,000
September	8,000	7,000	1,000	11,000	10,000
October-March	46,000	....	46,000	....	....
Total	339,000	100,000	241,000	160,000	57,000

With 120,000 acre-feet of storage available there is sufficient holdover capacity to tide the project over short years, excepting only where these occur in a series.

For a short year like 1900, preceded by a shorter year when no holdover is available, conditions would be as follows:

		Acre-feet.
Inflow, October to May, inclusive		132,000
Diversions by Montezuma project	40,000	
Diversions by Dolores project	45,000	
		85,000
Storage June 1		47,000
River discharge June–September, inclusive	60,000	
Diversions by Montezuma project	42,000	
Balance for Dolores project		18,000
Total for Dolores project		65,000
Total per acre, Dolores project		0.81

While this amount is relatively low, it is, however, sufficient together with precipitation to prevent total crop losses, and considering that such years do not occur frequently, the project may be expected to develop to this point.

Storage.—The relation of storage required to project area has been outlined. Additional storage may be available above the Dolores site, though no data are at hand. The Dolores reservoir, as planned, backs water to the Montezuma project dam, and additional storage by raising the reservoir could be accomplished only at considerable cost in reconstruction of the diversion system for that project. Lowering the outlet in Dolores reservoir would increase storage, but would also increase cost for the main canal by lowering the summit grade of the San Juan divide.

Conclusion.—The acreage available for this project is much larger than the water supply will care for and construction will depend wholly on unit costs, as the cost of the main features of the project will vary but little with considerable variation in acreage. Such unfavorable features of this project as its transportation facilities, large initial investment required, and probably high cost per acre will probably deter development for a long time.

SAN JUAN BASIN.

SAN JUAN DRAINAGE AREA.

The San Juan River and its tributaries drain a large part of southwestern Colorado, northwestern New Mexico, southeastern Utah, and northeastern Arizona. The drainage area is a high plateau of sedimentary origin resting at the northeast corner on the San Juan and minor mountain ranges from which practically all of the stream flow is derived. The character of the basin changes radically near Farmington, at the junction of the La Plata, Animas, and San Juan rivers. Below this point the San Juan receives no perennial streams, excepting the Mancos, whose flow is negligible.

The San Juan has cut a deep gorge through the country from Farmington to its junction with the Colorado, containing only a few small scattered areas susceptible of irrigation. Its tributaries enter in similar canyons but contain little or no water except when heavy local rainstorms cause sudden violent floods to enter the San Juan. Above Farmington, the area to the south is a rough mesa region without water supply, and in many places deeply dissected. North of the river and lying largely in Colorado is a highly irregular plain sloping sharply from the mountains.

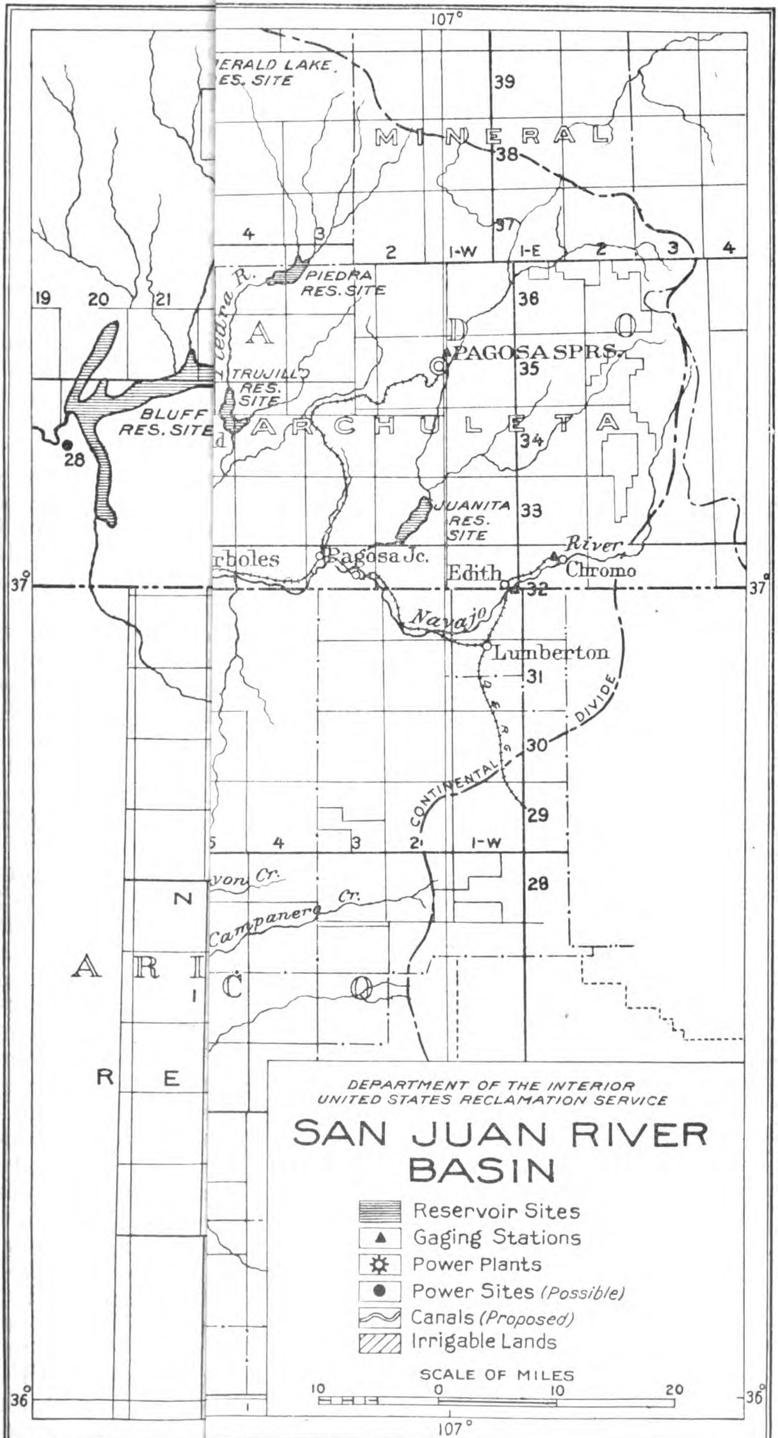
The streams originating in the higher mountains enter deep canyons close to their sources, these canyons gradually widening out and getting shallower as the San Juan River is approached, creating a highly irregular plain bounded by the San Juan River on the south and by a line passing through Edith, Bayfield, Durango, La Plata, and Cortez on the north, extending well into Utah. Through this plain the San Juan and its various tributaries have cut channels whose depth is in general proportional to the volume of water carried.

Interstream diversions are necessary for the reclamation of this area as many of the streams have insufficient water for the reclamation of land immediately adjacent and such diversions are in most cases not difficult. The total water supply, while far in excess of the demands for the available acreage, presents physical difficulties of diversion which will leave a large flow in the San Juan proper.

The irrigable lands have a deep loam soil of sedimentary origin, characterized by its high fertility. Most of the area has numerous drainage channels, though seepage to the extent of waterlogging is apparent in some of the old flatter areas.

Elevations range from 5,000 to 8,000 in the irrigable areas and from 4,000 to 14,000 within the whole basin.

Precipitation ranges from 8 inches, or less, at the mouth of the San Juan to probably 50 inches in some of the mountains. In the irrigable area, precipitation ranges from 10 to 24 inches and the mean annual temperature from 40° to 48°. The entire region is characterized by mild winters, hot summer days, and the occurrence of rains in the late summer season.


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
SAN JUAN RIVER BASIN
Reservoir Sites
Gaging Stations
Power Plants
Power Sites (Possible)
Canals (Proposed)
Irrigable Lands
SCALE OF MILES
10 0 10 20
107°
37°
36°
MINERAL
ARCHULETA
PAGOSA SPRS.
Piedra R.
PIEDRA RES. SITE
TRUJILLO RES. SITE
BLUFF RES. SITE
JUANITA RES. SITE
Pagosa Jc.
Edith
Chromo
Lumberton
Navajo River
CONTINENTAL DIVIDE
Campanero Cr.
rboles

Diversion duties will vary from 3.5 acre-feet in the lower altitudes to 1.5 acre-feet, or less, in the higher altitudes, the difference being due largely to variation in precipitation. Consumptive use will vary from 2 feet to 1 foot or less.

Power development.—There is one power development in the San Juan Basin at present. This is the Tacoma plant, located on Animas River, between Durango and Silverton. Water is supplied by Cascade and Elbert creeks through a 21,000 acre-foot reservoir. The plant has a 988-foot head. The installation of two units has a rated capacity of 4,500 kilowatts. The output is used for mining, milling, and lighting.

Opportunities for further power development by means of high head plants similar to the one constructed are probably existent though definite data are lacking. Developments on the main streams require storage since the winter flow is too small to warrant construction of power plants. Lack of storable water and present irrigation requirements further limit power possibilities to the Animas and San Juan rivers. The Animas has an average flow of 719,000 acre-feet annually, of which but 80,000 acre-feet are now in use with the possibility of further use of possibly 309,000 acre-feet, which would require the construction of Animas reservoir, leaving 330,000 acre-feet unused with ultimate irrigation development from this stream. Its capacity is sufficient to control the river and the irrigation release could be used for power purposes, the amount so used depending upon the elevation of the outlets for irrigation and the amount of water released for use below. In case of consolidation of the La Plata Meadows and Overland projects with a common outlet at considerable height above stream bed, the mean power output would be that derived from the release of approximately 600,000 acre-feet at a mean head of 100 feet, equivalent to a uniform power output of 7,000 horsepower.

On the San Juan River, power possibilities exist at the Hogback and Bluff sites, but since the former would entail considerable destruction of present irrigated area without offering any more advantages than the Bluff site, only the possibilities at Bluff will be outlined. At the Bluff site, the anticipated run-off when all outlined projects become developed will be 1,650,000 acre-feet annually which, if equated, will permit a power output of 35,000 horsepower with a mean head of 175 feet, which would allow 740,000 acre-feet of equalizing storage and 840,000 acre-feet of dead storage if the water surface is raised 225 feet. At the present time, silt carried past the dam site is estimated to be 29,000 acre-feet annually, which would give so short a life to the reservoir that it is hardly worth while developing when the irregular flow of the San Juan is considered. If irrigation should go ahead as estimated in the following pages, it would equalize the flow and decrease the annual silt to some extent so that this may become a feasible power site. It is not considered in estimates of power, however.

The Bluff site has also been considered for regulation of floods for protection of the lower river, but its effect in this direction would not be large.

Future development will probably be along the line of high head plants in the headwaters region and will be limited by local markets for power as present consuming centers are far removed with better power sites closer at hand.

Irrigation development to date.—Present irrigated acreage within the San Juan Basin is as follows:

Irrigated acreage, San Juan Basin.

Stream.	Colorado.	Utah.	New Mexico.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Navajo				
San Juan	12,000	12,000	14,000	38,000
Piedra				
Price	20,000		5,000	25,000
Florida	15,000			15,000
Animas	10,000		10,000	20,000
La Plata	19,000		5,000	23,000
Mancos	10,000			10,000
McElmo	[1] 25,000			25,000
Total	111,000	12,000	34,000	157,000

[1] From Dolores River.

The present developed area is the result of efforts largely of individuals singly or in small groups, very few projects requiring organized effort having been executed to date.

Future irrigation development.—Opportunities still exist for considerable increase in acreage by individual efforts in the headwaters region and by the extension of present irrigated areas under small ditches in the intermediate areas between the headwaters and the San Juan River valley proper, especially from the Pine and Florida rivers. On some of the streams, notably the La Plata and to a lesser extent the Pine and Florida rivers, diversions are not difficult, but storage will be required for any major extensions while with the other streams diversions except near the headwaters will be difficult.

The greatest possibilities lie in diversions from the Animas and San Juan rivers whose flow has been depleted very little, but where diversions are possible only with long, expensive canal systems.

The segregation of many localities into definite projects is impossible with available data and some of the listed projects are, in reality, rather a group of smaller projects.

Classification of projects.

Project.	Class A.	Class B.	Class C.	Class X.
Navajo River				17,000
Piedra River				9,000
Pine or Ignacio		50,000		
Florida River		15,000		
La Plata Mesas		40,000		
Overland project		83,000		
Turley project		125,000	275,000	
Mancos River				10,000
Total		313,000	275,000	36,000

General data—Irrigation development.

	Present.	Estimated additional possible.	Total ultimate.
Colorado	111,000	[1] 216,000	[1] 327,000
New Mexico	34,000	483,000	517,000
Utah	12,000	[2] 30,000	42,000
Total	157,000	729,000	886,000

[1] 75,000 acres by water from Dolores River.
[2] With Dolores River water.

Average annual discharge of basin at Bluff, Utah.

		Acre-feet.
Present annual discharge		2,700,000
Future depletion:		
Navajo, Piedra, and Mancos rivers, 36,000 acres, at 1 acre-foot	36,000	
Pine, Florida, and La Plata rivers, 55,000 acres, at 1.25 acre-feet	69,000	
La Plata Mesa, 40,000 acres, at 1.50 acre-feet	60,000	
Overland and Turley projects, 483,000 acres, at 2 acre-feet	966,000	
		1,131,000
Remainder		1,569,000
Return flow from Montezuma and Dolores projects (Dolores water)		81,000
Total		1,650,000

NAVAJO RIVER AND TRIBUTARIES.

No definite projects are planned but possibilities of further irrigation largely by individuals are known to exist. Discharge of the Navajo River has been recorded with a mean of 150,000 acre-feet. The distribution of this supply is such that the 17,000 acres additionally expected to be irrigated will require little or no storage. With a precipitation during the growing season of 10 to 14 inches, a consumptive use of 1 acre-foot is assumed.

PIEDRA RIVER.

Additional irrigation of 9,000 acres, all in Colorado, is expected, largely through individual effort. The present annual discharge of this river is 405,000 acre-feet. No storage will be necessary. With altitude ranging from 6,200 to 8,000 feet and precipitation in the growing season from 9 to 12 inches, a consumptive use of 1 acre-foot per acre is assumed.

IGNACIO PROJECT.

Irrigable area: Colorado, 42,000 acres; New Mexico, 8,000 acres; total, 50,000 acres.

Mean annual temperature, 47°.

Mean annual precipitation (Ignacio), 16 inches.

Precipitation during growing season, 8 inches.

Elevation, 6,200 to 7,000 feet.

Interval between killing frosts (summer), 130 days.

Transportation, Denver & Rio Grande Railroad, narrow-gage, runs through project.

Irrigation plan.—A 5-mile feeder canal from the Pine River at Bayfield will deliver water to the Dry Creek reservoir, which may be built to a capacity of 85,000 acre-feet. From the reservoir a 20-mile main canal will serve most of the irrigable area. A portion of the area will be covered by present ditches, which are to be enlarged and extended.

Duty of water.—A diversion of 2 acre-feet per acre is anticipated, of which 1.25 acre-feet will be consumed.

Water supply.—All water is to be taken from the Pine River, whose mean flow at Ignacio is 343,000 acre-feet. On the basis of an average year the relation of water supply and demand is estimated as follows:

Water supply and irrigation requirements.

Month.	Flow of Pine River.	Demands for prior rights.	Left for Pine River project.	Irrigation demand for Pine River project.	Draft on storage.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
April	41,000	6,000	35,000	8,000	....
May	83,000	16,000	67,000	20,000	....
June	97,000	24,000	73,000	30,000	....
July	42,000	16,000	26,000	20,000	....
August	14,000	12,000	2,000	15,000	13,000
September	9,000	6,000	3,000	7,000	4,000
Total	286,000	80,000	206,000	100,000	17,000

Storage.—The 17,000 acre-foot draft on storage may in ordinary years reach 30,000 acre-feet, considering variation in discharges and demands, and in a low year like 1918 the storage requirement would be 50,000 acre-feet. No hold-over capacity is required, and a storage capacity of 25,000 to 40,000 acre-feet will therefore provide an adequate supply in all years. With 85,000 acre-feet of storage available, the water supply for this project is beyond question.

FLORIDA RIVER PROJECT.

Irrigable area, 15,000 acres.
Mean annual temperature, 47°.
Mean annual precipitation, 17 inches.
Mean precipitation during growing season, 9 inches.
Elevation, 6,400 feet.
Interval between killing frosts (summer), 130 days.
Transportation, Denver & Rio Grande Railroad, narrow-gage, passes through the district.

Irrigation plan.—Water will be taken from the Florida River some 6 or 7 miles northeast of Durango and conducted to lands lying between the Florida and Animas rivers. Storage is expected to be provided by means of small reservoirs on the project.

Duty of water.—A diversion duty of 2 acre-feet per acre is anticipated.

Water supply.—The mean annual discharge of the Florida a short distance above the proposed diversion and above all present diversions is 92,000 acre-feet. In an average year the relation of supply to demand is estimated as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Supply.	Prior rights 10,000 acres.	Balance for project.	Project demands.	Demand on storage.
April	8,600	1,600	7,000	2,400	
May	27,400	4,000	23,000	6,000	
June	27,600	6,000	21,600	9,000	
July	12,100	4,000	8,100	6,000	
August	3,700	3,000	700	4,500	3,800
September	2,800	1,400	1,400	2,100	700
Total	82,200	20,000	62,200	30,000	4,500

In a low year like 1918 the demand on storage increases to 9,500 acre-feet.

Storage.—Allowing for unavoidable waste past the headgates in times of high discharges 8,000 acre-feet of storage would be necessary to prevent excessive shortages in low years. The existence of this amount of available storage at reasonable cost is doubtful and the project if constructed will probably run short of water frequently in late summer.

LA PLATA MESAS PROJECT.

Irrigable area, 40,000 acres.
Mean annual temperature, 46°.
Mean annual precipitation, 15 inches.
Precipitation in growing season, 8 inches.
Elevation, 6,200 to 7,000 feet.
Interval between killing frosts 130 days (summer).
Transportation, Denver & Rio Grande Railroad, narrow gage, 10 to 20 miles from land. Nearest station, Fort Lewis.

Irrigation plan.—A 200 second-foot transmountain diversion canal at an elevation of 7,600–7,700 will convey waters from Hermosa, Lightner, and Junction creeks in the Animas drainage area to the La Plata drainage, crossing the Animas-La Plata divide near Pine Ridge, and emptying into La Plata River near Fort Lewis. The total length of this canal will be 60 miles including 1 mile of siphons and 6 to 7 miles of flume. It is also planned to construct a new ditch or enlarge an existing ditch for the purpose of conveying La Plata River water to Cherry Creek near Mayday for the purpose of reclaiming lands tributary to Cherry Creek, the water so diverted from La Plata River to be replaced with Animas water. This scheme avoids the necessity of a long canal across the La Plata drainage to irrigate lands in the western part of this area with Animas water. A 5,000 acre-foot reservoir is proposed on Hermosa Creek to build up the total diversion from this drainage and additional storage is planned in the La Plata drainage area to use waters now being wasted and to permit of the operation of the diversion canal from Hermosa Creek for a greater portion of the year. The lands to be irrigated lie in scattered areas on the mesas between the various tributaries of the La Plata River.

Duty of water.—The probable high cost of construction for this development will tend to hold diversions to a minimum. This factor, combined with the 8-inch rainfall during the growing season and the water retentive properties of the soils of this area, will hold diversions to an average of 2 acre-feet per acre with consumptive use of 1.50 acre-feet per acre.

Water supply.—The water supply of the Animas River is but partially used even in the months of lowest run-off, and the project may be expected to be able to divert to the limit of its canal capacity from existing flows of the intercepted creeks. The only existing records are for 1920, with an abnormally high run-off. In 1920, diversions from the Animas watershed would have been possible as follows:

Water supply, 1920.

Date.	Divertible.		Date.	Divertible.	
	Sec.-ft.	*Acre-feet.*		*Sec.-ft.*	*Acre-feet.*
Apr. 1	200	36,000	Oct. 1	45	2,600
July 1	200	5,700	Nov. 1	40	2,400
July 15	180	4,500	Dec. 1	40	
Aug. 1	100	5,800			
Sept. 1	55	3,000	Total		60,000

In an average year the time during which the canal would be able to divert its full capacity would be reduced from 90 days as above to 60 days, but diversions after August 1 would be practically the same, resulting in a reduction of diversions to 50,000 acre-feet, which in low years may get down to 40,000 acre-feet. To this must be added 5,000 acre-feet of storage, which would be impounded every year, and conveyed to the La Plata drainage after August 1. The present unused water in the La Plata Basin within Colorado has been measured at the State line in 1920 and part of 1919. Comparing these flows with flows at Hesperus shows a difference of about 15,000 acre-feet annually between the two stations, and indicates an average of 30,000 acre-feet annually passing into New Mexico, of which probably 5,000 acre-feet is return flow in the vicinity of the State line not recoverable within Colorado. Total water supply for the project would then be as follows:

Water supply.

	Average year.	Low year.
	Acre-feet.	*Acre-feet.*
Direct diversions in Animas watershed	50,000	40,000
Storage from Animas watershed	5,000	5,000
Recoverable water in La Plata watershed	25,000	15,000
Total	80,000	60,000

Storage.—The relation of supply and demand in an average year would be as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Supply.	Irrigable demand.	Demand on storage.
April	12,000	6,400	....
May	33,000	16,000	....
June	19,000	24,000	5,000
July	8,000	16,000	8,000
August	5,000	12,000	7,000
September	3,600	5,600	2,000
Total	80,600	80,000	22,000

Of the above 22,000 acre-feet of storage required, 5,000 are to be provided in Hermosa Creek, leaving 17,000 to be found in La Plata drainage area. This storage is said to be available.

Conclusion.—The water supply for this project is apparently sufficient only for its bare needs and can not be considered ample. It can, however, be improved by the enlargement of the diversion canal from the Animas watershed or by the provision of additional storage in this watershed.

The construction cost will undoubtedly be high and deter construction for some time.

OVERLAND PROJECT.

Irrigable area, 83,000 acres.

Mean annual temperature, 50°.

Mean annual precipitation, 6 to 8 inches.

Precipitation during growing season, about 3 to 4 inches.

Elevation, 5,500 to 6,300 feet.

Interval between killing frosts (summer), 140 days.

Transportation, Denver & Rio Grande Railroad, Farmington branch (standard gage connecting with narrow gage at Durango), 3 to 25 miles away.

Irrigation plan.—Water is to be diverted from the Animas River near the State line by a gravity canal system. The main canal, with a length of about 100 miles, will cover most of the irrigable land in townships 12, 13, 14, and 15 of ranges 30 and 31 north. The main canal will run through much difficult country, and the lateral systems due to heavy southward slope of the country and deeply cut drainage systems will also be expensive.

Duty of water.—Diversions for this project, owing to the length of the canal system, are expected to reach 3 acre-feet per acre, with a consumptive use of 2 acre-feet, rainfall being so light as to help but little in the production of crops.

Water supply.—All water will be derived from the Animas with 10,000 acres now being irrigated and with anticipated diversions of 60,000 acre-feet annually for the La Plata Mesas project. The mean annual discharge of the Animas at Durango has been 719,000 acre-feet, of which 639,000 acre-feet would be available for this project. With diversions of 249,000 acre-feet, there would still be a big surplus. Relation of water supply to demand in a moderately low year like 1918 would have been as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Discharge of Animas River.	Demand for—		Balance for Overland project.	Demand of Overland project.	Demand on storage.
		Prior rights.[1]	La Plata Mesas project.			
April	32,000	2,000	10,000	20,000	20,000	....
May	116,000	4,000	12,000	100,000	50,000	....
June	167,000	6,000	12,000	149,000	75,000	....
July	55,000	4,000	10,000	41,000	50,000	9,000
August	36,000	3,000	4,000	29,000	37,000	8,000
September	46,000	1,000	4,000	41,000	17,000	....
Total	452,000	20,000	52,000	380,000	249,000	17,000

[1] Diversions partially above gaging station with only consumptive use as a loss for the stream flow.

From the above table the necessity of storage is comparatively small, and although shortages would be somewhat heavier in occasional years of low run-off, the provision of storage does not appear essential. Storage, if desired, can be provided to a necessary degree with small inland reservoirs within the project or by the construction of Animas reservoir just above Durango.

Conclusion.—All data on the physical details of this project are preliminary to the extreme, but from a review of available data the unit cost of construction will apparently be high. The project has but one diversion site, and the construction of a small main canal with a view of enlargement as settlement progresses does not appear feasible. The large initial investment required, together with a high unit cost per acre, will probably deter construction for a considerable time.

Suggestions have been made that this project be extended much farther west, and this seems physically possible. The ultimate acreage would then be governed by available water supply in the Animas River. Storage may be developed at the Animas reservoir just above Durango in sufficient quantity practically to control the river. With occasional rather severe shortages, the diversions could be based on the average available flow, of which 639,000 acre-feet would be available for this project. With the longer canals required for such a large project, diversions of 3½ acre-feet per acre may be expected, limiting the ultimate project to 183,000 acres.

As an alternative to the above scheme, diversion might be made from the Animas River at the Animas reservoir, the area so covered being in general the same as for the Overland and La Plata Mesas projects combined. Greater latitude of canal locations would be present with possibly lower total cost for the project.

TURLEY PROJECT.

Irrigable area roughly estimated at 400,000 acres.
Mean annual temperature, 50°.
Mean annual precipitation, 6 to 8 inches.
Elevation, 5,000 to 5,700 feet.
Interval between killing frosts (summer), 140 days.

Transportation, Denver & Rio Grande Railroad (standard-gage line, connecting with narrow gage at Durango).

Farmington, nearest station, is at the northern edge of the project and 50 miles from the outer portions.

Irrigation plan.—Diversion is anticipated on the San Juan River about 10 miles below the mouth of Pine River. The main canal will traverse steep, rocky hillsides for 35 miles and then emerge in the Chaco Canyon drainage area, which is a vast basin of mesa land with prominent drainage channels and eroded slopes. This area contracts at the Carrizo Mountains, on the Arizona State line, which forms the logical end of the project. The main canal to this point would be about 300 miles long. As an alternative the project might be developed only to include lands east of Chaco Canyon, the irrigable area then being possibly 125,000 acres and length of main canal 135 miles. The main canal with either development would cross much very difficult country, and the first 35 miles would be especially difficult. No instrumental surveys have been made for canal lines, and the rough reconnaissance observations made by various engineers agree on the costly construction and on not more than 50 per cent of lands covered being irrigable.

Duty of water.—With long main canals and a long dry growing season, a diversion of 3.5 acre-feet per acre is anticipated. Consumptive use of 2 acre-feet is estimated, making a return flow of 1.5 acre-feet per acre.

Water supply.—Discharge records are available as follows:

Recorded stream flow.

Year.	Period.	Discharge.	Station.
		Acre-feet.	
1908	June 6 to Dec. 31	1,080,000	Turley.
1909	January to November	1,150,000	Do.
1910	January to December	[1] 1,170,000	Bloomfield.
1911	January 15 to September	1,810,000	

[1] Partially estimated.

From 1913 to 1917, inclusive, discharge was measured at Farmington. Deducting the Animas River discharge from Farmington record gives an average of 1,400,000, which is comparable to the Bloomfield station, both including erratic unknown run-off from Largo Canyon.

The average annual run-off at the diversion site is estimated at 1,400,000 acre-feet, or just equal to the demand for 400,000 acres after deducting for consumptive use of additional areas on the headwaters to the extent of 26,000 acres at the rate of 1 acre-foot per acre on the Navajo and Piedra rivers and 50,000 acres at 1.25 acre-feet per acre on the Pine River. No account need be taken of present or future acreage below the point of diversion, as return flow from this project will fully supply them.

If 1914 be taken as an average year, storage requirements for projects of 125,000 acres and 400,000 acres would be as follows:

Water supply and irrigation requirements.

[Acre-feet.]

Month.	Stream flow.	Irrigation demand.			Demand on storage for—	
		Acre-feet per acre.	Acre-feet for—		125,000 acres.	400,000 acres.
			125,000 acres.	400,000 acres.		
April	183,000	0.20	25,000	80,000		
May	266,000	.70	88,000	280,000		14,000
June	292,000	1.00	125,000	400,000		108,000
July	108,000	.80	100,000	320,000		212,000
August	87,000	.60	75,000	240,000		153,000
September	75,000	.20	25,000	80,000		5,000
October	363,000					
Total	1,374,000	3.50	438,000	1,400,000		492,000

A project up to 125,000 acres could apparently operate without storage and encounter no shortages except in subnormal years, when shortages would occur but not severe enough to warrant reduction in acreage. For a project of 400,000 acres at least 1,000,000 acre-feet of storage would be necessary to avert frequent shortages. The hold-over capacity of 500,000 acre-feet as compared to demands in an average year would obviate shortages in most years. In a period of low run-off like 1900–1904, shortages would occur due to lack of supply in the river but their elimination by means of storage would probably not be feasible.

Storage.—The Turley reservoir site at the diversion is estimated to have a capacity of 1,100,000 acre-feet. It would undoubtedly be an expensive reservoir. Other reservoirs above the diversion which might be used in whole or in part for this project are as follows:

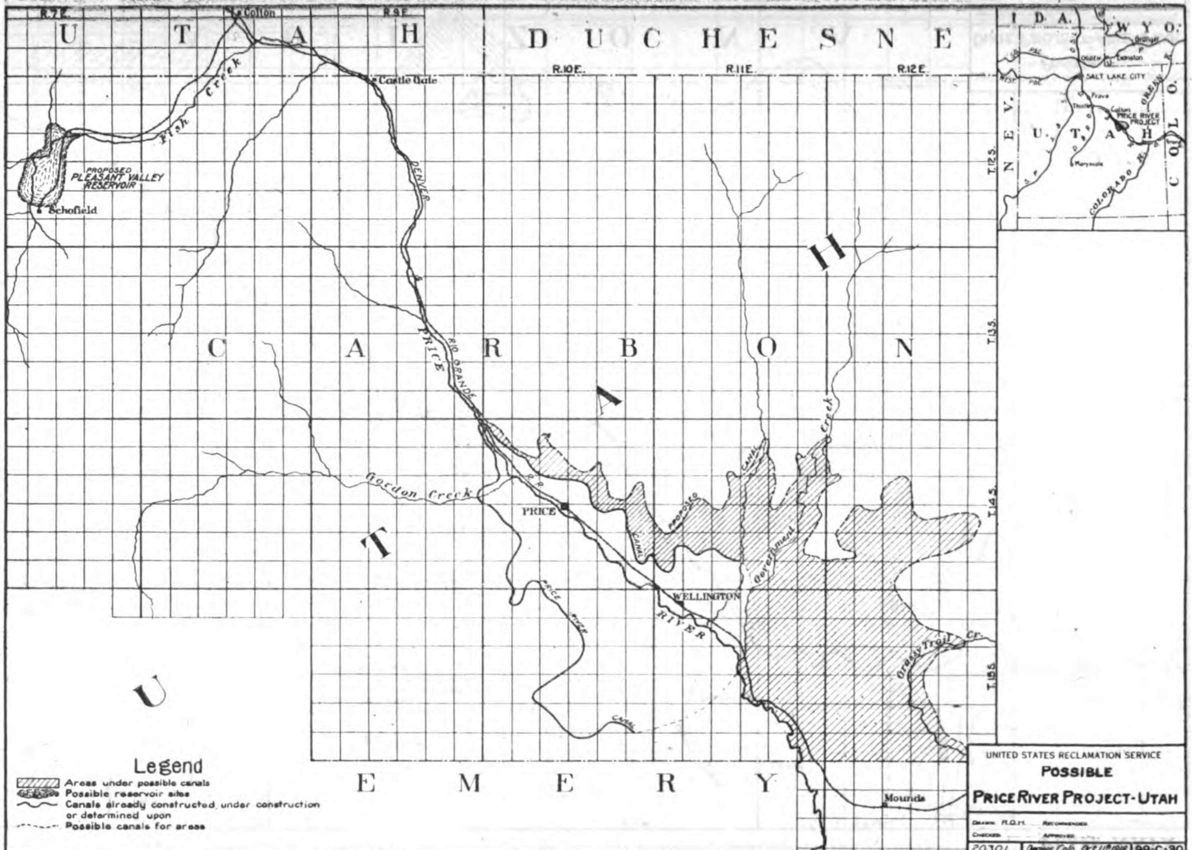
Stream.	Site.	Capacity.
		Acre-feet.
Pine River	Dry Creek	85,000
Do	Vallecito	100,000
Piedra River	Trujillo	90,000
Do	Piedra	(1)
San Juan River	Juanita	90,000
Total (including Piedra)		365,000

[1] Capacity unknown.

Conclusion.—This project from present highly preliminary data and plans will be very costly, and from this standpoint may not develop for many years, although the water supply is sufficient. Owing to the probable marked difference in total construction cost of a project of 125,000 acres without storage limited to the easterly side of Canon Chaco and one of 400,000 acres involving large storage, the former has been placed in class B and the balance of the project in class C.

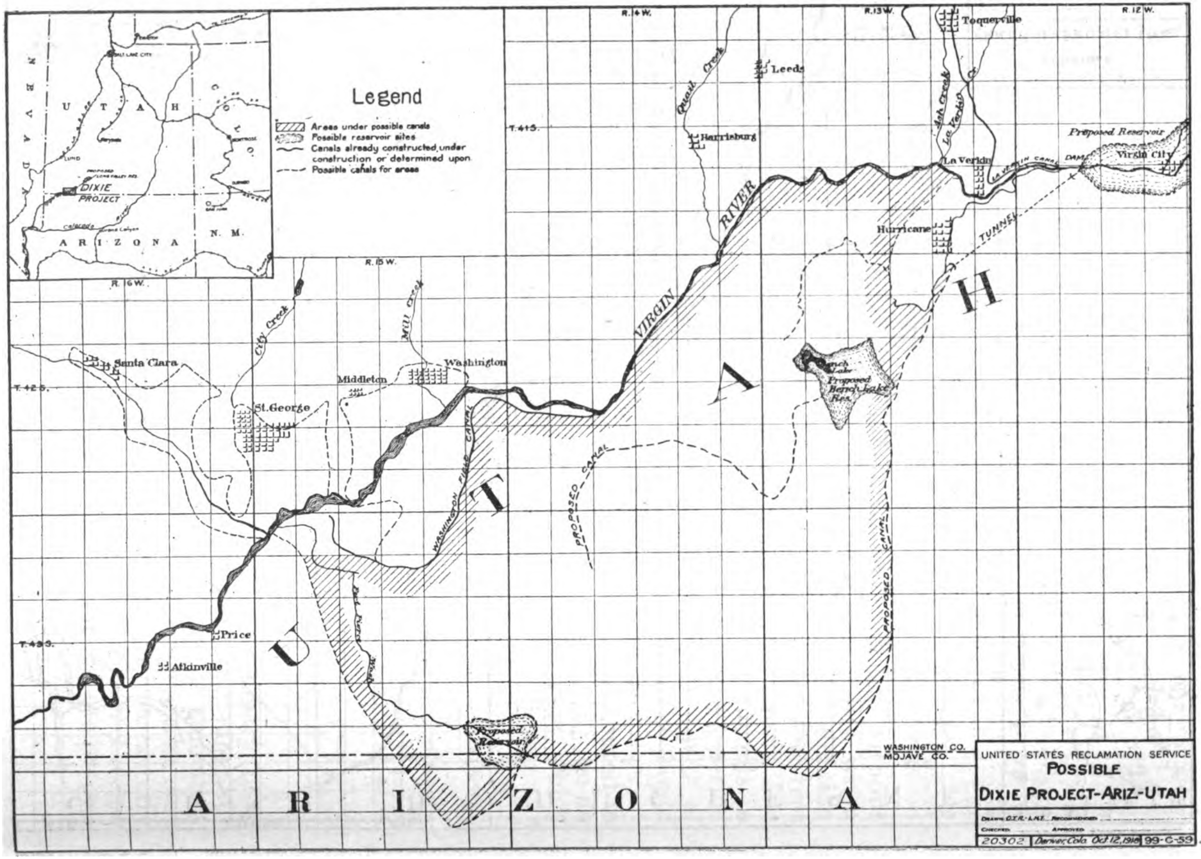
MANCOS RIVER AND M'ELMO CREEK.

There are no definite projects on this stream, but present water supply, augmented with a small amount of return flow from the Montezuma project, is expected to be spread over a larger acreage than at present, resulting in an increase in irrigated area of 10,000 acres. The additional water used consumptively will probably not exceed 1 acre-foot per acre.

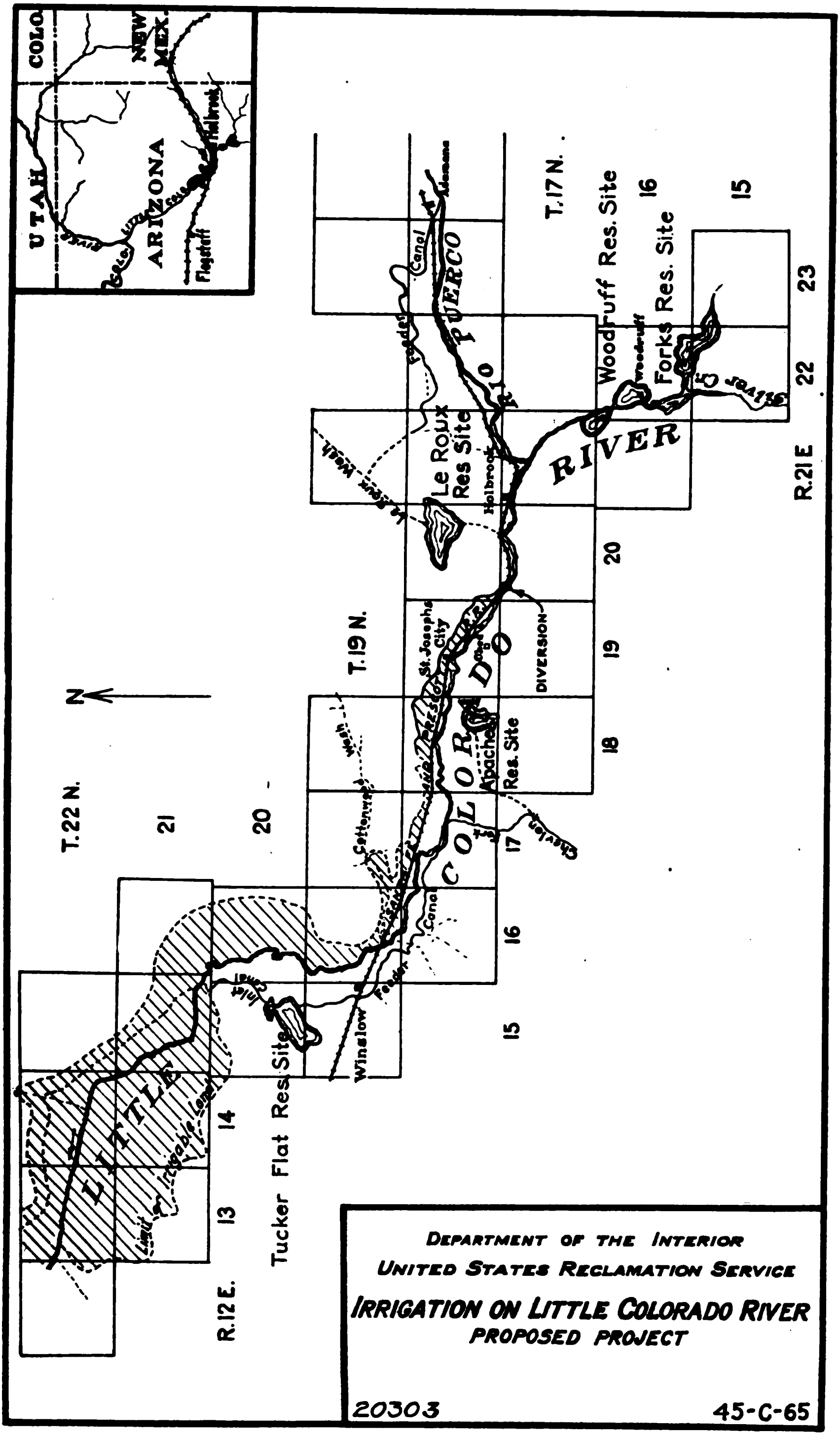


UTAH
DUCHESNE
CARBON
UTAH
EMERY
R.7E.
R.9E.
R.10E.
R.11E.
R.12E.
T.12S.
T.13S.
T.14S.
T.15S.
Colton
Castle Gale
Schofield
PROPOSED PLEASANT VALLEY RESERVOIR
Fish Creek
DENVER & RIO GRANDE R.R.
PRICE RIVER
Gordon Creek
PRICE
WELLINGTON
PROPOSED CANAL
CANAL
Government Canal
Creek
Grassy Trail Cr.
Mounds
IDA.
WYO.
NEV.
COLO.
SALT LAKE CITY
Ogden
Provo
Colton
PRICE RIVER PROJECT
COLORADO R.
GREEN R.
Legend
Areas under possible canals
Possible reservoir sites
Canals already constructed, under construction or determined upon
Possible canals for areas
UNITED STATES RECLAMATION SERVICE
POSSIBLE
PRICE RIVER PROJECT-UTAH
Drawn R.O.H.
Recommended
Checked
Approved
20301
Denver Colo. Oct. 11th 1918
99-C-30

PLATE XXIX



Legend
Areas under possible canals
Possible reservoir sites
Canals already constructed under construction or determined upon.
Possible canals for areas
NEVADA
UTAH
COLO.
ARIZONA
N. M.
DIXIE PROJECT
R.16W.
R.15W.
R.14W.
R.13W.
R.12W.
T.41S.
T.42S.
T.43S.
Toquerville
Leeds
Quail Creek
Harrisburg
Ash Creek
La Verkin Cr.
La Verkin
LA VERKIN CANAL
Proposed Reservoir
DAM
Virgin City
VIRGIN RIVER
Hurricane
TUNNEL
Proposed Berry Lake Res.
City Creek
Mill Creek
Santa Clara
Washington
Middleton
St. George
WASHINGTON FIELD CANAL
PROPOSED CANAL
Price
Atkinville
Fort Pierce Wash
Proposed Reservoir
WASHINGTON CO.
MOJAVE CO.
U T A H
A R I Z O N A
UNITED STATES RECLAMATION SERVICE
POSSIBLE
DIXIE PROJECT-ARIZ-UTAH
20302
Denver, Colo. Oct. 12, 1916
99-C-59


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
IRRIGATION ON LITTLE COLORADO RIVER
PROPOSED PROJECT
20303
45-C-65
UTAH
COLO.
NEW MEX.
ARIZONA
Flagstaff
Holbrook
LITTLE COLORADO RIVER
PUERCO RIO
Woodruff Res. Site
Forks Res. Site
Le Roux Res Site
Holbrook
St. Joseph City
DIVERSION
Apache Res. Site
Tucker Flat Res. Site
Winslow
Canal
Feeder
Inlet Canal
Limit of Irrigable Land
Le Roux Wash
Cottonwood Wash
Chevelon Fork
Silver Cr.
Adamana
Woodruff
T. 22 N.
T. 19 N.
T. 17 N.
R. 12 E.
R. 21 E.
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MISCELLANEOUS PROJECTS IN UPPER BASIN.

PRICE RIVER PROJECT, UTAH.

Acreage—gross, 40,000; net, 30,000; irrigated now, 10,000.
Precipitation, annual average, 12 inches.
Precipitation, irrigation season, 4 inches.
Temperature, annual average, 50°.
Between frosts (summer), 150 days.
Elevation, 5,500 feet.
Transportation, Denver & Rio Grande Railroad.

Irrigation plan.—New lands lying east of Price River in townships 14 and 15 south, ranges 10, 11, and 12 east, containing 20,000 acres net out of gross of 30,000, are to be irrigated by diversion near the town of Castle Gate; thence following the river closely for about 12 miles the canal reaches the irrigable land. Lands in the vicinity of Price and Wellington, lying on both sides of the river, are now irrigated but lack a late season supply which can be furnished if the project is built.

Lands.—The lands lie in a series of benches and alluvial slopes and are naturally well drained.

Crops.—The crops are grain, alfalfa, garden truck, and fruit.

Duty of water.

[Acre-feet.]

	Per acre.	For 30,000 acres.
May	0.50	15,000
June	.80	24,000
July	.70	21,000
August	.60	18,000
September	.40	12,000
Total	3.00	90,000

Water supply.—Price River discharge at town of Helper, 1905–1920, average:

	Acre-feet.
October to April (partially storable)	39,500
May	41,000
June	22,000
July	7,600
August	4,700
September	4,200
Total	119,000

Storage.—In an average year storage is needed after June 10, and the quantity in such a year is 40,000 acre-feet. To provide hold over for a dry year 80,000 acre-feet are required.

Reservoir.—A site exists near Schofield, on Fish Creek, with capacity of 175,000 acre-feet, with water raised not more than 90 feet. Discharge tributary to reservoir has been measured for three years, 1918–1920. The average for these years is 52,000 acre-feet, but by comparison with Price River discharge during 16 years the average run-off is estimated to be 68,000 acre-feet. From June to September, inclusive, no water could be stored, leaving an annual storable run-off estimated at 50,000 acre-feet, which is more than sufficient to supply the 3 acre-feet per acre demand for the 30,000 acres of land. Denver & Rio Grande branch railroad runs through the site.

DIXIE PROJECT, UTAH.

Acreage, gross, 50,000; net, 35,000 acres.
Precipitation, annual average, 9 inches.
Precipitation, in growing season, 6 inches.
Temperature, annual average, 60°.
Elevation, 2,500 to 3,350 feet.
Between frosts (summer), 175 days.
Transportation, 90-mile haul to Lund, Utah, on Salt Lake Railroad.
Irrigation season, March to October, inclusive, 8 months.
Duty of water, 4 feet at diversion.

Irrigation plan.—Diversion from Virgin River at a point 1½ miles east of Virgin City; thence by tunnel 3¾ miles long to irrigable lands, which all lie south of the river.

Duty of water.

[Acre-feet.]

	Per acre.	35,000 acres.		Per acre.	35,000 acres.
March	0.30	10,000	August	0.60	21,000
April	.50	17,500	September	.50	17,500
May	.50	17,500	October	.30	10,500
June	.65	23,000			
July	.65	23,000	Total	4.00	140,000

Water supply, average discharge, Virgin River at Virgin City, 1910 to 1918.

November to February (inclusive)	47,000
March	28,000
April	34,000
May	34,000
June	12,000
July	14,000
August	11,000
September	14,000
October	14,000
	208 000

Present rights require 50,000 acre-feet, leaving 158,000 for a new project.

Storage.—Sixty-five thousand acre-feet are required in the average year and for complete holdover for a low year 130,000 acre-feet. Nothing is known of available reservoir sites but there are said to be several possible ones.

LITTLE COLORADO PROJECT.

Irrigable lands, gross, 93,000 acres; net, 60,000 acres.
Precipitation, mean annual, 6 inches.
Precipitation, in growing season, 4 inches.
Temperature, mean annual, 54°.

Between frosts (summer), 150 days.
Elevation, 5,000 feet.
Transportation, Santa Fe Railroad.
Irrigation season, April to September, inclusive, 6 months.
Duty of water, 4 feet at diversion.
Water supply, Little Colorado River.

Irrigation plan.[1]—Diversion from the Little Colorado River to the north side in the northwest corner of township 17 north, range 20 east. Diversion again to north side in southeast corner township 21 north, range 15 east, about 35 miles down the river. Diversion to south side at same point as the latter north side diversion. Diversion to south side and to Tucker Flats reservoir about midway between the above two diversions. Use of Tucker Flats and Forks reservoirs.

Lands.—The irrigable lands lie largely in the bottoms and are easily reached and lie well for irrigation. Diversion from the river is possible at almost any point.

Water supply.—Gaging stations have been maintained as follows:

Stream flow records.

Station.	Stream.	Period.	Average annual discharge during period of record.
Holbrook	Little Colorado	March, 1905, to April, 1907	170,000
Woodruff	do	March and April, 1905; August, 1905, to April, 1907; all 1917; parts of 1918 and 1919.	95,000
Winslow	Chevlon Creek	January, 1906, to December, 1907; January, 1916, to December, 1920.	63,000

All streams flow very erratically and are subject to short, flashy floods.

Reservoirs.—For control of these floods reservoir sites have been surveyed as follows:

Reservoir sites.

Site.	Stream.	Height of dam.	Area.	Capacity.
		Feet.	*Acres.*	*Acre-feet.*
Woodruff	Little Colorado	100	3,160	109,000
Forks	do	85	5,020	148,000
La Roux	La Roux wash	35	3,730	54,000
Tucker Flats	Side stream	50	3,850	118,000
Apache	Inland from Chevlon Creek			90,000

The reservoirs listed were planned to be filled as follows:
La Roux, feeder from Rio Puerco.
Tucker Flats, feeder from Little Colorado.
Apache, feeder from Chevlon Creek.
Forks and Woodruff are directly on the Little Colorado.
La Roux site may be eliminated; because of its small capacity it would be soon filled with silt brought down by the La Roux wash.

[1] This is only one of many possible plans.

The Woodruff site on the Little Colorado embraces the town of Woodruff, which would be submerged if the reservoir were built. As it is immediately below the Forks site, which is better and which will control the river, it also may be eliminated.

Tucker Flats reservoir site will give opportunity to store the winter discharge of the Puerco, which otherwise would be lost with the elimination of the La Roux.

All reservoir sites will eventually fill with silt.

Water supply.—May total about 200,000 acre-feet annually, judging from the meager records, and about 400,000 acre-feet of reservoir capacity is available to control it. About 1,200 acres are irrigated now, which have prior draft on the water supply.

Some pumping from ground water is now being done, and it may be possible to extend this, but water-bearing strata do not exist in large parts of the valley. From the meager data it is difficult to estimate ultimate irrigation, but for this report it is assumed to be 40,000 acres in addition to the present.

GREEN RIVER PROJECT, UTAH.

Area, gross, 240,000 acres; net, assumed 150,000 acres.

Temperature, mean annual, 52°.

Precipitation, mean annual, 9 inches; irrigation season, 5 inches.

Elevation, 4,000 to 4,600 feet.

Transportation, Denver and Rio Grande Railroad.

Between frosts (summer), 180 days.

Project is covered by Utah Carey Act segregation No. 10 by Green River Canal Co. This company has relinquished its rights and the project is now being investigated by the Reclamation Service.

Irrigation plan.—As proposed by the company, diversion dam 230 feet high on Green River just below mouth of Coal Creek. Outlet at 200 foot level giving 102,000 acre-feet of storage. Main canal to follow west side of the canyon 13 miles through difficult construction, requiring ditch lining, four tunnels, and a double 8-foot siphon across Price River. Below this are required 100 miles of main carriage canals and a siphon across Green River.

Irrigable lands lie on both sides of Green River, with the larger part on the west side. The land lies in uniform slopes, and some artificial drainage will be required. Soil ranges from sandy loam to adobe. Large differences of opinion exist as to the amount of irrigable land, estimates ranging from 45,000 up.

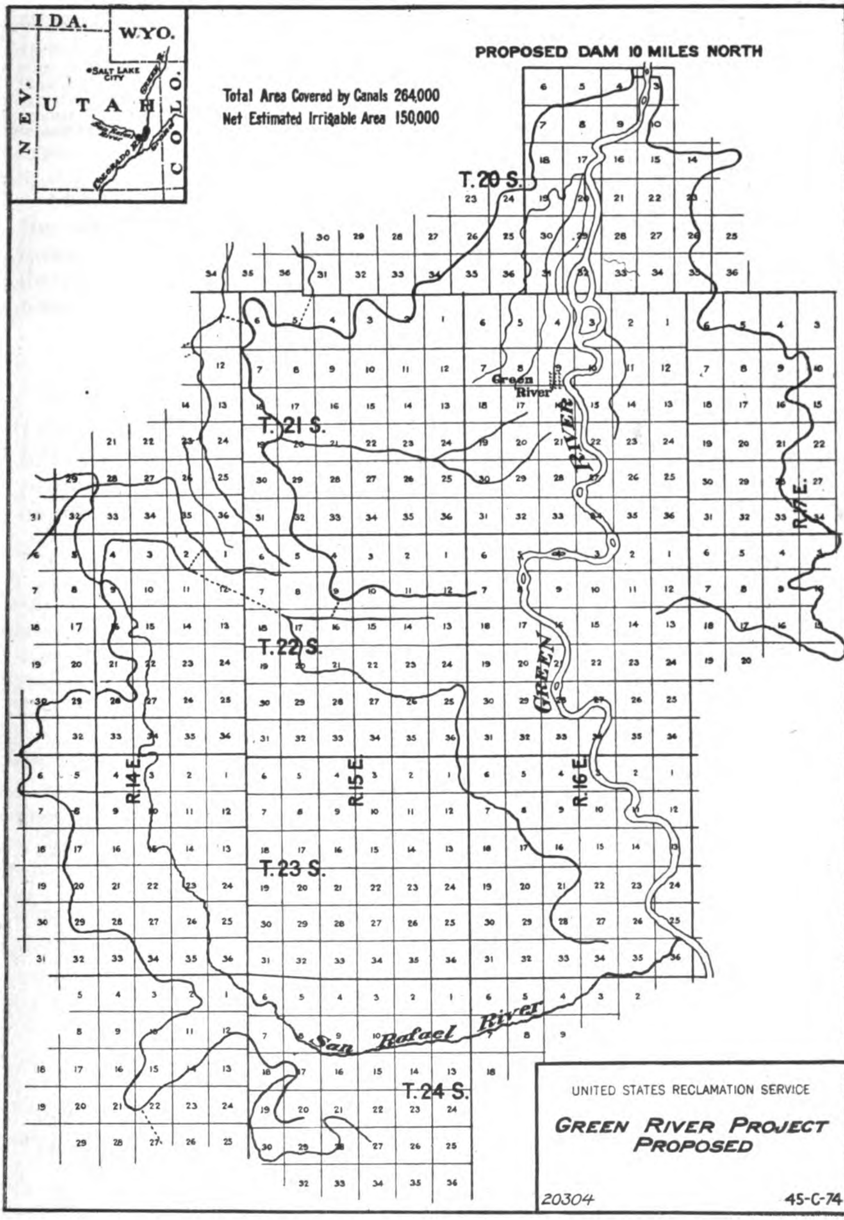
Consumptive use of water is estimated to be 2 feet in depth on irrigated land.

Duty of water.

[Acre-feet.]

	Per acre.	150,000 acres.		Per acre.	150,000 acres.
April	0.20	30,000	September	0.50	75,000
May	.40	60,000	October	.30	45,000
June	.80	120,000			
July	.90	135,000		4.00	600,000
August	.90	135,000			

PLATE XXXI


IDA.
WYO.
NEV.
UTAH
COLO.
SALT LAKE CITY
GREEN R.
San Rafael River
COLORADO R.
PROPOSED DAM 10 MILES NORTH
Total Area Covered by Canals 264,000
Net Estimated Irrigable Area 150,000
T. 20 S.
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R. 14 E.
R. 15 E.
R. 16 E.
R. 17 E.
Green River
GREEN RIVER
San Rafael River
UNITED STATES RECLAMATION SERVICE
GREEN RIVER PROJECT
PROPOSED
20304
45-C-74

Water supply.

	Average year.	Lowest year, 1919.	Storage required low year.
April	513,000	474,600	....
May	1,237,000	916,000	....
June	1,599,000	553,000	....
July	760,000	108,000	35,000
August	296,000	74,000	61,000
September	202,000	107,000	....

Storage to be provided in the plan is therefore sufficient for the lowest year of record. Development of irrigation above will increase the amount of storage necessary, but if reservoirs above are developed for power also, it is probable no storage will ultimately be necessary for irrigation.

DIVERSIONS OUT OF COLORADO RIVER BASIN.

The first recorded diversion from the Colorado Basin was made in 1879 from Strawberry River to lands in Provo Basin, Utah. The following table summarizes development up to the present and also proposed plans on which considerable sums have been spent in engineering investigation:

Transmountain diversions from Colorado Basin.

[Average annual acre-feet.]

From—	Present diversion.	Expected addition to present diversion by extension and better operation.	Proposed plans involving large expenditure.	Total.
Duchesne River (Strawberry River)	82,500	....	....	82,500
Price River (White River)	[1] 1,500	....	....	1,500
Virgin River (Grass Valley Creek)	[1] 23,000	....	....	23,000
Total in Utah	107,000	....	....	107,000
Grand River:				
North Fork	[2] 15,000	[2] 10,000	(2)	25,000
Fraser River	[2] 500	[2] 3,500	110,000	114,000
Williams River	....	....	[2] 50,000	50,000
Blue River	[2] 800	[2] 1,200	[2] 100,000	102,000
Eagle River	[2] 1,200	[2] 800	[2] 40,000	42,000
Gunnison River (Cochetopa Creek)	[2] 2,500	[2] 1,500	....	4,000
Total in Colorado	20,000	17,000	300,000	337,000
Grand total	127,000	17,000	300,000	444,000

[1] No recent data available. Taken from Water Supply Paper No. 395, E. C. LaRue. Estimate of probable future with improvements now completed.
[2] Estimates made by R. I. Meeker, special deputy State engineer, Colorado.

In addition to those in the above table, a diversion from the Duchesne to the Provo has been proposed (shown on Map of Uinta Basin), but is not here considered because believed infeasible on account of small yield due to prior users below on the Duchesne River. Also from tributaries on the Grand River it is doubtless possible, by means of longer tunnels than yet seriously considered, to intercept a large run-off from a comparatively low altitude.

All diversions present and proposed are in Colorado (see map following) or in Utah. None of any considerable size in other parts of the watershed is likely to be proposed because of local conditions, which practically prohibit such enterprises.

In Wyoming the climate of the territory surrounding Green River Basin, especially the northern part, makes it impossible to make the large expenditures per unit of yield necessary for any noteworthy transmountain diversion. Farther south, in Wyoming, on the east, the Continental Divide is low, precipitation small, and stream run-off erratic, while the flat divide would make necessary so long a diversion ditch as to be out of the question. On the west in the southern part, if diversion is practical, yet use of the water in Green River Basin itself would be better. At about the Colorado State line the Continental Divide rises from the low plateau in Wyoming abruptly to the crests of the lofty Gores Range. The Yampa River rises on the western slope of these. To the east is what is called North Park at the headwaters of the North Platte River. The streams into the park have heavy run-off, the valley floor all lies above 8,000 feet, and the rigorous climate is not favorable to large expenditure for water.

South of this the headwaters of the Grand make a large bay in the outline of Colorado Basin, extending well to the east. The run-off from the high mountains is very heavy and to the east of the northern part lie Denver and the fertile South Platte Valley. This valley has a favorable climate and large areas of good land easily reached by canals, far in excess of what can be supplied from local sources which are now quite intensively although not fully developed. Denver also must look for a water supply within a few years to sources outside the South Platte or purchase South Platte water now used on agricultural land in the vicinity, thereby losing one of its assets. (From statement of W. F. R. Mills, manager of the board of water commissioners of Denver, Colo.) Of the diversions listed in the preceding table those from the Fraser, Williams, and Blue rivers, aggregating 260,000 acre-feet annually, are proposed by the city of Denver in accordance with a plan somewhat similar in its economic features to that undertaken and put through by the city of Los Angeles, when Owens River water was diverted for use of that city and also for irrigation of adjacent land.

South of the South Platte conditions in the Arkansas Valley are similar, and while it may be that fewer opportunities for diversion exist one which will divert 40,000 acre-feet annually from the Eagle is proposed.

In the Colorado Basin the Gunnison, which is the main tributary of the Grand and lies to the south of the main stem, is contiguous on the east to the Arkansas River headwaters and also to the Rio Grande. No plans are known to divert this water to the Arkansas, but to the Saguache, a tributary of the Rio Grande, one diversion has been constructed from Cochetopa Creek. (Ranges 1 and 2 east, townships 43 and 44 north.) The first irrigable land on the Rio Grande is the San Luis Valley. Although the irrigable acreage in this valley is large, it is probable that local run-off will take care of it, and no pressure of need for water exists as in the South Platte and Arkansas valleys.

South of the Gunnison lie the headwaters of the San Juan, with a large but comparatively early run-off. To the east lies the Rio Grande, but no diversions have been proposed from it, nor is any such diversion believed feasible because of the extraordinary difficulties which will be encountered in getting water from the deep canyons of the San Juan. Moreover, the expense of reaching large areas of irrigable land along the Rio Grande from the Rio Grande River is almost prohibitive in itself.

South from the San Juan, the Continental Divide is low and flat, precipitation is small, and stream discharge so erratic that transmountain diversions are not likely to be successful.

On the west side of the Colorado Basin and in that portion of the divide between the Great Basin and the Colorado, which lies south of the Uinta Mountains, there are no areas of large precipitation such as are found on the eastern margin of the basin. Nevertheless, in the valleys of the Great Basin in Utah returns from irrigation are large and the divide offers no such obstacles to diversion as are found on the more precipitous and colder slopes of the Continental Divide. Hence some diversions have been made and as there has been opportunity to construct reservoirs on the Colorado Basin side, which go far to make such projects a success, the present diversion exceeds that to the east on the opposite side of the basin. However, it is believed that little opportunity exists for diversions additional to those now operating.

In general, transmountain diversions to the east from the Grand River have been expensive and disappointing on their yield, but when large enough to warrant close observation and maintenance are quite successful.

No reservoir sites are known on the headwaters of the Grand, such as have made the Reclamation Service diversion from Strawberry River to Spanish Fork so successful in Utah, and such as have been constructed for diversion from the Virgin River in Utah. (Located in secs. 19 and 20, T. 38 S., R. 14 W., Utah.) It is believed, however, by engineers conversant with the situation that although the expense of constructing the diversions proposed as noted in the table will be heavy per unit of yield, yet, because their size will justify adequate maintenance, they can be successfully operated.

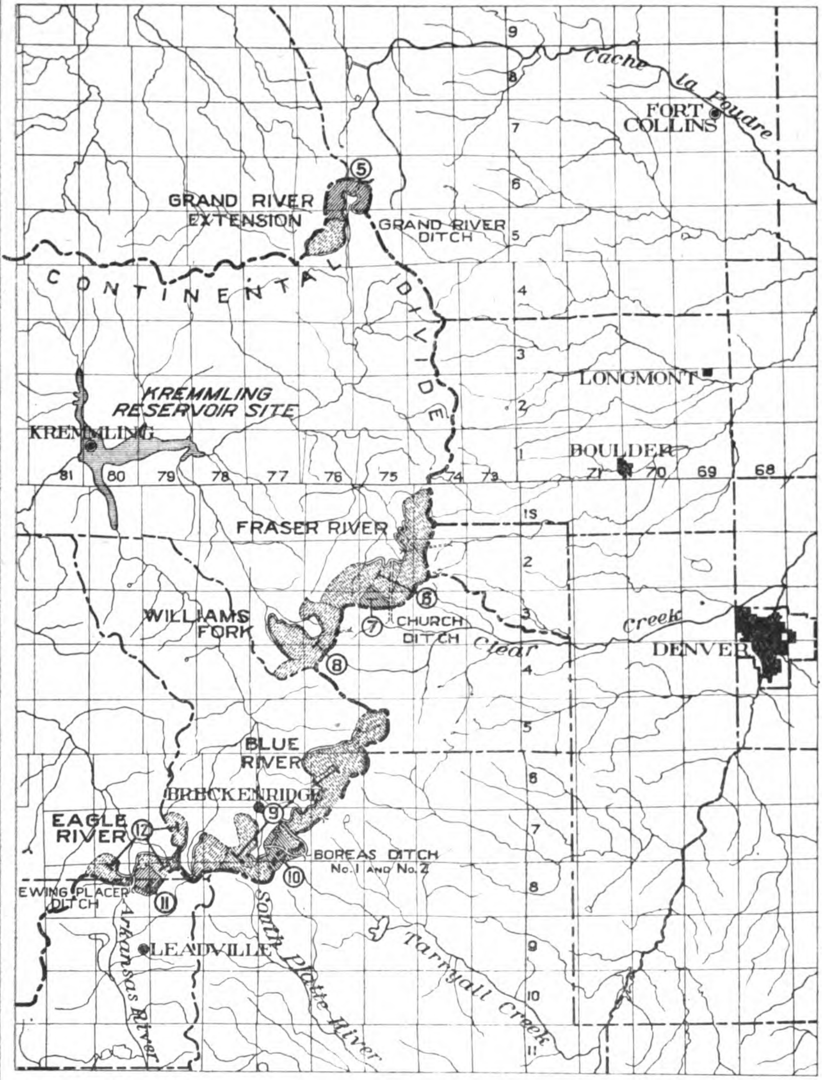
In this report, only those listed are considered in water supply computations since data are not available concerning other projects which may have been proposed.

On the following pages, tabular descriptions of existing and proposed diversions are given. It will be observed that proposed diversions from the Grand contemplate expensive tunnels and average 1,000 feet lower than operating diversions, thereby giving much greater water opportunity.

Operating transmountain diversions from Colorado River Basin.

Index number on map.	Year first used.	Name.	Source.	To—	Pass.	Elevation.	Length.	Capacity.	Present average annual diversion.	Description.
						Feet.	*Miles.*	*Second-feet.*	*Acre-feet.*	
1	1899	Daniels Pass	Strawberry River	Provo River	Daniels			33–55	4,500	5 small open ditches.
2	1913	Strawberry Valley	do	Spanish Fork		7,518	3.77	635	78,000	Strawberry reservoir of 250,000 acre-foot capacity on Strawberry River, feeder canals from Indian and Trail creeks. Tunnel 3.77 miles long from reservoir.
3	1896	Soldier Summit	Price River	do	Soldier Summit			15	1,500	Open ditch.
4	1909	New Castle	Virgin River	Pinto Creek			1	200	23,000	Grass Valley reservoir of 23,000 acre-feet on creek of same name. Feeder canal from Santa Clara Creek.
5	1891	Grand River	North Fork, Grand	Cache la Poudre	Mount Meadow	10,500	11	150	15,000	North and south ditches, open and unlined.
7	1906	Church	Fraser	Clear Creek	Berthoud	11,300	4	50	500	Tunnel, ditch, and wood-stave pipe.
10	1910	Boreas	Blue	Tarryall	Boreas	11,500	.75	10	800	Open, unlined ditch.
11	1906	Ewing Placer	Eagle	Arkansas	Tennessee	10,300	2	15	1,200	
13	1913	Cochetopa	Cochetopa	Rio Grande-Saguache	Cochetopa	10,000	3	40	2,500	
		Total							127,000	

Strawberry River is a tributary of the Duchesne. The last five items are from tributaries of the Grand. Total in Utah, items 2, 3, 4, and 5, 107,000 acre-feet. Total in Colorado, items 6, 8, 11, 12, and 13, 20,000 acre-feet. Items 2, 4, and 5, from La Rue, W. S. 395. Items 6, 8, 11, 12, and 13, compiled by R. I. Meeker.



CONSTRUCTED AND PROPOSED DIVERSIONS
FROM
COLORADO RIVER BASIN
TO
MISSISSIPPI RIVER BASIN

EXPLANATION

Constructed — Proposed

20305

UNITED STATES RECLAMATION SERVICE

45-C-76

Proposed transmountain diversions from Grand River Basin to Eastern Slope, Colorado.

[Arranged in order from north. Compiled by R. I. Meeker, Apr. 21, 1921.]

Index number on map.	Project.	Source.	To.	Elevation.	Approximate annual diversion.	Utilization.	System.
				Feet.	*Acre-feet.*		
5	Grand River extension	North Fork Grand	Cache la Poudre	10,500	10,000	Irrigation	6 miles open canal.
6	Fraser River	Fraser and tributaries.	Clear Creek or South Boulder.	9,200	110,000	Municipal and irrigation, city of Denver.	Tunnel 6 to 8 miles. Collection canals 30 to 50 miles.
8	Williams Fork	Williams Fork	Clear Creek	10,300	50,000	do	Tunnel 3 miles. Collection canals 21 miles.
9	Blue River	Blue and tributaries Ten Mile.	South Platte	10,300	100,000	do	Tunnel 5 miles. Collection canals 50 to 80 miles.
12	Eagle River	Eagle and tributaries Ten Mile.	Arkansas	10,200	40,000	Irrigation	Tunnel, 2 miles. Collection canals 25 miles.
	Total				310,000		

(Compiled from filings State engineer's office, Denver.)

NOTE.—Other interstream diversions have been planned and discussed. Specific data are not at hand. For example, a 10-mile tunnel from Grand Lake to either the St. Vrain or Big Thompson rivers, at an elevation of 8,400 feet. West Portal would have a physical water opportunity of 250,000 acre-feet per year.

APPENDIX E.

POWER.

For convenience, this is discussed under two heads.

(1) Power sites, both constructed and possible, which are on the headwaters of the main tributaries or on the minor feeders of the main tributaries. This may be characterized as intrastate power and to date the only existing installations are in such locations.

(2) Power sites which are in the canyon and plateau region of the upper basin on the main tributaries and on the Colorado itself, in both upper and lower basins. No installations have been made in this region. This may be characterized as interstate power.

POWER ON TRIBUTARIES.

On the small tributaries of the streams in the upper basin the steep slopes are favorable to diversion of water for power. It is possible that many sites exist concerning which no knowledge is available. For the purpose of this report, power in these locations is of little importance. At the close of this appendix is a list of existing installations and known undeveloped sites.

POWER ON MAIN TRIBUTARIES AND COLORADO RIVER.

After leaving the mountains all streams enter the great central plateau and canyon region where diversion for irrigation is impossible except at one point (proposed Green River project, Utah) and even there it is extremely difficult. In this region the flat grade of the rivers gives opportunity for immense reservoirs. The narrow canyons are favorable to the construction, where foundations justify, of high dams behind which the discharge can be stored and its annual as well as seasonal irregularities smoothed out.

This opportunity exists on every major tributary except the Duchesne. On the White, however, exploration of dam foundations has not been made. On the Grand the size of the reservoir is limited by location of the Denver & Rio Grande Railroad, and on the San Juan the large amount of silt carried probably makes such a reservoir not worth while because of short life. Foundation at dam site on this river has not been explored. The main Colorado also flows in a succession of canyons where high dams can control the flow and where huge reservoir sites are found.

It is the potential power below these reservoirs that must be investigated in connection with a proposal to use them for Imperial Valley irrigation storage. Different requirements for discharge generally but not always makes the use of a reservoir for irrigation incompatible with use for commercial power to the fullest possible extent.

For this report, therefore, an estimate is necessary of the potential power not only on the Colorado River but also below the large reservoir sites on the tributaries, which latter are also below most irrigation possibilities on the respective tributaries. Power possibilities above may be neglected.

In the following an estimate is made of the potential power assuming that the total fall can be utilized. However, it is known that the total fall of the stream can not be utilized although conditions are favorable on the Colorado and its tributaries. Some head will be lost in creating storage to equate the stream; it will always be necessary to lose a small amount at the tailrace of power plants; dam sites may not exist at the proper places or it may not be possible to build as high dams as necessary at the sites which can be used. Railroads may be located at such points as to prohibit raising the water surface behind good dam sites. A multitude of circumstances may interfere, but in the present state of knowledge no other basis for comparable estimates appears.

The proper height of dam at any of the known locations has not received study from this standpoint, and it may be found that, for the purpose of creating head alone, higher dams than at present proposed are economically feasible.

As to stream discharge no account is taken of loss by evaporation from reservoir surface, the total of which would be large if all sites are built.

GREEN RIVER.

The major upper site on the Green River is the Flaming Gorge of 4,000,000 acre-feet capacity. Below this the main tributaries are the Yampa and White from the east and the Duchesne from the west. Below the Duchesne, the Price and San Rafael also enter from the west but are of no importance to power because of small discharge.

For convenience the basin is taken up by sections, and tributaries are discussed first.

Calculated power is horsepower at turbines based on 88 per cent efficiency.

YAMPA RIVER.

Juniper reservoir site to mouth of Little Snake.

[Juniper reservoir site (13) is the controlling reservoir.]

Juniper reservoir site, capacity	acre-feet	1,800,000
Present average annual discharge	do	1,300,000
Estimated ultimate after irrigation develops above	do	1,140,000
Storage capacity to equate stream	do	1,550,000
Raise in water surface for 1,800,000 acre-foot capacity	feet	240
Head below 1,550,000 acre-foot storage	do	150
Equated discharge:		
Present	second-feet	1,800
Ultimate	do	1,600
Elevation of outlets	feet	6,090
Elevation at mouth of Little Snake, about	do	5,850
Total fall	do	240
Distance	miles	25
Potential horsepower at dam site:		
Present		27,000
Ultimate		24,000
Potential horsepower in section:		
Present		43,200
Ultimate		38,400

Mouth of Little Snake to mouth of Yampa.

[Control by Juniper reservoir on Yampa and possible reservoir on Little Snake, or on Yampa below mouth of Little Snake.]

Present average annual discharge	acre-feet	1,880,000
Estimated ultimate after irrigation develops above	do	1,560,000
Equated discharge:		
Present	second-feet	2,600
Ultimate	do	2,180
Elevation at mouth of Little Snake about	feet	5,850
Elevation at mouth of Yampa	do	4,980
Total fall	do	870
Distance	miles	45
Potential horsepower:		
Present		226,000
Ultimate		190,000

WHITE RIVER.

Rangely reservoir site to mouth.

[Rangely reservoir site (17) is the controling reservoir.]

Rangely reservoir site, capacity	acre-feet	900,000
Present average annual discharge	do	550,000
Estimated ultimate after irrigation above	do	360,000
Storage capacity to equate stream	do	330,000
Raise in water surface for 900,000 acre-foot capacity	feet	200
Head below 330,000 acre-foot storage	do	160
Equated discharge:		
Present	second-feet	760
Ultimate	do	500
Elevation of outlets	feet	4,960
Elevation at mouth of river	do	4,640
Total fall	do	320
Distance	miles	70
Potential horsepower at dam site:		
Present		12,200
Ultimate		8,000
Potential horsepower in section:		
Present		24,300
Ultimate		16,000

MAIN STREAM OF GREEN RIVER.

Flaming Gorge reservoir site to mouth of Yampa.

[Flaming Gorge is the controling reservoir.]

Flaming Gorge reservoir site (9) capacity	acre-feet	4,000,000
Present average annual discharge	do	1,920,000
Estimated ultimate after irrigation development above	do	1,120,000
Storage capacity to equate stream	do	1,000,000
Raise in water surface for 4,000,000 acre-foot capacity	feet	240
Head below 3,000,000 acre-foot capacity	do	210
Equated discharge:		
Present	second-feet	2,700
Future	do	1,600
Elevation of outlets	feet	6,035
Elevation at Yampa mouth	do	4,980
Total fall	do	1,055
Distance	miles	80
Potential horsepower at dam site:		
Present		56,700
Ultimate		33,600
Potential horsepower between outlets and mouth of Yampa:		
Present		285,000
Ultimate		169,000

Mouth of Yampa to mouth of White and Duchesne.

[Control by Flaming Gorge and Juniper reservoir sites.]

Present average annual discharge:		
Below mouth of Yampa	acre-feet	3,800,000
Above mouth of Duchesne	do	4,600,000
Average	do	4,200,000
Estimated ultimate after irrigation develops above	do	3,100,000
Equated discharge:		
Present	second-feet	5,800
Ultimate	do	4,300
Elevation at Yampa mouth	feet	4,980
Elevation at Duchesne mouth	do	4,645
Fall in river	do	335
Distance	miles	90
Potential horsepower:		
Present		194,000
Future		144,000

Mouth of Duchesne to mouth of Green River.

Present average annual discharge	acre-feet	5,590,000
Estimated future after irrigation development above	do	3,890,000
Stream probably not entirely equated because Duchesne River uncontrolled		
Equated discharge:		
Present	second-feet	7,800
Future	do	5,400
Elevation at Duchesne mouth	feet	4,645
Elevation at mouth of Green River	do	3,875
Total fall	do	770
Distance	miles	240
Potential horsepower:		
Present		601,000
Ultimate		416,000

GRAND RIVER.

Dewey reservoir site to mouth.—Dewey reservoir would be the control. About 4,000,000 to 4,500,000 acre-foot capacity is necessary to equate the stream, but location of the Denver & Rio Grande Railroad limits capacity to 2,270,000 acre-feet.

Possible plan for power.

Present average annual discharge	acre-feet	6,670,000
Estimated ultimate after irrigation develops above	do	5,590,000
Raise in water surface for 2,270,000 acre-foot capacity	feet	215
Reserve for stream control, storage	acre-feet	1,500,000
Head below 1,500,000 acre-feet	feet	150
Equated discharge, entire flow	second-feet	7,750
Continuous discharge possible with 1,500,000 storage both present and ultimate	second-feet	6,000
Elevation of outlets	feet	4,225
Elevation at mouth of Grand	do	3,875
Total fall	do	350
Distance	miles	125
Potential horsepower:		
At dam site		90,000
In section		210,000

COLORADO RIVER.

From junction Green-Grand to San Juan.

[Assumed control by reservoir at junction.]

Present average annual discharge	acre-feet..	12,260,000
Estimated ultimate after irrigation development above	do....	9,480,000
Equated discharge:		
Present	second-feet..	17,000
Ultimate	do....	13,000
Elevation at junction	feet..	3,875
Elevation at San Juan, about	do....	3,475
Total fall	do....	400
Distance	miles..	200
Potential horsepower:		
Present		680,000
Ultimate		520,000

From San Juan mouth to high water proposed Boulder Canyon reservoir.

Present discharge at mouth of San Juan	acre-feet..	14,960,000
Present discharge at Boulder Canyon	do....	15,700,000
Average for section	do....	15,400,000
Estimated ultimate after irrigation above	do....	11,200,000
Equated flow:		
Present	second-feet..	21,000
Ultimate	do....	15,500
Elevation at mouth of San Juan	feet..	3,475
Elevation water surface Boulder Canyon reservoir	do....	1,275
Total fall	do....	2,200
Distance	miles..	325
Potential horsepower:		
Present		4,620,000
Ultimate		3,410,000

Because of necessity for preserving the Grand Canyon National Park from industrial invasion, probably only half the potential power in this section is actually realizable.

From Boulder Canyon to mouth of Colorado.—At Boulder Canyon the Colorado River begins to emerge from the deep canyons which have confined it up to that point. Dam sites are not frequent below Boulder Canyon nor can high dams be built because of shallow canyons. The river grade is flat and irrigable lands and towns might be submerged by reservoirs.

Assuming a part of the head at Boulder Canyon to be used for regulation, there are three power sites as follows:

	Head.
Boulder Canyon	320
Bulls Head	155
Williams Fork	75
Total	550

Irrigable lands between Boulder Canyon and Williams Fork will affect to some extent the equation of the flow, as will also the demands for Imperial Valley. Neglecting these, however, the items used in other sections of the river are as follows:

Present average annual discharge..........acre-feet..	15,700,000
Estimated ultimate after irrigation above..........do....	11,700,000
Equated flow:	
Present..........second-feet..	22,000
Ultimate..........do....	16,000
Total head..........feet..	550
Potential horsepower:	
Present..........	1,210,000
Ultimate..........	880,000

Summary of potential power in canyon region.

From—	To—	Second-feet equated flow.		Miles.	Total fall.	Potential horsepower at turbines, continuous output 88 per cent efficiency.	
		Present.	Ultimate.			Present.	Ultimate.
GREEN RIVER BASIN.							
Main Stem:					Feet.		
Flaming Gorge......	Yampa..........	2,700	1,600	80	1,055	285,000	169,000
Yampa..........	Duchesne..........	5,800	4,300	90	335	194,000	144,000
Duchesne..........	Colorado..........	7,800	5,400	170	770	601,000	416,000
Yampa River: Juniper..	Mouth..........	2,600	2,200	70	1,120	289,000	244,000
White River: Rangely...	.....do..........	760	500	70	320	24,300	16,000
Total..........	....	......	......	......	......	1,393,300	989,000
GRAND RIVER BASIN.							
Dewey..........	Mouth..........	6,000	6,000	125	350	210,000	210,000
SAN JUAN BASIN.							
[Possibilities not attractive.]							
COLORADO RIVER.							
Junction of Green and Grand.	San Juan..........	17,000	13,000	200	400	680,000	520,000
San Juan..........	High water, Boulder Canyon reservoir.	21,000	15,500	325	2,200	4,620,000	3,410,000
Boulder Canyon..........	Gulf..........	22,000	16,000	450	550	1,210,000	880,000
Total..........	....	......	......	......	......	6,510,000	4,810,000
Grand total, Colorado Basin.	....	......	......	......	......	8,115,000	6,011,000

Summary of all power possibilities.

[Possible horsepower at turbines 88 per cent efficiency.]

	Estimated potential power in river.		Power site possibilities.[1]
	Present.	Ultimate.	
Green River:			
Yampa..........	289,000	244,000	45,000
White..........	24,300	16,000	12,200
Main stem..........	1,080,000	729,000	612,000
Grand River..........	210,000	210,000	90,000
Colorado River..........	6,510,000	4,810,000	5,985,000
Total..........	8,113,000	6,009,000	6,744,000
Per cent..........	100	74	83

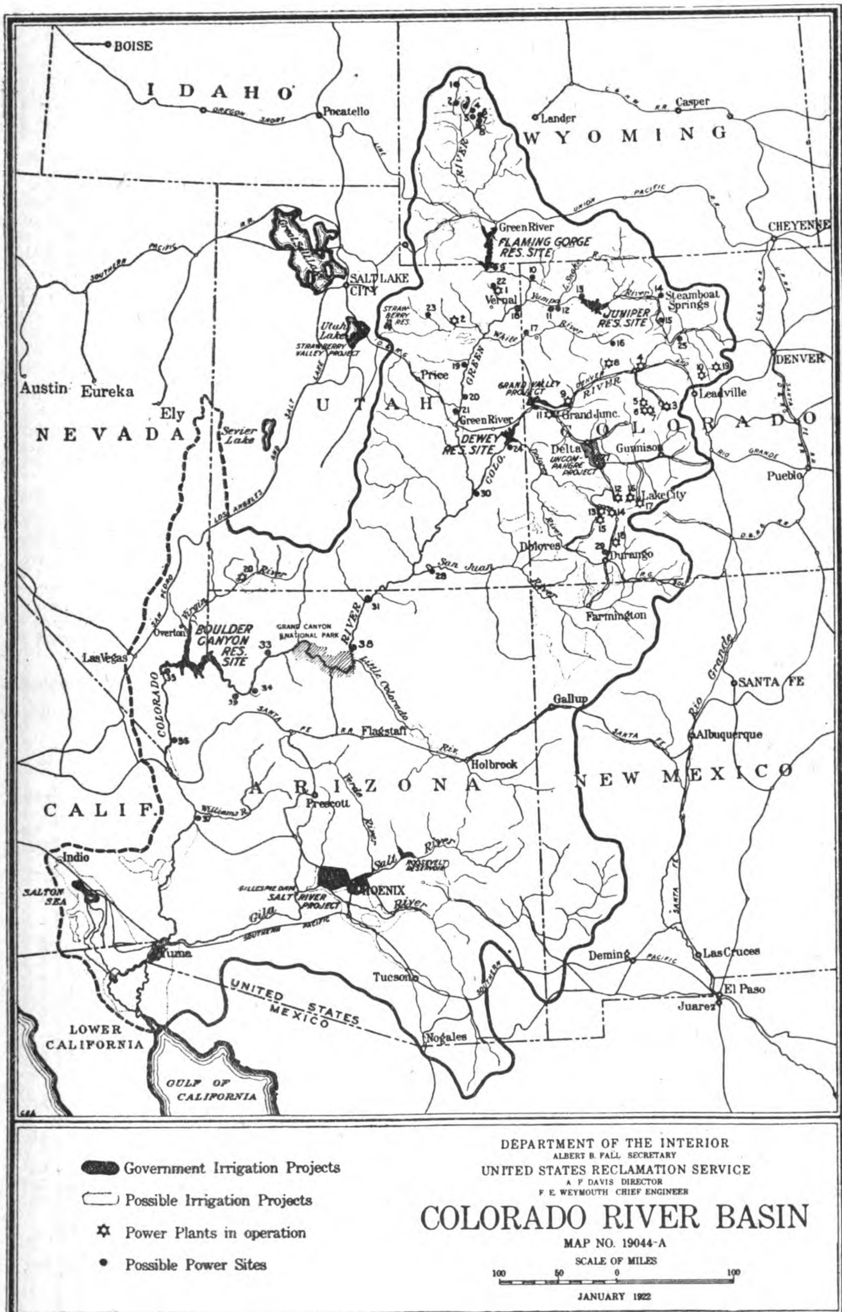
[1] Based on heads at sites applied for to Federal Power Commission or known by surveys or taken from Water-Supply Paper No. 395, by E. C. La Rue. Discharge as at present.

Power sites, Colorado River Basin below Flaming Gorge, Juniper, Rangely, and Kremmling.[1]

Index No. on map.	Name.	Stream.	State.	Average present discharge.	Head.	How created.	Horsepower at 88 per cent efficiency at turbines.
				Sec.-ft.	*Feet.*		
13	Juniper	Yampa River	Colorado	1,800	[2] 150	Dam	27,000
12	Cross Mountain	do	do	1,800	[2] 100	do	18,000
	Total, Yampa River.						45,000
17	Rangely	White River	Colorado	760	[2] 160	Dam	12,000
9	Flaming Gorge	Green River—main stem.	Utah	2,700	[3] 440	225-foot dam, 215-foot tunnel.	119,000
10	Browns Park	do	Colorado	2,700	[2] 300	Dam	81,000
18	Split Mountain Canyon.	do	Utah	5,800	[2] 250	Dam and tunnel.	145,000
19	Minnie Maud	do	do	7,800	[4] 200	Dam	156,000
20	Rattlesnake	do	do	7,800	[4] 165	do	129,000
21	Coal Creek	do	do	7,800	[4] 160	do	139,000
	Total, Green River—main stem						769,000
25	Kremmling	Grand River	Colorado	1,600	[5] 411	Dam and tunnel.	65,000
24	Dewey	do	do	6,000	[2] 150	Dam	90,000
	Total, Grand River						155,000
30	Cataract Canyon	Colorado River	Utah	17,000	[2] 400	Dam	680,000
31	Glen Canyon	do	Arizona	20,500	[2] 450	do	922,000
38	Marble Canyon	do	do	20,500	[2] 300	do	[6] 615,000
33	Andrus Canyon	do	do	20,500	[2] 125	do	[6] 256,000
34	Diamond Creek	do	do	20,500	[2] 285	do	[6] 584,000
39	Spencer Canyon	do	do	20,500	[2] 185	do	[6] 379,000
35	Boulder Canyon	do	Arizona-Nevada.	22,000	[2] 480	do	1,056,000
36	Bulls Head	do	do	22,000	[2] 155	do	341,000
37	Williams Fork	do	do	22,000	[2] 75	do	165,000
	Total, Colorado River below junction						4,998,000
	Total, Colorado River Basin (exclusive of San Juan).						5,979,000

[1] Omitting the Grand Canyon region.
[2] From reclamation data.
[3] Head is from application before Power Commission. Power created is from multiplying this head by estimate of available flow made for this report and is not the power given in application.
[4] From E. C. La Rue, Water-Supply Paper No. 395, as to head; discharge is from analysis made for this report.
[5] Head and discharge from E. C. La Rue, Water-Supply Paper No. 395.
[6] Based on assumption of regulation of flow by storage above these sites.

PLATE XXXIV


BOISE
IDAHO
Pocatello
Lander
Casper
WYOMING
Green River
FLAMING GORGE RES. SITE
CHEYENNE
SALT LAKE CITY
Utah Lake
STRAWBERRY VALLEY PROJECT
Vernal
JUNIPER RES. SITE
Steamboat Springs
DENVER
Leadville
Price
GRAND VALLEY PROJECT
Grand Junc.
Green River
DEWEY RES. SITE
Delta
UNCOMPAHGRE PROJECT
Gunnison
COLORADO
Pueblo
Lake City
Dolores
Durango
Austin
Eureka
Ely
NEVADA
Sevier Lake
UTAH
San Juan
Farmington
Overton
BOULDER CANYON RES. SITE
GRAND CANYON NATIONAL PARK
Las Vegas
SANTA FE
Gallup
Flagstaff
Holbrook
Albuquerque
NEW MEXICO
ARIZONA
CALIF.
Prescott
Indio
SALTON SEA
SALT RIVER PROJECT
PHOENIX
Yuma
Tucson
Deming
Las Cruces
El Paso
Juarez
UNITED STATES
MEXICO
Nogales
LOWER CALIFORNIA
GULF OF CALIFORNIA
Government Irrigation Projects
Possible Irrigation Projects
Power Plants in operation
Possible Power Sites
DEPARTMENT OF THE INTERIOR
ALBERT B. FALL SECRETARY
UNITED STATES RECLAMATION SERVICE
A. P. DAVIS DIRECTOR
F. E. WEYMOUTH CHIEF ENGINEER
COLORADO RIVER BASIN
MAP NO. 19044-A
SCALE OF MILES
100 50 0 100
JANUARY 1922

List of power applications, Colorado River Basin,[1] *to Jan. 1, 1922.*

No.	Name of applicant.	Horsepower.		Stream and State.
		Primary (90 per cent of time.)	Estimated installed capacity.	
30	Beckman & Linden Engineering Corporation.	115,200	200,000	Colorado River, Ariz.
59	Edward L. Beyard [2]	1,400,000	1,800,000	Do.
90	Frank G. Baum	9,400	15,000	Little Colorado River, Ariz.
91	.....do	5,560	7,000	Black River, Ariz.
111	Southern California Edison Co	2,500,000	3,300,000	Colorado River, Ariz.
[3] 113	Great Basin Power Co	3,950	10,000	North Fork Duchesne River, Utah.
[3] 121	James B. Girand	60,000	120,000	Colorado River, Ariz.
150	Pacific Gas & Electric Co			Transmission line, Arizona.
158	Utah Light & Power Co.[2]	80,000	100,000	Green River, Utah.
163	James F. Myser and Edward E. Drach	50,000	100,000	Frying Pan River, Colo.
165	Utah Power & Light Co.[2]	78,500	125,000	Green River, Utah.
[3] 190	Uinta Power & Light Co	2,425	2,425	Pole Creek and Uinta River, Utah.
202	Green River Power Co.[2]	911,600	1,200,000	Green River, Utah.
[3] 203	Thos. P. Mitchell			Transmission line, Colorado.
230	James B. Girand [2]	65,000	130,000	Colorado River, Ariz.
231	.....do [2]	65,000	130,000	Do.
236	Blue Mountain Irrigation Co	40	40	Pole Canyon, near Monticello, Utah.
238	City of Los Angeles [2]	596,000	800,000	Colorado River, Ariz.
240	Stene Consolidated Copper Co	14,000	28,000	Bill Williams River, Ariz.
258	Southern California Edison Co.[2]	900,000	1,200,000	Colorado River, Ariz.-Nev.
263	William J. Barker	52,000	65,000	Grand River, Colo.
265	Guy P. Mohler [2]	316,800	400,000	Colorado River, Ariz.-Nev.

[1] See pp. 177–192, First Annual Report of Federal Power Commission.
[2] In conflict with other applications listed.
[3] Favorable action taken by Federal Power Commission.

Undeveloped power sites on tributaries of Colorado River above main regulating reservoirs.

[Compiled from data contained in Water Supply Paper No. 395 by E. C. La Rue.]

Index No. on map	Stream.	Location.	Name.	Horsepower.	Head.	Remarks.
1	Green River	Green River Basin		3,125	100	150 foot dam, 10 miles above Kendall.
2	.....do	.....do		5,340	120	At Kendall.
3	New Fork River	.....do		450	110	New Fork Lake.
4	Willow Creek	.....do		420	110	Willow Lake.
5	Pine Creek	.....do		3,100	310	Fremont Lake.
6	Pole Creek	.....do		1,780	280	Half Moon and Fayette lakes.
7	Fall Creek	.....do		860	225	Burnt Lake.
8	Boulder Creek	.....do		1,750	200	Boulder Lake.
14	Yampa River	Yampa River Basin, Colo.	Steamboat Springs			No data.
15	.....do	.....do	Upper Bear	1,350	100	Upper Bear reservoir site.
16	South Fork White River.	White River Basin	Stillwater			
22	Ashley Creek	Uinta Basin, Utah	Ashley Creek	18,900		
23	Duchesne River	.....do	Duchesne	8,760		
25	Grand River	Grand River Basin, Colo.	Gore Canyon	60,000	411	By tunnel 24,000 feet long.
27	Uncompahgre River.	Montrose, Colo	Montrose			No data.
28	San Juan River	Utah	Bluff			No data; not attractive unless irrigation above regulates flow.
29	Las Animas River.	Durango, Colo	Durango	7,000	100	Animas reservoir site.

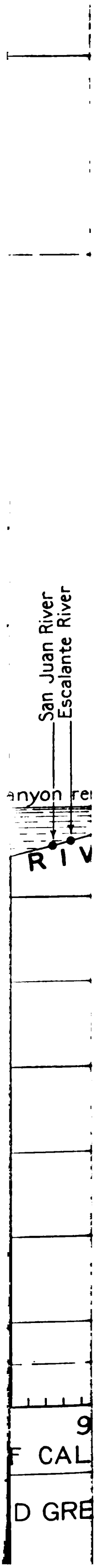
Power plants on tributaries of Colorado River above main regulating reservoirs.

[Compiled from data contained in Water Supply Paper No. 395, by E. C. La Rue.]

Index No. on map.	Name.	Stream.	Location.	Head.	Kilo-watt.	Horse-power.
				Feet.		
1	Ashley Creek	Ashley Creek	Uinta Basin, Utah	84	250	400
2	Myton	Lake Fork	do		150	250
3	Castle Creek	Maroon Creek Castle Creek Hunter Creek	Grand River Basin, Colo.	356 340 870	400 400 800	2,900
4	Shoshone	Grand River	do	415	10,000	18,000
5	Crystal River	Crystal River	do	390	1,300	1,750
6	Yule Creek	Yule Creek	do	90	300	424
7	Osgood	Crystal River	do		65	85
8	Rifle	Rifle Creek	do	70	150	247
9	Cameo plant	Abandoned				
10	Spruce Creek	Spruce Creek	do	250	450	[1] 700
11	Grand Junction	Gunnison River	do			
12	Ouray	Uncompahgre River	do	350	450	800
13, 14	Ames	Howards Fork of Lake Fork.	do	580 835	3,600	6,200
15	Ilium	South Fork San Miguel.	do	490	1,200	1,600
16	Hidden Treasure	Henson Creek	do	90	128	321
17	Hinsdale	Lake Fork	do	65	200	160
18	Tacoma	Animas River	San Juan River Basin, Colo.	963	4,500	6,700
19	Summit County	Snake Creek	Grand River Basin, Colo.	500	1,000	1,600
20	St. George	Cottonwood Creek	Virgin River, Utah	325	45	60
21	Cottonwood	do	Green River Basin, Utah	75	50	75

[1] Two plants.

Digitized by Google


San Juan River
Escalante River
anyon re
R I V
9
F CAL
D GRE

Appendix F.

PROFILES OF DAM SITES AND RESERVOIR CAPACITY CURVES.

Plates XXXVI to XLVIII, inclusive.

ALL-AMERICAN CANAL PLANS.

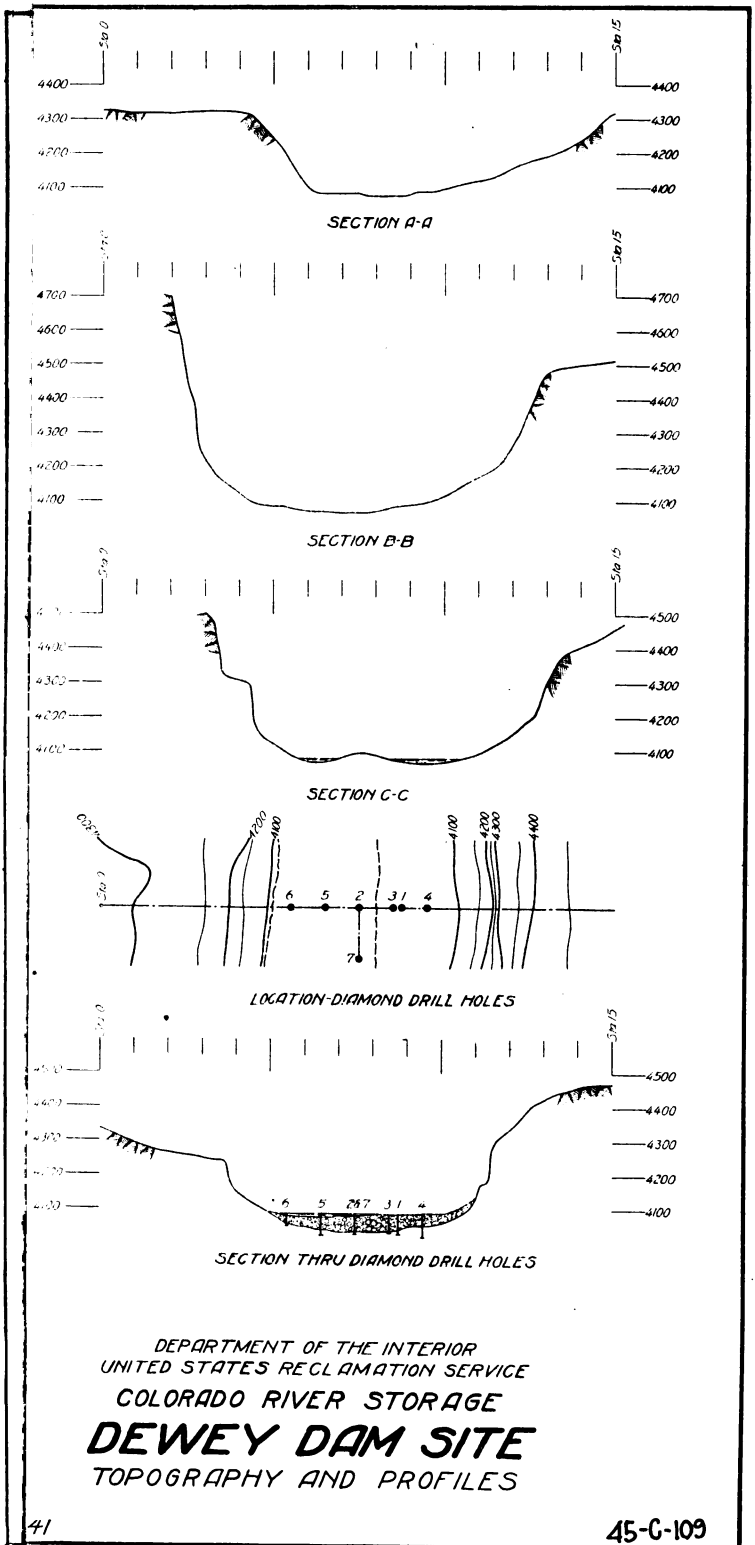
Plates XLIX to LII, inclusive.

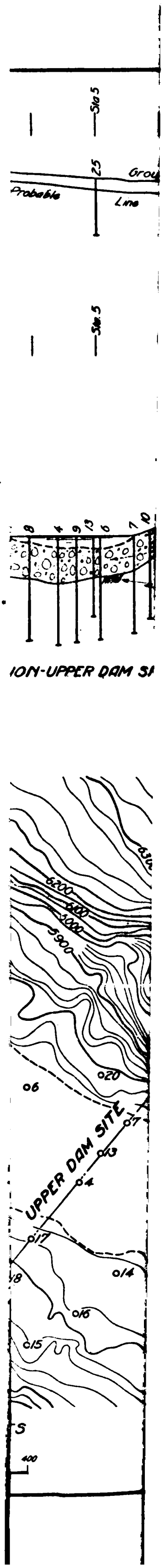
SENTINEL RESERVOIR, GILA RIVER, ARIZONA.

Capacity Table.

Raise in water surface:	Acre-feet.
25 feet	16,500
50 feet	170,000
75 feet	560,000
100 feet	1,200,000
125 feet	2,000,000
150 feet	3,200,000

Construction of this reservoir has been proposed to 2,200,000 acre-feet for flood control.


SECTION A-A
SECTION B-B
SECTION C-C
LOCATION-DIAMOND DRILL HOLES
SECTION THRU DIAMOND DRILL HOLES
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
COLORADO RIVER STORAGE
DEWEY DAM SITE
TOPOGRAPHY AND PROFILES
41
45-C-109


Sta 5
25
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Line
Sta 5
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10
ION-UPPER DAM S
6200
6100
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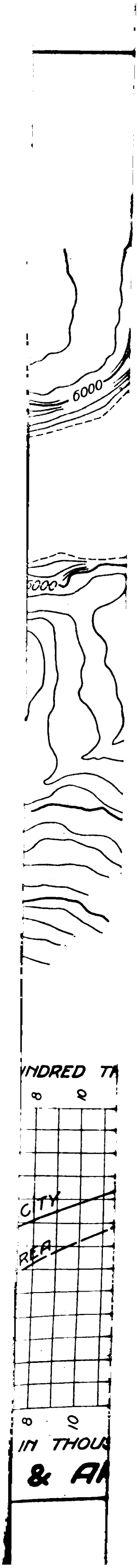
5900
o20
o6
UPPER DAM SITE
o7
o13
o4
o17
o14
o16
o15
S
400


6000
6000
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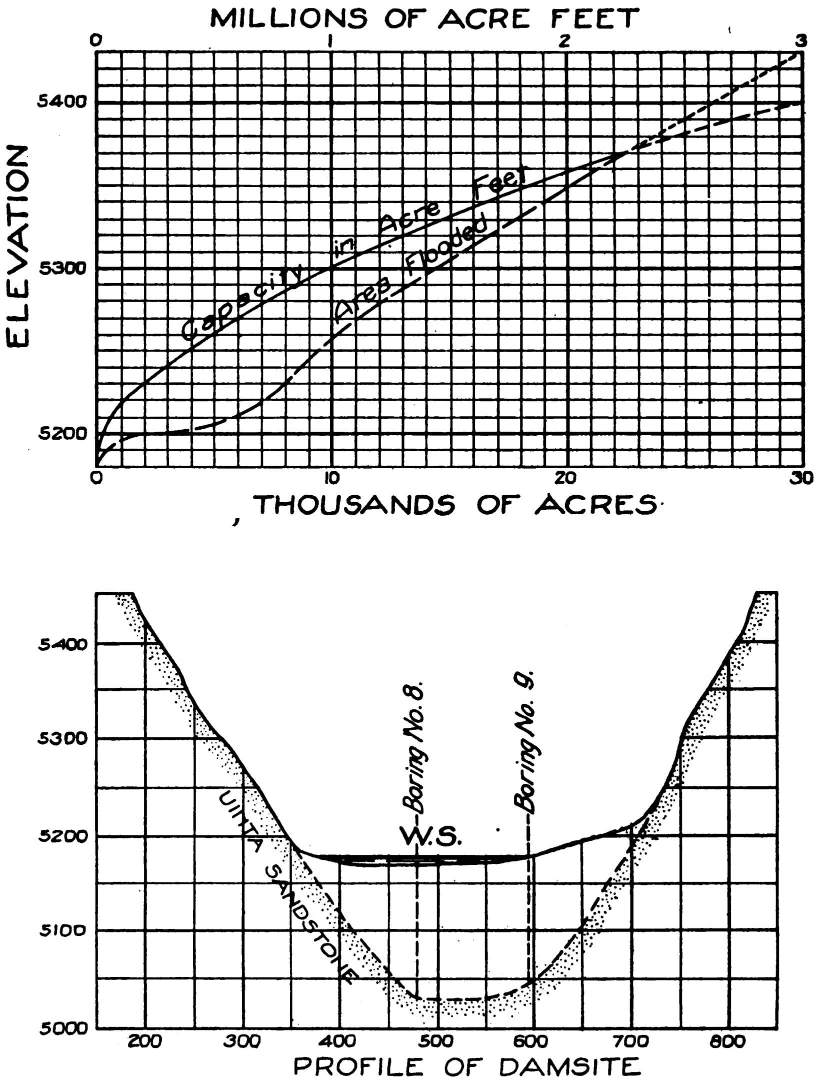
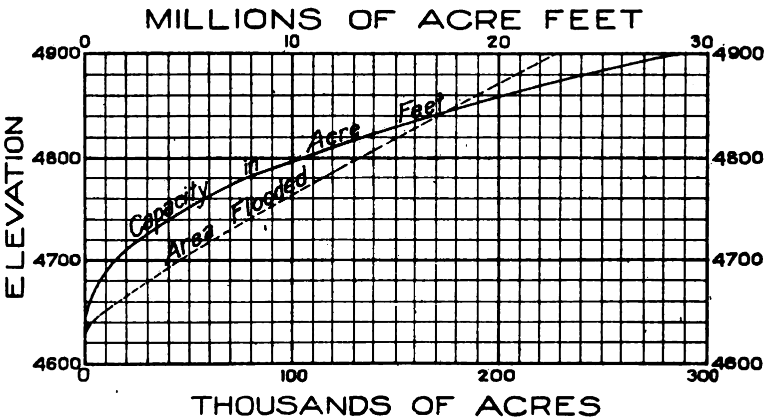
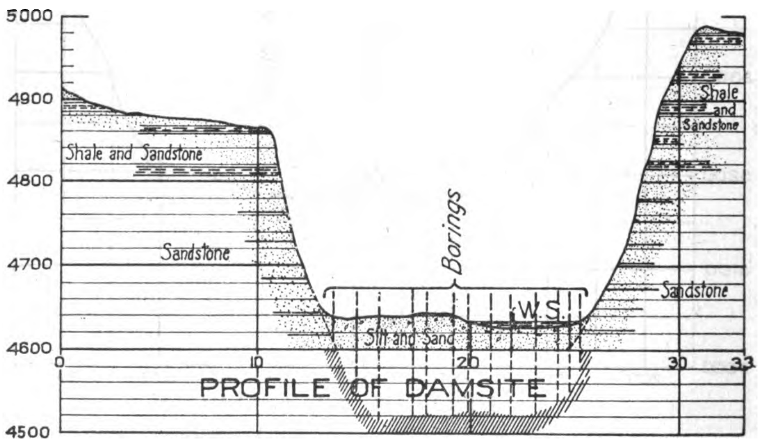
CITY
REA
IN THOU
& A



SECTION AND CURVE
BROWN'S PARK DAMSITE
GREEN RIVER
SEC. 29 - T. 9 N. - R. 102 W.
COLORADO

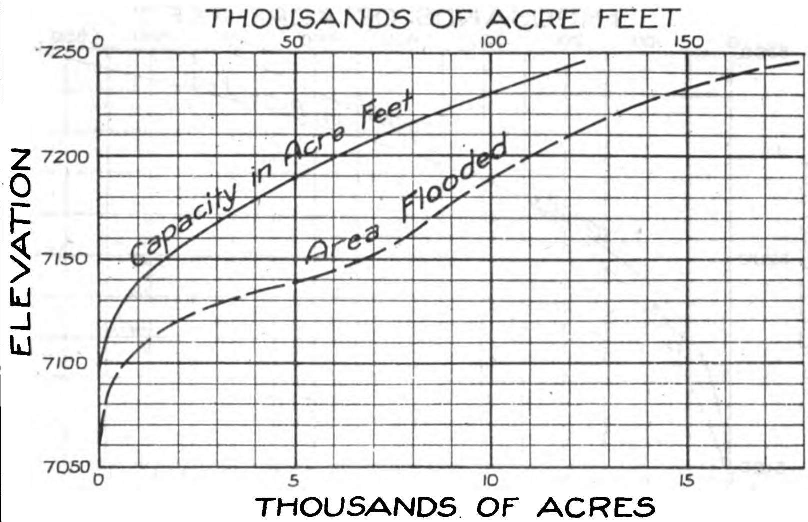
20307 UNITED STATES RECLAMATION SERVICE 45-C-90

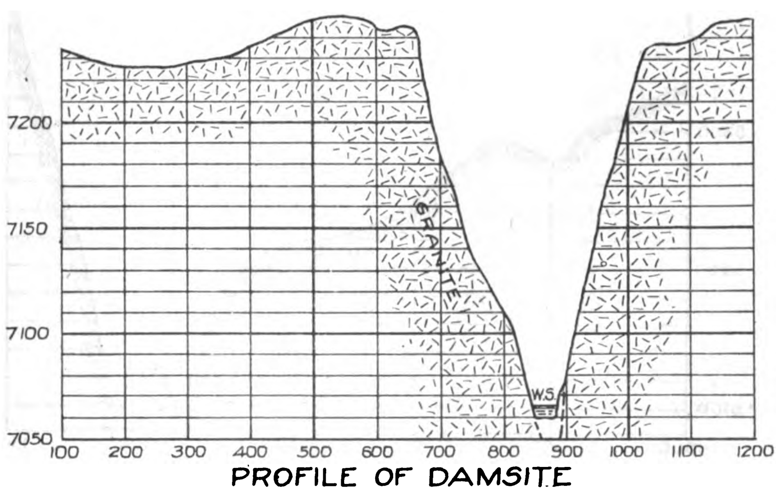




SECTION AND CURVE
OURAY DAMSITE
GREEN RIVER
SEC. 7-18-T. 10 S. - R. 19 E.
UTAH

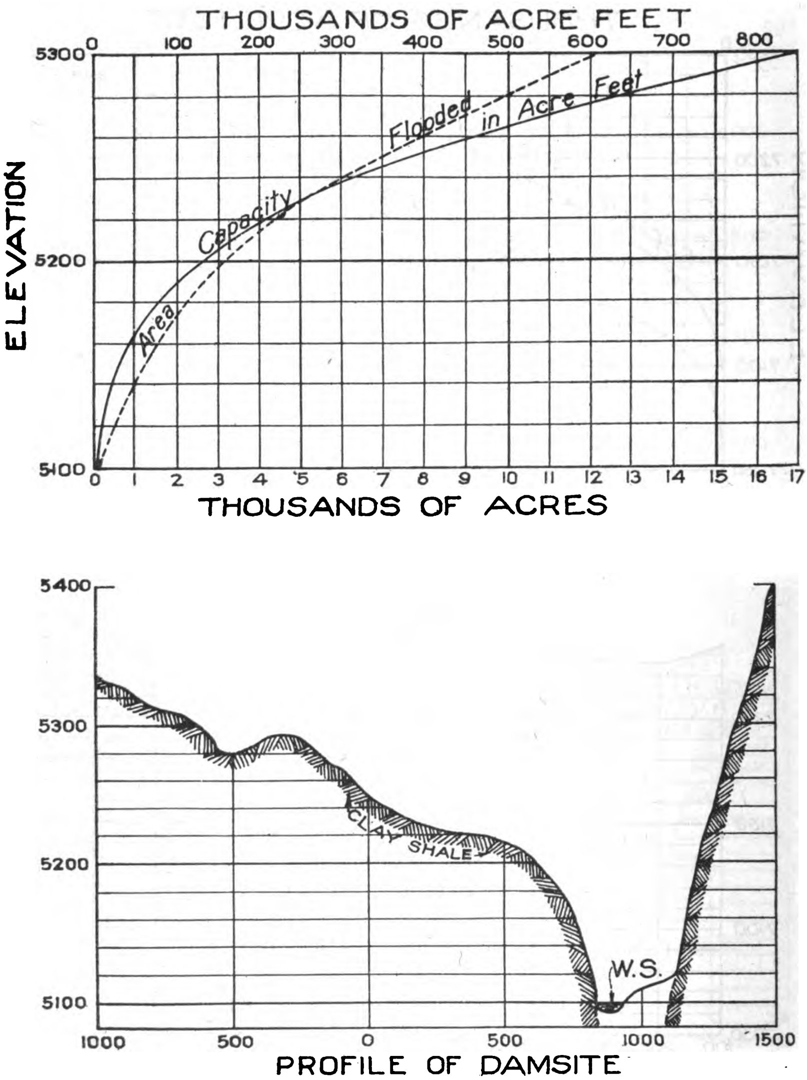
20308 UNITED STATES RECLAMATION SERVICE 45-C-91





SECTION AND CURVE
UPPER BEAR DAMSITE
BEAR RIVER
SEC. 29-T.4N-R.84W.
COLORADO

20309 UNITED STATES RECLAMATION SERVICE 45-C-92



SECTION AND CURVE

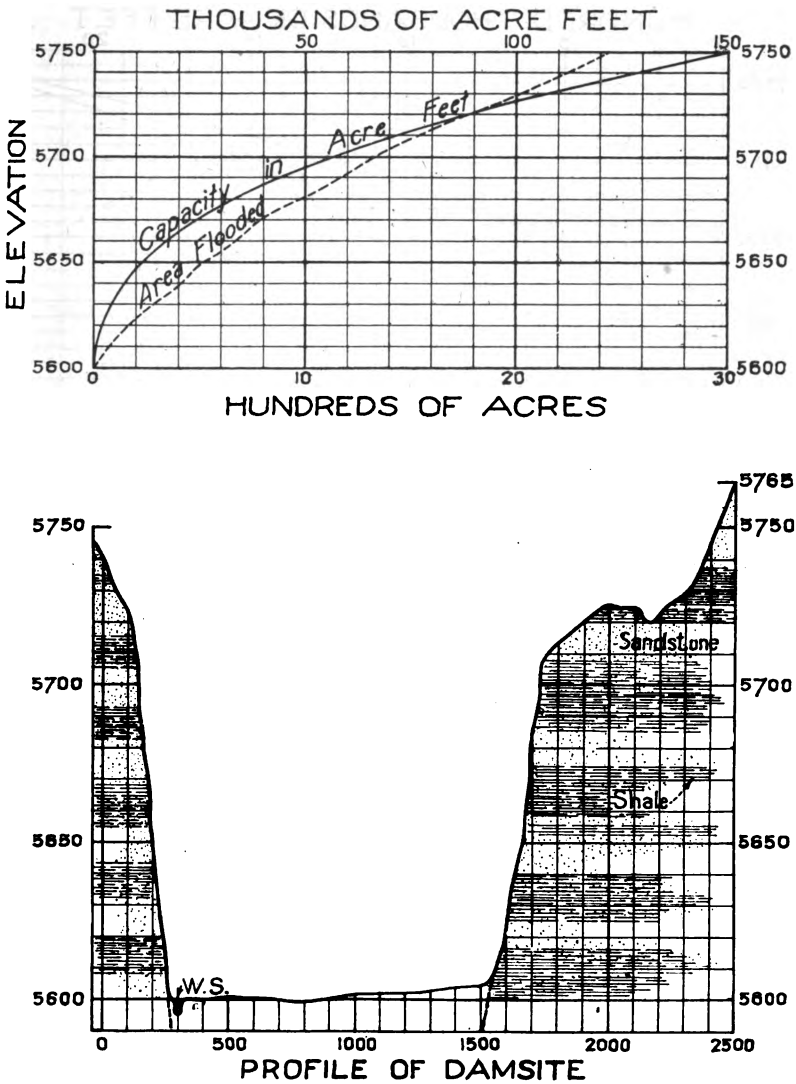
RANGELY DAMSITE NO. 2

WHITE RIVER

SEC. 12 - T. 1 N. - R. 104 W.

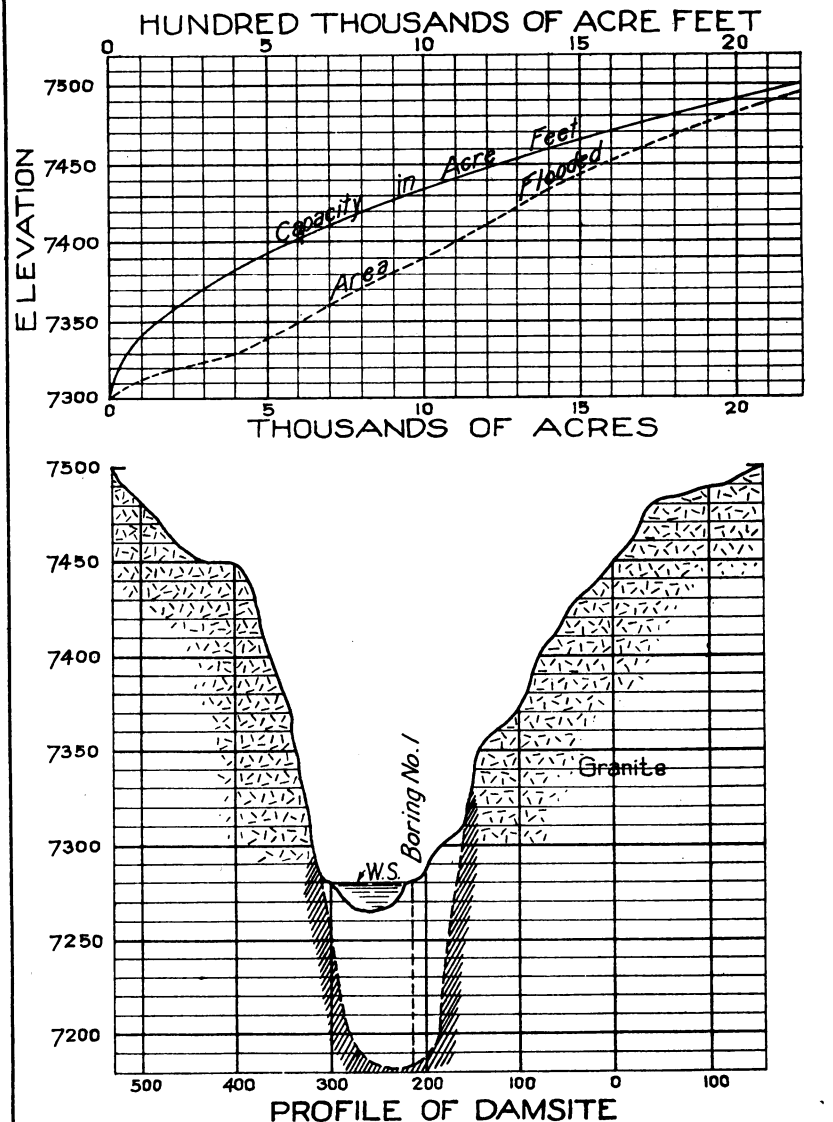
COLORADO

20310 UNITED STATES RECLAMATION SERVICE 45-C-94



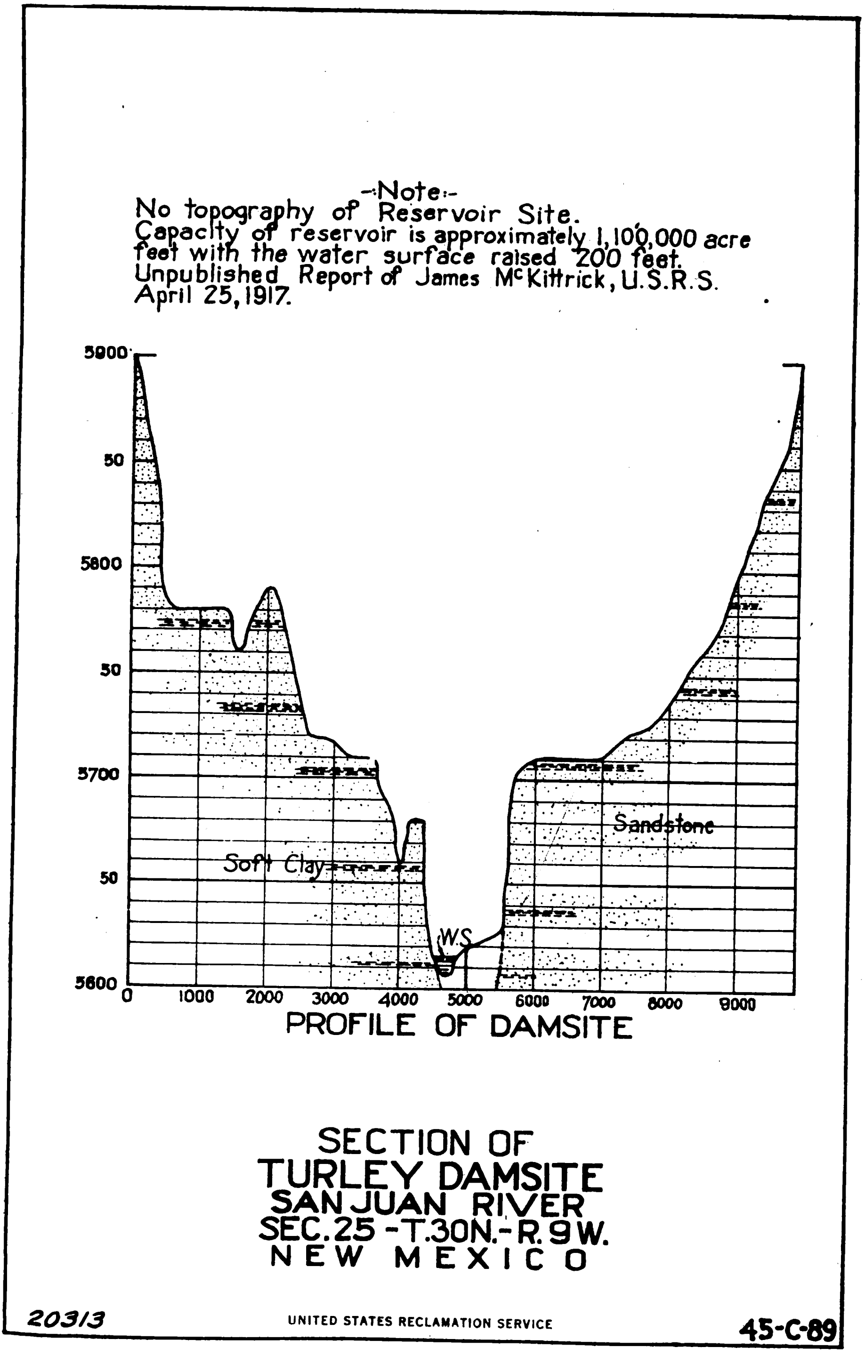
SECTION AND CURVE
STARVATION DAMSITE
STRAWBERRY RIVER
SEC. 28 – T. 3S. – R. 5W.
UTAH

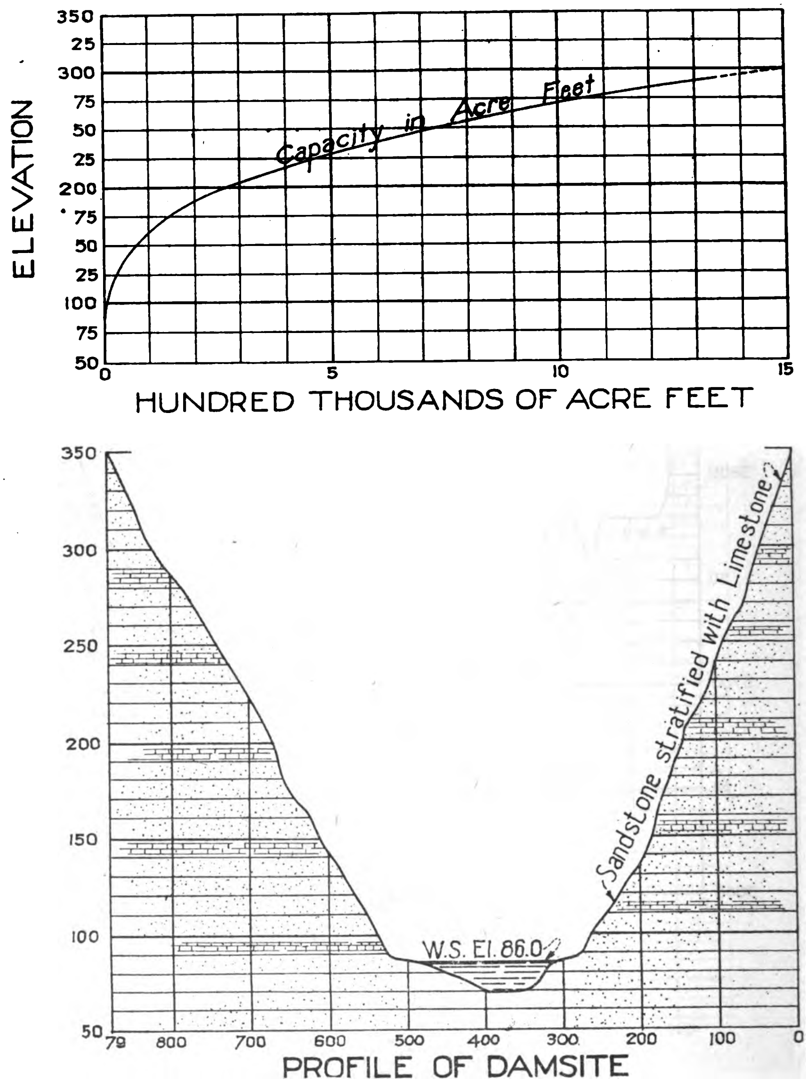
20311 UNITED STATES RECLAMATION SERVICE 45-C-98



SECTION AND CURVE
KREMLING DAMSITE
GRAND RIVER
SEC. 23 -T. 1 N. - R. 81 W.
COLORADO
UNITED STATES RECLAMATION SERVICE

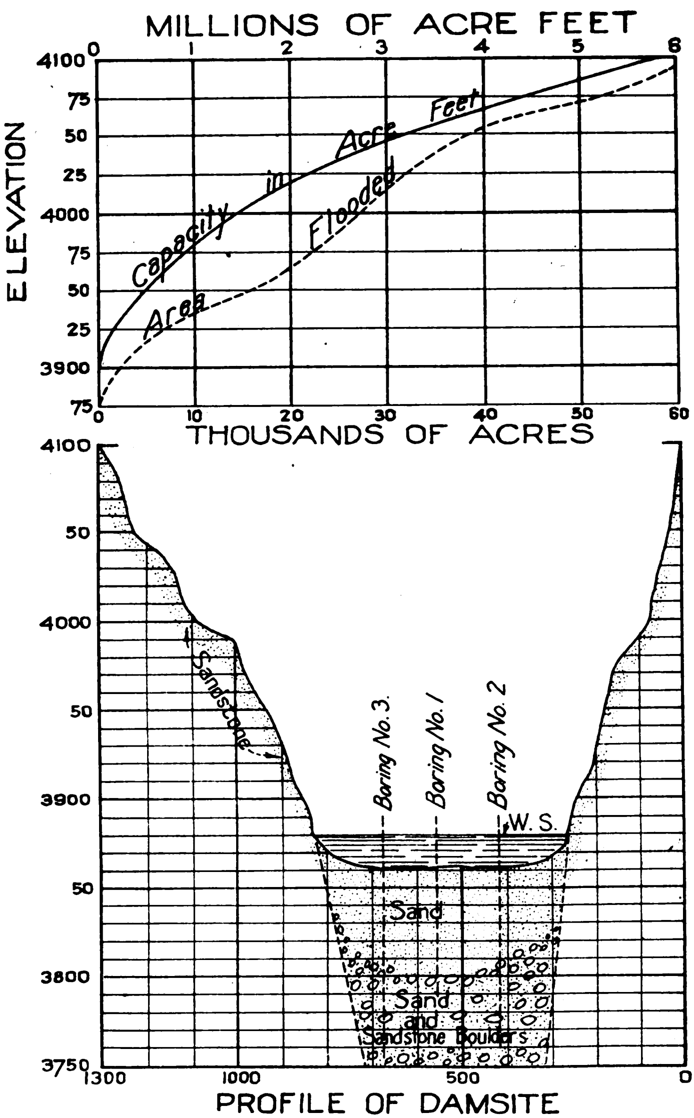
203/2 45-C-96


-:Note:-
No topography of Reservoir Site.
Capacity of reservoir is approximately 1,100,000 acre feet with the water surface raised 200 feet.
Unpublished Report of James McKittrick, U.S.R.S.
April 25, 1917.
5900
50
5800
50
5700
50
5600
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Soft Clay
Sandstone
W.S.
PROFILE OF DAMSITE
SECTION OF
TURLEY DAMSITE
SAN JUAN RIVER
SEC. 25 - T. 30 N. - R. 9 W.
NEW MEXICO
20313
UNITED STATES RECLAMATION SERVICE
45-C-89



SECTION AND CURVE
BLUFF DAMSITE
SAN JUAN RIVER
SEC. 19 - T. 41 S. - R. 20 E.
UTAH

20314 UNITED STATES RECLAMATION SERVICE 45-C-93

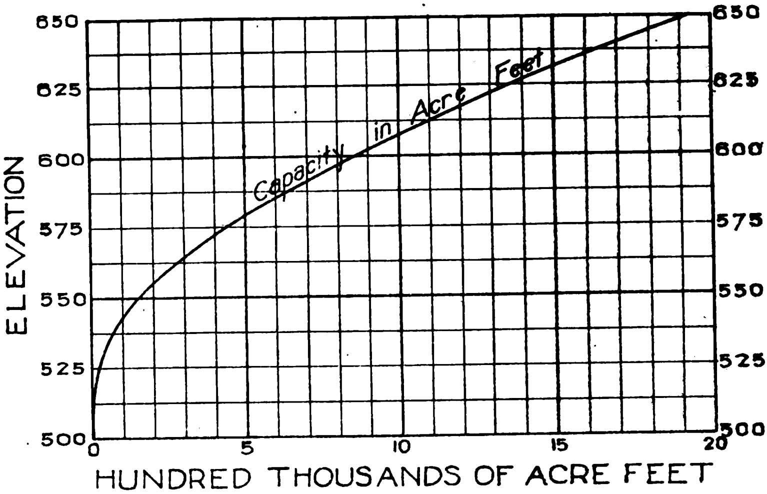


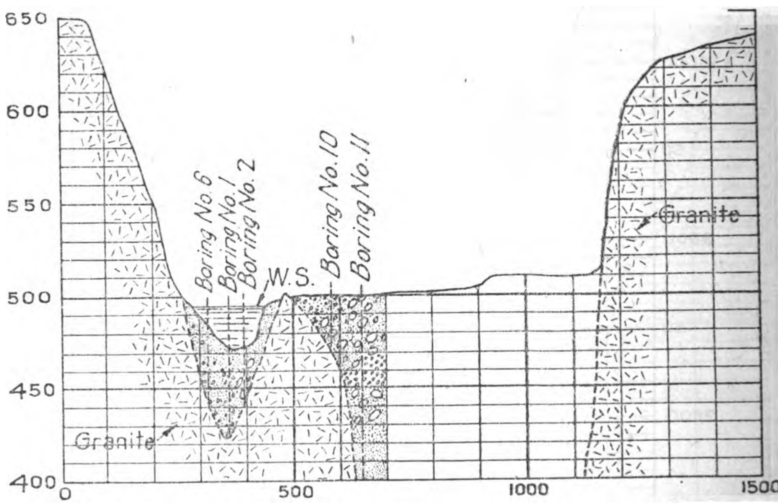
SECTION AND CURVE
JUNCTION DAMSITE
COLORADO RIVER
SEC. 26 - T. 30 S - R. 18 E.
UTAH

203/5

UNITED STATES RECLAMATION SERVICE

45-C-97



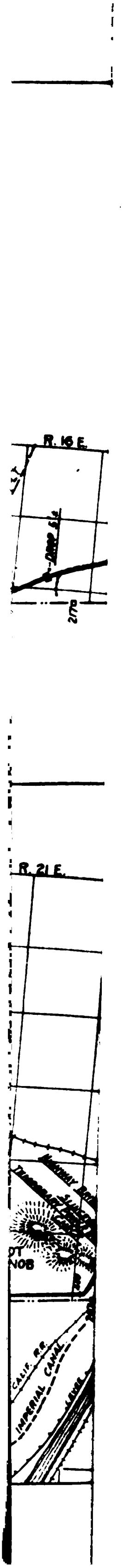


PROFILE OF DAMSITE

SECTION AND CURVE
BULLS HEAD DAMSITE
COLORADO RIVER
SEC. 18 - T. 21 N - R. 21 W.
ARIZONA

UNITED STATES RECLAMATION SERVICE

20316 45-C-95


R. 16 E.
2170
R. 21 E.
NOB
CALIF. R.R.
IMPERIAL CANAL

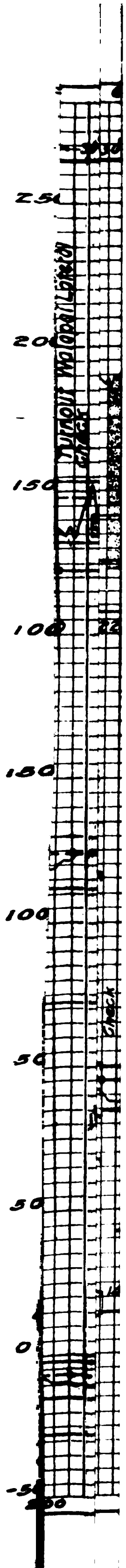
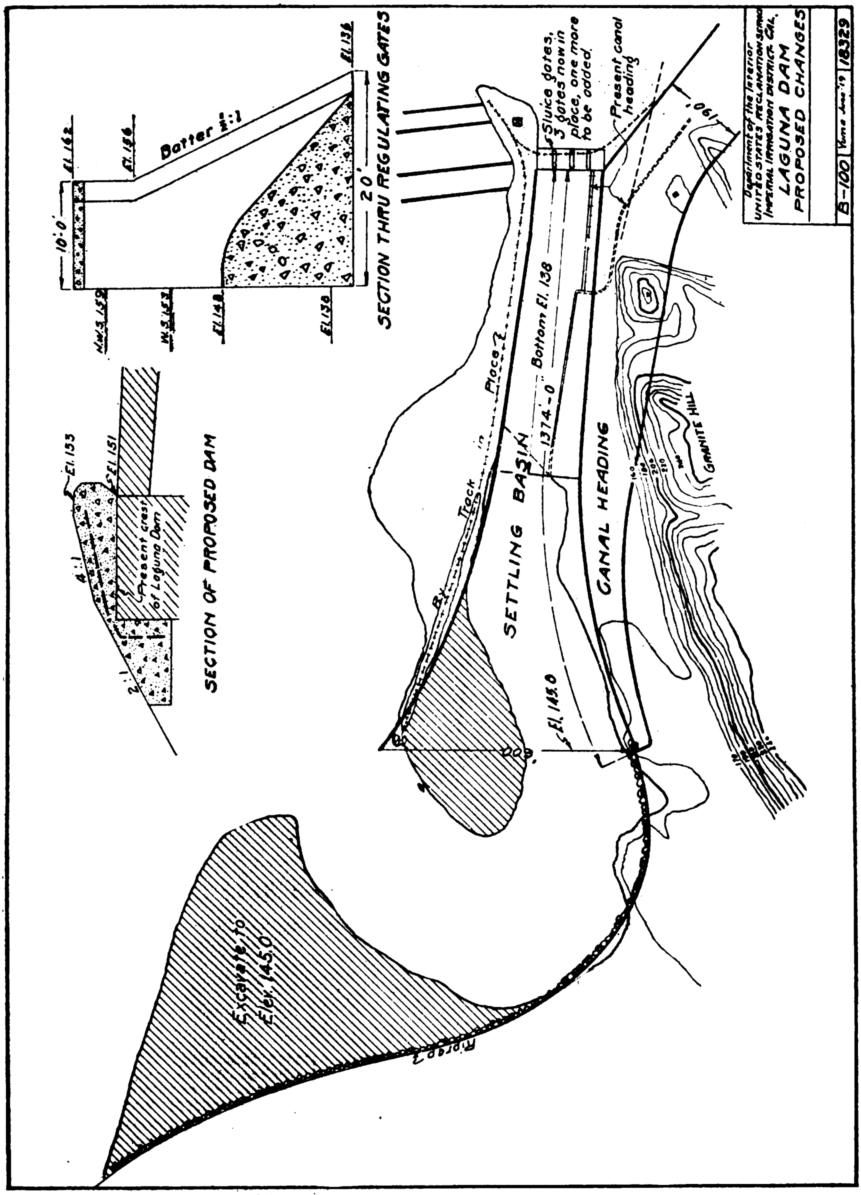

250
200
150
100
150
100
50
50
0
Check

PLATE LI


SECTION THRU REGULATING GATES
Batter ½:1
El. 162
El. 156
10'0"
20'
El. 136
W.S. 159
W.S. 153
El. 148
El. 138
SECTION OF PROPOSED DAM
El. 153
El. 151
Present crest of Laguna Dam
4:1
2:1
Sluice gates, 3 gates now in place, one more to be added.
Present canal heading
SETTLING BASIN
Bottom El. 138
1374'-0"
By Track in Place
CANAL HEADING
El. 145.0
GRANITE HILL
Excavate to Elev. 145.0
Riprap
Department of the Interior
UNITED STATES RECLAMATION SERVICE
IMPERIAL IRRIGATION DISTRICT, CAL.
LAGUNA DAM
PROPOSED CHANGES
B-100
18329

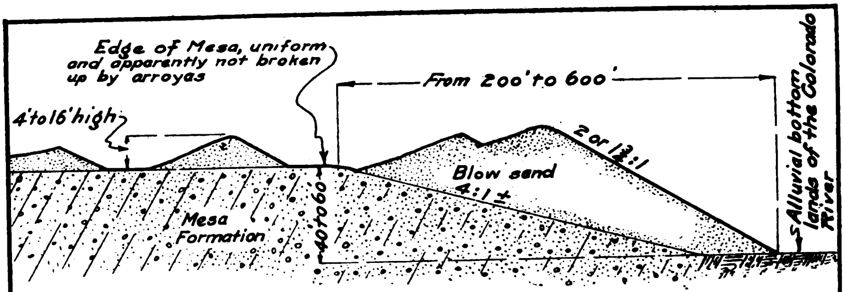


Fig. I

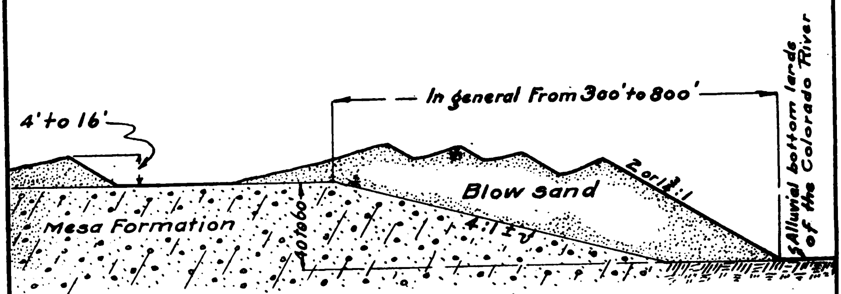


Fig. II

Fig. III

Department of the Interior
United States Reclamation Service
IMPERIAL IRRIGATION DISTRICT - CAL.
ALL AMERICAN CANAL
TYPICAL SECTIONS AT THE SOUTH END OF SAND HILLS

A-101 | Yuma Ariz Mch 4 '19 | 18331

APPENDIX G.

RESERVOIR SITES, CONSTRUCTED RESERVOIRS, PRECIPITATION RECORDS, AND TEMPERATURE RECORDS.

Reservoir sites, Green River Basin, Wyoming.

Name.	Stream.	Location.	Capacity.	Height of dam.	Remarks.	Wyoming State filing number.
			Acre-feet.	*Feet.*		
Boulder Lake	Boulder Creek.	T. 33 N. R. 107 W.	130,000		Permit pending.	
Basin	Henrys Fork	T. 3 N., R. 16 E., Utah.	107,000	125	No filings	
Eden No. 2	Big and Little Sandy.	T. 30 N., R. 104 W.	105,000	105	Earth dam	947
Upper Green River lakes.	Green River	T. 39 N., R. 108 W.	100,000		Permit pending.	
Fremont Lake	Pine Creek	T. 34 N., R. 109 W.	100,000		do	
Half Moon Lake	Pole Creek	T. 34 N., R. 108 W.	95,000		do	
Hams Fork	Hams Fork	T. 21 N., R. 116 W.	70,000	90	No filings	
New Fork Lake	New Fork	T. 36 N., R. 110 W.	23,800 / 22,100		Permit pending.	480
Burnt Lake	Fall Creek	T. 34 N., R. 107 W.	23,100 / 6,900		do	2,127
Willow Lake	Willow Creek.	T. 35 N., R. 109 W.	19,000		Permit pending.	
Patterson	Black Fork	T. 17 N., R. 114 W.	18,000	35	One feed canal	1,677
Eden No. 1	Big and Little Sandy.	T. 26 N., R. 105 W.	18,300	20	Constructed	5,718
Middle Piney	Middle Piney Lake.	T. 30 N., R. 115 W.	11,100	60	Earth and loose-rock dam.	1,754
Reservoir No. 2	Black Fork	T. 2 N., R. 12 E, Utah.	6,300	25	Reservoir in Utah.	
Taylor	North Piney	T. 31 N., R. 115 W.	5,180	37		1,427
Reservoir No. 3	Black Fork	T. 2 N., R. 11 E, Utah.	4,615	50	Reservoir in Utah.	
"67"	North Piney	T. 31 N., R. 115 W.	4,329	24	Constructed; earth puddle core.	535
La Barge	La Barge	T. 29 N., R. 116 W.	4,030	55	Earth dam	2,246
North Piney Lake	North Piney	T. 31 N., R. 115 W.	1,573	22	do	1,426
Reservoir No. 1	Black Fork	T. 2 N., R. 12 E.	857	25	Reservoir in Utah.	

Reservoir sites, White River Basin, Colorado.

Compiled by R. I. Meeker. Arranged in order of size. Map and data on file in State Engineer's office.

Name.	Stream.	Location.	Capacity.	Stream flow available.	Height of dam.	Remarks.	Colorado State filing number.
			Acre-feet.	*Acre-ft.*	*Feet.*		
Rangely	White	At Rangely	400,000	549,000	115	Channel site, U. S. R. S. survey and estimate of cost.	
White River and Beaver (Buford).	do	Junction north and south forks.	100,000	460,000	110	Channel site preliminary survey only for Blue Mountain Canal.	7,979
Pass Butte	Milk Creek, north fork White.	7 miles southeast Axial Yampa Basin.	110,000	245,000	185	Feeder canal from North Fork White River.	6,926
Lost Creek No. 2	Lost Creek	11 miles northeast Buford.	31,000		125	Water supply questionable.	6,501
Stillwater	South Fork White.	5 miles above mouth.	15,000	211,000	60	Channel site, U. S. R. S. survey.	7,980
Trappers lake	North Fork White.	Head North Fork White.	12,000			U. S. R. S. survey.	6,208 6,430 6,926
Marvine lakes	Marvine Creek	Head Marvine Creek.	10,500		60		6,430 6,926
Red Wash	Red Wash	12 miles north Rangely.	9,000		100	Water supply questionable.	6,662
Skull Creek	East and West Skull creeks.	14 miles northeast Rangely.	6,000		100	do	6,040
Willow Creek	Willow Creek	12 miles northwest Rangely.	4,870		100		6767
Blue Mountain	do	do	2,690		80		10563
Wolf Creek	Wolf Creek	19 miles northwest Rangely.	4,160		100		7685
Do	do	do	1,630		80		8555
Watkin	Coal Creek	10 miles northeast Meeker.	600		78		12808
Violet	Yellow Creek	6 miles northwest Piceane.	550				146–160
Twin Wash	East Twin Wash.	11 miles northwest Rangely.	460		20		11107
Keystone	Deep Channel.	18 miles northwest Meeker.	207				119

Reservoir sites, Uinta Basin.

Name.	Stream.	Location.	Capacity.	Stream flow available.	Height of dam.	Remarks.
			Acre-feet.	*Acre-feet.*	*Feet.*	
Starvation	Strawberry River	4 miles above Duchesne.	95,000	195,000	125	Pikes Peak Highway through site.
Upper currant Creek.	Currant Creek.	Near headwaters	50,000		100	Water supply insufficient.
Moon Lake	Lake Fork	T. 2 N., Rs. 5 and 6 W.	40,000	179,000		
Stillwater	Rock Creek	12 miles above mouth.	39,000	120,000	120	Earth dam proposed.
Three Forks	Strawberry River.	Junction Avintaquin and Red creeks.	32,000		130	Location of D. & S. L. R. R. through site.
Hades	North Fork of Duchesne.	T. 2 N., R. 9 W., at Hades Creek.	24,000	35,000	120	Survey by Great Basin Power Co.
Lower Currant Creek.	Currant Creek.	3 miles above Red Creek.	60,000		170	Investigation contemplated.
Brown Duck Lake	Lake Fork	Headwaters, T. 2 N., Rs. 6 and 7 W.	2,000			
Tabiona reservoir site.	Duchesne	At Junction Farm Creek.			110	Not feasible.

Reservoir sites, Gunnison and Dolores rivers.

Name.	Stream.	Location.	Capacity.	Remarks.
			Acre-feet.	
Gunnison River:				
Taylor Park	Taylor River	T. 14 S., R. 82 W.	150,700	Dam 170 feet.
Fruitgrowers	Canal to Gunnison River.	T. 14 S., R. 94 W.	7,000	Enlargement of reservoir.
Dolores River:				
Bedrock	Dolores River	T. 47 N., R. 18 W.	485,000	Dam 187 feet.
Dolores	do	T. 38 N., R. 16 W.	230,000	Dam 220 feet (Junction Beaver Creek).
Custer	Canal to Disappointment Creek.	T. 43 N., R. 16 W.	17,000	Inland reservoir.
San Miguel River:				
Miramonte	Canal to Beaver Creek.	T. 43 N., R. 13 W.	63,550	Do.
Lillyland	Canal to Naturita Creek.	T. 43 N., R. 14 W.	6,915	Do.
Stone Cabin	Canal to San Miguel River.	T. 44 N., R. 16 W.	12,200	Do.

Reservoir sites, San Juan Basin.

Name.	Stream.	Location.	Capacity.	Stream flow available.	Height of dam.	Remarks.
			Acre-feet.	*Acre-feet.*	*Feet.*	
Bluff	San Juan River	12 miles below Bluff City, Utah.	1,450,000	2,700,000	206	Silt 29,000 acre-feet annually.
Hog Back	do	Junction of San Juan and Chaco rivers.	1,200,000		220	No survey; not feasible.
Chaco	Rio Chaco	do	700,000		185	Navajo Indian Reservation; not feasible.
Las Animas	Las Animas River.	2 miles above Durango.	500,000	692,000	144	Silverton branch of D. & R. G. R. R. through site.
Largo	Junction Largo Arroya and Munyon Creek.	9 miles southeast of Largo, N. Mex.	320,000	(1)	180	Feed canal from San Juan River; not feasible.
Arboles	San Juan River	8 miles below Arboles, Colo.	140,000	643,500	100	Lands within site of low value.
Trujillo	do	4 miles below Trujillo, Colo.	90,000	320,000	125	
Turley	do	T. 6, 7, 8, 9, R. 30, 31, below mouth Las Pinos River.	1,100,000	1,400,000	200	
State Line	La Plata River	Dam site ¾ mile below State line, Colo.-N. Mex.	30,675		115	
Narrows	do	8 miles southwest of La Plata.	12,400		65	
No. 2	Cherry Creek	At Thompsons Fork.	10,000		100	Not feasible.
No. 1	Upper La Plata River.	5 miles above Hesperus, Colo.	5,100		70	Do.
No. 3	do	4 miles northeast of La Plata.	1,095		50	Right to site lapsed.
La Boca	Las Pinos River.	6 miles below La Boca, Colo.	40,000		100	
Piedra	Piedra River	3 miles below Weninuche River.	(2)	405,000	500	Good dam site.
Three, off-stream on Overland project.			60,000			

1 No record. 2 Control of river.

Constructed reservoirs, Colorado River Basin, Colorado.

[Compiled by R. I. Meeker from records of State engineer's office May 7, 1921.]

Name.	Source of water supply.	Location.	Capacity (acre-feet).	Completed.	Filing No.	Remarks.
Cascade (Electra Lake).	Elbert and Cascade Creeks.	Animas Basin, 18 miles north of Durango.	20,900	190	2333	Hydro-power. equalization, 55-foot dam, 8,000 horsepower, 3.5-mile flume, Cascade Creek feeder 3-mile flume to reservoir No. 3.
Cascade No. 3	do	Animas Basin, 17 miles north of Durango.	100		2337	Regulating reservoir head; pipeline to power house, 970-foot head.
Summit	Lost Canyon Creek and Turkey Creek, tributaries of Dolores River.	Mancos Basin, 8 miles northwest of Mancos.	4,690		1990 10362 10619	Irrigation; height of dam 39 feet.
Puett Big Pine	} do	Mancos	370			Irrigation.
Webber	Middle Mancos	Mancos Basin	180		3225	20-foot dam.
Bauer lakes 1 and 2.	West Mancos, Chicken Creek.	do	300		7876	Irrigation.
Narraguinnep	Dolores River	McElmo Creek drain, tributory to San Juan, 7 miles west of Dolores.	6,000			Irrigation; Montezuma Valley.
Ground Hog	Fish Creek	Dolores Basin on Ground Hog Creek, tributary to Fish Creek, tributary to West Fork Dolores 20 miles northeast of Dolores.				Irrigation; Montezuma Valley, water not stored, per cent of seepage at dam, capacity 17,260 acre-feet.
Totten Lake	Dolores	McElmo Creek Drain, 3 miles northeast of Cortez.	1,150			Irrigation; Montezuma Valley.
Trout Lake	Lake Fork San Miguel.	San Miguel Basin; 10 miles southwest of Telluride.	5,000			
Cone	Cone Creek, tributary of Naturita Creek.	11 miles west of Placerville.	2,140			
Gurley	Beaver Creek, tributary of San Miguel.	do	4,190			
Geyser	Geyser Creek and Two Mile Creek, tributaries of Rock Creek.	16 miles northwest of Bedrock.	1,240			Located in Utah.
Buckeye	Deep Creek, tributary of Rock Creek, tributary of Dolores River.	12 miles northwest of Bedrock.	3,000			
Onion Valley	Crystal Creek and tributaries, Gunnison and tributaries of North Fork Gunnison.	18 miles northeast of Montrose.	5,000			
Fruitgrowers	Surface Creek, tributary of North Fork Gunnison.	9 miles northeast of Delta.	3,000			
Monument	Minnesota Creek, tributary of North Fork Gunnison.	5 miles east of Paonia.	500			
Overland	Hubbard Creek, tributary of North Fork Gunnison.	15 miles north of Paonia.	4,000			

Constructed reservoirs, Colorado River Basin, Colorado—Continued.

Name.	Source of water supply.	Location.	Capacity (acre-feet).	Completed.	Filing No.	Remarks.
Aggregate small reservoirs.	Leroux Creek, tributary of North Fork Gunnison.	14 miles northwest Paonia.	3,000	....	....	
Do...........	Headwaters Forked Tongue and Surface Creek, tributaries of North Fork Gunnison.	13 to 25 miles north and northeast of Delta.	37,830	....	....	
Do...........	Headwaters Plateau Creek, tributary of Grand River.	11 miles south and southwest of Collbran.	12,000	....	....	
Spring Park.......	Cattle Creek.......	8 miles northeast of Carbondale.	2,830	....	6703	2 miles feeder canal.
Aggregate nine small reservoirs.	Tributaries of Roaring Fork.	....	870	....	....	
Grass Valley......	East Rifle Creek..	9 miles northeast of Rifle.	4,000	1910	6624	Irrigation; 60-foot dam.
Dunstan..........	Second Creek, tributary of Williams Fork-Yampa.	4 miles east of Pagoda.	130	....	6339	
Timber...........	Timber Lake......	....	....	....	2190	
Lake..............	Four Mile.........	....	1,100	1920	0038	District 54.
Finney, Gilderbloom.	Mud Springs Creek, tributary of Grass Creek, tributary of Yampa.	....	1,860	....	7337	
			126,000			

NOTE.—Incomplete data in files of State engineer's office show that there are over 50 small constructed reservoirs not included above. A rough estimate of the total capacity is 20,000 acre-feet which should be added to the above figure. These figures are exclusive of storage for municipal purposes.

Precipitation records on or near irrigable lands, Colorado Basin.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Wyoming, Green River Basin:													
Green River	0.56	0.74	0.78	0.59	1.09	0.32	0.16	0.60	0.80	0.59	0.63	0.44	7.30
Daniel	1.08	1.30	1.17	.79	1.37	1.17	.85	1.14	.79	.72	.47	.85	11.70
Colorado:													
Yampa River Basin—													
Lay	1.17	1.22	1.44	1.15	1.33	.69	1.00	.98	1.35	1.10	.80	.87	13.10
Pagoda	1.31	1.85	1.95	1.87	1.44	1.09	1.31	1.58	1.82	1.68	.97	1.62	18.49
Steamboat Springs	2.54	2.58	1.72	1.84	2.03	1.40	1.28	1.61	1.60	1.69	1.52	2.45	22.26
White River Basin, Meeker	1.09	1.05	1.42	1.52	1.44	.93	1.45	1.60	1.73	1.50	1.02	1.08	15.83
Grand River Basin—													
Grand Junction	.62	.61	.71	.73	.81	.41	.60	1.01	.89	.96	.57	.46	8.38
Breckenridge	1.79	2.48	2.58	2.76	2.04	1.08	2.37	2.24	1.43	1.45	1.63	2.08	23.93
Glenwood Springs	1.32	.81	1.07	1.09	1.00	.65	1.33	1.50	1.10	1.00	.85	1.20	12.92
Dolores River Basin [1]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
San Juan River Basin, Durango	1.88	1.77	1.74	1.45	1.04	.73	2.00	2.11	1.82	2.04	1.16	1.62	19.36
Gunnison River Basin—													
Delta	.59	.53	.70	.65	.82	.30	.88	.89	.93	.78	.47	.58	8.12
Gunnison	.86	.70	.59	.86	.75	.63	1.35	1.30	.78	.64	.54	.64	9.64
Montrose	.77	.66	.80	1.02	.83	.41	.85	1.34	.98	.96	.52	.75	9.89
New Mexico, San Juan Basin:													
Bloomfield	.51	.71	.74	.84	.60	.40	.68	1.11	.80	.71	.54	.62	8.26
Fruitland	.27	.70	.30	.39	.44	.14	.62	.52	.72	.37	.33	.36	5.16

[1] No records.

Precipitation records on or near irrigable lands, Colorado Basin—Continued.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Utah:													
Duchesne River Basin, Fort Duchesne	0.49	0.49	0.70	0.53	0.77	0.28	0.49	0.79	1.23	0.57	0.41	0.47	7.22
Green River Basin, Green River	.25	.60	.32	.66	.55	.05	.19	.86	.92	.22	.53	.23	6.38
San Rafael River Basin, Castle Dale	1.07	.79	.41	.73	.48	.39	.53	1.14	.89	.57	.97	.55	8.52
Fremont River Basin—													
Hite	.54	.74	.62	.41	.66	.13	.44	.74	.19	.32	.95	.62	6.36
Emery	.43	.87	.30	.34	.51	.37	.45	1.60	1.08	.58	.42	.53	7.48
Virgin River Basin, St. George	1.07	1.10	.86	.42	.47	.05	1.31	1.05	.71	.48	.48	.66	8.66
Kanab Creek Basin, Kanab	1.80	1.58	2.59	.90	.79	.26	.94	1.01	.71	.94	1.56	.94	14.02
Arizona:													
Little Colorado River Basin—													
Flagstaff	2.91	2.62	2.90	1.33	1.59	.47	2.45	2.89	1.43	1.18	1.61	2.49	23.87
Holbrook	.75	.69	.66	.53	.31	.14	1.41	1.41	.81	.71	.87	.70	8.99
Gila River Basin—													
Phoenix	.78	.87	.62	.33	.11	.07	1.12	.94	.65	.41	.65	.84	7.39
Clifton	1.08	1.27	.98	.42	.35	.45	2.08	2.43	1.51	.96	.61	1.02	13.16
Florence	1.01	1.00	1.04	.32	.18	.29	1.48	1.51	.71	.49	.67	1.02	9.72
Imperial Valley—													
Indio	.01	.18	.17	.11	.21	.47	.72	.45	.34	.07	.03	T.	2.76
Yuma	.37	.47	.34	.08	.04	.02	.20	.58	.22	.21	.30	.43	3.26

Temperature records on or near irrigable lands, Colorado Basin.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Wyoming, Green River Basin:													
Green River, mean	19.7	21.6	31.9	43.4	48.9	58.0	67.3	65.5	55.9	43.0	31.0	18.8	42.2
Daniel, mean	14.0	12.4	20.6	32.4	42.1	49.5	55.9	54.8	46.4	37.9	27.0	16.0	34.1
Colorado:													
Yampa River Basin—													
Lay—													
Maximum	34.2	35.8	45.1	57.1	66.8	78.2	85.7	84.1	73.9	61.3	50.2	35.1	
Minimum	1.4	4.7	18.6	27.0	32.9	39.6	46.9	45.9	36.9	26.7	15.0	5.9	
Mean	18.0	20.0	31.1	42.1	49.6	58.9	66.4	65.3	55.9	43.6	31.3	19.2	41.8
Pagoda—													
Maximum	35.5	36.9	46.2	57.5	66.9	77.6	84.7	83.2	75.6	63.0	49.0	35.6	
Minimum	6.7	7.8	18.6	26.8	32.4	37.3	43.0	43.5	35.4	26.2	17.0	6.3	
Mean	20.4	22.5	32.0	42.0	49.7	57.4	63.8	63.4	55.6	44.4	32.8	20.8	42.1
Steamboat Springs—													
Maximum	29.8	33.5	43.2	56.9	68.6	77.2	82.5	80.6	73.5	61.2	46.9	32.5	
Minimum	0.8	2.0	10.9	23.3	29.1	33.3	38.7	38.0	31.4	22.4	11.9	5.7	
Mean	14.8	17.7	26.7	39.2	48.2	55.2	61.0	59.4	53.1	42.4	30.3	16.3	38.7
White River Basin, Meeker—													
Maximum	35.8	39.1	48.1	59.7	68.7	78.9	84.3	31.8	73.4	61.2	49.8	35.4	
Minimum	5.4	8.1	20.0	27.3	33.1	38.6	45.0	44.7	36.3	26.4	16.7	5.5	
Mean	20.4	23.8	34.1	43.7	51.1	58.8	64.9	63.5	55.2	43.8	33.2	20.1	42.7
Grand River Basin—													
Grand Junction—													
Maximum	36.5	43.3	55.1	65.6	74.1	85.9	91.1	88.6	79.5	65.8	52.4	38.0	
Minimum	15.2	22.1	31.9	39.8	47.4	56.5	63.7	62.2	52.8	40.0	28.6	17.0	
Mean	25.6	32.8	43.2	52.7	61.0	71.3	77.4	75.2	66.0	52.8	40.5	27.4	52.2
Breckenridge—													
Maximum	30.0	30.3	36.6	43.9	53.3	65.2	70.1	69.9	63.9	51.7	40.7	30.3	
Minimum	0.8	1.0	8.3	16.2	24.8	31.9	36.8	36.1	29.3	20.1	10.5	0.1	
Mean	15.8	16.0	22.3	30.2	39.0	48.2	53.3	53.2	46.6	36.7	25.9	16.4	33.6
Glenwood Springs—													
Maximum	36.9	40.5	50.3	61.1	68.8	79.6	94.9	83.8	76.2	65.0	51.9	38.2	
Minimum	7.5	12.6	24.0	30.0	35.2	39.5	44.8	44.5	37.7	27.5	19.3	8.6	
Mean	22.1	26.7	37.5	46.3	53.3	60.4	66.5	61.8	57.9	46.7	34.7	26.1	45.0
Dolores Basin[1]	...	...	...	...	...	...	...	...	...	...	...	...	...
San Juan River Basin—													
Durango—													
Maximum	38.9	43.3	51.2	60.8	68.9	79.8	83.9	82.5	75.4	63.9	52.8	40.1	
Minimum	12.8	16.7	24.4	30.8	36.4	42.6	50.7	50.2	42.3	32.5	23.3	12.3	
Mean	25.9	30.3	38.1	46.1	52.9	61.6	67.1	66.4	58.9	48.2	37.7	26.9	46.7

[1] No records.

Temperature records on or near irrigable lands, Colorado Basin—Continued.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Colorado—Continued.													
Gunnison River Basin—													
Delta—													
Maximum	38.4	45.4	57.3	68.7	77.2	88.5	93.8	91.1	82.6	69.2	55.7	38.7	
Minimum	10.9	17.4	25.8	33.5	40.6	46.9	54.4	52.1	42.4	30.6	21.9	11.6	
Mean	24.4	31.2	41.2	50.6	58.7	67.5	74.1	71.8	62.7	50.0	37.7	25.3	49.6
Gunnison—													
Maximum	24.3	29.4	41.3	56.7	66.7	76.1	80.1	78.4	71.8	62.3	41.7	26.3	
Minimum	8.9	4.5	10.5	22.5	28.4	35.1	42.3	40.8	32.1	20.7	17.0	6.2	
Mean	7.9	12.9	26.1	39.4	47.6	55.5	61.2	59.4	52.0	41.1	27.5	11.7	36.8
Montrose—													
Maximum	36.5	43.5	53.3	62.2	70.5	81.2	86.4	83.9	76.6	64.4	50.8	38.4	
Minimum	12.1	19.4	27.4	34.0	40.8	48.1	54.3	52.3	44.7	33.3	23.1	13.9	
Mean	24.3	31.3	39.8	47.9	55.2	64.6	70.2	67.9	60.6	48.6	36.8	26.1	47.8
New Mexico:													
San Juan River Basin—													
Bloomfield, mean	27.8	33.2	41.9	50.0	58.0	68.0	74.5	72.4	64.7	51.9	39.0	28.2	50.8
Fruitland, mean	29.8	35.1	43.7	51.7	60.2	68.4	74.9	72.8	63.4	50.8	39.0	30.2	51.7
Utah:													
Uinta Basin, Fort Duchesne, mean	11.8	19.3	36.2	48.2	56.1	64.8	70.9	69.4	60.6	46.4	33.4	18.4	44.6
Green River Basin, Green River, mean	25.0	34.7	46.8	54.0	63.8	72.9	79.7	77.1	65.0	52.3	39.3	25.1	53.0
San Rafael Basin, Castle Dale, mean	22.4	28.1	38.1	45.8	53.0	62.9	68.8	67.4	58.2	47.5	36.8	24.7	46.1
Fremont River Basin—													
Hite, mean	36.0	43.3	51.0	59.5	67.7	77.3	84.4	82.4	72.3	60.0	47.3	36.4	59.8
Emery, mean	25.9	30.4	37.6	44.5	51.0	58.6	65.2	65.7	55.5	46.0	36.3	27.7	45.4
Virgin Basin, St. George, mean	37.7	42.0	49.2	57.3	66.7	73.4	82.2	80.7	71.2	59.1	47.3	37.8	58.7
Kanab Creek Basin, Kanab, mean	33.1	33.8	40.5	47.8	53.0	63.0	69.1	68.8	60.4	51.2	42.0	28.0	49.2
Arizona:													
Little Colorado Basin, Holbrook, mean	32.0	39.1	45.8	53.4	60.9	69.0	75.0	74.8	67.6	54.7	42.9	34.7	54.2
Gila River Basin—													
Phoenix—													
Maximum	65.5	68.5	73.7	81.7	89.6	100.1	102.7	100.9	96.7	85.4	74.2	64.8	
Minimum	39.4	43.3	46.9	52.2	59.1	68.6	76.2	75.7	68.4	56.1	45.7	38.0	
Mean	52.4	55.3	60.3	67.0	74.3	84.6	89.9	88.3	82.6	70.7	60.0	51.4	69.7
Clifton—													
Maximum	58.7	63.4	72.4	80.1	90.3	98.1	92.2	97.2	92.9	81.8	67.5	54.2	
Minimum	34.3	36.6	45.0	49.5	58.4	67.9	71.8	71.6	66.4	53.9	41.8	33.0	
Mean	46.5	50.0	58.7	64.8	74.3	83.1	85.0	84.4	79.7	67.9	54.6	43.6	66.0
Florence—													
Maximum	64.4	67.6	75.9	83.6	94.1	103.7	105.1	102.1	97.8	85.5	73.6	65.0	
Minimum	35.7	38.0	43.5	48.9	54.0	64.3	73.9	74.0	63.6	51.1	42.0	35.9	
Mean	49.8	52.7	59.1	66.2	74.5	84.6	89.1	87.3	80.5	69.2	57.4	50.4	68.4
Imperial Valley—													
Indio—													
Maximum	67.0	72.9	79.2	87.6	92.5	101.4	107.1	105.3	100.8	90.3	79.5	69.6	
Minimum	39.7	43.9	51.0	58.2	63.7	71.0	78.8	77.0	70.0	57.8	47.2	38.4	
Mean	52.9	58.7	65.3	72.5	80.1	88.3	94.5	93.0	86.5	75.4	62.6	56.6	73.9
Yuma—													
Maximum	66.9	71.6	77.9	85.4	92.3	101.1	105.4	104.0	99.4	87.7	76.1	67.4	
Minimum	42.6	45.7	49.8	54.2	60.3	67.7	76.6	76.8	69.0	57.8	48.6	43.4	
Mean	54.7	59.2	64.5	70.1	76.8	84.7	90.9	90.1	83.9	72.4	61.9	55.7	72.1

APPENDIX H.

ACT OF MAY 18, 1920 (41 STAT., 600).

AN ACT To provide for an examination and report on the condition and possible irrigation development of the Imperial Valley in California.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior is hereby authorized and directed to have an examination made of the Imperial Valley in the State of California, with a view of determining the area, location, and general character of the public and privately owned unirrigated lands in said valley which can be irrigated at a reasonable cost, and the character, extent, and cost of an irrigation system, or of the modification, improvement, enlargement, and extension of the present system, adequate and dependable for the irrigation of the present irrigated area in the said valley, and of the public and privately owned lands in said valley and adjacent thereto not now under irrigation which can be irrigated at a reasonable cost from known sources of water supply by diversion of water from the Colorado River at Laguna Dam.

SEC. 2. That the said Secretary shall report to Congress not later than the 6th day of December, 1920, the result of his examination, together with his recommendation as to the feasibility, necessity, and advisability of the undertaking or the participation by the United States, in a plan of irrigation development with a view of placing under irrigation the remaining unirrigated public and privately owned lands in said valley and adjacent thereto, in connection with the modification, improvement, enlargement, and extension of the present irrigation systems of the said valley.

SEC. 3. That the said Secretary shall report in detail as to the character and estimated cost of the plan or plans on which he may report, and if the said plan or plans shall include storage, the location, character, and cost of said storage, and the effect on the irrigation development of the other sections or localities of the storage recommended and the use of the stored water in the Imperial Valley and adjacent lands.

SEC. 4. That the said Secretary shall also report as to the extent, if any, to which, in his opinion, the United States should contribute to the cost of carrying out the plan or plans which he may propose; the approximate proportion of the total cost that should be borne by the various irrigation districts or associations or other public or private agencies now organized or which may be organized; and the manner in which their contribution should be made; also to what extent and in what manner the United States should control, operate, or supervise the carrying out of the plan proposed, and what assurances he has been able to secure as to the approval of, participation in, and contribution to the plan or plans proposed by the various contributing agencies.

SEC. 5. That, for the purpose of enabling the Secretary of the Interior to pay not to exceed one-half of the cost of the examination and report herein provided for, there is hereby authorized to be appropriated the sum of $20,000: *Provided*, That no expenditure shall be made or obligation incurred hereunder by the Secretary of the Interior until provision shall have been made for the payment of at least one-half the cost of the examination and report herein provided for by associations and agencies interested in the irrigation of the lands of the Imperial Valley.

Approved, May 18, 1920.

APPENDIX I.

STREAM-GAGING DATA.

1. Records compiled in the following tables are to be found in the following reports and Water Supply Papers:

Publications of the United States Geological Survey containing results of stream measurements in Colorado River Basin.

Year.	Water Supply Paper.	Annual report.	Year.	Water Supply Paper.	Annual report.
1899	37, 38, 39	21st, Part IV.	1910	289	
1900	50, 52	22d, Part IV.	1911	309	
1901	66, 75		1912	329	
1902	85		1913	359	
1903	100		1914	389	
1904	133		1915	409	
1905	175, 177		1916	439	
1906	211		1917	459	
1907–8	249		1918	[1] 479	
1909	269		1919–20	[1] 509	

[1] In manuscript.

State engineer biennial reports for Colorado, Wyoming, and New Mexico contain stream gaging records for streams in their respective States.

Water Supply Paper 395, Colorado River and its utilization, by E. C. La Rue, contains summaries of monthly discharge prior to 1915 for the principal gaging stations in the basin excepting Gila River.

2. Colorado River Basin gaging stations:

NOTE.—Dash after a date indicates that station was being maintained September 30, 1920. Period after a date indicates discontinuance.

Green River (head of Colorado River), near Kendall, Wyo., 1910–1912.
Green River near Daniel, Wyo., 1915—
Green River at Green River, Wyo., 1915–16; 1915—
Green River at Bridgeport, Utah, 1911–1915.
Green River at Jensen, near Vernal, Utah, 1903–1906; 1914–15.
Green River at Ouray, Utah, 1904–5.
Green River at Green River (formerly Blake), Utah, 1894–1899; 1905–1911.
Green River at Little Valley, near Green River, Utah, 1910—
Colorado River at Bulls Head, near Mohave, Ariz., 1902–3.
Colorado River at Hardyville, Ariz., 1905–1907.
Colorado River near Topock, Ariz., 1917—
Colorado River at Yuma, Ariz., 1891—
    Horse Creek at Daniel, Wyo., 1915—
    Cottonwood Creek, near Big Piney, Wyo., 1916—
    East Fork at East Fork Canal, Wyo., 1916—
    East Fork at New Fork, Wyo., 1905–6; 1915—
        New Fork at Alexander's ranch, near Cora, Wyo., 1910–11.
        New Fork at Pinedale crossing, near Cora, Wyo., 1905.
        New Fork near Boulder, Wyo., 1915—
            Pine Creek at Fremont Lake outlet, near Pinedale, Wyo., 1905–6; 1910–1912; 1915—
            Pine Creek at Pinedale, Wyo., 1915—
            Pole Creek near Fayette, Wyo., 1904–1906.
            Pole Creek near Pinedale, Wyo., 1910.
                Fall Creek at Fayette, Wyo., 1904–5.
            Boulder Creek near Boulder (New Fork), Wyo., 1904–1906; 1915—

Colorado River tributaries—Continued.

- North Piney Creek near Marbleton, Wyo., 1915–16.
  - Middle Piney Creek near Big Piney, Wyo., 1915—
- Labarge Creek near Labarge, Wyo., 1915–16.
- Fontenelle Creek near Fontenelle, Wyo., 1915—
- Big Sandy Creek at Leckie's ranch, near Big Sandy, Wyo., 1910–11.
- Big Sandy Creek near Eden, Wyo., 1911–12.
- Big Sandy Creek near Farson, Wyo.; 1915—
  - Dutch Joe Creek at Dutch Joe ranger station, near Big Sandy, Wyo., 1911-12.
  - Squaw Creek near Eden, Wyo., 1911–12.
  - Little Sandy Creek near Eden, Wyo., 1911–12.
- Blacks Fork near Urie, Wyo., 1913—
- Blacks Fork above Hams Fork, near Granger, Wyo., 1896–97.
- Blacks Fork below Hams Fork at Granger, Wyo., 1897–1900; 1916.
- Henrys Fork near Linwood, Utah, 1916.
- Beaver Creek at Myer's ranch, near Lodore, Colo., 1910–11.
- Hams Fork, Kemmerer, Wyo., 1918—
- Vermilion Creek at Bassett's ranch, near Lodore, Colo., 1910–11.
- Piceance Creek at Mouth, 1918.
- Yampa River at Yampa, Colo., 1910–1915.
- Yampa River at Steamboat Springs, Colo., 1904–1906; 1910—
- Yampa River at Craig, Colo., 1901–2; 1904–1906; 1910–1916.
- Yampa River near Maybell, Colo., 1904–5; 1910–1912; 1916—
  - Terrible Creek:
    - Fish Creek at Steamboat Springs, Colo., 1919—
    - Trout Creek at Pinnacle, Colo., 1910–11.
  - Soda Creek at Steamboat Springs, Colo., 1910–1919.
  - Elk River at Hinman Park, Colo., 1912–1918.
  - Elk River near Clark, Colo., 1910—
  - Elk River near Trull, Colo., 1904–1906; 1910—
  - Big Creek near Steamboat Springs, Colo., 1918–19.
    - Mad Creek near Steamboat Springs, Colo., 1912–1917.
  - Sage Creek:
    - Fish Creek at Dunkley, Colo., 1910–11.
    - Elk Head Creek at Hays' ranch, 1910; 1920—
  - Elk Head Creek near Craig, Colo., 1906; 1910–1918.
  - North Fork Elk Head Creek at Hay's ranch, 1910; 1920—
  - East Fork Elk Head at Hays' ranch, 1910, 1920—
  - Fortification Creek at Craig, Colo., 1905–6; 1910–1918.
  - Fortification Creek at Chapman's ranch, 1910.
  - Little Bear Creek, 1910.
  - Williams River near Pyramid, Colo., 1910–11.
  - Williams River at Hamilton, Colo., 1904–1906; 1910—
  - Milk Creek near Axial, Colo., 1904–5.
  - Little Snake River, Middle Fork, near Battle Creek, Colo., 1912—
  - Little Snake River near Dixon, Wyo., 1910—
  - Little Snake River near Maybell, Colo., 1904.
    - South Fork of Little Snake River near Battle Creek, Colo., 1912—
    - Slater Creek at Baxter ranch, near Slater, Colo., 1912—
    - Slater Creek near Savery, Wyo., 1915—
    - Beaver Creek:
      - Willow Creek near Baggs, Wyo., 1912—
    - Muddy Creek near Baggs, Wyo., 1915–1918.
    - Fourmile Creek near Baggs, Wyo., 1912—
- Ashley Creek above Dry Fork, near Vernal, Utah, 1911–1918.
- Ashley Creek below Dry Fork, near Vernal, Utah, 1900–1904.
  - Vernal Milling & Light Co.'s tailrace near Vernal, Utah, 1917—
  - Dry Fork of Ashley Creek at Vernal, Utah, 1904.
- Duchesne River, North Fork (head of Duchesne River), above Forks, Utah, 1904.
- Duchesne River at Duchesne, Utah, 1918—
- Duchesne River at Myton, Utah, 1899—
  - West Fork of Duchesne River above Forks, Utah, 1904.
  - Rock Creek (East Creek), 10 miles above mouth, Utah, 1904.
  - Strawberry River above mouth of Indian Creek, in Strawberry Valley, Utah, 1903–1906; 1909–10.
  - Strawberry River below mouth of Indian Creek, in Strawberry Valley, Utah, 1908–9.

Colorado River tributaries—Continued.
 Duchesne River at Myton, Utah, 1899—Continued.
  Strawberry River at Duchesne (Theodore), Utah, 1908–1910; 1914—
   Indian Creek in Strawberry Valley, Utah, 1905–6; 1909–10.
    Trail Hollow Creek in Strawberry Valley, Utah, 1909–10.
   Currant Creek, 13 miles above mouth, Utah, 1904.
   Currant Creek, 3 miles above mouth, Utah, 1904.
    Red Creek above Narrows, Utah, 1904.
  Lake Fork, West Fork of (head of Lake Fork), 10 miles above Forks, Utah, 1904.
  Lake Fork below Forks near Altonah, Utah, 1904; 1907–1910.
  Lake Fork above U. S. Lake Fork Canal near Altonah, Utah, 1917–18.
  Lake Fork near Myton, Utah, 1900–1903; 1907—
   East Fork of Lake Fork, 8 miles above Forks, Utah, 1904.
  Uinta River near Whiterocks, Utah, 1899–1904; 1907–1918.
  Uinta River at Fort Duchesne, Utah, 1899–1904; 1906–1910.
  Uinta River at Ouray school, Utah, 1899–1904.
  Whiterocks River near Whiterocks, Utah, 1899–1904; 1907–1918.
 White River, North Fork (head of White River), near Buford, Colo., 1903–1906; 1910—
 White River at Meeker, Colo., 1901–1906; 1910—
 White River at White River City, Colo., 1895.
 White River at Rangely, Colo., 1904–5, 1918.
 White River near Dragon, Utah, 1906.
 White River near Ouray, Utah, 1904.
  Marvine Creek near Buford, Colo., 1903–1906.
  South Fork of White River near Buford, Colo., 1903–1906; 1910–1915; 1919—
 Price River near Helper, Utah, 1894–95; 1904—
 Price River at Woodside, Utah, 1909–1911.
 Fish Creek at Schofield, Utah, 1918—
 Huntington Creek (head of San Rafael River) near Huntington, Utah, 1909.
 Huntington Creek near Castledale, Utah, 1911—
 San Rafael River near Green River, Utah, 1909—
  Cottonwood Creek near Orangeville, Utah, 1909—
  Ferron Creek (upper station) near Ferron, Utah, 1911—
  Ferron Creek near Ferron, Utah, 1909–1911.
  Ferron Creek near Castledale, Utah, 1911–1914.
 Grand River, North Fork (head of Grand River), near Grand Lake, Colo., 1904–1918
 Grand River near Granby, Colo., 1908–1911.
 Grand River at Hot Sulphur Springs, Colo., 1904—
 Grand River near Kremmling, Colo., 1904–1918.
 Grand River near Wolcott, Colo., 1906–1908.
 Grand River at Shoshone, Colo., 1897.
 Grand River at Glenwood Springs, Colo., 1899—
 Grand River near Palisades, Colo., 1902—
 Grand River near Grand Junction, Colo., 1894–1900.
 Grand River near Fruita, Colo., 1911—
 Grand River near Cisco, Utah, 1914—
 Grand River near Moab, Utah, 1913–14.
  North inlet to Grand Lake at Grand Lake, Colo., 1905–1912.
  Grand Lake outlet at Grand Lake, Colo., 1904–1913.
  South Fork of Grand River near Lehman, Colo., 1907–8.
  Fraser River near Arrow, Colo., 1910—
  Fraser River at upper station, near Fraser, Colo., 1908–1911.
  Fraser River at lower station, near Fraser, Colo., 1907–1909.
  Fraser River at Granby (Coulter), 1904–1909.
   Big Jim Creek near Fraser, Colo., 1907–1909.
    Little Jim Creek near Fraser, Colo., 1907–1909.
   Vasquez Creek at upper station, near Fraser, Colo., 1908–9.
   Vasquez Creek at lower station, near Fraser, Colo., 1907–1909.
   Elk Creek near Fraser, Colo., 1907–1909.
   St. Louis Creek at upper station, near Fraser, Colo., 1908–9.
   St, Louis Creek at lower station, near Fraser, Colo., 1908–9.
   North Ranch Creek at upper station, near Rollins Pass, Colo., 1908–9.
   North Ranch Creek at lower station, near Rollins Pass, Colo., 1907–1909.
    Middle Ranch Creek at upper station, near Arrow, Colo., 1908–9.
     South Ranch Creek at upper station, near Arrow, Colo., 1908–9.
     South Ranch Creek at lower station, near Arrow, Colo., 1907–1909.

Colorado River tributaries--Continued.
Grand River tributaries--Continued.
Williams Fork near Scholl, Colo., 1910–1917.
Williams Fork near Parshall (Sulphur Springs), Colo., 1904—
Troublesome Creek at Troublesome, Colo., 1904–5.
Muddy Creek at Kremmling, Colo., 1904–5.
Blue River at Breckenridge, Colo., 1914–15.
Blue River at Dillon, Colo., 1910—
Blue River near Kremmling, Colo., 1904–1908.
Spruce Creek (upper station) near Breckenridge, Colo., 1914–15.
Spruce Creek (lower station) near Breckenridge, Colo., 1914–15.
Crystal Creek near Breckenridge, Colo., 1914–15.
Snake River at Dillon, Colo., 1910–1919.
Tenmile Creek near Kokomo, Colo., 1904.
Tenmile Creek near Uneva Lake, Colo., 1903.
Tenmile Creek at Dillon, Colo., 1910–1919.
Eagle River at Redcliff, Colo., 1911—
Eagle River above Brush Creek, at Eagle, Colo., 1911—
Eagle River below Brush Creek, at Eagle, Colo., 1905–1907.
Eagle River at Gypsum, Colo., 1907–1909.
Turkey Creek at Redcliff, Colo., 1913—
Homestake Creek at Redcliff, Colo., 1911–1918.
Gore Creek near Minturn, Colo., 1911–1914.
Beaver Creek at Avon, Colo., 1911–1914.
Brush Creek at Eagle, Colo., 1911–1913.
No Name Creek near Glenwood Springs, Colo., 1911–1914.
Glenwood Light & Power Co.'s flume near Glenwood Springs, Colo., 1911–1913.
Roaring Fork at Aspen, Colo., 1911—
Roaring Fork below Aspen, Colo., 1913–1918.
Roaring Fork near Emma, Colo., 1908–9.
Roaring Fork at Glenwood Springs, Colo., 1906–1918.
Hunter Creek at Aspen, Colo., 1911–1913.
Castle Creek near Aspen, Colo., 1911—
Maroon Creek at upper station, near Aspen, Colo., 1911–1917.
Maroon Creek at lower station, near Aspen, Colo., 1914–15.
Snow Mass Creek at Snow Mass, Colo., 1911–1913.
Fryingpan Creek at Norrie, Colo., 1911–1917.
Fryingpan Creek at Thomasville, Colo., 1911—
Fryingpan Creek at Basalt, Colo., 1908–9.
North Fork of Fryingpan Creek near Norrie, Colo., 1911–1917.
Crystal River at Marble, Colo., 1910–1917.
Crystal River at Carbondale, Colo., 1908–9.
Elk Creek, West Fork (head of Elk Creek), near Newcastle, Colo., 1911.
Middle Fork of Elk Creek near Newcastle, Colo., 1911–1914.
East Fork of Elk Creek near Newcastle, Colo., 1911–1915.
West Divide Creek (head of Divide Creek) at Hostetler's ranch, near Raven, Colo..1909.
West Divide Creek at Beard's ranch, near Raven, Colo., 1910–11.
West Divide Creek at Raven, Colo., 1909–1911.
Plateau Creek, Moline, Colo., 1912.
West Mamm Creek near Rifle, Colo., 1909–10.
Taylor River (head of Gunnison River) near Almont, Colo., 1905.
Taylor River at Almont, Colo., 1910—
Gunnison River near Gunnison, Colo., 1910–1914, 1916—
Gunnison River near Iola, Colo., 1900–1903.
Gunnison River near Cimarron, Colo., 1903–1905.
Gunnison River at River Portal, Colo., 1905–1911.
Gunnison River near Cory, Colo., 1903–1905.
Gunnison River at Roubideau, Colo., 1897.
Gunnison River at Whitewater, Colo., 1895; 1897; 1901–1906.
Gunnison River near Grand Junction, Colo., 1894–95; 1897–1899; 1917—
East River at Almont, Colo., 1905; 1910—
Cement Creek near Crested Butte, Colo., 1910–1913.
Tomichi Creek at Sargents, Colo., 1917—
Tomichi Creek near Gunnison, Colo., 1910.
Lake Fork at Lake City, 1920—
Quartz Creek near Pitkin, Colo., 1910–1913.
Cimarron Creek at Cimarron, Colo., 1903–1905.

Colorado River tributaries—Continued.
  Grand River tributaries—Continued.
    Gunnison River tributaries—Continued.
      Crystal Creek near Maher, Colo., 1917—
      North Fork of Gunnison River near Hotchkiss, Colo., 1903–1906.
      Surface Creek at Cedaredge, Colo., 1917—
      Kannah Creek near Whitewater, 1917—
      Leroux Creek near Lazear, Colo., 1917—
      Surface Creek, at Cedaredge, Colo., 1917—
      Sapinero Creek at Sapinero, Colo., 1911–1914.
      Uncompahgre River near Colona, Colo., 1903–1906.
      Uncompahgre River at Ouray, Colo., 1908; 1911–1918.
      Uncompahgre River below Ouray, Colo., 1913—
      Uncompahgre River near Colona, Colo., 1917—
      Uncompahgre River near Fort Crawford, Colo., 1910–11.
      Uncompahgre River at Fort Crawford, Colo., 1895–1899; 1908–1911.
      Uncompahgre River at Montrose, Colo., 1900; 1903—
      Uncompahgre River near Delta, Colo., 1903—
        Canyon Creek at Ouray, Colo., 1911–1915.
    Dolores River at Rico, Colo.. 1914; 1919—
    Dolores River at Dolores, Colo., 1895–1903; 1910–1912.
    Dolores River at Bedrock, Colo., 1918—
      Rico Mining Co.'s tailrace at Rico, Colo., 1914.
      San Miguel River near Fall Creek, Colo., 1895–1899; 1910.
      San Miguel River at Placerville, Colo., 1910–1912.
      San Miguel below Placerville, Colo., 1895–1899; 1909–1912.
      San Miguel at Naturita, Colo., 1918—
    Mill Creek near Moab, Utah, 1914—
    Fremont River near Thurber, Utah, 1909–1912.
      Muddy Creek near Emery, Utah, 1909–1914.
      Muddy Creek (lower station) near Emery, Utah, 1911–1914.
      Ivie Creek near Emery, Utah, 1911–12.
    Escalante Creek (head of Escalante River) near Escalante, Utah, 1909–1913.
    San Juan River at Pagosa Springs, Colo., 1911–1914.
    San Juan River at Arboles, Colo., 1895–1899; 1910–1920—
    San Juan River at Turley, N. Mex., 1907–8.
    San Juan River at Blanco, N. Mex., 1908–1910.
    San Juan River near Bloomfield, N. Mex., 1909–1911.
    San Juan River at Farmington, N. Mex., 1904–1906; 1912–1918.
    San Juan River near Shiprock, N. Mex., 1911; 1915–1920—
    San Juan River near Bluff, Utah, 1914—
      Navajo River at Chromo, Colo., 1911–12.
      Navajo River at Edith, Colo., 1912–1920—
      Piedra River at Piedra, Colo., 1911–12.
      Piedra River at Arboles, Colo., 1895–1899; 1910–1920—
      Los Pinos River near Ignacio, Colo., 1899–1903; 1910–1920—
      Animas River at Silverton, Colo., 1903.
      Animas River at Tacoma, Colo., 1909–9; 1911.
      Animas River above Lightner Creek, at Durango, Colo., 1895–1905.
      Animas River below Lightner Creek, at Durango, Colo., 1910–1920—
      Animas River at Aztec, N. Mex., 1904; 1907–1915.
      Animas River at Farmington, N. Mex., 1912–1920—
      Animas River near Farmington, N. Mex., 1904–5.
      Evaporation at Farmington, N. Mex., 1914–15.
        Hermosa Creek near Hermosa, Colo., 1911–1914.
        Florida River near Durango, Colo., 1899; 1901–1903; 1910–1920—
        Aztec Light & Power Co.'s canal at Aztec, N. Mex., 1912–1914.
      La Plata River at Hesperus, Colo., 1904–1906; 1910; 1917—
      La Plata, Colo., N. Mex. line, 1919—
      La Plata River at La Plata, N. Mex., 1905–1920—
      Mancos River at Mancos, Colo., 1898–1901.
        West Mancos River near Mancos, Colo., 1910–11.
      Montezuma Creek, North Fork, at Monticello, Utah, 1914–1916.
        Gordon canal near Monticello, Utah, 1914–15.
        Wood high-line canal near Monticello, Utah, 1914–15.
        North canal near Monticello, Utah, 1914–15.
        Middle canal near Monticello, Utah, 1914–1916.

Colorado River tributaries—Continued.
  San Juan River tributaries—Continued.
    Montezuma Creek, North Fork at Monticello, Utah, 1914–1916—Continued.
      South Fork of North Montezuma Creek near Monticello, Utah, 1914–15.
        Pioneer canal near Monticello, Utah, 1914–15.
        South canal near Monticello, Utah, 1914–1916.
        Christensen canal near Monticello, Utah, 1915.
        Spring (Vaga) Creek near Monticello, Utah, 1914–1916.
          Davenport and Campbell canal near Monticello, Utah, 1914–1916.
          Green canal near Monticello, Utah, 1914–1916.
    Verdure (South Montezuma) Creek near Verdure, Utah, 1914–15.
  Little Colorado River at St. Johns, Ariz., 1906–1909.
  Little Colorado River at Woodruff, Ariz., 1905–1908; 1915—
  Little Colorado River at Holbrook, Ariz., 1905–1909.
    Zuni River at Black Rock, N. Mex., 1903–1905; 1908—
    Silver Creek at Snowflake, Ariz., 1906–1908; 1915–16.
    Silver Creek at Canyon station, near Snowflake, Ariz., 1906.
    Woodruff ditch at Woodruff, Ariz., 1906.
    Chevelon Fork near Winslow, Ariz., 1905–1908; 1915—
    Clear Creek near Winslow, Ariz., 1906–1909.
  Virgin River at Virgin, Utah, 1909—
    Zion Creek near Springdale, Utah, 1913–14.
    Ash Creek at Toquerville, Utah, 1915.
    Leeds (Quail) Creek near Leeds, Utah, 1915—
    Santa Clara Creek near Central, Utah, 1909—
    Santa Clara Creek at Santa Clara, Utah, 1915.
    Santa Clara Creek near St. George, Utah, 1909–1913.
      Town canal at Santa Clara, Utah, 1915.
      St. George and Santa Clara north canal at Santa Clara, Utah, 1915.
      St. George and Santa Clara south canal at Santa Clara, Utah, 1915.
    Muddy River at Home ranch, near Moapa, Nev, 1913—
    Muddy River above Indian reservation, near Moapa, Nev., 1914—
    Muddy River at railroad pumping plant, near Moapa, Nev., 1914—
    Muddy River at Weiser ranch, near Moapa, Nev., 1915—
    Muddy River near Moapa and Logan, Nev., 1904–1906; 1909–10; 1913-14.
    Muddy River near St. Thomas, Nev., 1913–1916.
  Williams River near Swansea, Ariz., 1910–1915.
  Gila River near Cliff, N. Mex., 1904–1907.
  Gila River near Silver City, N. Mex., 1912-1919.
  Gila River near Gila, N. Mex., 1914.
  Gila River near Redrock, N. Mex., 1908—
  Gila River near Duncan, Ariz., 1914–15.
  Gila River at Guthrie, Ariz., 1910–1918.
  Gila River near Solomonville, Ariz., 1914—
  Gila River at San Carlos, Ariz., 1910–11.
  Gila River near San Carlos, Ariz., 1899–1905.
  Gila River near dam site, near San Carlos, Ariz., 1914—
  Gila River at Winkelman, Ariz., 1917—
  Gila River at Kelvin, Ariz., 1911—
  Gila River near Florence, Ariz., 1914.
  Gila River near Buttes, Ariz., 1889–90; 1895–1899.
  Gila River near Sentinel, Ariz., 1913—
  Gila River at Dome (Gila City), Ariz., 1903–1906.
  Gila River at mouth, near Yuma, Ariz., 1903—
    Sunset canal near Duncan, Ariz., 1914–15.
    Cosper and Martin canal near Duncan, Ariz., 1914–15.
    Cosper and Windham canal near Duncan, Ariz., 1914–15.
    Model canal near Duncan, Ariz., 1914–15.
    Valley canal near Duncan, Ariz., 1914–15.
    Black and McClesky canal at Duncan, Ariz., 1915.
    Colomonero canal near Duncan, Ariz., 1914–15.
    York Canal at York, Ariz., 1914–15.
    San Francisco River near Alma, N. Mex., 1904–1907; 1909–1914.
    San Francisco River at dam, above Clifton, Ariz., 1911.
    San Francisco River at Clifton, Ariz., 1910—
      Whitewater Creek near Mogollon, N. Mex., 1909–1920—
    Brown canal above wasteway, near Solomonville, Ariz., 1914–15.
    Brown canal below wasteway, near Solomonville, Ariz., 1914–15.

Colorado River tributaries—Continued.
Gila River Canals—Continued.
Fourness canal near Solomonville, Ariz., 1914–15.
San Jose canal near Solomonville, Ariz., 1914–15.
Michellena canal near Solomonville, Ariz., 1914–15.
Montezuma canal at Solomonville, Ariz., 1914–15.
Union canal near Solomonville, Ariz., 1914–15.
Graham canal near Safford, Ariz., 1914–15.
Oregon canal near Thatcher, Ariz., 1914–15.
Smithville canal near Thatcher, Ariz., 1914–15.
Bryce canal near Pima, Ariz., 1914–15.
Dodge canal at Pima, Ariz., 1914–15.
Nevada canal near Pima, Ariz., 1914–15.
Curtis canal near Fairview, Ariz., 1914–15.
Consolidated canal near Fairview, Ariz., 1914–15.
San Carlos River at San Carlos, Ariz., 1910–11; 1914–15.
San Pedro River at Lewis Springs (Charleston), Ariz., 1904–1906; 1910–11.
San Pedro River at diversion dam, near Fairbank, Ariz., 1911–12.
San Pedro River near Fairbank, Ariz., 1912—
San Pedro River near Dudleyville, Ariz., 1890.
Florence canal near Florence, Ariz., 1914–15.
O. T. canal, Florence, Ariz., 1914–15.
Price and Powell ditch near Florence, Ariz., 1914–15.
Pierson-Nicholas canal near Florence, Ariz., 1914–15.
Queen Creek at Whitlow's, near Superior, Ariz., 1896; 1915—
Santa Cruz River near Nogales, Ariz., 1907; 1909—
Santa Cruz River at Tucson, Ariz., 1905—
Rillito Creek near Tucson, Ariz., 1909—
Black River (head of Salt River) near Fort Apache, Ariz., 1912—
Salt River near Roosevelt, Ariz., 1901–1907; 1912—
Salt River below mouth of Cherry Creek near Roosevelt, Ariz., 1906.
Salt River 50 miles above Phoenix, Ariz., 1890.
Salt River at Arizona dam, Ariz., 1888–1891.
Salt River at McDowell, Ariz., 1897–1910.
North Fork of White River, at Whiteriver, Ariz., 1917—
White River at Fort Apache, Ariz., 1912—
East Fork of White River at Fort Apache, Ariz., 1912—
Tonto Creek near Roosevelt, Ariz., 1901–1904; 1913—
Verde River near Clarkdale, Ariz., 1915—
Verde River at Camp Verde, Ariz., 1912—
Verde River at Childs, near Camp Verde, Ariz., 1911—
Verde River near McDowell, Ariz., 1889; 1897–1899; 1901—
Beaver Creek at Camp Verde, Ariz., 1912—
Agua Fria River near Glendale, Ariz., 1910—
Hassayampa River near Wagoner (Walnut Grove), Ariz., 1912—
Hassayampa River at Wickenburg, Ariz., 1910–1912.
Imperial canal 10 miles below Yuma, Ariz., 1903–1905.
Imperial canal (main) near Calexico, Calif., 1904–5.
Boundary canal near Calexico, Calif., 1905.
Wisteria canal near Calexico, Calif., 1905.
Holt canal at Calexico, Calif., 1904–5.
Hemlock canal at Calexico, Calif., 1904–5.
Alamo channel near Calexico, Calif., 1904.
Alamitos canal near Calexico, Calif., 1904–5.
Whitewater Draw [1] near Douglas, Ariz., 1911—

3. Key stations at which yearly percentages of the mean annual run-off are computed and from which other streams in the same basin may be compared, viz: At the key station, for the years of which the selected stream is to be compared, take a mean of the percentages. This mean divided into the mean annual run-off of the stream selected for comparison will give results in proportion to the longer record of the key station.

[1] Flows into Gulf of California in Mexico.

Example: Ham's Fork at Kemmerer, Wyo., 1918–1920, mean annual, 123,000 acre-feet recorded. Per cent of mean of Green River at Green River, Wyo., for 1918–1920 inclusive $=\frac{265}{3}=88$ per cent of mean. $\frac{123,000}{88}=140,000$ acre feet = estimated average annual flow at Kemmerer for the longer period.

4. List of key stations:

Green River at Green River, Wyo., 1895–1906, 1905–1920.
Green River at Little Valley, Utah, 1895–1897, 1905–1920.
Colorado River at Yuma, Ariz., 1903–1920.
Yampa River at Steamboat Springs, Colo., 1904–1906, 1910–1920.
Duchesne River at Myton, Utah, 1900–1920.
White River at Meeker, Utah, 1902–1920.
Price River at Helper, Utah, 1905–1920.
Grand River at Glenwood Springs, Colo., 1900–1920.
San Rafael River at Green River, Utah, 1910–1918.
San Juan River at Arboles, Colo., 1897, 1911–1920.
San Juan River at Farmington, N. Mex., 1905–6, 1912–1920.
Virgin River at Virgin, Utah, 1909–1918.
Verde River at McDowell, Ariz., 1903–1917.
Salt River at Roosevelt, Ariz., 1901–1918.
Gila River at Yuma, Ariz., 1903–1920.

5. On the following pages the records of mean annual runoff at gaging stations on the Colorado and its tributaries are given. These stations are grouped by stream basins for readiness of comparison with the records at the key stations.

6. Following these will be found tables of monthly runoff in acre-feet for all principal gaging stations in the Colorado Basin.

GREEN RIVER BASIN.

[Arranged in order downstream.]

Stream.	Station.	Period of record.	Years.	Drainage area.	Mean annual recorded run-off.	Mean annual run-off.
				Sq. miles.	*Acre-feet.*	*Acre-feet.*
Green River	Kendall, Wyo	June-September, 1918		271	275,000	[1] 345,000
Do	Daniel, Wyo	1915-1918	6	932	543,000	[1] 558,000
Do	Green River, Wyo	1895-1906 and 1915-1920	17	7,450	1,466,000	1,466,000
Horse Creek	Daniel, Wyo	1913-1918	6	193	86,000	[1] 79,000
Cottonwood Creek	Big Piney, Wyo	1916-1919	3		59,000	[1] 54,000
East Fork Creek	East Fork Canal	(See at New Fork)				
Do	New Fork	1905-1906 and 1915-1920	7	348	141,000	[1] 138,000
New Fork Creek	Alexander's ranch, Cora, Wyo	(See Boulder)				
Do	Pinedale Crossing, Cora, Wyo					
Do	Boulder, Wyo	1915-1920	6	578	296,000	[1] 318,000
Pine Creek	Fremont Lake outlet	1916-1918	3	114	(2)	
Do	Pinedale, Wyo	1904-1906 and 1915-1920	9	128	127,000	[1] 130,000
Pole Creek	Fayette, Wyo	1904-1906	3	126		
Do	Pinedale, Wyo	(See Fayette)				
Fall Creek	Fayette, Wyo	1904-1906	3	60		
Boulder Creek	Boulder, Wyo	1904-1906 and 1915-1920	8	112	128,000	[1] 132,000
North Piney Creek	Marbleton, Wyo	1914-1916	3	58	28,000	[1] 32,000
Middle Piney Creek	Big Piney	1915-1918	5	46	15,000	[1] 14,000
Labarge Creek	Labarge	1915-1916	2	126	44,000	[1] 49,000
Fontenelle Creek	Fontenelle	1915-1918	4	224	72,000	[1] 66,000
Big Sandy Creek	Big Sandy	(See Farson, Wyo.)				
Do	Eden	do				
Do	Farson	1915-16	2	322	78,000	[1] 88,000
Dutch Joe Creek	Big Sandy	(See Big Sandy at Farson)				
Squaw Creek	Eden, Wyo					
Little Sandy Creek	do	1911-12	2		21,000	[1] 19,000
Blacks Fork	Urie	1914-1920	7	261	77,000	[1] 79,000
Do	Hams Fork, Granger, Wyo	1897-1900	4	2,840	437,000	[1] 367,000
Henrys Fork	Linwood, Utah	1916	1		30,000	[1] 25,000
Hams Fork	Kemmerer, Wyo	1918-1920	3		123,000	[1] 140,000

UINTA RIVER BASIN.

[Arranged in order down stream.]

Stream.	Station.	Period of record.	Years.	Drainage area.	Mean annual recorded run-off.	Mean annual run-off.
Duchesne River	At Duchesne, Utah	1918-1920	3		294,000	[3] 387,000
Do	At Myton, Utah	1900-1920	21	2,750	635,000	635,000
Strawberry River	Above Indian Creek	1903-1906 and 1910	5	132	61,100	[3] 58,200
Do	Below Indian Creek	May-September, 1909	1		193,000	[3] 113,000
Do	At Duchesne	1908-1910 and 1914-1920	10	1,040	189,000	[3] 182,000
Indian Creek	In Strawberry Valley	April, 1905-July, 1906, and October, 1909-November, 1911.	3		19,900	[3] 17,800

Trail Hollow Creek	....do	October, 1909–November, 1910	1	21		
Lake Fork, West Fork	Above Forks, Utah					
Lake Fork	Below Forks, Utah	1908–1910	3	331	316,000	[3] 243,000
Do	Near Myton, Utah	1901–1903 and 1908–1920	15	475	165,000	[3] 171,000
Do	Above United States Lake Fork Canal	1918	1		134,000	[3] 189,000
Uinta River	Near Whiterocks	1901–1903, 1908–1910, and 1918	7	218	201,000	[3] 202,000
Do	At Fort Duchesne	1900–1904 and 1908–1910	8	672	177,000	[3] 177,000
Do	At Ouray School	1900–1904	5	967	163,000	[3] 196,000
Whiterocks River	Near Whiterocks	1901–1903, 1908–1910, and 1918	7	114	109,000	[3] 110,000
		PRICE RIVER BASIN.				
Fish Creek	At Schofield, Utah	1918–1920	3		52,500	[4] 68,200
Price River	Near Helper, Utah	1905–1920	16	530	119,000	119,000
Do	At Woodside, Utah	1910	1	1,500	227,000	[4] 174,000
		SAN RAFAEL BASIN.				
Huntington Creek	Near Huntington, Utah	1910–1917	8	158	88,900	[5] 85,500
Do	Near Castledale, Utah	1912–1917	6	325	48,200	[5] 45,500
San Rafael	Near Green River, Utah	1910–1918	9	1,690	196,000	196,000
Cottonwood Creek	Near Orangeville, Utah	1910–1917	8	240	96,900	[5] 93,200
Ferron Creek	Upper station near Ferron	1912–1917	6	150	58,000	[5] 54,700
Do	Near Ferron	1910–11	2	153	25,800	[5] 25,800
Do	Near Castledale	1912–1914	3	235	34,200	[5] 31,000
		VIRGIN RIVER BASIN.				
Virgin River	At Virgin, Utah	1909–1918	9	1,010	208,000	208,000
Zion Creek	Near Springdale, Utah	1914	1	330	114,000	[6] 109,000
Ash Creek	At Toquerville, Utah	April–June, 1915				
Leeds Creek	Near Leeds, Utah	February–September, 1915				
Santa Clara	Near Central, Utah	1910–1920	11	84	20,400	[6] 20,400
Do	At Santa Clara	February–September, 1915		468		
Do	Near St. George, Utah	April, 1909–December, 1912	3	540	25,100	[6] 22,800
Muddy River	Near Moapa, Nev	1914–1917	4	1,080	34,400	[6] 32,800
Do	Above Indian reserve, near Moapa	1915–1917	3	1,100	34,300	[6] 32,700
Do	Railway pumping plant, near Moapa	1915–1917	3			
Do	Weiser ranch, near Moapa	1916–1917	2			
Do	Near Moapa and Logan, Nev	1910 and 1913		3,740		
Do	Near St. Thomas, Nev	1914–1916	3	3,980	13,700	[6] 12,100

[1] Mean annual run-off compared with Green River at Green River, 1895–1906 and 1915–1920.
[2] About 5 per cent less than Pinedale.
[3] Mean annual run-off compared with Duchesne River at Myton, Utah, 1900–1920.
[4] Mean annual run-off compared with Price River at Helper, 1905–1920.
[5] Mean annual run-off compared with San Rafael River, near Green River, Utah.
[6] Mean annual run-off compared with Virgin River at Virgin, Utah, 1910–1918.

COLORADO AND GREEN RIVERS.

Stream.	Station.	Period of record.	Years.	Drainage area.	Mean annual recorded run-off.	Mean annual run-off.
				Sq. miles.	Acre-feet.	Acre-feet.
Green River	At Bridgeport, Utah	1912–1915	4	15,700	2,087,000	
Do	At Jensen, Utah	1904, 1906, and 1914–15	3	26,100	4,574,000	
Do	Little Valley, Utah	1895–1897, and 1905–1920	19	41,000	5,592,000	
Colorado River	Hardyville, Ariz	1906–7	2	169,000	18,800,000	
Do	Topock, Ariz	February, 1917–March, 1920	2	171,000	16,700,000	
Do	Above Laguna Dam	1899–1920	22		16,400,000	
Do	At Yuma, Ariz	1903–1920	18	242,000	17,400,000	

GILA RIVER BASIN.

Stream.	Station.	Period of record.	Years.	Drainage area.	Mean annual recorded run-off.	Mean annual run-off.
Gila River	At Cliff, N. Mex	1906	1	2,450	338,000	[7] 174,000
Do	Near Silver City, N. Mex	1913–1918	6		128,000	[7] 96,200
Do	Near Gila, N. Mex	1914				
Do	Near Redrock, N. Mex	1910, and 1913–1920	9	3,500	190,000	[7] 177,000
Do	Near Duncan, Ariz	1915	1		466,000	[7] 253,000
Do	At Guthrie, Ariz	1911–1918	8		259,000	[7] 244,000
Do	At Solomonville, Ariz	1915–1920	6		794,000	[7] 533,000
Do	At San Carlos, Ariz	1910–1911				
Do	Near San Carlos, Ariz	1901–1904, and 1915–1920	10	13,460	519,000	
Do	At Kelvin, Ariz	1912–1920	9		842,000	[7] 787,000
Do	At Sentinel, Ariz	1914	1		318,000	See Yuma.
Do	At Dome, Ariz	1904–1906	3		1,900,000	See Yuma.
Do	At Yuma, Ariz	1903–1920	18	57,000	1,060,000	1,060,000
San Francisco River	Near Alma, N. Mex	1905–1907, 1909–1910, and 1913	6	1,670	106,000	[7] 92,200
Do	At Dam, Clifton, Ariz	1911–1912				
Do	At Clifton, Ariz	1913–1917	5		304,000	[7] 199,000
White Water Creek	Near Mogollon, N. Mex	1910–1920	11	34	13,560	[7] 14,700
San Carlos River	At San Carlos, Ariz	1910–1911, and 1914–1915				
San Pedro River	At Lewis Springs, Ariz	1904–1906	2		43,000	[7] 15,900
Do	Near Fairbank, Ariz	1913–1917	5		72,200	[7] 47,200
Queen Creek	Near Superior, Ariz	1916–1917, 1919, and 1920	4		12,900	[7] 7,590
Santa Cruz	Near Nogales, Ariz	1913–1917	5		18,800	[7] 12,300
Do	At Tucson, Ariz	1906–1909, and 1913–1917	8		25,400	[7] 18,000
Rillito Creek	Near Tucson, Ariz	1914–1917	4		59,700	[7] 31,400
Black River	Near Fort Apache, Ariz	1914–1915				
Salt River	At Roosevelt, Ariz	1901–1907, and 1911–1917	14	4,222	981,000	
Do	At McDowell, Ariz	1904–1910	7	6,260	1,690,000	[7] 1,470,000
White River	At Fort Apache, Ariz	1913–1916	4		246,000	[7] 151,000
East Fork White River	At Fort Apache, Ariz	1913–1916	4		56,900	[7] 34,900

Tonto Creek	Near Roosevelt, Ariz.	1902–1903, and 1914–1917	6	1,004	109,000	
Verde River	Near Clarkdale, Ariz.	1916	1		198,000	[7] 46,700
Do.	At Camp Verde, Ariz.	1914–1917	4		322,000	[7] 170,000
Do.	Near McDowell, Ariz.	1903–1917	15	6,000	664,000	[7] 609,000
Do.	At Childs, near Camp Verde, Ariz.	1913–1914				
Beaver Creek	At Camp Verde, Ariz.	1913–1917	5		89,200	[7] 58,300
Aqua Fria River	Near Glendale, Ariz.	1915–1917	3		432,000	[7] 181,000
Hassayampa	Near Wagoner, Ariz.	1914–1915	2		19,500	[7] 17,300

[7] Mean annual run-off compared with Gila River at Yuma, 1903–1920.

YAMPA BASIN.

[Arranged in order downstream.]

Stream.	Station.	Period of records.	Years.	Drainage area.	Elevation.	Mean annual recorded run-off.	Remarks.
				Square miles.	*Feet.*	*Acre-feet.*	
Yampa River	Yampa	1910–1915	6	52	7,880	21,900	
Do.	Steamboat Springs	1904–1906 and 1910–1920	14	525	6,680	370,000	
Do.	Craig	1901–1906 and 1910–1916	12	1,730	6,180	934,000	Poor station.
Do.	Maybell	1904–5, 1910–1912, 1916–1920	10	3,670	5,900	1,296,000	
TRIBUTARIES.							
Fish Creek	Steamboat Springs	1919–20	2	26			At mouth.
Soda Creek	do	1910–11 and 1913–1919	10	47		36,500	Do.
Elk River	Hinman Park	1912–1918	9	61	7,800	138,000	
Do.	Clark	1910–1920	11	206	7,300	277,000	Glen Eden.
Do.	Trull	1904–1906, 1910 and 1920	14	415	6,650	454,000	
Big Creek	Mouth	1918–19	1	41		35,000	
Mad Creek	do	1912–1917	6	40		92,200	
Trout Creek	Pinnacle	1910–11	2	27		20,000	
Fish Creek	Dunkley	1910–11	2	29		10,000	
Elk Head	Hays Ranch	1910–1920	1			50,000	East Fork.
Do.	Craig	1906 and 1910–1918	10	249	6,200	86,600	
North Fork	Hays Ranch	1910 and 1920	1			20,000	
Fortification	Champmans	1910	1			20,000	
Do.	Craig	1905–6, 1910–1918	11	256	6,180	45,100	
Little Bear	Skiles Ranch	1910	1			15,000	
Williams River	Pyramid	1910–11	2	98		75,000	
Do.	Hamilton	1904–1906 and 1919–20	14	341	6,400	166,000	
Milk Creek	Axial	1904–5	2	75		20,000	
Little Snake River	Dixon, Wyo	1910–1920	11	1,294	6,300	582,000	
Do.	Maybell	1904	1	4,456	5,900		

YAMPA BASIN—Continued.

Stream.	Stations.	Period of records.	Years.	Drainage area.	Elevation.	Mean annual recorded run-off.	Remarks.
				Square miles.		*Acre-feet.*	
South Fork	Goodard Ranch	1912–1920	9	41	7,000	33,000	
Middle Fork	do	1912–1920	9	120	7,000	100,000	
Slater Fork	Baxters Ranch	1912–1920	9	80	7,000	61,400	
Savery	Savery, Wyo	1915–1920	5	354	....	80,300	
Willow Creek	Ryans Ranch	1912–1920	9	8	7,600	7,650	
Four Mile Creek	Ranger Station	1912–1920	9	8	7,500	5,460	
Muddy Creek	Baggs, Wyo	1915–16 and 1918	3	3	....	36,800	

WHITE BASIN.

[Arranged in order downstream.]

Stream.	Station.	Period of records.	Years.	Drainage area.	Mean annual recorded run-off.	Remarks.
				Sq. miles.	*Acre-feet.*	
White River	Meeker	1891–1906 and 1910–1920	17	634	468,000	
Do	Rangely	1904–5 and 1918	3	3,266	549,000	
North Fork	Bufford	1903–1906	4	181	....	
Do	do	1910–1915 and 1919–20	8	240	245,000	
Marvine	do	1903–1906	4	50	90,100	
South Fork	do	1903–1906, 1910–1915, and 1919–20	10	148	210,700	
Piceance Creek	At mouth	1918	1	642	20,000	At mouth.
MISCELLANEOUS—GREEN BASIN.						
Beaver Creek	Lodore	1910–11	2	27	....	Insufficient data.
Vermillion Creek	do	1910–11	2	1,017	100,000	Rough.

GRAND RIVER BASIN.

[Arranged in order downstream.]

Grand River	North Inlet, Grand Lake	1904–1912	7	365	53,900	
Do	Grand Lake outlet	1904–1912	8	62	95,600	
Do	Grandby	1908–1911	4	484	339,000	
Do	Sulphur Springs	1904–1920	17	946	569,000	
Do	Walcott	1906–1908	3	2,740	1,650,000	
Do	Kremmling	1904–1918	15	2,380	1,320,000	
Do	Glenwood Springs	1900–1920	20	4,520	2,390,000	
Do	Palisades	1902–1920	19	8,546	3,930,000	
Do	Grand Junction	1897–1899	3	8,644	4,240,000	
Do	Fruita	1908–1920	13	16,800	6,180,000	
Do	Cisco, Utah	1915–1917	3	23,800	7,270,000	
Do	Moab, Utah	1914	1	24,300	8,530,000	
TRIBUTARIES.						
North Fork of Grand River	Grand Lake	1904–1918	15	125		
South Fork of Grand River	Lehman	1907–1908	2	79		
Fraser River	Arrow	1911–1920	10	28	34,600	
Do	Fraser	1907–1909	3	24	32,900	Empties into Grand.
Do	Grandby	1904–1909	6	220	163,000	
Elk	Fraser	1907–1909	3			Empties into Fraser.
Vasquez	Fraser	1907–1909	3	12		Do.
St. Louis	do	1908–9	2	19		Do.
North Ranch	Rollins Pass	1907–1909	3	2		Do.
Middle Ranch	Arrow	do	3	3		Do.
South Ranch	do	do	3	3		Do.
Big Jim	Frazer	do	3	4		Do.
Little Jim	do	do	3	3		Do.
Williams Fork	Scholl	1910–1917	8	141	126,000	Empties into Grand.
Do	Pershall	1904–1920	17	185	126,000	
Troublesome	Troublesome	1904–5	2	175		
Blue	Dillon	1910–1920	11	110	96,800	Do.
Do	Kremmling	1904–1908	5	690	468,000	Do.
Ten Mile	Dillon	1910–1919	10	113	109,000	Empties into Blue.
Snake	do	do	10	92	59,500	Do.
Muddy	Kremmling	1904–5	2	320		Empties into Grand.
Eagle	Red Cliff	1911–1920	10	74	52,000	Do.
Do	Eagle	1906, 1911, and 1920	11	630	497,000	
Do	Gypsum	1907–1909	3	800	464,000	
Homestake	Red Cliff	1911–1918	8	64	76,200	Empties into Eagle.
Turkey	do	1913 and 1915–1920	7	27	22,900	Do.
Gore	Minturn	1911	1	98		Do.
Beaver	Avon	do	1	15	12,000	Do.
Brush	Eagle	1911–12	2	146	48,500	Do.

GRAND RIVER BASIN—Continued.

Stream.	Station.	Period of records.	Years.	Drainage area.	Mean annual recorded run-off.	Remarks.
TRIBUTARIES—continued.				*Sq. miles.*	*Acre-feet.*	
Roaring Fork	Aspen	1911–1920	10	109	133,000	Empties into Grand.
Do	Below Aspen	1913–1918	6	223	310,000	
Do	Emma	1908–9	2	550	765,000	
Do	Glenwood Springs	1906–1920	14	1,450	....	
Hunter	Aspen	1913–1920	2	42	40,900	Empties into Roaring Fork.
Castle	do	do	8	72	75,700	Do.
Maroon	do	1911–1917	7	42	65,600	Do.
Do	Aspen lower station	1914–1916	2	54	64,000	Do.
Snow Mass	Snow Mass	1911–1913	3	89	89,000	Do.
Frying Pan	Norrie	1911–1913 and 1915–1917	6	92	105,000	Do.
Do	Thomasville	1911–1920	10	190	182,000	
Do	Basalt	1908–9	2	320	....	
North Fork Frying Pan	Norrie	1911–1917	7	42	46,200	Empties into Frying Pan.
Crystal	Marble	1910–1915 and 1917	7	77	183,000	Empties into Roaring Fork.
Do	Carbondale	1908–9	2	350	460,000	Do.
East Elk	New Castle	1911–1913 and 1915	4	60	38,500	Empties into Grand.
West Divide	Raven	1909 and 1911	2	82	19,900	Do.
Plateau	Noline	1912	1	464	195,000	Do.

GUNNISON RIVER BASIN.

[Arranged in order downstream.]

Stream.	Station.	Period of records.	Years.	Drainage area.	Mean annual recorded run-off.	Remarks.
Gunnison River	Gunnison	1911–1920	9	1,014	706,000	Made up of East and Taylor.
Do	Iola	1900–1903	4	2,298	600,000	
Do	Cimarron	1903–1905	3	3,844	1,058,000	
Do	River Portal	1905–1916	11	4,140	1,542,000	
Do	Cory	1903–1905	3	5,233	1,780,000	
Do	Whitewater	1902–1906	5	7,868	2,020,000	
Do	Grand Junction	1897–1899, and 1917–1920	7	7,920	2,310,000	Empties into Grand.

TRIBUTARIES.						
Taylor	Almont	1910–1913, and 1915–1920	10	413	298,000	Tributary to Gunnison.
East	do	1910–1913, and 1916–1920	9	295	306,000	Do.
Cement	Crested Butte	1910–1913	4	32	34,000	Tributary to East River.
Tomichi	Sargents	1917–1920	4	165	48,500	Tributary to Gunnison.
Quartz	Pitkin	1911–1913	3	54	38,200	Tributary to Tomichi.
Sapinero	Sapinero	1911–1913	3	84	53,000	Tributary to Gunnison.
Henson Creek	Lake City	1918–1919	2	83	64,200	Tributary to Lake Fork.
Lake Fork	do	1918–1920	3	126	85,300	Tributary to Gunnison.
Cimarron	Cimarron	1903–04	2	210	86,200	Do.
Crystal	Maher	1917–1919	3	....	25,000	Do.
North Fork Gunnison	Hotchkiss	1903–1905	3	850	512,000	Do.
Leroux	Lazear	1917–1920	4	52	65,000	Do.
Surface	Cedaredge	1917–1920	4	43	28,600	Do.
Kannah	Whitewater	1917–1920	4	38	35,000	Do.

UNCOMPAHGRE RIVER BASIN.

[Arranged in order downstream.]

Uncompahgre River	Ouray	1908 and 1911–1918	9	44	56,000	
Do	Below Ouray	1913–1920	8	76	119,000	
Do	Colona	1903–1920	18	443	197,000	
Do	Fort Crawford	1898–1899, 1908–09, and 1911	5	443	158,000	
Do	Montrose	1903–1909, and 1911–1920	17	565	140,000	
Do	Delta	1903–1908, 1911–1913, and 1915–1920	15	1,130	122,000	
Cannon	Ouray	1911–1916	5	26	44,900	

DOLORES RIVER BASIN.

[Arranged in order downstream.]

Dolores River	Rico	1919–20	2	....	93,000	
Do	Dolores	1895–1899, 1900–1903, and 1910–1912	11	524	291,000	
Do	Bedrock	1918–1920	3	1,910	357,000	
TRIBUTARIES.						
San Miguel River	Fall Creek	1895–1899	5	176	136,000	
Do	Placerville	1910, 1911, and 1912	3	304	207,000	
Do	Below Placerville	1895–1899 and 1909–1912	9	328	192,000	
Do	Naturita	1918, 1919, and 1920	3	1,909	272,000	

SAN JUAN RIVER BASIN.

[Arranged in order downstream.]

Stream.	Station.	Period of records.	Years.	Drainage area.	Mean annual recorded run-off.	Remarks.
				Sq. miles.	*Acre-feet.*	
San Juan	Pagosa Springs	1912–1914	3	287	320,000	
Do	Arboles	1895–1899 and 1910–1920	15	1,394	705,000	
TRIBUTARIES.						
Navajo	Edith	1912–1920	9		150,000	
Piedra	Arboles	1895–1899 and 1910–1920	15	650	405,000	
Pine	Ignacio	1899–1903, 1896, and 1910–1920	17	450	3.3,000	
Animas	Silverton	1903	1	66		
Do	Tacoma	1908 and 1909	2	408	595,000	
Do	Durango	1895–1905 and 1910–1920	22	694	719,000	
Florida	do	1899, 1901–1903, and 1910–1920	11	96	91,700	Empties into Animas.
La Plata	Hesperus	1904, 1906, 1910, and 1917–1920	7	37	45,300	
Do	Colorado-New Mexico line	1919–20	2		66,000	
Do	La Plata	1905–1910 and 1913–1920	14	340	37,100	
Mancos	Mancos	1898–99	2	83	32,800	
West Mancos	Cranes Ranch	1910–11	2	46	40,300	
San Juan River	Turkey, N. Mex	1908	1	4,700	1,190,000	
Do	Blanco, N. Mex	1909	1		2,055,000	
Do	Near Bloomfield	1910–11	2	5,190	1,390,000	
Do	At Farmington	1905–6 and 1913–1917	7	6,920	2,400,000	
Do	Near Shiprock	1916–1920	5	13,100	3,040,000	
Do	Near Bluff, Utah	1915–1917	3	24,000	3,110,000	
Animas	At Aztec, N. Mex	1904 and 1908–1915	8	1,300	876,000	
Do	At Farmington	1905 and 1913–1920	9		920,000	

MISCELLANEOUS.

Stream.	Station.	Period of records.	Years.	Drainage area.	Mean annual recorded run-off.	Remarks.
Fremont River	Near Thurber, Utah	1910–1912	3	720	81,400	
Muddy Creek	Near Emery, Utah	1911–1914	4	87	39,600	
Do	Near Emery (lower station)					
Escalante Creek	Near Escalante, Utah	1910–1912	3	315	32,700	
Montezuma Creek	North Fork at Monticello, Utah	April–June, 1914		10.5		
Do	South Fork	April–July, 1914		15		
Spring (Vaga)	Near Monticello, Utah	June–August, 1914				
		April–September, 1915				
		April–August, 1916		8.5		

Little Colorado	At St. Johns, Ariz.	April, 1906–December, 1909	3	6,000	41,900
Do	At Woodruff, Ariz.	1906–7 and 1917–1920	5	6,000	94,000
Do	At Holbrook, Ariz.	March, 1905–April, 1907	2	17,630	180,000
Zuni Creek	At Black Rock, N. Mex.	1904, 1905, 1908, 1909, and 1911–1916	10	660	33,200
Silver Creek	Near Snowlake, Ariz.	May–December, 1906			
Chevlon Fork	At Winslow, Ariz.	1906 and 1916–1919	5		57,400
Ashley Creek	Above Dry Fork near Vernal, Utah				
Do	Below Dry Fork near Vernal, Utah	1901–1904, 1912, and 1915–1917	8	250	97,600
Dry Fork	Ashley Creek at Vernal				
Williams River	Near Swansea, Ariz.	1913–1915	3		74,500

Monthly record of run-off at important gaging stations.

GREEN RIVER AT GREEN RIVER, WYO.

[Sec. 22, T. 18 N., R. 107 W. Unit of run-off, 1,000 acre-feet. Drainage area, 7,450 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1895	44.0	34.0	27.0	24.0	22.0	[1]40.0	[1]100.0	244.0	271.0	253.0	105.0	38.0	1,202.0	82
1896	29.0	17.9	18.4	18.4	17.3	21.5	60.7	132.0	702.0	258.0	90.4	51.7	1,417.3	97
1897	45.5	35.7	30.7	27.7	22.2	24.6	117.0	601.0	449.0	172.0	98.4	27.7	1,651.5	113
1898	62.1	45.2	33.8	30.7	22.2	27.7	158.0	250.0	539.0	284.0	87.3	38.4	1,578.4	108
1899	21.3	23.8	18.4	18.4	22.2	27.7	95.2	201.0	744.0	892.0	318.0	123.0	2,505.0	171
1900	112.0	....	....	....	....	....	....	....	....	....	....	....	....	....
1901	36.9	35.7	30.7	30.7	22.2	30.7	78.6	415.0	323.0	169.0	86.7	37.6	1,296.8	89
1902	30.7	26.8	24.6	18.4	16.7	18.4	50.2	139.0	422.0	164.0	85.5	39.0	1,035.3	71
1903	20.2	17.9	18.4	18.4	13.9	36.9	71.4	113.0	569.0	245.0	89.8	92.2	1,306.1	89
1904	62.1	47.6	36.9	30.7	40.3	55.3	117.0	377.0	607.0	323.0	125.0	53.0	1,874.9	128
1905	42.9	32.7	30.7	24.6	22.2	33.8	52.5	97.2	354.0	213.0	68.9	38.0	1,010.5	69
1906	29.9	23.8	18.4	18.4	16.7	30.7	121.0	309.0	406.0	299.0	138.0	75.0	1,485.9	101
1907	40.6	....	....	....	....	....	....	....	....	....	....	....	....	....
1915	44.0	34.0	27.0	24.0	22.0	40.0	84.5	99.6	168.0	163.0	68.2	75.6	849.9	58
1916	71.9	48.6	38.4	25.6	32.7	121.0	157.0	239.0	496.0	336.0	132.0	53.4	1,751.6	119
1917	53.7	30.8	24.9	23.0	20.2	32.5	134.0	293.0	601.0	640.0	148.0	79.7	2,080.8	142
1918	57.2	47.0	27.0	23.0	20.0	42.6	107.0	188.0	797.0	263.0	96.5	53.6	1,721.9	117
1919	55.3	44.6	27.6	22.0	19.2	40.3	95.2	159.0	127.0	33.3	32.2	29.7	685.4	47
1920	44.5	26.6	27.0	23.0	20.0	57.5	102.0	270.0	517.0	249.0	89.2	51.9	1,477.7	101
Mean	44.2	33.7	27.1	23.6	21.9	40.1	100.1	242.8	476.0	291.5	109.4	56.3	1,466.5	....
Per cent	3	2	2	2	1	3	7	17	32	20	7	4	....	....

YAMPA RIVER AT STEAMBOAT SPRINGS.

[Unit of run-off, 1,000 acre-feet. Drainage area, 500 square miles.]

1904	....	....	....	....	....	....	[1]48.4	[1]121.0	93.7	17.1	10.2	9.1	300.0	89
1905	10.2	....	....	....	....	....	24.9	86.4	145.0	156.0	5.7	4.3	422.0	126
1906	5.4	....	....	....	....	....	48.6	137.0	149.0	24.5	10.2	10.2	380.0	110
1907	9.8	....	....	....	....	....	....	....	....	....	....	....	....	....
1910	....	....	....	....	....	26.6	44.8	110.0	59.3	8.2	8.2	6.8	237.0	71
1911	6.8	8.0	4.8	5.6	5.6	12.5	28.7	89.1	101.0	18.3	6.5	5.3	249.0	74
1912	11.7	8.2	....	....	9.0	9.5	33.2	113.0	175.0	67.9	20.7	13.1	423.0	126
1913	16.0	11.4	....	....	....	....	[1]47.9	113.0	53.0	9.3	5.1	4.9	234.0	70
1914	5.4	4.5	[1]4.4	....	....	[1]11.9	46.6	149.0	140.0	18.9	11.4	9.4	375.0	112
1915	13.4	8.7	....	....	....	....	[1]56.2	78.7	76.8	101.0	4.3	4.8	322.0	96
1916	6.5	4.8	3.5	....	....	[1]21.1	52.3	91.6	120.0	19.0	15.7	9.1	308.0	92
1917	13.1	8.1	....	....	....	....	[1]31.5	109.0	224.0	67.6	12.8	9.4	454.0	135
1918	6.9	7.4	6.6	7.4	6.9	15.4	35.9	104.0	149.0	34.6	9.2	9.5	342.0	102
1919	14.1	12.0	....	....	....	....	[1]35.9	129.0	46.0	6.4	3.9	3.3	224.0	67
1920	4.1	6.5	4.3	4.6	5.8	7.1	20.9	172.0	186.0	30.4	12.6	8.0	430.0	128
Mean	9.4	....	....	....	....	....	38.3	115.0	123.0	41.4	9.7	7.6	336.0	....
Year	9.4	8.0	4.7	5.5	6.8	14.9	38.3	115.0	123.0	41.4	9.7	7.6	384.0	....
Per cent	2	2	1	1	2	4	10	30	32	11	3	2	....	....

WHITE RIVER AT MEEKER, COLO.

[Unit of run-off, 1,000 acre-feet. Drainage area, 634 square miles.]

1901	....	....	....	....	....	....	[1]26.9	[1]127.0	117.0	44.3	27.9	21.5	365.0	107
1902	23.1	....	....	....	....	....	25.8	119.0	50.4	25.5	22.9	23.1	267.0	78
1903	23.8	....	....	....	....	....	27.3	103.0	151.0	50.5	21.6	27.3	381.0	112
1904	27.6	....	....	....	....	....	44.4	108.0	93.4	34.4	25.4	24.3	330.0	97
1905	24.8	....	....	....	....	....	26.1	91.6	145.0	35.2	24.9	22.7	346.0	101
1906	23.1	....	....	....	....	....	37.4	129.0	150.0	51.5	22.9	20.5	411.0	120
1907	18.0	....	....	....	....	....	....	....	....	....	....	....	....	....
1910	24.6	....	....	....	....	....	[1]32.1	[1]69.7	98.5	26.7	21.8	21.2	270.0	79
1911	21.6	19.9	20.6	20.8	18.7	22.8	35.3	89.8	109.0	31.7	19.6	18.5	304.0	89
1912	27.6	25.5	....	....	....	26.8	23.8	113.0	175.0	74.8	28.6	19.6	435.0	128
1913	21.4	18.8	....	....	....	....	[1]32.3	70.8	67.8	35.4	21.6	23.2	251.0	74
1914	21.0	[1]14.6	....	....	....	....	[1]28.5	111.0	135.0	44.8	23.7	17.5	361.0	106
1915	23.7	29.0	....	....	....	[1]19.0	34.0	54.6	71.6	27.0	18.1	19.6	225.0	66
1916	20.9	19.6	23.3	....	....	[1]25.1	36.8	89.2	124.0	49.6	31.8	25.4	357.0	105
1917	31.3	20.2	....	....	....	22.5	26.5	74.4	184.0	111.0	36.0	28.4	460.0	135
1918	27.4	21.2	23.1	21.6	20.1	24.0	27.1	91.0	137.0	42.2	23.5	19.9	341.0	100
1919	22.3	21.2	....	....	....	....	[1]47.0	92.8	46.2	21.6	17.2	20.4	245.0	72
1920	21.8	20.1	17.6	[1]20.0	19.2	20.2	21.2	121.0	186.0	69.5	30.3	24.6	453.0	133
Mean	....	....	....	....	....	....	31.3	97.3	120.0	45.6	24.6	22.2	341.0	....
Year	23.8	21.0	21.0	20.8	19.3	22.9	31.3	97.3	120.0	45.6	24.6	22.2	470.0	....
Per cent	5.1	4.5	4.5	4.4	4.1	4.9	6.7	20.7	25.5	9.7	5.2	4.7	....	....

[1] Estimated.

Monthly record of run-off at important gaging stations—Continued.

PRICE RIVER AT HELPER, UTAH.

[Unit of run-off, 1,000 acre-feet. Drainage area, 530 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1904	.....	.....	.....	.....	[1]2.1	2.7	9.6	[1]21.0	[1]14.0	3.5	2.4	2.3	.....	....
1905	1.8	1.3	1.1	1.3	2.0	3.1	4.3	23.3	15.1	1.6	1.2	5.2	61.2	51
1906	1.6	1.2	.7	.4	.9	2.4	17.3	58.4	26.5	11.7	7.0	2.5	131.0	110
1907	1.8	1.6	1.2	1.5	2.3	4.4	[1]21.0	[1]57.0	[1]27.0	14.9	8.7	4.0	145.0	121
1908	3.3	2.7	2.7	2.5	2.3	15.2	15.9	15.7	10.1	3.1	3.5	1.0	78.2	65
1909	2.1	2.3	1.8	.9	.7	3.6	21.7	63.3	55.0	10.3	9.0	8.5	179.0	150
1910	4.4	3.2	2.9	9.5	2.3	19.6	47.2	49.3	8.1	2.7	2.1	3.7	155.0	130
1911	4.2	2.3	2.9	2.6	3.2	12.4	13.4	34.3	14.0	5.0	2.3	7.6	104.0	87
1912	5.5	4.4	4.0	1.5	1.7	2.2	7.2	27.7	26.4	7.4	4.0	3.0	94.8	79
1913	4.5	1.8	1.7	1.1	1.0	4.5	29.8	29.5	14.2	11.9	4.0	5.3	109.0	91
1914	2.9	2.9	1.8	2.0	2.2	7.8	28.0	71.3	27.7	12.8	7.2	3.0	170.0	143
1915	4.4	2.4	2.2	1.8	2.2	4.5	12.3	20.0	12.4	7.9	3.5	3.0	76.6	64
1916	1.9	2.3	1.9	2.1	2.0	10.8	29.4	52.3	22.1	12.0	8.7	3.9	149.0	125
1917	5.2	2.3	2.1	2.1	3.0	4.4	21.6	56.7	63.7	10.9	3.4	3.2	178.0	150
1918	2.8	2.2	2.5	2.5	2.3	5.3	6.8	17.6	7.4	5.8	1.7	3.4	60.2	50
1919	3.6	2.7	3.1	2.1	1.9	5.9	18.6	34.3	6.1	2.2	2.8	7.8	91.1	76
1920	1.1	.7	.7	1.3	1.7	2.3	6.2	67.0	27.3	4.7	8.1	3.8	125.0	105
Mean	3.2	2.3	2.1	2.2	2.0	6.5	18.3	41.1	22.0	7.6	4.7	4.2	119.0	....
Per cent	3	2	2	2	2	6	15	35	19	6	4	4	....	....

DUCHESNE RIVER AT MYTON, UTAH.

[Unit of run-off, 1,000 acre-feet. Drainage area, 2,750 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1900	24.8	23.7	21.3	21.0	18.9	24.2	27.8	143.1	101.3	23.2	16.7	17.6	463.6	73
1901	19.3	18.1	21.0	17.2	15.6	17.8	29.6	194.8	88.4	36.7	27.9	18.3	504.7	79
1902	19.8	18.8	18.4	17.2	15.5	17.9	39.0	121.1	133.2	34.1	16.8	15.4	467.2	74
1903	18.3	19.2	18.4	20.3	26.7	29.5	28.5	81.9	180.4	56.1	23.1	19.6	522.0	82
1904	23.6	21.0	19.8	19.0	20.0	21.9	41.1	175.6	205.5	63.4	38.3	21.9	671.1	106
1905	24.7	20.6	23.4	18.8	19.3	20.0	26.7	75.0	184.0	51.0	30.0	37.0	530.5	84
1906	21.8	18.0	23.4	18.8	19.3	29.6	53.6	204.0	269.0	85.0	30.0	30.8	803.3	126
1907	30.2	25.1	23.4	18.8	19.3	29.6	99.0	202.0	321.0	349.0	95.9	52.0	1,265.3	199
1908	42.6	33.6	30.8	18.0	19.0	21.6	48.4	71.3	143.0	75.6	53.4	32.1	589.4	93
1909	41.9	31.1	32.4	19.0	20.0	30.0	50.0	175.0	350.0	155.0	91.6	90.4	1,086.4	171
1910	53.2	43.5	39.2	18.0	19.0	60.2	126.0	227.0	117.0	36.2	23.6	29.8	792.7	125
1911	32.8	27.3	21.0	18.0	16.0	29.6	46.6	135.4	186.0	65.0	15.1	15.2	608.0	96
1912	26.0	21.4	21.1	18.4	16.1	21.8	25.2	90.4	247.0	67.0	19.2	17.8	591.4	93
1913	30.1	27.1	20.8	17.2	16.7	25.1	39.4	124.0	98.8	45.8	15.6	39.1	499.7	79
1914	32.3	26.5	19.7	24.3	21.1	30.3	50.4	205.0	225.0	63.3	24.4	17.4	739.7	117
1915	29.5	22.6	19.5	19.1	17.8	21.9	33.0	67.0	149.0	31.2	8.2	22.6	441.4	69
1916	29.0	22.2	23.2	22.8	23.0	54.0	61.9	132.0	171.0	38.6	28.2	16.0	621.9	98
1917	40.5	24.4	17.1	15.1	31.4	52.4	47.6	105.0	343.0	146.0	32.5	31.2	886.2	139
1918	29.2	29.6	28.7	20.4	21.7	24.5	20.3	51.0	162.0	41.8	7.9	16.7	452.8	71
1919	33.0	27.1	25.5	15.4	19.4	38.9	38.7	127.0	45.8	6.7	8.5	17.4	403.4	63
1920	22.9	22.6	18.6	17.8	21.6	32.1	27.1	136.0	196.0	40.2	33.5	19.2	587.6	93
Mean	29.8	25.0	23.2	18.9	19.9	30.1	47.1	135.4	186.5	60.5	30.2	27.5	635.0	....
Per cent	4½	4	4	3	3	5	8	21	29	9½	5	4	....	....

SAN RAFAEL RIVER NEAR GREEN RIVER, UTAH.

[Unit of run-off, 1,000 acre-feet.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1909	.....	.....	.....	.....	.....	.....	.....	[2]40.0	146.0	32.2	45.8	39.0	....	....
1910	7.9	9.6	[1]4.0	[1]3.0	[1]4.0	44.8	44.5	73.8	18.3	6.8	2.7	14.0	233	119
1911	13.6	5.9	6.2	13.8	10.9	10.1	9.7	30.3	36.2	6.1	5.4	9.0	157	80
1912	21.9	3.8	3.7	3.1	4.0	6.2	5.7	25.0	93.4	13.7	4.6	3.6	189	96
1913	23.6	11.8	2.9	2.5	2.8	8.4	20.1	66.4	27.6	8.4	3.2	14.1	192	98
1914	4.5	7.4	4.0	3.4	3.6	5.5	14.9	100.0	98.2	18.1	2.8	1.5	264	135
1915	9.8	2.5	3.7	3.0	2.6	12.8	11.7	23.4	26.7	2.3	.1	2.0	101	52
1916	.5	7.3	4.2	3.6	4.6	23.3	12.3	33.3	55.5	12.1	21.1	4.2	182	93
1917	52.1	4.8	5.4	1.2	5.6	8.1	11.5	52.6	134.0	22.8	6.7	13.0	318	162
1918	4.0	4.7	3.9	3.4	4.1	6.7	6.4	8.7	35.0	33.9	7.7	7.7	126	64
Mean	15.3	6.4	4.2	4.1	4.7	14.0	15.2	45.9	58.3	13.8	6.0	7.7	196	....
Per cent	7.8	3.3	2.2	2.1	2.4	7.2	7.8	23.5	29.7	7.0	3.1	3.9	....	....

[1] Estimated.

[2] Partial record.

Monthly record of run-off at important gaging stations—Continued.

GRAND RIVER AT GLENWOOD SPRINGS.

[Unit of run-off, 1,000 acre-feet. Drainage area, 4,520 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1900	[1] 45.0	[1] 45.0	[1] 50.0	54.7	49.0	73.0	108.0	736.0	882.0	192.0	69.7	47.6	2,350	104
1901	46.4	48.0	41.8	42.3	41.6	51.6	112.0	849.0	724.0	304.0	117.0	62.3	2,440	108
1902	56.6	52.4	48.5	44.4	43.1	49.4	85.2	602.0	437.0	115.0	[3] 54.0	[3] 45.0	1,630	72
1903	[3] 60.0	[3] 50.0	44.5	[1] 28.0	30.2	45.5	100.0	355.0	762.0	321.0	99.2	80.0	1,980	87
1904	80.8	51.0	31.8	33.1	34.8	56.0	136.0	478.0	628.0	272.0	140.0	106.0	2,050	90
1905	81.3	50.8	36.8	46.3	37.3	55.7	98.6	411.0	988.0	222.0	107.0	80.7	2,210	98
1906	70.2	63.5	42.1	37.5	38.0	65.1	186.0	600.0	827.0	365.0	170.0	199.0	2,660	117
1907	106.0	65.6	49.3	41.4	47.4	95.4	189.0	419.0	110.0	702.0	202.0	99.2	2,130	94
1908	86.3	63.6	51.6	58.6	42.9	69.6	132.0	233.0	469.0	202.0	128.0	52.6	1,590	70
1909	59.1	52.7	40.4	47.4	36.9	52.9	94.0	358.0	1,460.0	521.0	179.0	148.0	3,050	135
1910	89.8	66.0	47.5	51.7	40.5	114.0	190.0	416.0	458.0	137.0	81.8	81.5	1,770	79
1911	60.8	53.7	40.0	43.1	41.6	57.9	107.0	486.0	694.0	309.0	119.0	76.1	2,090	92
1912	88.5	54.4	40.1	47.8	43.4	49.5	84.1	473.0	1,180.0	603.0	200.0	98.9	2,960	131
1913	88.9	51.4	45.8	[1] 46.4	37.4	43.3	177.0	432.0	424.0	198.0	88.0	82.7	1,710	75
1914	86.7	63.1	41.9	45.1	41.9	62.1	155.0	769.0	1,110.0	358.0	167.0	101.0	3,000	132
1915	101.0	58.3	38.0	38.6	37.1	45.7	136.0	284.0	567.0	273.0	85.3	60.7	1,730	76
1916	68.9	48.0	42.7	44.0	39.5	76.9	143.0	454.0	702.0	299.0	188.0	105.0	2,210	98
1917	96.5	62.5	48.3	42.7	40.9	48.1	173.0	422.0	1,180.0	584.0	155.0	90.4	2,940	130
1918	72.6	69.0	59.3	50.8	49.0	78.7	126.0	566.0	1,170.0	328.0	112.0	100.0	2,780	123
1919	89.2	67.8	52.0	47.0	40.2	63.3	156.0	456.0	320.0	144.0	92.6	68.4	1,600	71
1920	63.3	60.1	51.6	44.6	39.7	47.0	75.0	726.0	988.0	360.0	153.0	91.0	2,700	119
Mean	76.1	57.0	45.0	44.5	40.6	61.9	132.0	501.0	766.0	324.0	129.0	89.3	2,266	....
Per cent	3.4	2.5	2.0	2.0	1.8	2.7	5.8	22.1	33.8	14.3	5.7	3.9	......	....

SAN JUAN RIVER NEAR FARMINGTON, N. MEX.

[Unit of run-off, 1,000 acre-feet. Drainage area, 6,920 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1904	....	....	....	....	....	....	....	....	......	23.1	162.0	81.8	......	....
1905	365.0	64.7	21.4	14.9	37.9	99.9	255.0	622.0	1,087.0	222.0	107.0	99.6	3,000	125
1906	104.0	77.7	66.6	....	....	....	....	....	......	....	....	....	......	....
1912	....	....	....	....	....	....	....	....	......	....	....	[2] 15.6	......	....
1913	58.1	64.9	30.6	28.5	26.2	42.0	277.0	493.0	350.0	109.0	38.2	86.3	1,604	67
1914	91.0	55.5	42.1	36.7	104.0	213.0	267.0	488.0	589.0	262.0	124.0	95.8	2,368	99
1915	189.0	79.7	49.3	34.4	35.4	100.0	404.0	443.0	568.0	346.0	96.1	66.3	2,411	100
1916	56.2	34.8	29.7	40.0	56.9	299.0	300.0	592.0	572.0	285.0	289.0	191.0	2,746	114
1917	463.0	115.0	51.7	63.7	62.4	116.0	291.0	453.0	1,040.0	[1] 650.0	[1] 100.0	[1] 90.0	3,496	146
1918	[1] 45.0	[1] 23.0	22.5	26.2	34.4	109.0	123.0	297.0	405.0	156.0	94.6	117.0	1,240	52
Mean	171.0	64.4	39.2	34.9	51.0	140.0	274.0	484.0	659.0	257.0	126.0	103.0	2,400	....
Per cent	7.1	2.7	1.6	1.5	2.1	5.8	11.4	20.0	27.5	10.7	5.3	4.3	......	....

VIRGIN RIVER AT VIRGIN, UTAH.

[Unit of run-off, 1,000 acre-feet. Drainage area, 1,010 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1909	....	....	....	....	....	....	[1] 70.0	50.4	18.7	7.9	[1] 2.2	[1] 13.7	......	......
1910	[1] 11.0	13.9	13.9	17.6	12.6	50.5	36.9	20.4	6.4	6.2	15.2	18.9	224.0	110
1911	10.0	6.4	9.0	48.6	15.4	47.1	55.8	45.9	13.4	29.8	8.1	30.0	320.0	154
1912	11.6	8.2	8.9	7.4	7.1	8.6	11.4	26.7	9.6	17.2	11.7	8.0	136.0	65
1913	30.3	9.8	8.8	8.8	8.5	13.9	23.9	13.3	9.0	9.0	12.7	9.8	158.0	76
1914	8.7	11.2	10.4	17.2	15.9	19.4	48.1	40.0	14.7	17.2	7.1	6.2	216.0	104
1915	13.5	10.0	10.3	16.6	10.0	14.5	29.8	54.4	18.1	7.1	5.6	20.5	210.0	101
1916	10.5	13.3	13.8	15.8	13.1	48.0	52.1	39.0	15.9	22.3	27.1	11.5	282.0	135
1917	18.6	8.6	7.8	9.9	11.2	10.4	23.7	38.3	16.4	[1] 8.0	[1] 5.0	4.9	163.0	79
1918	7.5	8.8	9.5	7.8	62.2	38.6	20.4	27.7	7.7	11.7	7.7	13.5	167.0	80
Mean	13.6	10.0	10.3	16.7	11.1	27.9	33.6	34.0	12.3	14.2	11.1	13.6	208.0	......
Per cent	6.5	4.8	5.0	8.0	5.3	13.4	16.1	16.3	6.0	6.8	5.3	6.5	......	......

[1] Estimated. [2] Partial record. [3] Deduced from Palisade record.

Monthly record of run-off at important gaging stations—Continued.

GILA RIVER AT YUMA, ARIZ.

[Unit of run-off, 1,000 acre-feet. Drainage area, 71,050 square miles.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Per cent of mean.
1903	0.0	0.0	0.0	30.2	0.8	0.0	0.0	9.2	7.3	13.7	0.0	0.0	61	6
1904	......	......	......	......	......	......	5.8	140.0	41.7	32.8	6.5	......	227	21
1905	189.0	680.0	1,020.0	768.0	300.0	43.1	4.3	.0	3.0	11.2	273.0	375.0	3,670	345
1906	136.0	168.0	576.0	423.0	122.0	4.6	.0	25.1	4.3	.0	.0	604.0	2,060	194
1907	64.0	59.4	289.0	71.5	.0	.0	.0	.4	93.2	58.0	13.6	.0	649	61
1908	.0	392.0	163.0	.0	.0	.0	.0	94.7	44.2	.0	.0	404.0	1,100	104
1909	72.0	175.0	147.0	96.0	14.2	.0	21.0	54.5	81.0	.0	.0	.0	661	62
1910	213.0	9.2	.0	1.5	.0	.0	.0	.0	.0	.0	.0	.0	224	21
1911	60.0	40.0	84.0	.0	.0	.0	34.7	.0	.0	30.2	17.3	.0	266	25
1912	.0	.0	121.0	70.0	.6	.0	12.5	39.7	.0	1.4	.0	.0	245	23
1913	.0	.6	58.0	15.7	.0	.0	.0	.0	.0	.0	4.7	17.0	96	9
1914	40.0	146.0	23.0	2.8	.0	.0	12.7	42.7	29.9	45.5	54.4	39.2	436	41
1915	140.0	694.0	321.0	389.0	367.0	16.9	2.4	21.8	.0	.0	.0	.0	1,950	184
1916	2,090.0	690.0	747.0	559.0	27.1	2.5	.0	.0	70.9	222.0	53.7	27.5	4,490	424
1917	164.0	83.3	133.0	448.0	244.0	.0	.0	82.3	.0	.0	.0	.0	1,150	109
1918	2.0	12.4	243.0	17.2	.1	.0	.0	52.6	.0	.0	.0	2.8	330	31
1919	12.0	24.4	19.0	60.1	3.1	.0	42.6	54.2	8.7	21.5	188.0	307.0	740	70
1920	40.0	424.0	190.0	108.0	14.6	.0	.0	.0	.0	.0	[1]10.0	[1]13.0	800	75
Mean	179.0	200.0	230.0	170.0	60.8	3.7	7.6	34.4	21.3	24.2	34.5	99.4	1,060	....
Per cent	16.9	18.8	21.7	16.0	5.7	.3	.7	3.2	2.0	2.3	3.1	9.3	......	....

[1] Estimated.

At Yuma, Ariz., 1903, 1915–1920; at Dome, Ariz., 1904–1906; at Sentinel, 1914; 1907-1912, from report of W. W. Schlecht, for 1918.

GREEN RIVER AT LITTLE VALLEY, UTAH.

[Unit of run-off, 1,000 acre-feet. Drainage area, 41,000 square miles.]

Year.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Total.	Per cent of mean.
1895	69.2	174.0	138.0	133.0	119.0	232.0	493.0	1,320.0	869.0	580.0	205	105	4,440	79
1896	124.0	95.6	79.9	81.8	80.0	151.0	293.0	830.0	1,630.0	413.0	199	182	4,160	74
1897	130.0	102.0	[1]79.9	[1]61.5	66.6	123.0	383.0	2,670.0	1,580.0	389.0	200	192	5,980	107
1905	[1]132.0	[1]135.0	[1]80.0	[1]65.0	70.0	184.0	242.0	793.0	1,450.0	470.0	168	149	3,940	70
1906	152.0	122.0	81.2	86.1	90.0	376.0	570.0	1,520.0	1,860.0	824.0	379	302	6,360	114
1907	186.0	194.0	149.0	150.0	273.0	416.0	833.0	1,520.0	2,310.0	1,940.0	689	287	8,950	160
1908	226.0	152.0	90.4	79.9	88.0	220.0	392.0	713.0	1,080.0	633.0	419	201	4,290	77
1909	220.0	129.0	49.3	122.0	95.5	499.0	553.0	1,380.0	2,760.0	1,550.0	633	593	8,580	153
1910	242.0	177.0	79.3	61.5	139.0	701.0	744.0	1,300.0	815.0	199.0	133	121	4,710	84
1911	202.0	135.0	93.5	143.0	191.0	386.0	326.0	719.0	1,150.0	520.0	180	117	4,160	74
1912	234.0	133.0	101.0	106.0	104.0	227.0	390.0	990.0	2,240.0	1,000.0	422	215	6,160	110
1913	225.0	209.0	93.5	141.0	124.0	256.0	762.0	1,010.0	1,150.0	904.0	266	228	5,370	96
1914	219.0	193.0	103.0	120.0	147.0	395.0	750.0	1,750.0	2,120.0	836.0	284	156	7,080	127
1915	243.0	162.0	94.1	92.2	98.3	186.0	443.0	676.0	928.0	379.0	128	186	3,620	65
1916	242.0	168.0	116.0	106.0	129.0	558.0	625.0	1,290.0	1,370.0	633.0	354	153	5,740	103
1917	307.0	152.0	127.0	79.3	116.0	206.0	708.0	1,610.0	2,760.0	1,720.0	410	239	8,430	151
1918	200.0	184.0	167.0	144.0	136.0	251.0	385.0	848.0	1,730.0	707.0	202	153	5,110	92
1919	226.0	179.0	130.0	87.3	97.2	277.0	474.0	916.0	553.0	108.0	74	107	3,230	58
1920	122.0	125.0	90.4	108.0	140.0	244.0	389.0	1,640.0	2,030.0	627.0	279	151	5,950	106
Mean	194.8	153.8	102.3	103.5	121.3	309.9	513.4	1,236.5	1,599.1	759.6	296	202	5,590	....
Per cent	3.5	2.7	1.8	1.8	2.2	5.5	9.2	22.0	29.0	13.5	5.2	3.6	......	....

[1] Estimated.

Monthly record of run-off at important gaging stations—Continued.

COLORADO RIVER AT YUMA, ARIZ.

[Unit of run-off, 1,000 acre-feet. Drainage area, 242,000 square miles.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Per cent of mean.
1903	190	187	376	852	2,074	3,163	2,304	668	404	522	321	267	11,300	65
1904	224	218	368	479	1,703	2,607	1,417	1,054	691	716	366	275	10,100	57
1905	500	1,561	3,108	2,251	2,593	4,550	1,864	744	386	494	714	947	19,700	113
1906	422	531	1,560	1,930	3,330	5,010	2,400	1,180	696	719	578	1,130	19,500	112
1907	1,320	1,040	1,480	2,100	2,330	5,640	5,930	2,310	1,380	836	643	458	25,500	147
1908	389	817	990	1,060	1,670	2,550	2,000	1,490	678	585	481	978	13,700	79
1909	615	772	978	1,800	3,330	6,250	4,890	2,510	2,890	861	562	517	26,000	149
1910	1,160	509	1,500	1,710	3,470	2,800	904	592	367	429	467	427	14,300	82
1911	541	743	1,070	1,210	2,760	3,820	3,080	1,130	530	1,760	722	465	17,800	102
1912	331	424	818	1,260	2,510	6,430	2,870	1,400	582	676	702	403	18,400	106
1913	238	337	558	1,520	2,380	2,830	1,300	580	525	635	472	393	11,800	68
1914	462	646	923	1,360	3,310	6,570	3,170	1,350	591	842	613	818	20,700	119
1915	564	1,510	953	1,790	2,940	2,890	1,890	682	270	442	356	354	14,600	84
1916	2,820	1,630	2,200	2,120	3,360	3,540	2,260	1,670	738	1,640	708	454	23,100	133
1917	562	440	603	1,560	3,030	5,350	5,770	1,440	536	465	422	420	20,600	118
1918	405	323	1,008	767	1,787	3,675	2,660	710	406	474	480	451	13,100	75
1919	231	398	543	1,224	2,221	2,024	1,243	654	307	325	606	944	10,700	62
1920	702	2,188	1,113	1,212	2,842	7,690	2,647	1,080	501	400	619	452	21,400	123
Mean	649	794	1,122	1,460	2,650	4,300	2,700	1,180	693	769	547	509	17,400	....
Per cent	3.7	4.6	6.5	8.4	15.2	24.7	15.5	6.8	4.0	4.4	3.2	3.0	....	....

Monthly discharge of Colorado River at Yuma, Ariz., for years 1902–1920.

[Gaging station, sec. 35, T. 16 S., R. 22 E. Drainage area, 242,000 square miles.]

Month.	Discharge for year ending Dec. 31, 1902.				Discharge for year ending Dec. 31, 1903.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	4,520	3,230	3,727	229,000	3,900	2,694	3,089	190,000
February	4,720	3,300	3,955	220,000	4,100	2,800	3,370	187,000
March	5,340	4,340	4,903	301,000	9,525	3,375	6,120	376,000
April	11,400	4,340	6,197	368,000	31,600	9,200	14,300	852,000
May	59,200	11,400	35,960	2,211,000	56,400	13,100	33,700	2,070,000
June	56,200	29,000	42,520	2,530,000	72,219	28,300	53,100	3,160,000
July	27,000	5,130	12,530	770,000	69,500	20,350	37,500	2,300,000
August	5,560	3,230	4,180	257,000	19,900	6,200	10,900	668,000
September	8,360	3,050	3,820	227,000	9,200	5,000	6,800	404,000
October	6,600	3,140	4,300	264,000	15,806	6,128	8,400	522,000
November	5,540	3,140	4,190	249,000	6,386	4,675	5,400	321,000
December	12,600	3,590	5,410	333,000	5,345	3,170	4,300	267,000
Year	59,200	3,050	10,970	7,960,000	72,219	2,694	15,600	11,300,000

Month.	Discharge for year ending Dec. 31, 1904.				Discharge for year ending Dec. 31, 1905.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	4,007	3,350	3,635	224,000	27,500	3,750	8,130	500,000
February	4,310	3,340	3,800	218,000	82,800	5,800	28,100	1,560,000
March	9,320	4,450	6,000	368,000	111,000	23,500	50,500	3,110,000
April	19,400	5,600	8,060	479,000	97,500	19,500	37,800	2,250,000
May	45,900	17,000	27,700	1,700,000	59,000	33,900	42,200	2,590,000
June	51,200	32,800	43,800	2,610,000	94,300	61,500	76,500	4,550,000
July	38,900	14,600	23,000	1,417,000	57,800	16,800	30,300	1,860,000
August	24,000	13,000	17,100	1,050,000	17,500	6,850	12,100	744,000
September	18,500	5,540	11,600	692,000	9,670	5,060	6,500	387,000
October	23,200	5,660	11,600	716,000	15,500	5,220	8,040	494,000
November	7,960	4,750	6,150	366,000	103,000	5,620	12,000	714,000
December	5,080	3,480	4,480	275,000	77,400	5,900	15,400	945,000
Year	51,200	3,340	13,900	10,100,000	111,000	3,750	27,300	19,710,000

Monthly discharge of Colorado River at Yuma, Ariz., for years 1902–1920—Continued.

Month.	Discharge for year ending Dec. 31, 1906.				Discharge for year ending Dec. 31, 1907.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	16,100	4,620	6,870	422,000	44,300	12,700	21,500	1,320,000
February	14,800	6,360	9,560	531,000	31,300	12,400	18,800	1,040,000
March	75,000	6,740	25,400	1,560,000	68,700	14,800	24,100	1,480,000
April	44,100	25,500	32,500	1,930,000	50,500	24,700	35,300	2,100,000
May	79,800	35,100	54,100	3,330,000	68,800	28,600	37,900	2,330,000
June	99,200	65,000	84,200	5,010,000	115,000	72,200	94,800	5,640,000
July	74,200	27,000	39,000	2,400,000	114,000	52,400	96,500	5,930,000
August	25,600	13,400	19,200	1,180,000	61,900	23,100	37,600	2,310,000
September	14,500	9,600	11,700	696,000	43,300	13,100	23,200	1,380,000
October	15,900	8,600	11,700	719,000	18,800	10,100	13,600	836,000
November	12,500	8,430	9,710	578,000	16,300	8,800	10,800	643,000
December	60,000	6,800	18,300	1,130,000	8,800	5,800	7,450	458,000
Year	99,200	4,620	26,900	19,500,000	115,000	5,800	35,100	25,500,000

Month.	Discharge for year ending Dec. 31, 1908.				Discharge for year ending Dec. 31, 1909.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	7,400	5,600	6,320	389,000	31,500	5,800	10,000	615,000
February	45,000	6,300	14,200	817,000	25,100	11,400	13,900	772,000
March	33,000	10,100	16,100	990,000	35,900	11,100	15,900	978,000
April	35,000	12,900	17,800	1,060,000	46,800	20,300	30,300	1,800,000
May	33,700	23,000	27,200	1,670,000	73,900	32,400	54,100	3,330,000
June	61,700	30,000	42,900	2,550,000	149,500	75,100	105,000	6,250,000
July	53,800	18,900	32,600	2,000,000	133,700	34,400	79,600	4,890,000
August	36,100	18,600	24,300	1,490,000	54,100	25,000	40,800	2,510,000
September	19,300	7,000	11,400	678,000	93,200	21,300	48,500	2,890,000
October	20,600	6,600	9,510	585,000	20,700	11,000	14,000	861,000
November	10,200	6,000	8,090	481,000	10,900	8,300	9,440	562,000
December	72,500	6,000	15,900	978,000	11,900	4,100	8,410	517,000
Year	72,500	5,600	18,900	13,700,000	149,500	4,100	35,800	26,000,000

Month.	Discharge for year ending Dec. 31, 1910.				Discharge for year ending Dec. 31, 1911.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	67,500	4,600	18,800	1,160,000	18,700	3,700	8,800	541,000
February	10,800	8,100	9,160	509,000	25,700	7,000	13,400	743,000
March	40,200	7,700	24,400	1,500,000	34,500	6,100	17,400	1,070,000
April	38,900	22,500	28,700	1,710,000	25,900	15,600	20,400	1,210,000
May	70,300	40,900	56,500	3,470,000	64,200	27,000	45,000	2,760,000
June	69,400	26,500	47,000	2,800,000	78,300	50,300	64,200	3,820,000
July	25,200	6,900	14,700	904,000	69,000	37,800	50,100	3,080,000
August	13,200	6,300	9,620	592,000	46,500	10,000	18,400	1,130,000
September	11,300	4,600	6,170	367,000	13,300	6,300	8,900	530,000
October	13,500	4,300	6,980	429,000	60,200	7,800	28,600	1,760,000
November	9,500	6,300	7,850	467,000	19,200	9,300	12,140	722,000
December	8,200	5,600	6,940	427,000	10,100	5,500	7,600	465,000
Year	70,300	4,300	19,700	14,300,000	78,300	3,700	24,600	17,800,000

Month.	Discharge for year ending Dec. 31, 1912.				Discharge for year ending Dec. 31, 1913.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	8,200	3,400	5,390	331,000	6,700	2,600	3,860	238,000
February	8,800	6,500	7,370	424,000	7,500	5,300	6,070	337,000
March	24,800	7,000	13,300	818,000	11,800	7,700	9,070	558,000
April	34,700	13,700	21,100	1,260,000	40,500	9,300	25,600	1,520,000
May	76,500	15,400	40,800	2,510,000	49,700	27,300	38,400	2,360,000
June	144,000	57,100	108,000	6,430,000	62,500	32,000	47,500	2,830,000
July	65,200	33,400	46,600	2,870,000	32,000	12,700	21,200	1,300,000
August	42,000	11,900	22,700	1,400,000	16,700	5,000	9,430	580,000
September	15,000	7,500	9,780	582,000	18,800	4,400	8,820	525,000
October	20,700	9,200	11,000	676,000	25,000	7,200	10,300	635,000
November	18,500	8,500	11,800	702,000	10,500	5,800	7,930	472,000
December	8,300	5,200	6,560	403,000	8,400	4,500	6,390	393,000
Year	144,000	3,400	25,300	18,400,000	62,500	2,600	16,200	11,700,000

Monthly discharge of Colorado River at Yuma, Ariz, for years 1902–1920—Continued.

Month.	Discharge for year ending Dec. 31, 1914.				Discharge for year ending Dec. 31, 1915.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	21,500	3,300	7,520	462,000	30,000	5,700	9,170	564,000
February	27,000	5,800	11,600	646,000	90,000	14,800	27,100	1,510,000
March	27,000	11,200	15,000	923,000	21,800	11,400	15,500	953,000
April	34,600	12,000	22,900	1,360,000	47,500	21,500	30,100	1,790,000
May	89,500	33,200	53,800	3,310,000	66,200	28,600	47,800	2,940,000
June	137,000	89,300	110,000	6,570,000	57,800	39,900	48,600	2,890,000
July	89,000	33,800	51,500	3,170,000	57,300	15,000	30,800	1,890,000
August	47,000	10,600	22,000	1,350,000	35,200	4,700	11,100	682,000
September	19,800	5,600	9,930	591,000	12,500	2,700	4,540	270,000
October	30,300	6,700	13,700	842,000	10,200	3,500	7,190	442,000
November	13,500	6,600	10,300	613,000	7,900	4,000	5,980	356,000
December	49,200	5,800	13,300	818,000	7,000	4,800	5,760	354,000
Year	137,000	3,300	28,500	20,700,000	90,000	2,700	20,200	14,600,000

Month.	Discharge for year ending Dec. 31, 1916.				Discharge for year ending Dec. 31, 1917.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	240,000	3,800	45,800	2,820,000	20,800	5,300	9,140	562,000
February	113,000	18,300	28,400	1,630,000	13,500	6,400	7,930	440,000
March	68,400	20,000	35,800	2,200,000	15,100	6,800	9,800	603,000
April	59,000	27,500	35,600	2,120,000	69,900	8,600	26,300	1,560,000
May	74,800	40,300	54,700	3,360,000	85,500	32,700	49,300	3,030,000
June	72,200	44,300	59,500	3,540,000	134,000	68,600	89,900	5,350,000
July	65,600	20,400	36,700	2,260,000	143,000	34,800	93,900	5,770,000
August	37,300	14,800	27,200	1,670,000	43,500	11,500	23,500	1,440,000
September	27,000	8,300	12,400	738,000	12,200	6,700	9,010	536,000
October	68,500	6,300	26,600	1,640,000	8,700	5,600	7,600	465,000
November	16,800	7,800	11,900	707,000	8,200	5,900	7,100	422,000
December	9,500	5,100	7,390	454,000	7,700	6,000	6,830	420,000
Year	240,000	3,800	31,600	22,940,000	143,000	5,300	28,400	20,600,000

Month.	Discharge for year ending Dec. 31, 1918.				Discharge for year ending Dec. 31, 1919.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Maximum.	Minimum.	Mean.	Total in acre-feet.
January	7,700	4,700	6,590	405,000	6,200	1,800	3,760	231,000
February	7,000	4,900	5,810	323,000	8,900	4,700	7,170	398,000
March	49,300	6,700	16,400	1,010,000	24,100	5,600	8,840	543,000
April	17,800	9,400	12,800	767,000	29,000	14,600	20,600	1,220,000
May	48,800	11,100	29,100	1,790,000	50,700	28,600	36,100	2,220,000
June	92,200	39,300	61,800	3,670,000	57,600	20,600	34,300	2,040,000
July	94,300	16,400	43,300	2,660,000	35,600	12,000	20,200	1,240,000
August	19,600	7,000	11,600	710,000	20,500	4,300	10,700	654,000
September	14,000	4,100	6,830	406,000	8,800	2,300	5,160	307,000
October	14,000	5,800	7,700	474,000	7,300	3,700	5,290	325,000
November	9,200	7,300	8,060	480,000	82,600	5,800	10,200	606,000
December	8,400	6,700	7,340	451,000	46,100	5,600	15,400	944,000
Year	94,300	4,100	18,100	12,150,000	57,600	1,800	14,800	10,740,000

Month.	Discharge for year ending Dec. 31, 1920.				Month.	Discharge for year ending Dec. 31, 1920.			
	Maximum.	Minimum.	Mean.	Total in acre-feet.		Maximum.	Minimum.	Mean.	Total in acre-feet.
January	32,500	6,800	11,400	701,000	August	23,200	12,600	17,600	1,080,000
February	165,000	9,000	38,000	2,190,000	September	13,300	5,300	8,430	501,000
March	53,700	10,100	18,100	1,110,000	October	8,000	5,800	6,500	400,000
April	34,000	12,900	20,400	1,210,000	November	12,600	8,000	10,400	619,000
May	81,100	15,800	46,200	2,840,000	December	9,000	5,100	7,350	452,000
June	190,000	73,800	129,000	7,690,000					
July	73,000	19,300	43,000	2,650,000	Year	190,000	5,100	29,700	21,450,000

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PROCEEDINGS OF THE CONFERENCE ON THE CONSTRUCTION OF THE BOULDER CANYON DAM, HELD AT SAN DIEGO, CALIF.

U. S. GRANT HOTEL,
San Diego, Calif., December 12, 1921—10 o'clock a. m.

Mr. JOHN L. BACON. Ladies and gentlemen, within the last few years San Diego has been honored by the presence of the President of the United States; a little later we were honored by the presence of and an address from one of the Secretaries of the President's Cabinet; each time they came here to present their side of some great public problem; and never, as far as I know, has San Diego been honored as it is being honored to-day. We have the representative of the President, the head of one of the great departments of the Government, who has come here, not to present his case but who has, in fact, moved his office here for the time being to hear our case—to hear us present our views and to hear our plea. It is an extremely great honor and an extremely great pleasure which I have at this time in presenting to you the Secretary of the Interior, the Hon. A. B. Fall. [Applause.]

Secretary of the Interior A. B. FALL. Mr. Mayor, ladies, and gentlemen, I am here for the purpose of conducting the hearing, acting in my supervisory character as Secretary of the Interior, for the Congress of the United States. The Interior Department has caused an investigation to be made of certain problems on the lower Colorado River and, following certain investigations, to make a report to the Congress of the United States. This investigation has been partially made. The Director of the Reclamation Service, who has been conducting the investigation some months since, made a report to the Secretary of the Interior for transmission to the Congress of the United States. Almost immediately telegraphic protests were made to the Secretary, and a hearing was requested that the protestants might present their side of the case, and that the Secretary might be properly informed, as they understood it, before transmitting his recommendations to the Congress of the United States. Various matters have precluded the holding of the hearing upon this protest until this time. One or two tentative dates have been fixed in Washington, but it was finally determined that it would be more satisfactory generally to have the hearing at some town in the Southwest, more accessible than the city of Washington to those who might desire to be heard pro or con.

Now, it is not my purpose to confine the hearing to the protest made by the Coachella district because of the report of the Director of the Reclamation Service. I shall call upon the director to state to you as briefly as possible the contents of his report and why he has made the recommendations as he has and whether he has in any manner modified his views up to this time. I will then be glad to hear from those who desire to be heard, either sustaining the report, protesting against the report, or rendering amendments to the report. It will be necessary, however, for us to proceed as rapidly as possible, and to do so it will be necessary for us to have some set program. After the director has made his statement I am going to call upon those who desire to be heard to announce themselves; then, if it is possible, we will take a recess for a short time, so that some representation of either of the interests or bodies desiring to be heard may be chosen, so that we may proceed as rapidly as possible and somewhat in the nature of a court in session.

Mr. Director, I will be glad to have you make your statement. [Applause.]

Director of the Reclamation Service, ARTHUR P. DAVIS. Mr. Secretary and gentlemen, the report that has been referred to is one authorized by an act of Congress approved May 18, 1920, and for a full understanding it may be desirable to go very briefly over the contents of the report, as the Secretary has requested, and over the history leading up to it.

Investigations for the development and to ascertain the proper lines of development of the Colorado River were begun before the passage of the reclamation act. There was at that time a law providing for future irrigation, in the powers of the Secretary of the Interior to withdraw reservoir sites, and providing also that irrigation works to be built by the United States in the future might be constructed upon lands subsequently filed upon, reserving a right of way for that purpose. That law was passed in 1891, 11 years before the final passage of the reclamation act. That being in line with the policy of the Government, investigations have been carried on for over 30 years with a view to the work that has since been performed under the provisions of the reclamation act, and, under the provisions of the law and those appropriations, investigations by measurement of water supply and otherwise were begun in the Colorado basin in the nineties, particularly about 1900; reservoir sites were tentatively selected and partially investigated and stream measurements particularly were carried on in various parts of the basin. These measurements are still in progress and constitute the basis of very much of the information that we have on the subject, and the results of those investigations are compiled and condensed in the report that is under discussion to-day. The usefulness of those investigations was demonstrated some time ago in the problems that arose concerning the welfare of the Imperial Valley—the water supply necessary for extensions of irrigation on the lower river and in other parts of the basin, and particularly the controversies that have grown up between the various interests, national, State, and international, in connection with the use of the waters of the Colorado River.

As most of you undoubtedly know, the Imperial Valley, the greatest single body of irrigated land in the United States and by far the greatest in the watershed of the Colorado River, has been menaced for some time by the floods of the Colorado River. It has been on the point of destruction more than once by submersion from the waters of the Colorado River, and had they not been stopped in the spectacular manner in which they were about 15 years ago, that valley would to-day be an inland sea instead of the site of the rich production that we see there now. The problems of the valley were so acute that the United States made an appropriation of a million dollars out of the Treasury at one time to control the floods of that river by means of levees and otherwise. The river is building up its bed and becoming more and more of a menace all the time until now the valley is under very heavy expense in attempting to divert the river into the lower channel where it will be less of the menace that very nearly submerged the valley last year. These problems led to the presentation to Congress of petitions for relief in various ways. One was granted in the appropriation, as I have said, of a million dollars for this protection that was spent some years ago under the supervision of Col. Ockerson under the direct charge of the Secretary of the Interior. Further legislation has been asked from time to time, and voluminous hearings have been held before the congressional committees which were considering the proposed legislation, and finally Congress decided that further information was necessary, and on the date that I have mentioned, May 18, 1920, an act was approved providing for further investigation. An appropriation of $20,000 was made to be expended by the Reclamation Service in connection with such contributions as might be made by interested parties. The appropriation was conditional upon such contributions, setting no particular limit, but requiring that at least an equal amount be subscribed by interested parties.

Under the provisions of that law a request was made by the Imperial Valley to contribute a large amount, because the amount was recognized as insufficient for complete investigation, and at the suggestion of the valley and under the provisions of this law various other communities were requested to contribute. The city of Los Angeles, the irrigation districts, and various other interests were invited, and finally contributions were made by the Imperial irrigation district, the Palo Verde district, the Coachella County water district, and the State of Arizona. A resolution, as I understand, was passed by the city of Los Angeles to carry on these investigations in addition to the other contributions to the extent that the money might be needed. In a subsequent interview the officials of the Imperial irrigation district requested that no contribution from the city of Los Angeles be accepted at that time, and they increased their own, and the work proceeded. The investigations included a compilation of the data that had been collected in the past 25 years and particularly the accumulation of the past 7 years. In the seven years preceding the present date we have carried on continuously and extensively investigations in all parts of the basin, and two or three years ago a voluminous report was prepared, which is now on file. The substance of this report and data obtained from the investigations that have been made under this appropriation are all condensed in the report which has been referred to to-day.

In the act of Congress making this appropriation it was required that a report be made upon the meeting of Congress about one year ago, December, 1920. As the work had not been completed at that time, a preliminary report, of which I hold a copy, was made in order to comply with the act of Congress. That preliminary report states that it is subject to revision. Some of the figures have been modified slightly by subsequent information, and it is nowhere complete in its scope, but the final report that has been mentioned here is more nearly complete and covers what was intended by the act of

Congress. That was submitted to the Secretary of the Interior on the 8th day of July, and on that date a protest was filed by the Coachella County water district against certain provisions of the report. Briefly, this report includes not only a compilation of all existing data, including water supply in concise form and reference to where it may be obtained in detailed form, but it describes certain and very extensive investigations carried on in the past seven years by the Reclamation Service of the possible development in the upper basin. In making that investigation we have investigated all of the propositions for irrigation brought to our attention that had any basis of authority or probability or possibility. The figures have been compiled and are included in this report,, showing that about 1,500,000 acres of land are now irrigated in the upper basin, that it is profitable, and as far as our information goes—and it is very complete considering the length of time—it is possible to irrigate about two and one-half million acres more in the portions of the basin above the point where the main stream of the Colorado crosses the Utah-Arizona line. This upper part is referred to as the upper basin, and the lower part as the lower basin.

The great canyon region makes a very important geographical division between these two basins, and one of the main purposes of this study was to secure information necessary to plan a comprehensive development of the Colorado River Basin that would not destroy any natural resources; in other words, to make the best use of the water that was feasible for irrigation, power, and other uses. The study showed that to comply with the urgent demand and necessity for water storage in the lower part of the Colorado River Basin for irrigation and flood control by the construction of reservoirs on the upper reaches of the river—which up to a few years ago was unanimously agreed upon by those who had been engaged in the investigation as the wisest policy—would not be the best use, in my judgment, at least, of the waters of the basin, for the reason that storage reservoirs constructed on the upper reaches of the river, for irrigation use below, if the rights were established, would necessarily be used in accordance with the needs of that section and the water turned out of these reservoirs only when it was needed to supplement the low water flow in the lower part of the basin. Obviously that water could not be used advantageously in the upper basin for any purpose, because it would not be used in the way that would be required; it could not be used for irrigation because it must run down for use below; it would not be turned out in accordance with the necessary use for power because its purpose was otherwise, and as the needs of irrigation in the lower basin do not coincide with the needs of power throughout the great canyon region where the great fall and the great power possibilities are, any reservoir built in the upper basin for use in the lower basin would to a very large extent sacrifice the possibility of development. It would not be the best use of the water even in the lower basin for the reason that it would take several weeks for water to flow from a reservoir in the upper basin to the lands needing it in the lower basin, and in order to meet the needs of the lower basin it would be necessary to attempt to predict several weeks or months ahead the needs of the lower basin, which is an impossibility; therefore it would be necessary to turn out a large excess from the basin above for use in the basin below in order to provide for contingencies that might arise, but seldom do, and consequently a large quantity of surplus would run to waste in the Gulf.

The principal reason for concluding, as some engineers did after making investigation, that the water should be stored in the upper basin was because the streams up there were clear, and the reservoirs would not fill with sediment or sand as soon as if constructed in the lower reaches of the river, where the water is very muddy and discharges a large amount of sediment every year. That is a very strong, vital reason and had to be carefully considered in providing for the best use of the water. Obviously, it would be idle to attempt to build a small reservoir in the lower basin; its life would be too short, as it is not commercially feasible to-day to take the sediment out of any reservoir by any mechanical means. It costs many times more than the cost of the construction of an additional storage reservoir.

To illustrate: We may build a reservoir at a cost of two or three dollars per acre-foot capacity, and there are many reservoirs in the basin that could be built for at least less than $10 per acre-foot. There is no known mechanical means by which sediment may be moved at the rate of $10 or even $20 per acre-foot, so as long as reservoir sites exist of anywhere near commercial feasibility in other respects, they are the cheapest means of providing for the disposition of silt. There are other means, though, than the direct removal of silt by which it may be washed out, but the con clusion that I have reached, and I think everyone is in agreement as far as I know, is that so long as further storage is necessary, possible, feasible, or within commercial feasibility, that is the best way of handling the silt problem, and will be for many centuries to come. The essential things are extension of irrigation and especially control of the floods in the lower valley and therefore the best place for a storage reservoir is as near these valleys as possible, other things being equal. After the investigations in the basin were completed by the engineer who had them in charge and he had filed his report, we instituted investigations on the lower basin, which had not then been made for storage, and about that time—about a year after we started the survey of the reservoir in the lower basin—Congress passed this law known as the Kinkaid Act, approved May 18, 1920——

Secretary FALL. Mr. Director, right there I wish you would read this act. There is a great misapprehension in the minds of the people as to what this is about.

Director DAVIS (reading):

APPENDIX A.

AN ACT To provide for an examination and report on the condition and possible irrigation development of the Imperial Valley in California. (41 Stat., 600.)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior is hereby authorized and directed to have an examination made of the Imperial Valley, in the State of California, with a view of determining the area, location, and general character of the public and privately owned unirrigated lands in said valley which can be irrigated at a reasonable cost, and the character, extent, and cost of an irrigation system, or of the modification, improvement, enlargement, and extension of the present system adequate and dependable for the irrigation of the present irrigated area in the said valley, and of the public and privately owned lands in said valley and adjacent thereto not now under irrigation which can be irrigated at a reasonable cost from known sources of water supply by diversion of water from the Colorado River at Laguna Dam.

SEC. 2. That the said Secretary shall report to Congress not later than the 6th day of December, 1920, the result of his examination, together with his recommendation as to the feasibility, necessity, and advisability of the undertaking or the participation by the United States in a plan of irrigation development with a view of placing under irrigation the remaining unirrigated public and privately owned lands in said valley and adjacent thereto, in connection with the modification, improvement, enlargement, and extension of the present irrigation systems of the said valley.

SEC. 3. That the said Secretary shall report in detail as to the character and estimated cost of the plan or plans on which he may report, and if the said plan or plans shall include storage, the location, character, and cost of said storage, and the effect on the irrigation development of the other sections or localities of the storage recommended and the use of the stored water in the Imperial Valley and adjacent lands.

SEC. 4. That the said Secretary shall also report as to the extent, if any, to which, in his opinion, the United States should contribute to the cost of carrying out the plan or plans which he may propose; the approximate proportion of the total cost that should be borne by the various irrigation districts or associations or other public or private agencies now organized or which may be organized, and the manner in which their contributions should be made; also to what extent and in what manner the United States should control, operate, or supervise the carrying out of the plan proposed, and what assurances he has been able to secure as to the approval of, participation in, and contribution to the plan or plans proposed by the various contributing agencies.

SEC. 5. That, for the purpose of enabling the Secretary of the Interior to pay not to exceed one-half of the cost of the examination and report herein provided for, there is hereby authorized to be appropriated the sum of $20,000: *Provided*, That no expenditure shall be made or obligation incurred hereunder by the Secretary of the Interior until provision shall have been made for the payment of at least one-half the cost of the examination and report herein provided for by associations and agencies interested in the irrigation of the lands of the Imperial Valley.

Approved May 18, 1920.

Secretary FALL. It was as the result of that law that the report was originally made and an extension granted and this report is now being made?

Director DAVIS. Yes, sir; this preliminary report is accompanied by a colored map showing the various regions interested in the problem of the lower river and the subsequent report now about prepared contains additional diagrams and maps further illustrating the result and the carrying out of the recommendations made.

Pursuing the thought that I dwelt upon awhile ago before reading this act, that the best use of the waters in the lower valley requires storage in the lower valley so as not to hamper or circumscribe the development in the upper valley, we found the problem very greatly simplified by the further detailed examination we had made of the entire basin. We found that that would not in any way prejudice the development in the lower valley, because the water supply of the Colorado River Basin, if properly conserved in a reservoir of adequate dimensions, would furnish sufficient water to irrigate all the lands which might be reached feasibly from that river with a good margin to spare in the lower basin, even assuming the successful irrigation and cultivation of all the lands in the upper basin, and the use of the water for power in that basin without any restriction by the rights acquired below.

Under present laws, as I understand them, and as I understand they are interpreted by most lawyers, a development in the lower basin, carried out and fully utilizing the water, would establish rights which would, if the laws were enforced, prevent any development in the upper basin that would interfere with the use to which these waters had been put; and if sufficient storage were not provided, and even if all the storage possible were provided, any irrigation in the upper valley would deplete the water supply, so that any rights completely secured to the waters of the Colorado River in the lower basin would absolutely stop all irrigation developments in the upper. That is assuming the extreme condition of a full utilization in the lower basin, and a full security of the rights as I understand they would be secured under present laws by that utilization. So that it is apparently necessary if we are to use the waters of the lower basin to the best advantage that use should be permitted only on the condition that these normal rights, if they exist as I believe they do, should be suspended; that is, that the United States being in control of the international, the national, and navigable stream of the Colorado, should provide any other developments of the lower valleys with storage, and further development there should not prejudice the possibilities of carrying out the valley irrigation and power use in any of the particular regions of the basin. That will require legislation, of course. I do not know anything else that can establish that right fully. To hold the best flow of the wet years over a series of years until the drought comes—the discrepancy between the wet and dry years is very great, and wet years and dry years sometimes succeed each other for several years—a reservoir must be provided large enough to hold the waters of the wet years for use in the dry years; therefore a large reservoir is necessary. It is also necessary for the reason that it must not be destroyed by the accumulation of silt.

Now we estimate that the flow of silt at Boulder Canyon, which has been investigated and is still under investigation, is about 80,000 acre-feet per annum; in other words, in 10 years, unless somehow relieved, that reservoir will store 800,000 acre-feet of solid matter. There will be a little water, of course, deposited with that, but it will not be available for use. It is necessary, therefore, for a reservoir to last that long to have a very much larger capacity than that; for that reason it is necessary to build the reservoir very large.

Fortunately, at the northwest corner of Arizona there is a profound and very deep, very narrow canyon of hard granite through which the river runs, and where a dam very much higher than anyone thinks necessary can feasibly be built if the foundations were sufficient, and one of the most extensive and slowest of the features of the investigation that has been made under the provisions of the Kinkaid Act is the exploration of sites in various parts of the canyon for the foundation for the dam. That exploration has proceeded to the point where we have a fairly good profile across what on the surface appears to be the best site for the dam, so that I am satisfied that the dam is feasible and shall recommend to the Secretary of the Interior that a feasible site there exists. That does not mean that these investigations are anywhere near complete. The dam may be shifted back or forth to get a better or more secure, or a cheaper, location, and we must also investigate for the foundation of the large and heavy cofferdam that must be provided to control that great torrential stream.

There are many other minor matters that must also be investigated at the same time concerning which engineering studies are necessary, as well as providing for a large construction plant. A railroad must also be built. We have investigated, as the congressional act requires, the soils, the canal systems, and all of the major works that are necessary for the irrigation of the additional lands in the lower valley; the results of those investigations are included in the report under discussion.

There is a large amount of power which can be developed by a high dam anywhere in the lower regions of the Colorado River because the quantity of water when regulated is very great and demands for power, of course, you all know.

And now to summarize and come to the recommendations. I will read them:

POWER DEVELOPMENT.

The development of power at the Boulder Canyon Reservoir is a by-product, which does not in all respects conform to the requirements of irrigation but can be made to conform thereto with some adjustment. The extremely arid and semitropic character of the lands in the lower Colorado Basin makes it necessary to irrigate throughout the year, and the irrigation requirements therefore conform more nearly to the requirements for power than do those in northern latitudes.

It is estimated that the feasible irrigation projects in the lower basin comprise 2,020,000 acres, of which about 60 per cent is in the United States and 40 per cent in Mexico. The full development of the proposed projects in the upper basin will subtract substantially from the total water supply, but there will still be left ample water to irrigate all the lands of the lower basin if it is conserved and regulated in a storage reservoir of ample capacity. The water can be used for power as drawn from the reservoir, and the amount of power that can be developed with different amounts of storage capacity and with different assumptions of irrigated land below is shown by the diagram in Plate VI. It shows that with 1,505,000 acres of land in the lower basin irrigated, and with a total storage capacity of 31,400,000 acre-feet, of which the lower 5,000,000 is reserved for silt storage and the upper 5,000,000 is reserved for flood control, it is possible to develop over 700,000 firm horsepower. With the entire 2,020,000 acres of irrigable land developed in the lower basin, the possibilities are still 600,000 firm horsepower, and besides this there is in both cases a large amount of secondary power which is not constant but will be of considerable value.

The great value of this power and the wide demand for it, together with its magnitude, indicate that the power privileges of the Boulder Canyon Reservoir should bear the entire portion of the cost of the dam. For preliminary purposes, it is recommended that this portion be fixed at 8 per cent, subject to adjustment by a board appointed for that purpose.

The markets for power are numerous and varied in this part of the country, consisting in general of the mining interests in Nevada and Arizona, the railroads of the Southwest, the pumping requirements in the Colorado River Valley, and the needs of the municipalities of Arizona, Nevada, Utah, and southern California for municipal and commercial uses. Possible municipal customers of importance are Prescott, Phoenix, San Diego, Riverside, and Los Angeles.

The last named city has indicated a desire to share in this development, as shown by the letter dated December 16, 1920, on page 92.

This city has already developed considerable power on the Los Angeles Aqueduct and owns a system for distributing electric current within the city limits. The demands, present and prospective, are far beyond the capacity of the city to supply with the present facilities, and this is considered the most effective and extensive of all of the power demands.

It is desirable, of course, to extend to all municipalities which desire to share in this development the same privileges, but in the tentative allotment of power the city of Los Angeles is the only one included because it is the only city which has indicated a desire to join. Others may apply later and should have equal privileges. The use of the name of the city of Los Angeles is merely typical of such cities as eventually may elect to share in this development.

In another place in this report emphasis is placed upon the importance of early action, especially for flood control. The present season has shown the growing imminence of this question in relation to the interests of the lower valleys. No policy should be adopted, therefore, that will involve undue delay.

In case it proves infeasible to secure prompt acquiescence and cooperation to the necessary extent, by the municipalities and States in the plans herein proposed, it is recommended that negotiations be undertaken with any possible customers for power, including the railroads, large mining interests, and power companies which may desire to participate in the development in connection with their other operations. Any such participation, however, should be carefully safeguarded by regulations such as the Federal Power Commission and the State commissions are competent to impose.

RECOMMENDATIONS.

1. It is recommended that through suitable legislation the United States undertake the construction with Government funds of the high-line canal from Laguna Dam to the Imperial Valley, to be reimbursed by the lands benefited, and also the Boulder Canyon Reservoir, to be reimbursed by the revenues from leasing the power privileges incident thereto: *Provided, however*, That each State or political subdivision thereof interested in this project shall have the right at its election to contribute to the cost of the construction of said project and receive for its contribution a proportionate share of power at cost.

2. The Secretary of the Interior should be empowered, after full hearing of all concerned, to allot to various applicants their due proportion of the power privileges and to allocate cost and benefits of the high-line canal.

3. It is recommended that every development thereafter authorized to be undertaken on the Colorado River by the Federal Government, or otherwise, be required by legal enactment, in both construction and operation, to give priority of right and use—

First. To river regulation and flood control.

Second. To use of storage water for irrigation.

Third. To development of power.

4. If the United States declines for any reason to enact legislation in conformity with the outline in the above paragraph it is recommended that legislation be enacted authorizing—

First. That the Government participate in building a high-line canal from Laguna Dam in proportion to the irrigable area it holds in public domain and Indian reservations, and that the lands and districts to be irrigated under the proposed project participate in the cost of its construction in proportion to their respective benefits.

Second. That the Secretary of the Interior be authorized in this legislation to contract with any agency or agencies to build a dam on the Colorado River for the power to be developed by such construction who will agree to construct the same under the following provisions: First, under Government control, supervision, and regulation; second, give priority to river control for flood protection; third, provide storage of water for irrigation needs; fourth, concede reservation of power sufficient for district needs by district being permitted to contribute to cost of power development.

5. It is recommended that the lands to be irrigated, whether Government owned or privately owned, pay their proportional share per acre for the construction of canals sufficient to carry water to them.

Those are the recommendations as laid upon the desk of Secretary Fall on July 8, and made the basis of the protest by the Coachella district.

The honorable Secretary in his opening remarks requested that I state what, if any, modifications my conclusions had undergone since that date, and I want to say a word by way of caution and explanation that by their request all the parties who have been invited to contribute to the cost of the investigation made under the Kinkaid Act were invited to come to conference before the formulations of these recommendations and the conclusions upon which the recommendations are based. Several conferences in various places were held, notably one just before the report was issued in July, in the city of Washington, and two of the conferees were still present at the time the report was submitted to the Secretary and appeared before him at that time.

In order to furnish each of the districts with a basis for conference or expression of their desires and views without the expense of sending representatives to the city of Washington, copies of a preliminary report as suggested by me after some conference were sent to those people who had offered to contribute, and who had contributed. These reports, which were confidential in their nature (though perhaps not in all cases so marked)—I am not criticizing anyone—received more or less publicity and circulation, which was not intended by me. The reports were simply sent out for discussion, and differed in some respects from the official report as finally determined upon after the final conference, which accounts for the discrepancies between reports that are in circulation. The matter obtained a great deal more publicity and excited a great deal more public interest than I anticipated, but I think no harm has been done if this be borne in mind.

The principal points upon which I have modified my views since submitting that report are as to the method of securing funds for the construction of the Boulder Canyon Dam and the All-American Canal, which are the major features included therein.

I have always regarded it as very desirable if possible for the United States to construct, own, and perpetually control any dam constructed in the canyons of the Colorado [applause] on account of the interstate, international, and navigable character of the stream, on account of the great magnitude, on account of the necessity of a comprehensive plan by which it will be done in the best manner, and particularly on account of the fact that, in my opinion, the United States is the only authority adequate to preserve the rights and interests of all of the seven States interested, and of the United States, which is also interested in the proper development of this river. [Applause.]

The only reason why that was not made a part of this report and recommended under it was because I did not believe it could be done. I did no believe that under the conditions of heavy debt under which the Government was struggling at that time it was possible to get quickly enough an appropriation adequate for the purpose, and for that reason I consulted with the various interests as to the possibility of raising funds otherwise, and have always regarded it as absolutely essential to the success of this scheme that all of the interests involved be united, and that all of the beneficiaries contribute to the cost of the proposed development. [Applause.]

After this report was submitted and he became acquainted with the major features of the recommendation, the Secretary of the Interior told me in positive terms that in his judgment the construction of dams in the canyon should be done by the United States Government only. [Applause.]

That announcement I did not feel authorized to make until he himself made it in very positive terms from the platform in Riverside a few days ago. I am in most hearty accord with that attitude, and with that attitude of the Secretary behind the report, and behind the recommendation, I think the chances are excellent that Congress will provide for carrying out the best means of developing the Colorado River, namely, by the construction and control of the dams in that river by the United States itself. So it is with the utmost pleasure that I desire to make that change in my recommendation, because that is the thing that should be done. It becomes all the more within the range of feasibility as we see the approaching success of this reduction of armament. [Applause.] And if the program for the reduction of navies alone, to say nothing of armies, by the United States should be carried out, as proposed and so ably advocated by our great Secretary of State and the President of the United States, the Boulder Canyon Dam and several more could be constructed in the time it would take to build one dam on that river. [Applause.]

That is the principal modification that I suggest for this report. Most of the other features that have been discussed are matters of more or less detail, but I shall be very glad to accept anything feasible and practicable, and, having discussed this many times with the Secretary of the Interior, I know there is no disagreement between us on this matter, and, of course, it is my utmost desire that not only all the interests, but that all of the Government officials, be united on a program of procedure for carrying out this development as proposed and advocated so well by the Secretary of the Interior, and therefore I am now able to announce with an entirely open mind that I am in complete harmony in every detail with the Secretary of the Interior. I bespeak for this project, which is so vital to the interests of the entire Southwest, to every man woman, and child in the Southwest, in the primary sense, especially in the Imperial Valley and the lower irrigated districts, and which is so very important not only to the States in the Colorado River Basin but to the entire West and the entire United States, that no natural resources shall be unnecessarily destroyed; we should carry out this development in the best possible way, subject to modifications as we proceed with the investigations, which are not yet complete.

Mr. Secretary, I thank you.

[Applause.]

Secretary A. B. Fall. Ladies and gentlemen, I requested the director to read the Kinkaid Act for your information, and I think that you, after hearing the act itself read and the recommendations of the director submitted to myself read to you by him, comparing the recommendations with the reports, will have learned that the recommendations are made under the direction of the Congress of the United States. He was required to state the facts and to recommend how the purpose of Congress, namely the irrigation of the lower valley including the private lands and public lands not now under irrigation, could best be carried out, and that if in his investigation he decided that a reservoir would be necessary, to call to the attention of Congress the site, the cost, and the most feasible means of construction of the reservoir, with the assistance of private or State capital. The recommendations are made in accordance with the direction of Congress. The modification which has been suggested was not directed, or at least he was not required to recommend whether the Congress of the United States should provide for the construction of this dam or not.

One of the districts which may be affected by this construction objected, protested to me against the adoption of this report, and after one or two dates were tentatively set this final date was set for the hearing. We are here for that purpose. We are here for the purpose of hearing first the protest of the Coachella district, if any, the protest of any other district or individual or interest, and any other observations which will be of an instructive character to me in preparing, with the assistance of the director, my final report and recommendation to the Congress of the United States.

Is the Coachella district represented here? What is your name? Give your name to the reporter. Now, gentlemen, it will be necessary, as I have stated in opening, for us to proceed. I do not know those who desire to be heard. I would like those desiring now to be heard to rise and announce their names.

Dr. F. S. M. Jennings, Coachella Valley water district.

Thomas E. Yeager, representing Coachella Valley.

J. S. Nickerson, representing Imperial irrigation district.

Mr. BRANDT. I desire to be heard representing the West Side Imperial irrigation district.

My name is Craig. I desire to be heard representing the Southern Sierras Power Co., the Nevada-California Power Co., and the Holton Power Co.

Joe Simons, a farmer in Imperial Valley, wishes to be heard.

F. C. Emerson, representing the State of Wyoming.

R. B. Peters, representing the County Farm Bureaus of the southern part of the State of California.

J. G. Scrugham, representing the government of the State of Nevada, and speaking for the State of Nevada.

J. H. MARSH. I desire to speak as representative of the State of Colorado. I also desire to state that Mr. L. Ward Bannister desires to speak as a representative of certain districts interested.

Mike Liepert, representing the Imperial County Farming Co.

Mr. Bartlett, representing the League of California Municipalities.

George L. Hoodengyl, representing the city of Long Beach.

J. E. Davis, representing the Chamber of Commerce of Long Beach.

Mr. Allen, representing the Taxpayers' Association of Imperial Valley.

W. T. Matthews, representing the city of Los Angeles.

Mr. Coiner, representing the city of Pasadena.

Peter Worthington, representing State executive committee of the American Legion, the American Legion of Imperial County, and others.

Ross D. Hiccox, representing the Associated Chambers of Commerce of Imperial County.

A. G. Brock, representing the city of Redlands.

Grant Lorraine, Alhambra, representing southern California and the city of Alhambra.

G. M. Bridge, representing the Yuma County Farm Bureau, Arizona.

William Wesner, representing the Yuma County Water Users' Association, Yuma, Ariz.

B. F. Fly, representing the Yuma Chamber of Commerce.

John Johnson, representing the city of Santa Barbara.

A. T. Warrington, representing the Palo Verde water district.

Mr. Williams, California Water Co.

R. E. Caldwell, State of Utah.

F. L. Hewing, representing the Yuma Mesa irrigation district.

W. F. McClure, representing the State of California.

F. A. Reed, representing the South Water Valley Water Users' Association.

Mr. Gibbon, representing the American Legion.

Mr. Bolger, representing the Boulder Canyon district of Arizona.

C. C. Bentley, representing the Fallbrook Chamber of Commerce.

C. F. Brown, Arizona Farm Bureau.

W. F. Headon, representing Yuma County, Ariz.

Capt. S. H. Nichols, representing the California Veterans' Welfare Board, chairman of the board.

Mr. Squires, representing the Chamber of Commerce of Las Vegas, near Boulder Canyon.

Frederico Ramos, representing Mexico and Mexican interests.

W. R. Wallace.

Mr. Chase, the Los Angeles Chamber of Commerce.

W. S. Norville, State of Arizona.

Albert Lonner, representing the city of Fullerton.

Clark W. Adair, 16 years a farmer in Imperial Valley.

R. S. Porter, representing the Southern California Cities League and the city of Riverside.

John L. Bacon, representing the city of San Diego.

W. H. Best, Water Company No. 4.

E. W. Cuss, city of Brawley.

Sims Ely, representing the governor of Arizona.

Harley A. Harmon, representing Park County, Nev.

R. H. Ballard, Southern California Edison Co.

G. A. Davidson, San Diego Chamber of Commerce.

Secretary A. B. Fall. Ladies and gentlemen, it is evident that to follow the suggestion of the Chair we may be here for some time. Each of you who has given his name here knows that he has so done. I am going to ask those who desire to be heard to remain in this hall, while those who are not going to talk may take a little recess, and I will ask you to complete your own organization, if possible, arrange the order in which you shall make your presentation, and limit yourselves as much as possible to the necessary time. Remember that I am going to take this somewhat as a court hearing, but I am going to give all latitude possible. We will see that everyone who has anything to say has an opportunity to say it, but we have not time to debate general questions in this particular hearing. We have had one debating society recently in California. [Applause.]

Director DAVIS. May I add a little?

Secretary FALL. Certainly.

Director A. P. DAVIS. Mr. Secretary, I omitted a point that I should speak of here, because it is sure to come up. One of my recommendations was that the allocation of the power from the Boulder Canyon Dam be determined in the future by a particular statute as therein described, and which might be modified. In order not to deter the work while the investigation and hearings are in progress, the report contains a recommendation that the preliminary expense that may be incurred be charged on a basis of 85 per cent against the interests that might consume power or for power purposes, 10 per cent against flood control, and 5 per cent against irrigation, clearly stating that this percentage distribution is subject to modification. The allocation was not made on the basis of justice or any other principle except the principle of where we could get the money; that everybody would be given credit for what they had contributed and the allocation made later. Subsequent information with which you are all familiar has convinced me, I am very glad to say, that it is not only possible but desirable that the expense of the dam itself be carried entirely by the power interests [applause], and that the costs of the benefits to irrigation and flood control be imposed upon the construction of that great reservoir without charge against those interests, because it is upon them very largely that the market for power depends, and they will eventually pay it back in the money they pay for the power. Thank you.

Secretary A. B. FALL. Before taking the recess it is desirable that I should make another statement here. The majority of you may be familiar with the fact that in addition to this act of Congress under which we are considering this particular report, Congress has at a more recent date enacted legislation with reference to the Colorado River problems generally. It is provided by law that each of the seven States interested should appoint a commissioner, and these commissioners have, as I understand, been appointed; that the United States should appoint a commissioner, and that these commissioners should undertake to report to Congress some settlement of the different conflicting interests and the rights of the respective States involved. The two things are entirely separate. This report relates to the lower valley, and, of course, those above are interested in seeing that the lower valley does not acquire adverse rights which they would be compelled to go to Congress to protect, and to that extent they are interested in this hearing at this time, and, of course, I am glad to hear from them. Now, I suggest, ladies and gentlemen, that we take a recess until, say, 1 o'clock, and that those who are going to be heard remain here until we have arrived at some decision as to the time that they will require, and the order, if possible, of the presentation of their statements. I would suggest this: That as there may be several delegates who desire to be heard from some one district or some one interest, if possible they should combine and choose one or as few speakers as possible to present their side of the case, and I hope you will place a reasonable limit upon the time allotted.

A VOICE. Mr. Secretary, we are supposed to have a Congressman in here some place; he seems to be somewhat modest, I suggest he be placed on the list.

Secretary FALL. I presume it is scarcely necessary except for the reporter's benefit to suggest the name of Judge Swing. [Applause.]

Congressman SWING. If after hearing all of the interests who have requested time, there is any time left, I will be glad to say a few words on behalf of the people of the eleventh congressional district, which I have the honor to represent. [Applause.]

Director DAVIS. Mr. Secretary, I am requested by the mayor of San Diego to read an announcement. The San Diego section of the American Society of Civil Engineers will hold a special meeting this evening, Monday, December 12, to meet visiting members of the society of engineers in attendance, and especially members of the American Society of Civil Engineers are invited to attend. The meeting will be in the auditorium of the Y. M. C. A. Building, at the corner of Eighth and C, at 8.30 p. m. Thank you.

Secretary A. B. FALL. Now, gentlemen, we go into recess until 1 o'clock, and after that we are going to attend to business, and those who desire to be heard must be here and be prepared to present their case. We are going to conclude this hearing at the very earliest possible moment; we can not remain here indefinitely. I leave you to the consideration of your own problems.

(The reporter is excused, and various committees go into session.)

AFTERNOON SESSION.

Secretary A. B. FALL. May we have a report from those desiring to be heard?

Mayor JOHN L. BACON. Mr. Chairman, as chairman of the meeting called among those who were to speak, the secretary left for downstairs just 10 minutes ago to furnish a complete report with the time allotted each speaker. In order to save the honorable Secretary's time, it was agreed that the Imperial Valley should first be heard——

Secretary FALL. Can you furnish me with a list of the speakers and the rotation in which they are supposed to come?

Mayor JOHN L. BACON. Just as soon as they have the list ready you will have it in your hand; it will be about 5 minutes.

Secretary A. B. FALL. Imperial Valley will be heard.

J. S. NICKERSON. Ladies and gentlemen, I will try, in as brief a way as possible, to state our condition in Imperial Valley, so that our northern brethren will feel more disposed to help us. We need their help. As I have stated several times, it will take all of us to get behind this Boulder Canyon and behind our Secretary to put this proposition through. Now, in the first place, the people of Imperial Valley pay out two hundred and fifty or three hundred thousand dollars a year for protection levee work alone. That is something. Now, we go on up to Hanlon Heading, where we divert our water, and the silt proposition costs us at least a half million dollars. That money has all to come out of the farmers of Imperial Valley. Then we have to overcome the silt. There is an expense all the time, most in flood time until we get through with our demand for water through the hot summer time. Now, then, to relieve that situation we have got to change our conditions. What will relieve that is to move to Hanlon Heading or to Laguna Dam, move our present intake in the Colorado River to the Laguna Dam. We have a contract with the Government for $1,600,000 to make the connection, at 20-year payments—20 years to pay for it in—2 per cent a year on the whole amount. Now, the Boulder Canyon Dam seems to be the only relief. It is the nearest to the point of the farmers. It is the storage that will help the farmers most. As to being a power proposition, I can not discuss that; that is up to the engineering department. Now, we want the Secretary to figure out the quickest, the cheapest, the most economical way in order to relieve our situation down there. Now, gentlemen, you northern men, we certainly want your cooperation.

These are facts, and if you do not believe it, if you will come into the office we can show you it is a fact. We ask for cooperation, and if we do not get cooperation from everybody that is tributary to the Colorado, and the municipalities in different States, why, we can not expect to get anything. It is a big proposition when we all come as a unit—come as one and speak in the same voice to get conditions. I believe one municipality, Los Angeles, or the power company, or other States, or one or two States, could hold this whole proposition up. Our Secretary wants to help us, and I know that he will help us if we try to help ourselves, but we can not give it to him separated. Many of you say it is a big proposition, it is fifty or sixty million dollars. The Panama Canal was a big proposition, they said it could not be achieved—it was the act of Teddy Roosevelt—it was because of Teddy Roosevelt it was built. I have known the Secretary for a good many years—I know he is a fighter—I know if he starts anything he is going to finish it, you can believe me; so just get behind him on the whole thing—and the only way we can ever expect anything is to come as a whole. Now, gentlemen, about all I have to say, is to leave it absolutely to the Secretary, as to the most comprehensive, the cheapest, and the quickest dam possible. Thank you.

Mr. Fall. I want to ask you some questions, Mr. Nickerson. You are president of the district, are you?

Mr. Nickerson. Yes, sir.

Mr. Fall. How much land is in cultivation under irrigation on the American side of the line, what is known as Imperial Valley?

Mr. Nickerson. Four hundred and fifty thousand acres.

Mr. Fall. How much, approximately, is now under cultivation on the Mexican side of the line?

Mr. Nickerson. One hundred and fifty thousand.

Mr. Fall. Then you have now on the Lower Colorado, in Mexico and the United States, approximately 600,000 acres of land?

Mr. Nickerson. Yes, sir.

Mr. Fall. Have you enough water for that land now?

Mr. Nickerson. Well, there are times in the year there is not—there are times there are not 2,000 feet in that river for a short time.

Mr. Fall. Where is the present head of Imperial Valley?

Mr. Nickerson. Right at Hanlon Heading.

Mr. Fall. What country is that in?

Mr. NICKERSON. It is in California.
Mr. FALL. In the United States?
Mr. NICKERSON. Yes, sir.
Mr. FALL. From whence does it proceed then?
Mr. NICKERSON. Proceeds into Mexico.
Mr. FALL. How far is it to the Mexican line?
Mr. NICKERSON. It is about a mile and a half.
Mr. FALL. Approximately, how far into Mexico does it run?
Mr. NICKERSON. It runs from Calexico to Hanlon Heading, in the neighborhood of 50 or 60 miles.
Mr. FALL. How is irrigation in Mexico carried on, through that main canal?
Mr. NICKERSON. Yes, sir.
Mr. FALL. By laterals?
Mr. NICKERSON. Yes, sir.
Mr. FALL. In Mexico?
Mr. NICKERSON. Yes, sir.
Mr. FALL. Then this canal, after running 50 or 60 miles through Mexico, returns to the United States, does it?
Mr. NICKERSON. Yes, sir.
Mr. FALL. And where is the first lateral canal taken out from this canal which irrigates land in the United States?
Mr. NICKERSON. That is High Line Canal.
Mr. FALL. About how far is that below Hanlon Heading?
Mr. NICKERSON. That is about 40 miles.
Mr. FALL. That heading, then, for the High Line Canal is in Mexico, then, is it?
Mr. NICKERSON. Yes, sir.
Mr. FALL. And it runs through Mexico and then into the United States?
Mr. NICKERSON. And it runs through Mexico and then into the United States.
Mr. FALL. So that your entire canal system there is complicated by virtue of the fact that it is in two different countries, United States of America and Mexico?
Mr. NICKERSON. Yes, sir.
(Some words were spoken between Secretary Fall and Mr. Nickerson, which were inaudible to the reporter, respecting a contract.)
Mr. FALL. When was that contract made?
Mr. NICKERSON. That was made in 1904.
Mr. FALL. By whom was it made?
Mr. NICKERSON. That was before my time. I think it was the California Development Co.—old-timers could answer that—with the Mexican Government.
Mr. FALL. Thank you.
[Applause.]
Mr. MCPHERIN. Mr. Secretary and gentlemen, in the brief time allotted us we are compelled to assume for the purpose of this discussion that the necessities as far as they relate to the condition of Imperial Valley have been proved; that fact is evidenced by the passage of the act under which the investigations now before you have been conducted.

We have heretofore had a mass of information and data, and I think, for the purposes of this discussion, we can assume that the necessities as they at present exist are proven. I merely wish to retail for the information of the gentlemen from the States in the basin north of the proposed structure that Imperial Valley has a threefold problem—that of flood control, diversion, and the stabilizing of the water supply as it is required for use in the valley. The key to the situation is the construction of storage. When this is accomplished we will be relieved of the expenditures in the annual upkeep of the levee system, which at the present time have aggregated, as expended by the district, some $2,500,000. It will relieve the apprehension and the menace, a danger that occurs annually, in the high water stages of the Colorado River. Until that is provided we will not be in position to remove our present diversion from its location at Hanlon Heading to the Laguna Dam, as we are obligated by contract to do. That is imperative for the reason that the maintenance of the temporary structure or obstruction in the river at our heading is and has been a menace to the Yuma Valley. We are under contract to change that, and must do so. The stabilizing of the water resulting from the construction of the storage and the installation of the new diversion will make possible, and it will not be possible until then, the construction of a high-line canal for the irrigation of new lands, and will permit the extension of the irrigated area, and make it possible that the Coachella Valley procure this at another water supply.

It occurs to us that our project is only a part of the general scheme for the development of the ultimate resources of the Colorado River Basin. We believe it has a logical and necessary connection with the whole, and a completion of our project at the present time will not interfere with nor be an unconnected part of that whole development. Our entire suggestion is that the apprehension of other communities, that their rights will not be fully protected respecting future development, should not delay this present development. We wish to affirm in the strongest possible manner that we recognize the equitable, moral, and legal right of the States upstream to be guaranteed the future fullest opportunity of development of their own projects. We anticipate that the contract which will be entered into among the respective States as required by the act recently passed will cover that in the most comprehensive and satisfactory manner to all of the States in the basin. But our thought is this: That at the present time for the purposes of immediate construction there is no other agency available to us than that of the Government to control, regulate, and provide the plan and the financing of that part of the whole project in which we are so immediately concerned, and we anticipate that the Secretary, by consultation with the representatives of the upstream States, and having in mind the provision, the intent, and the requirements of the compact act, will be able to provide a plan for immediate construction and financing that will guarantee the rights of every State and make possible immediate progress.

Mr. Fall. May I ask you a question, sir? When was the original diversion made, about what year, if you know, for the irrigation of Imperial Valley?

Mr. McPherin. Work commenced in 1900, in April.

Mr. Fall. That is for the irrigation of Imperial Valley?

Mr. McPherin. Yes, sir.

Mr. FALL. Now, this Laguna Dam that you speak of, where is that with reference to which point of diversion?

Mr. MCPHERIN. That is upstream, some 15 miles above Yuma.

Mr. FALL. By whom was that dam constructed?

Mr. MCPHERIN. By the Government through the agency of the Reclamation Service.

Mr. FALL. That is to provide water for what is known as the Yuma project?

Mr. MCPHERIN. Yes, sir.

Mr. FALL. Also for the Yuma Indians under that project?

Mr. MCPHERIN. Yes, sir.

Mr. FALL. And your contract with it, referred to by the speaker who preceded you, Mr. Nickerson, is with the Government, that you shall have the right to remove the point of your present diversion from the Colorado River to the Laguna Dam at some time in the future?

Mr. MCPHERIN. Yes, sir.

Mr. FALL. It is supposed to cost you approximately a million or a million and a half dollars?

Mr. MCPHERIN. Yes, sir.

Mr. FALL. All right; thank you.

[Applause.]

Capt. T. J. WORTHINGTON, representing the Intercoast Council of American Legion. Mr. Secretary, ladies and gentlemen, speaking as a member of the State executive committee of the American Legion, as the official representative to this body, of the Intercoast Council of the American Legion of Imperial County, and in behalf of the ex-service men and women of the entire Nation, I wish to present a few facts and a few thoughts which we have felt in Imperial Valley, which will in a way take care of some of the pressing needs with reference to the ex-service men and women of the country.

We have what we consider in connection with this Boulder Canyon project a very constructive program. It is in full accordance with those things which have been advanced by the other parties in Imperial Valley, the other organizations from Imperial Valley. Imperial Valley to-day is 100 per cent united on one thing, that is the Boulder Canyon Dam and the All-American Canal under Government construction, Government ownership, and Government control. [Applause.] The very fact of the divided interests in Imperial Valley and the fact that they are united on this one thing certainly should convince any of you we are satisfied that it is the right thing. The lands to be irrigated by this All-American Canal, and that is the thing which we as an organization are more particularly interested in, consist of approximately 200,000 acres in the one particular project. The poorest of that land is as good as the average Imperial Valley land. The best of it is better than any of the Imperial Valley land. All of it, it has been said by those who are in a position to know, a great proportion of it will be worth $500 an acre the minute that water is put on. I do not think, myself, that is an exaggeration.

I have a copy of a program outlined by the Intercoast Council after months of deliberation, after getting the advice from the council and the different interests which are interested in this project, and with your permission, Mr. Secretary, I would like to read the program. It is short, and it comments on a few of the reasons for making the findings which we have. [Reads:]

The following resolution was adopted by the Imperial County Interpost Council, American Legion, Department of California, in special session assembled at El Centro, Calif., December 10, 1921, to be presented to Secretary Fall at conference called by him in San Diego, December 12, 1921.

We recommend:

(1) The immediate construction by the Government of the Boulder Canyon Dam and the All-American canal at Government expense and same to remain under Government control.

(2) That the Government supervise the distribution of all power rights and privileges.

(3) That ex-service men and women of the Nation be given a preferential filing right to all arid or agricultural land under this project for a period of at least 90 days.

(4) Owing to the fertility of the land within this project and the consequent intrinsic value thereof when properly reclaimed from their desert state, that disposition of such lands be made in areas of an average of 40 acres to one applicant or entryman.

(5) That filings on these lands shall be nonassignable for a period of at least 12 months from date of entry.

(6) That such applications to enter as now exist and which have not been allowed, upon lands heretofore withdrawn, or which may hereafter be withdrawn from entry by the Government under this project be canceled.

(7) That the Secretary of the Interior be empowered to cooperate and contract with such authorized State agencies as may be in position to assist in the reclamation and irrigation of public arid lands and to dispose of portions of such public lands to such State agencies, conditioned upon their assisting ex-service men and women in the reclamation thereof in tracts—not exceeding an average of 40 acres to any one person.

I hereby certify that this is a true copy of the resolution above referred to.

T. J. WORTHINGTON.

An explanation of two or three of these items is required: No. 3, with reference to the preferential rights, it has been suggested by many we extend that to a period of six months. When we think of the millions of ex-service men and women in the United States, hundreds of thousands of whom are looking for a small home where they can establish themselves, some place where they can be helped to help themselves, we realize that the small amount of land which we have is not going to last for any time at all. That land will all be gone immediately it is thrown open to entry, therefore we have recommended this limit as we do, practically in accordance with the limit which now exists of 60 days. We are receiving now hundreds and hundreds of communications from all over the United States with reference to the land in Imperial Valley. The entire Nation is looking this way to see what we are going to do for them.

With reference to No. 4, the 40-acre provision, it is this: We of the Legion do not want to see these lands made speculative in any way, shape, or form; we do not want to ask the Government to step in and provide the means whereby ex-service men, regardless of what we think of them, can come in there and by clearing 80 or 160 acres of land on which the Government is going to provide water, make a fortune for themselves immediately. We are only looking for homes for these people, something that will give them an opportunity to be independent, not necessarily wealthy. We are specifying an average of 40 acres because we realize there may be certain tracts wherein a man could not have 40 acres—however, it will be up to the departments to decide and adjudicate these particular conditions—but we are asking for the 40 acres for the reason that we want to establish as many homes as we can possibly establish and at the same time give the man something that will make him independent; and to those who know Imperial Valley, 40 acres of Imperial land properly farmed will make any man independent, and that is far better than to give that same man 160 acres and let him try to farm it, particularly when his finances will be limited, as are the finances of these men.

The filings on this land will be nonassignable. I just answered the Secretary with reference to that question; we want to absolutely prevent any phase of speculation. We ourselves, if it were possible, would place more drastic restrictions on the assigning of these lands; we would like to fix it so that these lands could not be assigned for a period of five years, but that is statutory and we can not touch it; that such applications as now exist on lands and which have not been allowed on lands heretofore withdrawn or which may hereafter be withdrawn from entry by the Government under this project be canceled. Every acre of this land, ladies and gentlemen, has already been filed upon; applications for filing have been entered, I mean. The Secretary perhaps knows that these entries are in existence to-day, the filings of some of them date back for years, and we apprehend that many of these applicants will get together and, with the proper counsel, hold up this whole proposition, while they will worry the Land Department with the possibility of getting their applications allowed. The applications were made in anticipation of a speculative proposition, and in order to make this a monumental ex-service man's proposition we must of necessity wipe out anything and everything but a bona fide application for entry.

"That the Secretary of the Interior be empowered to cooperate and contract with such authorized State agencies as may be in position to assist in reclamation and irrigation of arid lands," and so forth. The State of California now has functioning a veterans' welfare board created by our last legislature. That veterans' welfare board has certain moneys on hand to-day. If we were in a position to get hold of land of this kind to-day, they are in a position to expend a million dollars right now of moneys lying in the Treasury waiting to be spent to put that land in shape for use by the ex-service men, and we are simply making the suggestion, or recommendation, rather, that the Secretary of the Interior be empowered to cooperate with agencies of that kind; nothing speculative about it at all. This land is purchased or taken over by the veterans' welfare board, improved, and turned over to the ex-service man ready for him to go to work on.

With reference to the veterans' welfare board, their chairman, Capt. Nichols, is present, but owing to the limited amount of time we have he will not address you; but he has authorized me to make the statement that his board absolutely indorses this program from start to finish. The State organization, of which I have the honor to be a member, and which has also an official representative with us to-day—Walter Kibbe—is right back of this program from start to finish. They are willing to back it up in any way that they possibly can for the benefit of the ex-service men and women of the Nation. We also have the assurance that when the time comes for us to get back of the Secretary with proper force, our national legislative committee, a committee of the national executive committee of the American Legion, will also use all the power that they have—and I want to assure you it is considerable—to see that this wonderful proposition goes through. The whole thing resolves itself back into the one thing we must have in order to get water onto these lands—we must have the Boulder Canyon Dam at Government expense, under Government control, and those things which go with it, which is control of the All-American Canal, and in behalf of the ex-service men and women of the entire country, not only of California, but of the entire Nation, I beseech you to get back of this thing with all the force that you have to assist us in making this the thing which we seek to make it. I know that the Secretary and Mr. Davis will both appreciate your efforts from that angle alone. They are with us, heart and soul, and we assure them that the ex-service men of the country realize that and are going to be with them to the limit. [Applause.]

Mr. FALL. Is it the desire of the ex-service men for an All-American Canal?

Capt. WORTHINGTON. Yes, sir.

Mr. FALL. Do the ex-service men recognize and expect to have protected the Mexican right?

Capt. WORTHINGTON. The ex-service men realize and appreciate the fact that there are certain vested interests in Mexico which must, of necessity, be protected, not alone because they are legal rights, but because they are moral rights. There is no disposition on the part of any ex-service man who is in a position to speak—and I have not heard it on the part of any other—to take from the lands in Mexico, or from any other lands or other States up the river, or from other irrigation in this State, any rights which they should have. We realize that we have got enough of our own if we get what we want. We do not need the thing which the other fellow has and we are only too anxious to help him get and keep what he has already got—get more and keep more.

Mr. FALL. You live in the Imperial Valley?

Capt. WORTHINGTON. I have lived in Imperial Valley for many years.

Secretary FALL. Are you familiar with the conditions there?

Capt. WORTHINGTON. Yes.

Mr. FALL. Can Mexican rights be protected from the high-line canal, as the American canal?

Capt. WORTHINGTON. As I understand it, the building of the Boulder Canyon Dam and this high-line canal, or as it is commonly known, the All-American Canal, will be the one thing which will absolutely protect Mexican rights, and there is nothing else that will do it. [Applause.]

MIKE LIEPERT. (Reads:)

To the Hon. ALBERT B. FALL,
Secretary of the Interior.

GREETINGS:

In response to your invitation, transmitted through the Hon. Phil D. Swing, Member of Congress from the eleventh district of California, the Imperial County Farm Bureau begs leave to place before you our needs in the matters of irrigation, flood protection, power development, and reclamation of the arid public lands in Imperial Valley and immediate vicinity.

The farm bureau is composed of elected representatives of 18 farm communities, comprising all sections of the irrigated district of Imperial Valley. Its members are the owners of the land, the tillers of the soil, the direct users of water for irrigation only on the United States side of the international boundary line, and hence have the greatest and most direct interest in the problems which you have called us into consultation to consider.

Organized originally for the purpose of solving the distinctive difficulties of agriculturists, the bureau was immediately brought face to face with the overwhelming importance of problems connected with irrigation and its kindred projects, and hence assumed active participation in those matters which keenly affected all industries in which farmers participated and upon which depended the developments, progress, security, and prosperity of all residents and investors of the valley.

Through negotiations and with the assistance of the United States Reclamation Service, the officials of the Department of the Interior, the Department of Agriculture, the California State Agricultural College, and the University of California a general policy has been developed and formulated upon which all Imperial Valley, State, and National interests have united, which has the approval of State and Federal engineers, and which forms the agenda of the conference to be held at San Diego December 12.

That the standing, influence, and strength of the farm bureau may not be discounted, we beg your indulgence in reciting a few pertinent points of Imperial County Farm Bureau history.

The Imperial County Farm Bureau organized in December, 1915, with seven centers represented.

In 1916 proposed and arranged a conference of the United States Reclamation officials and Imperial Valley representatives to discuss measures to secure relief from unstable water diversion.

In 1916 proposed and joined in requesting the Secretary of the Interior and the University of California to investigate Imperial Valley conditions regarding flood protection, irrigation, and reclamation of arid lands in pursuance of which a board of engineers made such investigation and joined in a report sustaining the contentions of the farm bureau.

In 1917 the farm bureau compiled, in response to a request of such board of engineers, a declaration of its policies in which it proposed a division between lands in the United States and Mexico on an acreage basis of the costs of flood protection and irrigation, also the construction of storage works sufficient to insure flood protection, irrigation of all lands then reclaimed, and the reclamation of all public lands possible, such works to be constructed and maintained by the United States Government. In the same declaration was suggested the creation by Federal law of a Colorado River commission to adjust all disputes arising between the States adjoining and interested in the Colorado River Basin.

In 1917 the farm bureau suggested and advocated connection of Imperial Valley's canal system to Laguna Dam, the construction of a high-line canal to serve mesa lands, drainage of lands in Imperial irrigation district, consolidation of all irrigation activities and services in the board of directors of Imperial irrigation district.

From its organization the farm bureau has fostered, supported, and contended for the construction of a diversion system wholly on United States soil, popularly known as the all-American canal, but questioning the advisability of such plan and at this time admitting the soundness of the proposition.

Among other achievements of the farm bureau in which we take particular pride was the fact that the first official declaration favoring reservation of public lands for service men was made and promulgated by this organization in 1918.

In many other ways the farm bureau aided in reaching the present defined policy of Imperial Valley in water matters, and was also active in carrying on, fostering, and caring for policies and programs for the successful winning of the war, the prosperity and progress of agriculture, and civic and public betterment.

Through resolution and motion, during its entire history, the farm bureau has developed its present policy regarding irrigation, flood protection, reclamation of arid public lands for ex-service men, development of hydroelectric energy, until at the present time our principles may be defined in the following declaration:

The Imperial County Farm Bureau favors and asks the cooperation and assistance of the United States Government in the securing of—

1. Irrigation security and extension by means of a storage dam to be constructed in Boulder Canyon of the Colorado River.

2. Protection from flood dangers by proper control of Colorado River waters flowing over and through the Boulder Canyon Dam.

3. Economical and secure irrigation by means of a canal connecting with Laguna Dam and constructed wholly on United States soil to connect with the present canal system of the Imperial irrigation district north of the international boundary, which is popularly known as the all-American canal project.

4. Reclamation of all arid lands in Imperial and Coachella Valleys which can be irrigated by gravity by means of a high-line canal connecting with the all-American canal.

5. Allotment of public lands to men and women who served in the United States armed forces during any period of war, with reclamation on such terms that those most in need of assistance can be financed and given the aid which a grateful Nation feels is due.

6. Development of hydroelectric energy from the waters flowing from the Boulder Canyon Reservoir and those waters which flow through the canals connecting with Laguna Dam.

7. Financing, construction, ownership, and control of all the above projects and their products to rest in the United States Government, through its proper departments and bureaus.

8. That all of such units shall be considered portions, incomplete in themselves, of a unified project, under no conditions to be separated one from the other.

Advancing as reasons for our advocacy of such project, we submit:

That the lands, and their owners, of Imperial Valley have always been and are placed at a disadvantage by the present system of diverting water through Mexico. That costs are not and can not be equably apportioned between the two interests, because lands on the American side are compelled to stand as security for large issues of bonds, are taxed to meet deficits in expenses and construction of flood and irrigation works in Mexico, while Mexican lands are immune from taxation and can be compelled to pay for irrigation water only the rate charged in the United States, because of Mexican laws and provisions of the contract under which water is brought through Lower California.

That the interests of landowners in Mexico and the United States are in direct conflict, because Mexican lands seek additional reclamation through raising the Colorado River to a greater altitude, while security from floods in the United States requires the river channel to be at as low an altitude as is practicable, and Mexican landowners have always been able to induce the Mexican Government to prevent carrying out of plans formulated in the United States for this purpose.

That because of these conditions in a land of pioneers who need financial aid for development purposes, the Federal farm loan banks and other loaning associations have refused to enter or have withdrawn from Imperial Valley, resulting in the landowners and farmers being compelled to pay a higher rate of interest for shorter term loans in order to secure funds to carry on operations; that for the same reasons securities issued by the Imperial irrigation district have low standing and can not be sold at actual value; that loaning institutions collect in penalties from Imperial Valley farmers and all other local institutions excessive interests because of the hazard under which they claim the loans are made, all to the loss, detriment, and credit injury of all Imperial Valley interests.

That because of the activities of the Imperial irrigation district, the Boulder Canyon dam site was developed and proved, at an expense to Imperial Valley, of over $100,000, which we believe gives the people of this valley a prior and superior interest in that project, which should be considered by the United States Government in its legislation.

That even under these adverse conditions, Imperial Valley in 1920 established a new production record for the United States, marketing and shipping to a hungry world over 45,000 carloads of food, or more than a carload per capita for each resident, adult or minor, in the valley, giving true indication of the inexhaustible resources of the valley under conditions which we foresee if our needs are properly protected by the policy here outlined.

That prosperity and progress of Imperial Valley and its surrounding trade territory require a secure, economical, and permanent water diversion, freedom from dangers of flood, increased area of cultivation, elimination of international complications, more complete Americanization of our population by the introduction of some thousands of those men and women who backed their Americanism with their lives, economical power for manufacturing purposes, to the end that we may be a contented people, realizing our ability to remain in the land we have selected for our homes; that our schools may be upbuilded, our social institutions made permanent, our homes secure, our property safe, and our future assured.

In closing we wish to place additional stress upon our desire that storage, power development, river flow, permanent diversion, and soldier settlement shall be under the ownership and control of the United States Government, and shall be provided for under single legislative act of Congress.

Respectfully submitted.

IMPERIAL COUNTY FARM BUREAU,
By MIKE LIEPERT, *Vice President.*

Attest:
PAULINE LYON.

Signed this 8th day of December, 1921, at El Centro, Calif.

Mr. LIEPERT. I wish to make one statement in addition to that, that some of us might not realize, and that is, that there is not a question that comes up before the farmers of Imperial Valley, no matter what it is, even to the question of the schools, but what it has its root in the water system; or, in other words, the present water situation over in the valley has its effect. It deters or holds us back, jeopardizes any work, no matter what it is, although it is not directly connected with the water. Mr. Secretary, the Imperial County Farm Bureau indorses the Secretary's policy and comprehensive scheme of the Colorado River development and truly is behind the rrigation district in solving its problems.

H. H. CLARKE. Ladies and gentlemen, you know I think we are wasting an awful lot of good time. Before lunch I was tempted to rise from my chair and make a motion that I believe it was the unanimous opinion of everybody present that the whole matter had been settled since the withdrawal of the few objections that there had been, and that I believe we were all unanimously in favor of the program that has been placed before us by our worthy Secretary and Mr. Davis.

A great many of you people probably do not know that we have had some conflicting interests in Imperial Valley. They have been lightly touched upon here by the last speaker. He is not well posted, because if he were, he would know that to-day there is not a conflicting interest in Imperial Valley. [Applause.]

In Imperial Valley, on the north side, I own something like eleven or twelve or thirteen hundred acres, all under cultivation. Consequently my financial interests are not all on the American side of the Imperial Valley. I am also the manager of what has been referred to—and a good many times with the nose turned pretty high in the air—as "the Mexican interests" on the lower side of the valley. We are farming below the valley somewhat extensively; our interests are identically the same. Questions have come up between us—on both sides of the valley—from the Imperial side, thinking that the Mexican side was not doing its fair share, on the Mexican side thinking that the American side was not doing what was right by them. This is the situation as I understand it from the last few conferences that I have had with members of the irrigation district, and we have agreed upon a policy, and we are carrying it out. I believe those things are all of the past; I hope so.

Now, I, as an American farmer, somewhat extensive, as a representative of the large interests below the line—not the Mexican interests; I do not mean the Mexican Government interests; I mean the private interests below the line—I want to say that I am heartily in accord with the program of the Legion as it was placed here to-day before our Secretary. I am heartily in accord with the American Government building the Boulder Canyon Dam. We have always been in accord with it; we have always been and are to-day. I am speaking now from the Mexican side of the situation, ready to contribute our share of the building of that Boulder Creek Dam.

Now, from the American point of view—I am kind of a Jekyll and Hyde; I have to be on both sides of the line. It is a little hard to get both right so that I do not conflict sometimes, but I believe that, being interested as I am on both sides of the line, I can say from an absolutely fair standpoint, and I believe it is only fair that the land below the American line should contribute to the building of this Boulder Creek Dam; and I know that it is the desire—and it has been so stated for many years past—that whenever the proper work on the river, permanent work, was started, that the interests below the line were ready to contribute their share, and I can say that that is the opinion to-day of the people who own the lands.

Now, let us just forget everything but the one main thing—I do not see where there can be any possible question brought here before these people—I am speaking of the Secretary and Director Davis—that should conflict in the least with the program that they have outlined to us here. They say that the Government should build the Boulder Creek Dam and the All-American Canal. I say it, too. I say this, further, that I think the Government should own for all time the Boulder Creek Dam. I say that they should retain the power interests of the Boulder Creek, and any other power on the Colorado River, and that that power be licensed to those people who may be the best able to build these power lines and carry them on, and let that money eventually pay the Government back for the work that they have done [applause] and let that money make a sinking fund. Let it make a sinking fund so that, should anything happen to this dam requiring the expenditure of a lot of money, they have not got to turn around and assess everybody for it, but they have got the money accumulated from the sale of the power. As far as power is concerned, let it go to the man who will pay the most to the Government for it. [Applause.]

Mr. Secretary, I have nothing further to say.

Thomas C. Yeager. Mr. Secretary, on July 8 of this year we requested that you hear certain suggestions of the Coachella County water district on the report as prepared by Mr. Davis, and as that report affected the Coachella Valley. You granted us that privilege, and shortly after that we prepared a letter on the suggestions that we had to make, and with your permission I will read the letter now. [Reads letter:]

Coachella Valley County Water District of Riverside County,
Coachella, Calif., October, 1921.

Hon. Albert B. Fall,
Secretary of the Interior, Washington, D. C.

Dear Sir: The Coachella Valley county water district on July 8, 1921, respectfully requested that you hear the suggestions of this district upon the report prepared by the Reclamation Service and submitted to you under the Kinkaid Act.

One of our principal reasons for asking for this hearing was that we might be given an opportunity to study and digest the report as it affected our interests, and to consult with the various districts and organizations interested in this development. and come to you in unison upon a plan that is feasible, practical, and yet harmonious to the spirit of the report, and request your approval and support.

In order that we may expedite the presentation of our position, and our objections to certain parts of this report, we submit to you the following proposal, which has received the indorsement of several of the various interests, and, as we believe, all interests can indorse the same as being a fair program for all to follow:

Suggestion No. 1:

That the Boulder Canyon Dam, also All-American, and High Line Canal, and canals necessary for the irrigation of lands below said dam be immediately constructed by the United States Government, and that the cost of such construction be borne by sale, rental, or other distribution of the power developed therefrom, provided, however, that each State or political subdivision thereof interested in this project shall have the right at its election to contribute to the cost of the construction of said project, and receive for its contribution a pronortionate share of power at cost. We urge that any and every development hereafter authorized to be undertaken on the Colorado River by the Federal Government, municipalities, private capital, or any combination of interests be required in both construction and operation, by legal enactment, to give priority of right and use, first, to river regulation and flood control; second, to use of storage water for irrigation; third, to development of power.

Suggestion No. 2:

If the Government refuses, for any reason, to enact legislation in conformity with the outlines in paragraph 1, it is proposed that legislation be enacted authorizing—

1. That the Government participate in building an all-American and high-line canal in proportion to the irrigable area it holds in public domain and Indian reservations, and that the lands and districts to be irrigated under the proposed project participate in the cost of its construction in proportion to their irrigable area.
2. That the Secretary of the Interior be authorized in this legislation to contract with any agency or agencies to build a dam on the Colorado River for the power to be developed by such construction, who will agree to construct the same under the following provisions:
   1. Under Government control, supervision, and regulation.
   2. Give priority to river control for flood protection.
   3. Provide storage of water for irrigation needs.
   4. Concede reservation of power sufficient for district needs by district being permitted to contribute to cost of power development.

In submitting this proposal we do so upon the theory that this entire project is a reclamation project, primarily for the development of agricultural land, and should be constructed by the Government, under the Interior Department, retaining or disposing of the power as your department may best determine, as an asset or by-product of this development.

We are cognizant, however, of the difficulty probably to be encountered in securing any legislation of appropriation sufficient to finance this enormous undertaking, and therefore have endeavored, under paragraph 2 of the above proposal, to provide a means of financing this project in the event Congress should refuse to enact legislation to appropriate sufficient moneys for this construction or provide other means of raising the funds.

The construction of the Boulder Canyon Dam or other dams investigated and filed upon by the Southern California Edison Co. has shown the possibility of the development of enormous hydroelectrical horsepower and at the same time the regulation of the Colorado River for irrigation purposes and for the protection of the proposed irrigable area from the ravages of flood. This horsepower is of sufficient value to prompt the city of Los Angeles and the Southern California Edison Co., and perhaps other organizations, to offer to undertake this construction, affording primarily protection to the irrigable area for the power to be developed. We therefore, in view of these offers, believe that the Secretary of the Interior would have no trouble in contracting for the construction of the dam on the Colorado River in accordance with the above outline without cost to the lands to be irrigated. While we submit them as an objection to the allocation of the cost of the dam, or any portion thereof, to the agricultural territory as provided in this report, we are aware that these offers have been submitted since the formulation of the report of the Reclamation Service, and perhaps could not have been foreseen by this department. Our confidence in the Secretary of the Interior further prompts us to respectfully submit that the entire project should be constructed and supervised by this department without the appointment of a board for the purpose of allocating the cost as outlined in paragraph 3, page 41, under title "Recommendations." Further, that these offers eliminate the necessity of allocating any of the costs of the dam to the area to be irrigated.

We respectfully request, Mr. Secretary, that you give consideration to the or privately owned, should pay their proportional share per acre for the construction of a canal sufficient to carry water to them. This is entirely feasible and practical, as the lands to be irrigated under this project are of sufficient value, and are by nature very productive, and will stand the cost.

We respectfully request, Mr. Secretary, that you give consideration to the position of this district, and we wish to assure you that it is our sincere desire to support you in any fair plan for the irrigation and development of the lands under the project, as they are, with water, some of the most productive lands within the United States.

COACHELLA VALLEY COUNTY WATER DISTRICT,
By S. S. M. JENNINGS, *President*.

Mr. YEAGER. That, Mr. Secretary, was our position at that time, and since that time some of the modifications, as stated by Mr. Davis this morning, eliminate the objections that we desired to raise with you, principally that any of the cost of the dam be charged against the agricultural territory. We therefore want to assure you that the Coachella Valley County Water District and the Coachella Valley want to give you our support on any plans that you might devise for this work; all we desire is irrigation of our lands and its development.

A. E. WARRINGTON. Mr. Secretary, ladies, and gentlemen, I represent the part of the Palo Verde Valley. The valley is only a very small part in the wheel of the development of the Colorado River Basin. It represents, however, the all to a great many of the courageous men and women who have made their homes there. The Palo Verde Valley comprises approximately 40,000 acres under cultivation, producing annually a crop valuation of from five to six millions of dollars. There are remaining approximately 50,000 acres of land to be put under cultivation, which will, of course, when developed, more than double the present crop production of that valley.

The Palo Verde Valley—the farms that are being farmed there and the homes of the sturdy pioneers who are tilling the soil—is irrigated from the annual floods of the Colorado River and protected by an earthen dike. We know that dike is sufficient to withstand the waters that overflow the banks of the Colorado River, but experience has also taught us that those dikes are nothing more than shale when the mighty Colorado attacks that bank by direct impingement against it.

The astounding fact or discovery this year, in analyzing our tax statements in the city of Blythe, was that 50 cents and more out of every dollar paid for taxes went for the maintenance of that strip of earth. Mr. Secretary, our only reason in asking to be heard here to-day is to assure you that the 6,000 people who reside in that valley, and those who reside elsewhere but who are interested financially there, are as a unit back of Director Davis's plans for the development of the Colorado River. [Applause.]

We want, above everything else, flood protection, and we urge that it be not subordinated to either interstate or international adjudication of the waters of the Rio Colorado. That question and other controversial matters can be settled while that Boulder Canyon Dam is being constructed, and I think I speak advisedly when I say that nobody's toes are going to be trampled upon or nobody's interests are going to be imperiled, whether it is State, community, or individual, by the construction of the first unit in the development of the Colorado River project which will act as a retarding influence on the annual floods of the Colorado, and thus protect the lands that are now being cultivated from these waters.

We also wish to assure you, Mr. Secretary, that we hope the Boulder Canyon Dam can be constructed wholly by governmental agency and with governmental funds, notwithstanding the Palo Verde Valley stands to do its utmost and to pay whatever sums at whatever times you may designate, observing further the hope that the public use and disposition of the power will more than compensate us for any such sums so advanced. I thank you. [Applause.]

Ed. F. Williams, of the Palo Verde district. Mr. Secretary and gentlemen, I asked for two minutes and do not intend to have three minutes' grace.

The feasibility of a reservoir at Boulder Canyon of sufficient capacity to control the flood waters of the Colorado River and provide irrigation water for all the land that can be irrigated below that point has been determined to our satisfaction, determined by engineers in whose ability we have unalloyed confidence, and to demonstrate our confidence, at our last stockholders' meeting of the Palo Verde Mutual Water Co., we passed a resolution authorizing our board of directors to contribute our quota to that dam's construction whenever called upon by the Secretary of the Interior, and the Secretary of the Interior to determine that quota; no one can do anything further. Since that time, however, we have been informed that perhaps the power interests could pay the entire cost of this construction. We have made a little statement defining out attitude, which I will read with your permission, Mr. Secretary. [Reads:]

Considering the far-reaching possibilities in arid-land reclamation and in hydroelectric power development by the storage and control of the flood waters of the Colorado River, and realizing that a recurrence of a low-water flow similar to that of the years 1902 and 1903 would cause a loss in value of crop production amounting to many millions of dollars, that the flood menace of the Colorado River increases each year, and that there is an impending possibility of property destruction from this menace that would more than offset the entire cost of the construction of the proposed Boulder Dam; we propose that the Federal Government should immediately begin the construction of a reservoir at Boulder Canyon as the first unit in a project designed to eventually include the entire basin of the Colorado River in its irrigation benefits, and all of that portion of the West which it is practicable to serve, in its power benefits.

We believe that by the construction of a dam at Boulder Canyon sufficient hydroelectric power can be produced to defray by the marketing thereof the cost of the dam's construction, and we recommend that the financing of the proposed project by the disposal of the hydroelectric power be given first consideration; that the Federal Government, through such agencies as it may see fit to employ, should direct the distribution of the benefits, reserving to itself the title to and operation of the dam proper and the power appurtenances, but delegating to the various districts affected the administration of such irrigation and flood-protection benefits as may be allotted to them.

We propose that the power concessions be distributed to such public and private corporations as may become bidders for same, exercising the following order of precedence:

First. Irrigation and municipal corporations within the Colorado River Basin and closely adjacent thereto.

Second. Municipal and public corporations not within the Colorado River Basin proper.

Third. Private corporations.

We feel that in the development of hydroelectric power the fundamental object of the proposed reservoir's construction should not be lost sight of; that, regardless of the desirability of maximum power production, consideration must at all times be given—

First. To the control of the flood waters of the Colorado River.

Second. To the impounding of adequate irrigation water to provide for the irrigation during seasons of low-water run-off.

In the event that it be determined that the funds derived from the disposal of hydroelectric power be insufficient to pay for the dam's construction, then we believe that all districts that may derive benefits by the dam's construction should be contributing agencies thereto.

And we of the Palo Verde district pledge ourselves to participate in the cost of the construction of the Boulder Dam in proportion to the benefits that may be derived therefrom.

[Applause.]

Col. B. F. FLY, of Yuma Valley. Mr. Secretary and friends of this conference, I came to San Diego for the express purpose of saying something, but my friend the distinguished Secretary of the Interior, and my warm personal friend Director Davis, have taken all the say out of me.

I represent the commercial interests of the city of Yuma. I want to say to you that every man, woman, and child in the city of Yuma—in Yuma Valley, and on my beloved Yuma Mesa—stand squarely back of Secretary Fall and Director Davis in the enunciation that they have made here to-day. [Applause.]

We want the Boulder Canyon Dam built at the earliest possible moment. [Applause.] We want that dam built by Uncle Sam [applause]; operated by him for all time to come. [Applause.] Any power that is developed at that great dam, we want the price fixed to the consumers of this country by Uncle Sam. [Applause.]

We do not want a repetition of what we have just recently gone through on the Yuma project. We were compelled to buy power from the Southern Sierras High Power Co. to lift the water on my beloved Yuma Mesa. We entered into contract with them—I say "we," a company at Yuma, a distributing company—for a certain period of years at a certain number of cents per kilowatt for 15 years. That contract reduced to writing was to stand. We do not want this new power manipulated by the whims and caprices of any rate board of any State in the Union. [Applause.]

Well, gentlemen, I am only repeating the words that came from the mouth and the pen of that great statesman, our lamented friend, Franklin K. Lane, when over his signature he stated to Congress, in advocating the passage of the bill that made the reclamation of the Yuma Mesa possible, that it is the only frostless belt in the United States. [Applause.] You California fellows take that, if you please.

Now, then, our only method of getting water on the mesa is through electric energy. We have to lift that water 68 to 70 feet, and we put the first unit under water the first week in January of this year. Since we began the construction of that first unit which is under a special law, your Congress—the rate board—the rate-making board of California has raised the rates of the Sierras High Power Co., and that automatically raised our rates, notwithstanding we are under a 15-year contract. We do not want that to happen in the operation of the Boulder Canyon Dam, Mr. Secretary. [Applause.] It will not happen if it is left in the hands of Uncle Sam. [Applause.]

We in Yuma, probably more than any other community in the United States, know the beneficent influence of Uncle Sam in constructing this great reclamation project. We have the great Laguna Dam that stretches from the California side to the Arizona side, 4,780 feet long, across the river; that is our diversion dam, raising the water 10 feet; we take it out of our canal. Imperial Valley—God bless her, we are her friends—now wants to build the All-American Canal, and before she can ever build that she must go to Laguna Dam and take her water out of our dam. We have been in favor of that ever since it was first suggested. We are still in favor of it. We want the Government to distribute every drop of water that flows over that great dam, because we know it will be equitably distributed, and in the hands of our distinguished Secretary and in the hands of our great Director of the Reclamation Service, who has been in that service from the day it was founded up to the present time, I say we in Yuma have absolutely no fears but what everything will be in exact accord with the wishes of the vast majority of the people of the country. I thank you. [Applause.]

B. M. Bridge. Ladies and gentlemen, it affords me great pleasure to follow our distinguished brother from the Mesa. I happened to get in Yuma before Brother Fly did—in 1904—and in 1905 the Colorado River began to show us some of its tricks. It reminds me of a great power—or in other words, some of you probably taught school, and you have had some little boys and little girls, and some that were not so little—some of them were Irish, and you know what a young Irishman can not think of it isn't worth while for some other fellow to try to think about it—that energy has got to be spent—a child doesn't care much; he does care, too; but he will take the punishment; but he has got to expend that energy, and he will do it if he gets the punishment to-day; he will do it if he gets the punishment to-morrow, but the energy has got to be expended. If it is directed in the right channel it may be expended so that it will do somebody some good and help him, too, but if it is let go on a haphazard course, it is liable to hurt somebody else and him, too. This Colorado River puts me just exactly in mind of that boy. But we have got a place, as our honorable Secretary and our director have hunted out and found, where we can hold the power of this great Colorado River, grown to be a big Irishman and not an Irish boy, to-day, where we can bind him up up there—where we can take that power and that force that has been running wild, that has been coming down over you Imperial Valley people—it has made us sit up many a night in the Yuma Valley, and get out on the sand hills, get away from his pranks—in a few words, it can be fixed, so you can hold that boy there, and that energy that is going to waste, we can let come down and help and build in the good channels of trade, make almost everybody in the United States own a home, and want to make it; we can make that power through the Government of the United States directed by men like Director Davis and our Secretary here such that it will benefit the farmer, and when farmers benefit you are benefited, every power in the United States is benefited, and this energy to-day is the thing that we want controlled by the United States Government. The power that is generated from that to be controlled by the Government, the prices that the power produces that goes out to you and me in our homes in electric energy, we want that price fixed and controlled by Government in a fair, equitable manner to the power—to the corporations that produce that energy, and to us who use that energy. [Applause.]

H. C. Brandt, West Side Water Co. Ladies and gentlemen, I represent a great number of land locators and owners on the west side of Imperial Valley entirely beyond the present irrigated area. Many of us have been there for years endeavoring to get water on these lands. We believed originally that it was easy; we have found since that it was a long course, but we are still struggling, and we want to indorse the policy of our Secretary and Director Davis as expressed here this morning, and we are not only interested in the water, but also in the power, because much of our best land is above the gravity line and will require a slight pumping head, and for that reason we must have electric energy to raise that water to some of the best lands in Imperial Valley. We also believe that we have a frostless-belt mesa.

I thank you.

Frederico Ramos, of Mexico. Mr. Secretary, ladies and gentlemen, in order not to take too much of your time and attention I want to circumscribe my talk to three different items only.

First, the explanation to the persons here in this assembly of a Mexican delegation. After that, what that Mexican delegation has learned of your conventions, and after that, in the third place, what that Mexican delegation has obtained of your convention.

It has been by a cordial invitation of the secretary of the League of the Southwest extended to Gen. Obregon, President of our Republic, to the governor of the State of Sonora, the governor of the southern district—of the northern district of Lower California, and to some individual persons of Lower California that have been delegated to this commission.

The Mexican Government thought that the questions to be tried by the League of the Southwest and this convention were interesting, both from the standpoint of the league and the engineering standpoint, and as I am the commissioner of the Mexican section of the International Boundary Commission, my Government appointed me to attend those hearings and to report and to learn all about the western treatment and these meetings. Besides that Gen. Obregon personally appointed Engineer Delaroso (?) to give me a personal report about the same question, and there have been appointed also representatives of Lower California and of the State of Sonora and representatives of the chambers of commerce and chambers of Mexicali. All Mexican delegates agreed to make me the head of that commission in order for me to make an address regarding our proper interests.

I must say that we have learned many things about the technical question of the Colorado River from the legal and the engineering point of view. We have learned the most important thing, then, in hearing your honorable Secretary of the Interior, Mr. Fall, when he told us that in the development of all resources of the Colorado River every question, both from the interior point of view and from the international, would be from the standpoint of justice. [Applause.]

We know by the talk of your Secretary of the Interior it was not a matter of his duty to settle the international question, and we agree with him, and that is the reason we are present here.

In the third place, I must tell you what we have obtained by assisting at your convention. What we have obtained is that declaration of your honorable Secretary of the Interior which has placed us with character among you justifying our presence here. Allowing us to address this meeting confirms the assurance of Mr. Fall that justice shall always receive the approval of his Government just as must be expected of such a great Government, and of such a magnificent Government that governs such a magnificent country. [Applause.]

Louis E. Bartlett, representing the League of California Municipalities. Mr. Secretary, ladies, and gentlemen, I appear here this afternoon on behalf of the cities of California as president of the League of California Municipalities.

For your information, Mr. Secretary, I desire to say that this league is composed of 237 cities out of a possible total of about 250, and I think there is no city or town of a larger population than 2,000 that is not represented in this league. The league at its meeting last September had a very thorough discussion of the problem of municipal ownership, with its particular application to the development of the Colorado River Basin, and the league went on record in no uncertain terms as to what it thought should be done, and it is a matter of the greatest gratification to all of the cities and to all of the representatives of the cities that Secretary Fall has come out unequivocally as he has and stated that the Colorado River Basin is to be developed by the Federal Government and Boulder Canyon Dam is to be constructed. [Applause.]

That is the outstanding achievement, and great as the achievements of this administration may prove to be before the end, I want to venture my opinion that there is hardly any other subject in which the administration can ever be concerned where it will do so much good, not merely to those whom it immediately surrounds, but to the Nation as a whole, and our national life.

I desire to say most emphatically, on behalf of these cities that I represent, that we are back of you and we will champion anything that you may do to bring into fruition your plans for the Government building and control of the Boulder Canyon Dam. Let me read just a moment the final paragraph in the resolution of the league. [Reads:]

RESOLUTION ADOPTED BY THE EXECUTIVE COMMITTEE OF THE LEAGUE OF CALIFORNIA MUNICIPALITIES.

Whereas because of lack of coal and the fast diminishing supply of oil, cheap hydroelectric power is essential to the well being and development of California, and

Whereas the development of additional water supply is essential for the agricultural, industrial, and domestic purposes; and,

Whereas the great resources of unappropriated water and hydroelectric power lie in the public domain, in the great mountain systems of California, and in the Colorado River Basin, and have been held for the sole direct benefit of the people: Therefore be it

Resolved by the California League of Municipalities in convention assembled, at Santa Monica, September 29, 1921, That we call on the Federal Government and the Federal Water and Power Commission to maintain and carry forward the great reclamation policies as inaugurated by Theodore Roosevelt: Be it further

Resolved, That we call on the Federal authorities to build the necessary Boulder Creek Dam in the Colorado River Basin, and to hold the hydroelectric power that may be developed therefrom subject to the uses of the adjacent States and municipalities under public ownership.

RESOLUTION ADOPTED AT THE SANTA MONICA MEETING.

The League of California Municipalities congratulates the cities of San Francisco and Los Angeles on their leadership among American cities in the municipal ownership and operation of public utilities; and we pledge the people of both of these cities our support and cooperation in their courageous and far-seeing efforts to develop and distribute water and hydroelectric power in sufficient quantities to supply their rapidly increasing needs. We condemn the false propaganda by which certain private interests have sought to disparage and discredit public ownership of public utilities and foment jealousies and division among the cities and other communities of the State. We declare our purpose to work together, by securing under public ownership cheap and abundant water and power for all localities to upbuild California as an agricultural, industrial, and commercial State. We approve the principle that flood control, irrigation, and power development should each be provided and safeguarded in the order of their importance in the several projects to be undertaken. We indorse and approve the efforts of the city of Los Angeles to obtain for itself and the great Southwest the development of the Boulder Canyon of the Colorado River under public auspices and the efforts of the city of San Francisco to obtain water and power for the Bay Region from the Hetch Hetchy.

Mr. Secretary, we in California are already organized so that the cities can by some procedure organize themselves into districts and take advantage of some of the power and some of the water that may be developed in the magnificent project, but we have also a new method of cooperation which we hope to make definite by a constitutional amendment next year—California's water and power act, which will in a great measure make it easy for us to cooperate with the Federal Government in the development of these and similar projects. I shall not take your time to discuss that matter now, but I beg leave to file with you as an exhibit in this matter a copy of the California water and power act, and a copy of the proceedings of the League of Municipalities of last September. May I do so?

Mr. Fall. Certainly.

Mr. Bartlett. And with this brief word, Mr. Secretary, on behalf of the cities of California, I want to thank you for the splendid interest you are taking in the development of our State and our sister States. [Applause.]

CALIFORNIA'S WATER AND POWER ACT.

To the public:

This description of California's water and power act is submitted to aid you in reaching a decision as to the merits of the proposed constitutional amendment. You are urged to study this material carefully and write a letter, giving your conclusions regarding the act, to the State campaign committee, 905 First National Bank Building, San Francisco. Full and explicit answers will be given to any questions you may wish to ask. You will find here explanations of what this act is, why it was prepared, and by whom it was initiated. We believe that this outline, with the full text of the bill on the reverse side, will provide sufficient data to justify you in pledging enthusiastic support to this campaign. No more important issue has ever been presented to the people of California. Study the list of the sponsors of the act and you will be convinced of the good faith of this movement. Then write to the committee and get on record with a pledge of assistance in the campaign.

RUDOLPH SPRECKELS,
Executive Director Campaign Committee,
905 First National Bank Building, San Francisco.

(Following is a full text of the act:)

(Explanatory notes in brackets have been inserted in the following text. They will give a clear understanding of the machinery and procedure of the act. Note carefully the fact that this measure does not impose any burdens of taxation and that bonds are issued only as returns from water and power are assured.)

PROPOSED AMENDMENT TO CALIFORNIA CONSTITUTION—ARTICLE XIVa—WATER AND POWER DEVELOPMENT.

SECTION 1. It is hereby declared to be the policy and purpose of the State to conserve, develop, and control the waters of the State for the use and benefit of the people.

SEC. 2. [Irrigation and municipal interests and geographical divisions must be represented on board. This provision included to prevent domination of board by any interest or locality. Recall provided for incompetence or corruption.]

The California Water and Power Board, hereinafter called the board, is hereby established, composed of five members who shall be appointed by the governor, one of whom he shall designate as chairman and executive officer, who shall devote all his time to the duties of the office. The members shall be qualified electors of the State and shall be so appointed as to be fairly representative of the State geographically and of its irrigation and municipal interests. Members shall hold office for four years, except that of those first appointed one shall hold office until January 1, 1924, one until January 1, 1925, one until January 1, 1926, and two until January 1, 1927. The chairman shall receive a salary of $15,000 per annum. The other members shall receive a per diem of $20 while engaged in the performance of duty, and all members shall receive their necessary expenses. The legislature may increase their compensation. Each member shall execute to the State such bonds as the governor may require. The legislature shall have power by a two-thirds vote of all its members to remove any one or more of the members of the board from office for dereliction of duty or corruption or incompetency; and it shall be the duty of the legislature to provide by law for the removal of members by recall, following so far as pertinent the provisions of Article XXIII of the constitution, except that a successor of any member recalled shall be appointed by the governor for the unexpired term, as shall be done in the case of a vacancy otherwise arising. A majority of the members shall constitute a quorum for the transaction of business, and no vacancy in the board shall impair the right of the remaining members to exercise all powers of the board. The board shall maintain its office at Sacramento.

SEC. 3. [Full and adequate powers given to board. Limitation put on price board may pay for energy. This included to prevent payment of excessive prices to private companies, in cases where it is necessary to purchase additional energy.]

The board shall have power—

(*a*) To acquire by purchase, lease, condemnation, gift, or other legal means, land, water, water rights, easements, electric energy, and any other property necessary or convenient for the purposes of this article, and likewise to acquire, and also to construct, complete, and operate, works, dams, reservoirs, canals, pipe lines, conduits, power houses, transmission lines, structures, roads, railroads, machinery, and equipment, and to do any and all things necessary or convenient for the conservation, development, storage, and distribution of water, and the generation, transmission, and distribution of electric energy. No electric energy shall be purchased by the board at a price to exceed one-half of 1 cent per kilowatt hour at the power plant, based upon a 50 per cent load factor, except for stand-by service, as provided in section 12 hereof;

(*b*) To purchase, acquire, produce, manufacture, or otherwise provide facilities, materials, and supplies, raw or finished, and any property or thing necessary or convenient to the accomplishment of the purposes of this article;

(*c*) To supply water or electric energy or both to the State, political subdivisions, and other users, and subject to the provisions of this article, to prescribe the terms of contracts and fix the price thereof and collect the same;

(*d*) To use the waters and the lands of the State, or any material therein or thereon, and to require the reservation from sale or other disposition of such lands and material as, in the opinion of the board, will be required for the purposes of this article;

(*e*) To require for the reservation of water from appropriation for such periods as it may provide;

(*f*) In the name of the State to apply for and accept, under the provisions of the laws of the United States or of any State, grants, permits, licenses, and privileges in the opinion of the board necessary for the accomplishment of the purposes of this article;

(*g*) To cooperate and contract with political subdivisions of this State and with the approval of the governor, with the United States and other States, concerning the conservation and use of interstate and other waters and the generation and use of electric energy, and the acquisition, construction, completion, maintenance, and operation of works necessary or convenient for the accomplishment of the purposes of this article;

[Political subdivisions may acquire or construct their own distributing systems by the use of State credit. Full title will vest in the subdivision as soon as paid for.]

(*h*) To acquire or construct for political subdivisions distributing systems for water or electric energy bought from the State, upon terms that, in the opinion of the board, will repay to the State within 25 years the cost thereof with interest. The title to or interest of the State in such systems shall vest in the political subdivision when paid for;

(*i*) To sue and be sued, and to exercise in the name of the State the power of eminent domain for the purpose of acquiring any property, or the use or joint use of any property, deemed by the board necessary for the purposes of this article;

(*j*) To provide itself with suitable office and field facilities, and to appoint, define the duties, and fix the compensation of such expert and technical officers, legal and clerical assistants and other employees as it may require, subject to such civil service regulations as the board may provide;

(*k*) To define projects and to adopt rules and regulations to govern its activities;

(*l*) To exercise all powers needful for the accomplishment of the purposes of this article and such additional powers as may be granted by the legislature.

Sec. 4. The California Water and Power Finance Committee, herein called the committee, is hereby established, composed of the governor, controller, treasurer, chairman of the board of control and chairman of the California Water and Power Board, all of whom shall serve thereon without compensation. A majority of the committee shall constitute a quorum for the transaction of business.

Sec. 5. [This is a State control and State development act; the benefits are State wide and the pledge of responsibilty, based upon State assets of water and power, must be assumed by the State as such. There is no citizen of California who will not participate, directly or indirectly, in the returns of cheap water and power, new population and stimulus to industry. Hence the full faith and credit of the State is placed behind the bonds, which are sold only as they are needed for each project, and sufficient funds are provided to make the State, in cooperation with its political subdivisions, the dominant factor in water and power development.]

Bonds of the State of California, not exceeding the sum of $500,000,000, may be issued and sold from time to time to carry out the purposes of this article, and the full faith and credit of the State of California is hereby pledged for the payment of the principal of said bonds as the same mature, and the interest accruing thereon as the same falls due.

Sec. 6. Bonds herein authorized shall be issued and sold by the committee as herein provided and shall be serial bonds, payable in not more than 50 years from date of issuance, and shall be in such form or forms and denomination or denominations, and subject to such terms and conditions of issue, conversion, redemption, maturities, payment, and rate or rates of interest, not exceeding 6 per cent per annum payable semiannually, and time or times of payment of interest, as the committee from time to time at or before the issue thereof may prescribe. The principal and interest thereof shall be payable in

United States gold coin. Said bonds shall be signed by the treasurer and countersigned by the governor by his engraved signature; and the great seal of the State of California shall be impressed thereon; all coupons thereto shall be signed by the treasurer by his engraved or lithographed signature. The board shall pay, from funds available to it, the expense of issuing and selling such bonds and the necessary expense of the committee in connection therewith.

[Safeguards provided against injustice in sale of bonds; people given an opportunity to participate; sales to be regulated by special committee, and methods must be in conformity with public interest.]

Bonds herein authorized may from time to time first be offered at not less than par as a popular loan, under such regulations prescribed by the committee from time to time, as will in its opinion give the people as nearly as may be an equal opportunity to participate therein; but the committee may make allotment in full upon applications for smaller amounts of bonds in advance of any date which it may set for the closing of subscriptions and may reject or reduce allotments upon later applications and applications for larger amounts, and may reject or reduce allotments upon applications from incorporated banks and trust companies for their own account and make allotment in full or larger allotments to others, and may establish a graduated scale of allotments, and may from time to time adopt any or all of said methods, should any such action be deemed by it to be in the public interest: *Provided*, That such reduction or increase of allotments of such bonds shall be made under general rules to be prescribed by said committee and shall apply to all subscribers similarly situated. Any portion of the bonds so offered and not taken may be otherwise disposed of by the committee in such manner and at such price or prices, not less than par, as it may determine. The committee may cancel any of the bonds so offered and not taken and reissue them in different denominations.

SEC. 7. [Initial bond issue provided for expenses until projects begin bringing returns. The principal and interest of these bonds later to be paid from returns from water and power developed, and not by taxation. This section makes it possible for the board to conduct preliminary operations before projects yield returns. No projects will be approved or begun unless returns are definitely in sight, not only to pay for construction but to reimburse the State for any money advanced for the opening period of the system. There is no possible drain on existing State revenues under this provision. This merely is an auxiliary aid to the board in remaining solvent during the period of initial outlay and has no bearing on the fundamental processes of the act. Note carefully the concluding sentence of section 9.]

Bonds herein authorized shall be issued and sold only for the acquisition of such property and rights, and for the acquisition, construction, development, completion, operation, and maintenance of such projects as the board may deem necessary or convenient to the accomplishment of the purposes of this article: *Provided*, That from time to time upon written requisition of the board the committee shall issue and sell bonds not exceeding in the aggregate $5,000,000, the proceeds of which shall be placed in the water and power revolving fund in the State treasury, which fund is hereby created, to be used by the board for the purpose of defraying its expenses, acquiring property, rights, facilities, materials, and supplies, carrying charges during construction and meeting other costs incurred in carrying out the purposes of this article: *Provided further*, That if at any time the revenues from projects shall be insufficient to pay the interest on and principal of outstanding bonds as the same fall due, the committee, with the consent of the governor, in order to avoid appropriations from the general fund and resulting taxation, may issue and sell bonds to provide funds required to make such payments of interest or principal.

[Bonds issued to the extent of funds required for each project only, after investigation has given assurance that water and power in sight will pay for construction and all incidental costs in 50 years. Issue definitely limited to this basis of assured returns. This section provides the means of placing the credit of the State progressively behind localized development, as demand justifies and as each project is proven physically and financially feasible. Reclaimed water and power must pay the bills—no taxation, no bond indebtedness on land, no payment of principal or interest from other State revenues.]

Except as otherwise provided in this article, the committee shall issue and sell bonds only upon the written requisition of the board, stating the amount of money required and the purpose for which it is to be used, and accompanied by a duly authorized certificate of the board describing the property or rights to be acquired or the project proposed, and stating the estimated cost thereof and showing the same to have been investigated and approved, and in the case of a project, that plans and estimates therefor, a copy of which shall be annexed to such certificate, have been prepared and adopted by the board and further certifying that, in the opinion of the board, the revenue from the property or rights to be acquired or from the proposed project, together with available revenues from other projects, will be sufficient to pay within 50 years, in addition to other necessary expenses, the principal and interest of the bonds requested to be issued. The proceeds of the sale of such bonds shall be placed in the treasury and shall be used by the board exclusively for the purpose for which the same were issued.

SEC. 8. The board shall establish such rates for service as in its judgment will provide, in addition to the expenses of operation, maintenance, depreciation, insurance, and reserve for losses, funds to pay the principal and interest of all bonds issued under this article as the same fall due, together with all sums which may be advanced from the general fund and interest thereon as herein provided.

[Water and power at cost. Board is limited in adjustment of rates to making each project pay its way out in 50 years. Provision for reserve for losses and surplus consistent with good business, but protection against profits which would prevent users from getting water and power at cost. Flexibility in adjusting rates, within the foregoing limitations. Provision for repayment, by returns from water and power, of sums drawn from revolving fund as established in section 7.]

Each project, as the same may be defined by the board, shall be charged by the board with its cost, which shall include its proper share as fixed by the board of all expenditures from the water and power revolving fund, and the share so charged shall be credited to such revolving fund, which shall be replenished, to the extent of the amount so credited, from the proceeds of bonds sold to provide funds for the cost of such project. The board shall establish such rates for the service furnished by each project as in its judgment will pay, within 50 years, such cost thereof and the expenses of operation, maintenance, depreciation, interest, insurance, and reserve for losses: *Provided*, That where the rates are intended to provide for the repayment of expenditures made in acquiring or constructing distributing systems for political subdivisions they shall be so fixed as in the judgment of the board will repay the amount of such expenditures with interest within 25 years. The board may change rates when in its opinion advisable to meet changed conditions, and shall always keep its rates as near the amount required to pay such cost and expenses as practicable, and shall fix similar rates under substantially similar conditions.

SEC. 9. All revenues of the board, except proceeds from the sale of bonds, shall be paid into the State treasury and shall be applied, first, to payment of the expenses of the board, costs of operation, maintenance, depreciation, insurance, and losses; and, second, to the payment of interest on and principal of said bonds.

[Construction can not proceed under this act unless commensurate returns are immediately attainable. With these assets in hand, the State is justified in placing its full financial responsibility behind the bonds for such construction. These bonds must be sold in the open market, and for this reason it was both necessary and expedient to put the State's revenues behind them. The State in turn is safeguarded by the known, unfailing demand for power and water. Note carefully that State credit is pledged only to the extent of proven water and power assets.]

If at any time the moneys in the State treasury applicable to the payment of interest or principal of said bonds shall be insufficient to pay the same as it falls due, moneys shall be temporarily advanced from the general fund for that purpose; and there is hereby appropriated from the general fund in the State treasury such sum annually as will be necessary to pay such interest and principal; and there shall be collected each year in the same manner and at the same time as other State revenue is collected such sum in addition to the other revenues of the State as shall be required to pay the sums appropriated for payment of interest and principal as herein provided; and it is hereby made the duty of all officers charged by law with any duty with regard to the levy and collection of said revenue to do and perform each and every act which shall be necessary to collect such additional sum.

All moneys paid from the general fund in the State treasury for principal of or interest on such bonds shall be returned into said general fund out of the revenues of the board as soon as the same become available, together with interest thereon from the several dates of such advances until so returned at the rate of 6 per cent per annum compounded semiannually.

SEC. 10 [This appropriation to allow the board to organize and begin operations. To be paid out of returns.]

Out of any money in the State treasury not otherwise appropriated, the sum of $250,000 is hereby appropriated to be credited to the board, and an equivalent amount shall be returned into the general fund in the State treasury out of the first moneys available in the water and power revolving fund.

SEC. 11. [The committee may establish such funds in the State treasury as in its judgment may be required to carry out the purposes of this article.]

Moneys herein provided for the board shall be drawn from the treasury by warrants of the controller on demands made by the board and allowed and audited by the State department of finance.

The board, the controller, the treasurer, and the committee shall keep full and particular account and record of all their proceedings under this article, and shall transmit to the governor annually a report thereof, not less than 1,000 copies of which shall be printed, to be by the governor laid before the legislature biannually, and all books and papers pertaining to the matters provided for in this article shall at all times be open to the inspection of any officer or citizen of the State. All accounts of receipts and disbursements shall be audited annually by the State department of finance.

SEC. 12. [As between those otherwise equally entitled, localities nearest the source of supply get the first call on water and power. This is the basic principle upon which to settle sectional issues and accusations of water and power "grabbing." It provides the only absolute protection against any one section getting an undue share of the advantages under the system. It is the only possible solution of the problem of allotment. It is fundamentally just. Prior right of State and political subdivisions established.]

The State and political subdivisions shall have a preferred right to water and electric energy controlled by the board as against privately owned public utilities selling water or electric energy to the public, and no contract or act of the board shall interfere with such preferred right. As between those otherwise equally entitled, the board shall supply water or electric energy to political subdivisions near the source of supply, to the extent of their reasonable needs, in preference to those more remote.

[Allowance of sale of limited amount of power to privately owned utilities to provide for "stand-by" service, necessary in all large power operations. This means an interchange of service in times of breakdown, etc. Limitation put at 20 per cent to safeguard against sale of people's power to corporations.]

The board shall not supply water to a privately owned public utility for the production of electric energy and shall not supply directly or indirectly to privately owned public utilities which sell electric energy or water to the public more than 20 per cent of the total amount of electric energy or water under its control, and contracts therefor shall not extend over a longer period than five years or be renewed before one year prior to their expiration. Before making or renewing such a contract the board shall publish a notice of its intention so to do at least 6 days each week for a period of 60 days, in at least one newspaper published and circulated in this State and designated by order of the board for that purpose; and at least 30 days' prior notice shall be mailed to the legislative bodies of all counties and incorporated municipalities and to irrigation districts situate within the territory which, in the opinion of the board, may use such electric energy. Public utilities taking such contracts shall be required to provide the board with stand-by service at reasonable rates.

SEC. 13. [Full and absolute protection for municipalities or irrigation districts who wish to proceed independently of the system. This section makes it impossible for the board to reserve water which any city or district wishes to use or to interfere with any natural or vested right of any political subdivision. Local autonomy is one of the foundations of the act.]

Nothing contained in this article shall prevent any political subdivision itself or in cooperation with other political subdivisions, from developing any water or electric energy owned or controlled by it; but plans for any such development hereafter proposed shall be submitted to the board for suggestions and criticism, so that the cooperation of the board may be secured, if practicable, for the fullest development of the proposed project. The board may acquire and develop any such project unless the political subdivision claiming the same shall have adopted plans and estimates for the development, and authorized bonds to cover the cost thereof, or shall do so within two years after the board shall have notified each political subdivision of its readiness to proceed with such development.

[Equitable method of condemnation provided, with court procedure, just compensation and damages, and trial by jury if desired by adverse party. No water or power system of a political subdivision may be taken without its consent.]

In any proceeding in eminent domain brought by the board under the provisions hereof, the determination of the board that the taking of the property described in the complaint is necessary for the purposes hereof, shall be conclusive evidence of such necessity. In any such proceeding the State may take immediate possession and use of any property required for the purposes of this article by paying into the court such amount of money as the court upon five days' notice to the adverse party may determine as reasonably adequate to secure to the owner of the property sought to be taken immediate payment of just compensation for such taking and any damages incident thereto.

In any such proceedings, trial by jury may be demanded and secured by any party thereto, and any proceeding begun under the provisions of section 23a of Article XII of this constitution shall be dismissed on the filing therein of a written demand by such party. Such demand must be filed within 30 days after service upon such party of process in such proceeding.

Property appropriated to public use may be taken under the power of eminent domain for the purposes hereof, but, except as otherwise herein provided, this article shall not confer power to take the property or works owned or controlled by any political subdivision used or proposed to be used for supplying water or electric energy, or both, without its consent.

SEC. 15. All public officers, boards, commissions, and agencies shall make available to the board all data and information in their possession required by the board, and shall render every assistance in their power in carrying out the provisions of this article.

SEC. 16. As far as practicable, consistent with the speedy development of its operations, the board shall so shape its plans as to furnish work during periods of unemployment.

SEC. 17. The term "political subdivision," as used in this article, is hereby defined to mean and include any public board, public quasi corporation, public corporation, water district, lighting district, municipal-utility district, public-utility district, irrigation district, municipal corporation, town, city, and county, city or county, having authority to contract for the purchase, sale, or use of water, water power, or electric energy, but shall not be construed to include any privately owned public utility.

SEC. 18. This article is self-executing, but legislation may be enacted in furtherance of its purpose and to facilitate its operation.

CALIFORNIA'S WATER AND POWER ACT—CONSTITUTIONAL AMENDMENT, ARTICLE XIVa WATER AND POWER DEVELOPMENT.

Places State credit behind immediate development of water resources for domestic use, irrigation, and electric energy, and furnishes water and power to people at cost, eliminating private profit from California's greatest natural resource.

Provides sufficient funds for necessary construction to meet every immediate demand in any part of State.

Protects localities from interference by State regarding their property or plans.

Provides State funds for constructing or acquiring local distributing systems for water for domestic use or irrigation or for electic energy. Distributing systems to become property of locality upon repayment of cost to State.

Cost of all construction or purchase of existing projects to be met by sale of water and power to people. Cost to be returned to State in 50 years. No additional taxation.

Engineering plans for any project considered on their merits. Construction proceeding as demand justifies.

Recall by the people of any member of the board having charge of State development.

Water and power to be sold to localities on contract with State. No bonding of lands or municipalities.

State bonds issued only as projects have been thoroughly investigated and approved.

State funds fully safeguarded. State in cooperation with localities, made dominant factor in water and power development.

Protects the people against political machines, one locality having advantage over another, cumbersome machinery, corrupt or inefficient management, seizure or control by corporations, purchase of private holdings by public at extortionate valuations, sale of power to private corporations beyond necessary limits of stand-by service, exhorbitant salaries, and against possibilities of overcharge to users.

ATTENTION.

To members of State campaign committee, and the public:

Everyone interested in California's water and power act should fully understand just what must be done to get it on the ballot for the general election of November, 1922.

There will be a new registration of voters after January 1, 1922. Only registered voters are counted on an initiative petition, and the petition must be filed in full 90 days before the election. Our understanding is that registered voters of 1921 will not be counted on a petition filed in 1922, unless the total required number of petitioners have been signed up and the petition completed in full and filed prior to January 1, 1922.

If we wait until 1922 to sign up the petition, we will find that very few voters will be registered prior to May. We would then have May, June, and July in which to sign up the required number of petitioners and file same 90 days before the general election. We would be in competition with various other petitions and would have lost the value of our present campaign, which can be conducted most effectively while getting the signatures to the petition.

The only conclusion is that the signatures must be had immediately for the initiative petition.

We must have about 60,000 verified signatures, which means that not less than 100,000 signatures should be secured to allow for those which will be thrown out.

These signatures should be secured and filed in full by December 10, 1921, to insure their verification prior to January 1, 1922, although names secured and filed from December 10 to December 30, 1921, may be counted if the county clerk with whom they are filed chooses to count them.

Therefore, we face the necessity of signing and filing 100,000 names during the three months of September, October, and November, 1921. The petitions must be properly filed in each county in which they are secured.

We must know that the right people are securing the names. We do not want our enemies pretending to do this work for us.

There will be great opposition to the measure, misrepresentation and falsehoods circulated broadcast by the power companies and their allied interests. Already they are organized and spreading their propaganda over the entire State. This is being done in the form of circular letters, syndicated news stories, star-chamber resolutions passed by public bodies controlled by the interests, and by every other method at their disposal. They have already gathered together and reprinted such unfriendly newspaper comment as they could find and given it wide private circulation.

Our publicity must be released. Public meetings must be arranged. Citizens must volunteer in all parts of the State to help in securing the 120,000 signatures to this petition immediately.

The "sinews of war" must be provided. No fight like this can be won without money. There are those among us who have and will contribute liberally, but this is the people's fight, and the burden can not rest on a few men's shoulders. Each must do his or her share. If each will contribute what he can, there will be ample funds to carry this fight to the greatest victory for the people ever seen in this or any State.

Everyone interested in the success of the California water and power act is requested to—

1. Give your pledge for such amount of money to the campaign fund as you can afford.
2. Interest friends in similar pledges.

3. Interview the editors of the newspapers in your locality and try to secure pledges of cooperation, reporting immediately as to results.
4. Interview the leaders of your local commercial bodies and ascertain whether or not an indorsement can be had for this measure, arrange for public meetings before local organizations, or for public mass meetings of citizens.
5. Send in lists of names, both local and in other parts of the State, whom you personally know as likely to be interested in this movement.
6. Send in names of dependable registered voters in your locality who will personally help in circulating the petition.
7. Make any suggestions that you think will advance this cause.

Make contributions by check, payable to Rudolph Spreckels, treasurer.

A general campaign fund has been created and will be budgeted over the following items:

(*a*) General expense of campaign headquarters.
(*b*) Printing, mailing, and distribution of campaign pamphlets and literature.
(*c*) News service sent to all papers of State.
(*d*) Public speakers' expense.
(*e*) Solicitors of names upon initiative petition (50 or more solicitors required).
(*f*) Solicitors for contributions to campaign fund.
(*g*) Research. Examination of methods and results obtained elsewhere through public ownership.
(*h*) Interstate and national relations, establishing cooperation with the National Government and other States.

Your immediate and earnest cooperation is invited.

EXECUTIVE BOARD, STATE CAMPAIGN COMMITTEE,
By RUDOLPH SPRECKELS, *Executive Director.*

WHAT?—HERE'S HOW NEW MEASURE WORKS.

California's water and power act will place State credit behind local development of water and power.

It will enable users to obtain water and power at cost.

It will make water and power resources pay for development without taxation and without a cent of public charge for interest or principal on bond issues.

This act is a proposed constitutional amendment. It will be put on the ballot by the initiative. The circulation of initiative petitions will be begun immediately.

The amendment declares that it is "the policy and purpose of the State to conserve, develop, and control the waters of the State for the use and benefit of the people."

To carry out this purpose, State credit is made available for political subdivisions. Such credit will be used for the construction of works for the storage, diversion, and distribution of water for irrigation, domestic, or industrial uses, or for the generation and transmission of hydroelectric energy.

MACHINERY.

The following means of achieving this end are provided:

The California water and power board, of five members, empowered to carry out the purposes of the amendment. The members will be appointed by the governor, with the provision that "they shall be appointed so as to be fairly representative of the State geographically and of its irrigation and municipal interests."

Full powers delegated to the board to do all things necessary under the act, including provision for financial ways and means, condemnation of property by equitable court proceedings, a method insuring fair valuation, and safeguards against confiscation or invasion of public or private rights.

The California water and power finance committee, consisting of the governor, the State treasurer, the chairman of the board of controls, and the chairman of the California water and power board. This committee will advise with and assist the board in matters of finance and act without compensation.

PROCEDURE.

Any county, city, city and county, town municipal corporation irrigation district, public utility district, municipal utility district, electric lighting district, water district, or other public corporation having authority to contract for the use of water or power may avail itself of the privileges of the act. Any group or association of such political subdivision may act in unison.

Such unit or units may apply to the board for the construction of works for the delivery of water or power, or both.

The board examines plans submitted, and if the project is physically and financially feasible it enters into a contract with the applicant for the construction of such works.

The applicant in this contract agrees to buy the water or power thus supplied at rates which will provide for interest, maintenance, operation, and reserve for losses and reimburse the State in 50 years. Rates must be made on a cost basis.

The board then issues and sells State bonds to the extent of the funds required for constructing such project. The interest on the bonds is limited to 6 per cent.

With the funds thus obtained the board will construct the desired project and deliver water or power to the political subdivision at rates as nearly at cost as practicable, the board having only such latitude in rate making as may be necessary to keep it a going concern.

A political subdivision may call upon the board to acquire or construct a distributing system, upon execution of a contract by which such subdivision agrees to repay the State in 25 years, or to take water or power at rates which will write off the indebtedness with all incidental charges in 25 years. At the end of this time the title to such distributing system shall vest in the political subdivision.

The board may develop a surplus from any project or projects and proceed with the broad coordination of water and power development, as the basis of such coordination is scientifically established, to the end that all California's water and power resources may eventually be put to beneficial use.

Such development, including that immediately responsive to the needs of different localities and the more gradual coordination, must proceed without interference with the natural or vested rights of any municipality or irrigation district, or any political or geographical subdivision, or person. Rigid safeguards against invasion of either private or public rights are included in the amendment.

A limitation of $500,000,000 is placed upon the total of bonds to be progressively issued and paid for from water and power returns. Interest and principal must be paid entirely from returns.

It must be borne in mind that this measure does not impose on the people taxation of any kind, and that it does not necessitate a bond issue in the ordinary sense. These bonds must be liquidated entirely by the known, reclaimable assets and they will pay their own way. No burden of either interest or principal will fall on the taxpayers.

PEOPLE WON'T PAY TAXES OR INTEREST.

Isolated sections of California's water and power act have been reproduced and circulated to make it appear that this measure proposes a bond issue which would be borne by the people—that the development work contemplated would be paid for by taxation.

This is not only positively and definitely untrue, but it is a deliberate and unscrupulous misstatement of the whole method and purpose of the act.

The bill is specifically drawn to avoid taxation, paying all costs from revenues.

There is no bond issue which would be paid for out of present revenues or by bonding of land or by taxation of the people.

What is provided is a progressive issuance of State bonds which must be liquidated by the water and power reclaimed.

The bonds are issued and sold only to the extent of the proven assets obtainable as each project is proposed. Principal, interest, operation, and maintenance must be paid out of these assets.

A limitation of $500,000,000 is placed upon the State credit which would thus be pledged. The people may vote extensions as they desire.

Once for all, get this straight: Any talk of "30,000,000" interest payments, except and until revenues will meet them, is a deliberate and entirely groundless attempt to deceive. There are no payments of any kind by the people, except the purchase of water and electric energy; there is no possible drain on the State's resources. There is no increase in the State budget, except as the business of producing and selling water and electric energy justifies it and meets all cost.

FOUNDATIONS.

California's water development act will place the credit of the State behind localized water and power development. To justify such use of State credit, it is necessary, first of all, to show that the State has a sound and financial foundation for such procedure.

Fortunately, this work already has been done by the State railroad commission, the engineers and financial experts of the power companies, the State water commission, the State engineer, and the State university.

The State railroad commission, in a special report to the governor last October, set forth $1,500,000,000 as approximately the sum that must be spent on water and power development in California in the next 10 years.

Estimates of necessary expenditures by representatives of the power companies vary from $1,000,000,000 to $2,000,000,000. H. G. Butler, former State power administrator, estimates that if all the potential power in the State were developed, it would bring a return at eastern rates of $1,000,000,000 per year.

The State water commission, in its last annual report, says there are 9,699,600 acres of land in California available for irrigation. It is safe to conclude that irrigation would add $100 an acre to the value of this land. This means $969,960,000 of new wealth.

ARMY OF 75,000,000.

According to studies of separate sources, without regard to large-scale coordination and repeated use, there is approximately 8,000,000 horsepower still undeveloped in the State. This power is equivalent to the work of about 75,000,000 men.

On the Colorado River alone there is available 4,300,000 horsepower. This is enough to supply the industrial needs of 60,000,000 people; and the water, after being thus used, would be sufficient to irrigate 2,000,000 new acres.

The foregoing is a sufficient and satisfying accounting of the wealth which is lying on California's doorstep. Is it possible to conceive a sounder economic basis upon which to pledge the State's credit?

If you had a horse in your pasture which you had never tried to harness, you might be in doubt as to whether it would be worth while to break it to the plow, but if shrewd neighbors should make repeated and persistent efforts to buy it at increasingly high prices, you would conclude that the horse had possibilities.

California has 8,000,000 unharnessed horses in its pasture in the Sierra. Will they work for the corporations and return a profit to individuals, or will they work for the State and return prosperity to all the people?

If you believe in the latter alternative, sign the initiative petition, and vote for California's water and power act a year from next fall.

WHY?—BASIC REASONS FOR WATER BILL.

The people of California need profitable employment, productive land, freedom from exploitation, business opportunity, and stability and safety in agriculture and industry.

California, as a State, must compete against other States for population and industry. In order to win it must offer to its citizens more of the foregoing requirements than other States.

The people of the State and the State itself must succeed or fail together. Two things are necessary for such joint success. They are land and energy.

In California land must have water. The State has no coal, and its oil supply will fail. But it has 15 per cent of the potential hydroelectric resources of the United States. Hence, the two success factors of California statehood and manhood become water and power.

ENOUGH FOR ALL.

There are about 8,000,000 acres of land in California which may be irrigated and there is water enough running to waste to irrigate this land, supply domestic and industrial needs, and develop supplies of power sufficient to meet all possible demands.

These resources can be developed by the people and distributed to users on a cost basis. This will mean millions of new acres under cultivation, great industrial and manufacturing development, low rates for farmers, householders, and manufacturers, and a tremendous and continuing increase in population and wealth.

The foregoing summarizes the reasons for the preparation of California's water and power act. This act will place the control and development of water and power resources in the hands of the people. It will insure to the people the benefits of their use and it will open to the people the gateways of land and opportunity.

Private development of these resources will not gain the ends desired. The recurrent water and power shortage has proven that the corporations can not do the job. They are now paying around 8 per cent for money for development work. Consumers bear the burden of this high interest rate. Householders are now paying rates from 1,500 to 2,000 per cent above the cost of energy production.

PAY THEIR OWN WAY.

The employment of State credit will make these undeveloped resources pay their own way. The State can get money for 5 or 6 per cent. The consumer gets the benefit of this difference of 2 or 3 per cent in interest plus the difference between construction and operation on a cost basis and a system which carries all the overhead of private profits, high salaries, uncoordinated development, sectional competition, expensive propaganda, and political organization.

The failure of the people of the State to evolve a collective plan of development has resulted in stagnation in industry and agr.culture, retardation and lethargy in business, and the failure of California to grow in population and wealth in accordance with its resources.

California's water development act is the long-awaited solution of this problem. Sign the initiative pet.tion and vote for it in November, 1922.

MEMBERS OF EXECUTIVE BOARD.

Following are the members of the executive board of the State campaign committee, which will put forward California's water and power act:

William Kent, Kentfield, chairman; John Randolph Haynes, Los Angeles, vice chairman; Rudolph Spreckels, San Francisco, executive director and treasurer; Horace Porter, mayor of Riverside, secretary; L. L. Dennett, Modesto; William Mulholland, Los Angeles; William J. Locke, Alameda; Mrs. Anna L. Saylor, Berkeley; J. L. Matthews, Covina; Miss Esto B. Broughton, Modesto; Louis Bartlett, mayor of Berkeley; Franklin Hichborn, Santa Clara; Mrs. Herbert A. Cable, Los Angeles; Clyde L. Seavey, Sacramento; C. W. Koiner, Pasadena.

Heaquarters of the committee have been opened at 905 First National Bank Building, San Francisco. Other offices will be opened at Los Angeles, Sacramento, and Riverside. While the above board will have executive charge of the campaign, the State campaign committee will be the basic organization which will carry on the campaign. Additions to the committee are being made rapidly, and its final personnel will show a complete geographical, occupational, and urban and rural representation of the entire State.

WILL IT WORK?—PEOPLE'S CONTROL ALWAYS SUCCESS.

Will it work?

That is the question which the voters will want to have answered before they vote on California's water and power development act, which will place State credit behind local development and insure water and power at cost. The answer is that it has worked and is working wherever it has been tried. Here are just a few of the "high spots" in the record of successful municipal ownership and operation.

More than 3,500 cities own and operate public waterworks. They have reduced the cost of water to an average of 43 per cent less than that charged by private companies. They have paid or are paying for their plants out of earnings.

The Chicago municipally owned plant has returned as much as $3,000,000 in a single year. The rate is far less than that charged by private companies and the wages paid by the municipality are higher than those paid by the corporations.

Omaha, which took over its plant only a few years ago, has made six successive reductions in water rates.

RECORD OF SUCCESS.

There were 2,318 cities owning and operating municipal light and power plants in the United States in 1917.

The Cleveland (Ohio) municipal electric-light plant has for many years sold electric current at one-third the average charge of private companies. At this rate the municipality makes a profit of $194,000 per year.

In 1902 there were 815 municipally owned plants. In 1917 there were 2,318, an increase of 1,803. While privately owned plants increased only 80 per cent from 1902 to 1917, municipally owned plants increased 180 per cent, or over twice as fast. While the municipal plants were only 24 per cent of the whole number in 1902, by 1917 they were over 35 per cent of the whole.

In the period from 1881 to 1902 there were 13 plants which changed from municipal back to private ownership, while 170 plants went from private to public ownership.

WHY LOS ANGELES PROSPERS.

The Goodyear Rubber Co. was one of a number of great industries which have recently established plants in Los Angeles on account of the abundance of cheap water and power supplied by the municipality. In a public statement F. A. Sieberling, president of the company, said:

"By a process of elimination we got down finally to Oakland, Los Angeles, and San Diego. When we came to survey the coast, as we did for six weeks with skilled men, we found that Los Angeles had the cheapest fuel on the coast; we found that Los Angeles had the cheapest power on the coast; we found that Los Angeles had the only supply of fresh water sufficient for our needs. We had to come to Los Angeles if for no other reason than water."

The Los Angeles division of public works has prepared a curve of prosperity, based on population, new industries, bank clearings, etc. The curve shoots steadily upward from the month the city began supplying its own water and power. It has thus supplied users at rates which have attracted a great volume of new business and built up new prosperity, and at the same time have returned a substantial profit to the city.

Is it surprising that Los Angeles believes in municipal ownership, or that it should be strongly represented in the campaign for California's water and power act?

STORY OF ONTARIO.

In 1912 the Province of Ontario, Canada, began public ownership and sale of power. Their investment under the control of the commission is now $76,000,000; the municipal investments in plants total $23,000,000, making a total expenditure of $99,000,000. They began by serving 28 municipalities and 34,967 customers. In 1919 they served 235 plants and 180,000 customers.

Not one cent of the charges on this expenditure has been paid out of taxes by the people. Rates for power and light carried the entire load.

The average cost to consumers is about one-third the charges of private companies. In Hamilton the average rate to consumers per horsepower per year is $12.70. The private company rate in Buffalo, even nearer to the same source of supply, is $40 per year.

New Orleans and Seattle own and successfully operate great port and terminal facilities.

Chicago operates a $4,000,000 light plant and a $70,000,000 water-works system.

The San Francisco municipal street railway system has proven an unqualified success and has maintained a 5-cent fare in the face of increasing costs.

"BEFORE AND AFTER."

Study these comparative rates showing costs before and after municipal ownership:

	Before municipal ownership.	After municipal ownership.		Before municipal ownership.	After municipal ownership.
	Cents.	*Cents.*		*Cents.*	*Cents.*
Cleveland, Ohio	12.5	3	Calgary, Canada	14	5
Winnipeg, Canada	20	3	Jamestown, N. Y	10	5
London, Canada	9	3	Seattle, Wash	20	5.5
99 Canadian municipalities, average	10.4	3.1	Holyoke, Mass	18	6
Pasadena, Calif	15	5	Palo Alto, Calif	20	7

WHO?—ALL SECTIONS IN ON PEOPLE'S BILL.

California's water and power act was prepared and the campaign to make it a law will be conducted by a committee composed of men and women who are representative of all sections and interests of the State. It was decided that a general committee, including membership from the north and south, the agricultural and urban section, public organizations, and various groups and interests would be the most effective means of presenting this amendment.

Cooperating actively in drafting the amendment was a special committee appointed for this purpose by the League of California Municipalities at its meeting in Sacramento May 20. This committee has indorsed the measure. The league includes about 250 cities in its membership.

Members are being added daily and the completed committee will be so thoroughly representative of divergent factions and localities as to give final disproof of any charge that any single element has inspired this movement.

Among those who assisted in the preparation of the amendment are the following:

Rudolph Spreckels, San Francisco, financier; William Kent, former Congressman; W. B. Matthews, attorney for the Los Angeles board of public works; L. L. Dennett, counsel for the San Joaquin irrigation districts, and representing San Joaquin County in the State senate; Clyde L. Seavey, city manager of Sacramento and former chairman of the State board of control; Dr. John R. Haynes, of Los Angeles; Dr. Horace Porter, mayor of Riverside; William J. Locke, executive secretary of the League of California Municipalities and city attorney of Alameda; E. G. Scattergood, engineer of the Los Angeles power bureau; Louis Bartlett, mayor of Berkeley; Robert L. Shinn, city attorney of Sacramento; William Kehoe, former State senator; Paul Scharrenburg, secretary of the State Federation of Labor; Ray C. Eberhardt, assistant attorney for the Los Angeles board of public works; Esto Broughton, assemblywoman, of Modesto; Franklin Hichborn, Santa Clara; Francis J. Heney, Los Angeles; Charles W. Cleary, assemblyman, of Tulare County; Albert Braunschweiger, member of the Riverside board of public works; Senator William J. Carr, Pasadena; Mrs. Herbert A. Cable, Los Angeles; Mrs. Anna L. Saylor, assemblywoman from Berkeley; J. L. Matthews, Los Angeles, member of the State water commission; J. P. Mallon, of Colusa and Oakland; Judge D. J. Hall, city attorney of Richmond and chairman of the legislative committee of the League of California Municipalities.

The officers of the committee are: William Kent, chairman; John Randolph Haynes, vice chairman; Rudolph Spreckels, executive director and treasurer; Dr. Horace Porter, secretary.

Following are the members of the executive board: William Kent, John Randolph Haynes, Rudolph Spreckels, Dr. Horace Porter, L. L. Dennett, William Mulholland, Clyde L. Seavey, Miss Esto B. Broughton, J. L. Matthews, Louis Bartlett, Franklin Hichborn, Mrs. Herbert A. Cable, and C. W. Koiner.

There is no member of the above committee who can not show a record of years of disinterested public service. They are familiar with the water and power problem from years of work and effort in behalf of the people's right to control and use the public resources.

"DIVIDE STATE, ALIGN COUNTRY AGAINST CITY," CAMPAIGN SLOGAN OF ENEMIES OF PEOPLE'S BILL.

Here is the great principle of equitable distribution of water which California's water and power act will write into the law of California:

"SEC. 12. As between those otherwise equally entitled, the board shall supply water or electric energy to political subdivisions near the source of supply, to the extent of their reasonable needs, in preference to those more remote."

The power companies and allied financial interests will base their campaign against California's water and power act on an effort to align the north against the south and the city against the country. "Keep the State divided," is their campaign slogan.

Public organizations which the corporations can control have been and will be used to stir up this sectional issue. The interior counties committee of the Riverside Chamber of Commerce has circulated throughout the State a power company letter designed to arouse the rural districts and the northern sections against the so-called Los Angeles power grab. This letter was printed on the official stationery of the chamber of commerce and signed by the president. The natural conclusion was that the chamber of commerce was sending it out. Here is what Mayor Horace Porter, of Riverside, found out when he sought a copy of this letter:

"I asked the young woman attendant at the chamber of commerce for some literature," said Mayor Porter. "She offered pamphlets on various subjects.

"'I want a copy of that power letter which is being sent out,' I said. 'You will get that at the office of the Southern Sierras Power Co.,' she replied. 'Twelve thousand copies are being mailed from there.'"

APPEAL TO DISTRUST.

An appeal to sectional hatred and distrust is the basis of virtually all these misrepresentations. They have been circulated not only in California but in neighboring States. Nevada is being bombarded with the grotesque declaration that the new water measure is an onslaught on the water rights of adjoining States.

A State senator has been used to circulate crude misrepresentations on State senate stationery over his own signature. In this letter, sent to northern papers and individuals, he issues a warning against the rapacity of the south, which he implies is trying to seize all the power.

The State campaign committee includes men and women from the north and the south, the city and the country, and all have been zealous champions of the rights of their respective communities for years. It is sufficient to cite the public records of these men and women as final and absolute disproof of the charge that any one of them could or would participate in a plan designed to give one section an advantage over another.

The only advantage sought by the originators of this measure is the advantage of California. The one most imperative duty of all the citizens of California to-day is to unite on a program of California development—not of San Francisco or Los Angeles or San Joaquin or Sacramento Valley development. The control and use of water and power by the people is the foundation of this program. And bear this in mind:

There is water and power enough for all—to be had for the taking. Where there is an abundance, there is no fighting and bickering. That is the answer to any real or imagined issue of sectional competition. Put rats in a trap without food and they will gnaw each other; turn them loose in a granary and they are good friends.

W. B. MATTHEWS. Mr. Secretary, ladies, and gentlemen, I have the honor to come from and represent the city of Los Angeles. I am sure that the people of San Diego will permit me to further identify myself by saying that I come out of a little college in Kentucky, known as Center College [applause], which proposes to send to this city a bunch of Kentuckians and Texans who will have another great problem on the 26th day of this month.

Mr. Secretary, I am sure that this gathering of the people in this section and of the Southwest want me to say to you that we greatly appreciate and admire your way of becoming familiar with the western problem by coming west and seeking the information you need at points in the region concerned in that progress. [Applause.] Now, for the sake of brevity and conciseness, will you permit me to state the points and views that I am to present by reading from this paper [reads]:

Hearing before Secretary of the Interior Fall, at San Diego, Calif., December 12, 1921, on the report of Arthur P. Davis, Director of the United States Reclamation Service, upon the proposed development of Boulder Canyon Reservoir. Attitude of city of Los Angeles regarding the plan of development outlined in the report of Director Davis.

1. The city of Los Angeles favors and urges the development of the water and power resources of the Colorado River by the United States Government under a comprehensive plan, providing for flood control, irrigation, and power development.

2. The city of Los Angeles favors and urges as a unit in such general plan the development of Boulder Canyon Reservoir substantially on the basis of Director Davis's report, with subsequent modifications. The position of Los Angeles is set forth in a resolution adopted by the Los Angeles City Council on August 30, 1920, as follows:

"EXHIBIT A.

"RESOLUTION ADOPTED BY LOS ANGELES CITY COUNCIL.

"*Resolved*, That the Council of the City of Los Angeles, in keeping with the principle of public ownership embodied in our municipal charter, and with the overwhelming sentiment of our citizens, does strongly favor the obtaining by the city direct from the Colorado River of such quantity of electric power as, together with other power resources available to the city, will be sufficient for all future needs of its inhabitants.

"That, to such end, the council favors and urges the development of the Boulder Canyon Reservoir by the United States Government, or, if that be not provided for, then by the city of Los Angeles; such project, in either case, to be constructed and operated under conditions permitting participation with Los Angeles by other cities, communities, and districts of this and other interested States, in the power rights and benefits incident to such project.

"That such project, whether built by the Federal Government or by the city of Los Angeles, should make as a primary consideration ample provision for flood control and regulated stream flow in the interest of irrigation, as well as provide for the development of electric power, and be operated under such regulations as the Government may see fit to prescribe."

The position of the city is also shown in a letter to Director Davis, under date of December 16, 1920, signed by the mayor, president of the board of public service commissioners, chief engineer of water works, and chief electrical engineer of the city, copy of which is at page 28 of "Preliminary report on problems of the Imperial Valley and vicinity," made in pursuance of the provisions of the Kinkaid Act;

3. The city favors the utmost expedition practicable in commencing and completing the work on the Boulder Canyon project in order to give protection to Imperial Valley and other threatened sections of the lower Colorado River Basin against flood menace, and to that end favors the plan of joining with Imperial Valley and other communities similarly situated in requesting and urging a Federal appropriation for financing in whole or in part the construction of a suitable dam at Boulder Canyon for the purpose already specified.

4. The city favors the plan of imposing on the interests to whom power is allocated the burden of constructing the necessary works and of assuming such portion of the cost of construction, operating, and maintaining the dam as shall be fixed, payable to the Government in such manner as it may prescribe.

5. The city favors such plan of allocating power rights incident to such dam and storage project as shall give preference to public agencies in the interested States, substantially as provided in the Federal power act.

6. The city of Los Angeles wishes only an equitable share of the power which may be produced at the Boulder Canyon, and that such share should be allocated to it under a plan giving full and fair consideration to other interested communities, localities, and districts.

7. The population of Los Angeles now is conservatively estimated at 750,000, and at the present rate of growth it may reasonably be anticipated that it will have a population of at least 1,500,000 within 10 years. The city has a hydro-electric-power system which has cost more than $13,000,000, and it plans the extension of such system throughout the city. It is estimated that the total power resources of the city, developed and undeveloped, will be sufficient only for the requirements of the city for the next three to five years.

8. The city is firmly convinced that if the Government should undertake to construct and to finance the Boulder Canyon Reservoir project, the power possibilities thereby created can easily be made the basis of recoupment to the Government of the amount paid or advanced by it in financing such work.

Continue the investigations at Boulder Canyon.

Mr. Secretary, in concluding, permit me to say that the engineers and officials of the city of Los Angeles have made several visits to the site of the Boulder Canyon project, and they have thus acquired some direct information concerning that project, and it is our hope that you in your wisdom may see fit, according to your ability, to make provisions for continuing and completing the work of investigation that has been going on there in connection with that project. I thank you, Mr. Secretary.

Hon. HORACE PORTER. I have a claim against Uncle Sam, for on Brooklyn Bridge years ago a blast from one of Uncle Sam's war vessels scared a team of horses, which broke my knee as they ran away; but I have never made any claim of damages against Uncle Sam, and I shall be more than a million times repaid if Uncle Sam shall proceed along the lines indicated thus far in this convention to-day. [Applause.]

I will file with your secretary two or three papers representing particularly about 60 cities of the southern district of California assembled recently in a number of conventions to consider the power question, and I desire to say, first, Mr. Secretary, that all of them from San Diego to Santa Barbara and throughout southern California, when we have mentioned this situation, conceded—and when lately I addressed an assembly of men and women in Los Angeles, on this subject, they also conceded with applause of approval the statement that absolutely the first interest in this great movement is that of Yuma and Imperial Valley, Palo Verde, and in this great southern district around about the mouth of the great river. First, then, is irrigation; second, flood control [applause]; and, third, power. We say that because we believe it, and it is true, and it is just and right.

I present here this resolution, passed on the 28th day of October—a resolution which I will not read in detail, but file with you, sir, the conclusion of which is to this effect: Be it resolved that we urge upon the southern California district of cities in convention assembled, to urge upon the Secretary of the Interior to recommend to Congress that the Government proceed to develop the Colorado River project in accordance with the recommendations of Director Davis, from the point of view of irrigation, flood control, and production of hydroelectric power, and that we as cities—the cities representing the cities of southern California—that we as cities here represented, stand ready to take their proportionate share of power so developed at the power sites and pay for that at cost of production.

I desire to say, Mr. Chairman, that I hold here and will file with you a resolution passed by the Board of Public Utilities of the city of Riverside to this same effect, and pledging the city, which is now taking about 3,500 horsepower through our own distribution plants—we have not our own generating plants—and saying that at our present rate of development we shall need in 10 years at least 10,000 horsepower, which we will take at cost of production; that is, including all of the items that go into cost of production—sinking fund, upkeep, reconstruction, and everything—we will be a customer of the Government for the power, and that represents, sir, in its concrete action, the action of many other cities of southern California passed by their duly constituted civic authorities, which they will file with you assuring you the business—assuring you the patronage—and if there is anything on earth in southern California and these cities that is sure in its business return, if our civilization endures, it is the return on water and power, for they are our life.

Mr. Chairman and Mr. Secretary, I file these papers with you, reminding you that Riverside 28 years ago started one of the first municipally owned hydroelectric plants in the world, built the first high-voltage, long-distance power line in the world, and constructed the special instruments for doing that—the transformers, which were requested a few years ago at the Panama California Exposition at San Francisco, as an exhibit, and were sent up there—exhibiting the first transformers of the kind ever constructed.

Riverside, therefore, is a pioneer in this, with its distributing power, but not having its source of generating the power, believes that the Government should proceed, not only for irrigation and flood control, but in response to the necessities of the cities and the people in these Southwest States, with Government development and Government construction and Government sale, providing the waters cheaply at cost and the power to the people.

Some one has said here that he did not want speculation in the lands of the Imperial Valley. Neither, sir, do we want speculation in the power that shall come from that great source of power in the public domain, which ought to remain within the reach and in the ownership of the people who own the public domain. [Applause.]

Some one said here that the Government will sell the power to the highest bidder. I say no; the Government should keep that power and sell it at cost to the people. [Applause.]

The demand of our age, Mr. Chairman and Mr. Secretary, is for cheap water and cheap power as the source of our civilization and of our life. We have 41 square miles of city in the little village of Riverside—nearly all agricultural—our people have to pump; our hydroelectric power plant is an enormous industry; go about Riverside and see the great plants pumping the water up the hillside for our lemon groves and our orange groves, and essential to its success are cheap water and cheap power, Mr. Secretary. Strong men have stood before me in my office as mayor of Riverside in the past year and trembled, and with curling, trembling lip and profoundly stirred, as near a breakdown as a strong man ever permits himself to break down, they told me their problems—that the rate of power cost is beyond their reach, and I have seen, sir, and saw yesterday as I came to this meeting, alfalfa fields drying up because the farmer could not pay the high rate of violations of contract and readiness to serve charges.

These men are at the point of financial breakdown. Our agriculturists should have and must have of necessity cheap water and cheap power, and I know, Mr. Secretary, that our great country can do nothing better for all this great arid Southwest than to help us get cheap water and cheap power. [Applause.]

SAN DIEGO, CALIF., *December 12, 1921.*

The SECRETARY OF THE INTERIOR.

DEAR SIR: I desire to speak in behalf of the city of Riverside, Calif., in presentation of resolutions adopted by its board of public utilities, requesting the Government to develop the resources of the Colorado River, and offering to become a customer of the Government for power.

The city of Riverside uses power in large quantities for agricultural purposes for the pumping of water over 41 square miles of city largely devoted to orange and lemon growing. The city has an electric light and power distributing plant, with a small steam-generating plant, but must buy its power wholesale for the most part from private power companies; the wholesale rates for this power at the city are so excessively high as to make us extremely anxious to get power to a lower rate. We are paying as high as $121 a year horsepower wholesale for what we ought to receive at certainly one-half, or less, this amount.

The city of Riverside has owned its power plant for 28 years, built the first long-distance high-voltage transmission line in the world, built the original transformers, which were exhibited at the World's Panama Exposition at San Francisco.

In common with many other cities, Riverside desires the Government to develop the river and provide power at cost of production. We now use about 3,500 horsepower, and at present rate of increase will need 10,000 horsepower in 10 years.

Respectfully submitted.

HORACE PORTER,
Mayor of Riverside.

RESOLUTION.

It has been brought to the attention of the board of utilities of the city of Riverside that the question of the power development, including ways and means along the Colorado River, generally known as the Boulder Canyon project is to be considered at a hearing before Secretary Fall, of the Department of the Interior, at San Diego, Calif., December 12, 1921; and

Whereas the city of Riverside now owns and operates a municipal electric light and power system, including a steam-generating plant and a complete distribution system, and bought and sold through this distribution system a total of 9,456,220 kilowatt-hours during the year July 1, 1920, to July 1, 1921, Riverside will probably need 10,000 horsepower in 10 years; and

Whereas the city of Riverside is a rapidly growing community, and the use of power for domestic, agricultural, and industrial purposes is increasing still more rapidly; and

Whereas by the absence of coal and the diminishing supply of oil, hydroelectric power has become the very foundation of the domestic, agricultural, and industrial life of the Southwest: Therefor be it

Resolved, That the city of Riverside wishes to cooperate with the Federal Government in the taking of hydroelectric power from the Boulder Canyon project, or any other project developed by the Federal Government along the Colorado River; be it further

Resolved, That it is our purpose to pay the Government for this power at cost of production by the Government plus the amount needed to refund or retire bonds to cover the depreciation, upkeep, and other necessary cost; be it further

Resolved, That we respectfully urge immediate action by the Federal Government to finance and construct a proper dam and necessary works on the Colorado River, in order to afford not only irrigation and flood control, sorely needed, but to afford opportunity for generating hydroelectric power for ourselves and for the civic, agricultural, and industrial necessities of the entire Southwest.

HORACE PORTER,
Mayor of Riverside and President Board of Public Utilities.

NOVEMBER 30, 1921.

RESOLUTION ADOPTED BY SOUTHERN CALIFORNIA LEAGUE OF MUNICIPALITIES OCTOBER 18, 1921.

Wheras there exists in the Colorado River Valley in California and Arizona a crisis in irrigation and flood-control problems; and

Whereas the normal flow of the Colorado River in California is already exhausted by the demands of the three large irrigation projects now drawing upon this supply and none of these can make any further material development until storage of the flood flows has been effected, nor can such existing projects be free from annual flood menace until the freshet flows of the river have been so controlled; and

Whereas the many conflicting rights upon the Colorado River of State, interstate, and international character make any undertaking looking to the complete control and development of the irrigation and power possibilities of this stream essentially one that must be undertaken by the Federal Government; and

Whereas we believe that the intricate problems of water rights, flood control, and hydroelectric power in the valley of the Colorado can be administered only by the United States Government. Therefore be it

Resolved by the cities of southern California in convention assembled. That we urge upon the Secretary of the Interior to recommend to Congress that the Government proceed to develop the Colorado River project, in accordance with Director Davis's report, from the point of view of irrigation, flood control, and the production of hydroelectric power, and that the cities here represented stand ready to take their proportion of the power so developed at the power sites and pay for the same at cost of production.

We recommend this because of the immediate necessity for such procedure and as one means of helping to solve the great problem of the unemployed.

GRANT M. LORRAINE,
Secretary Southern Section League of California Municipalities.
HORACE PORTER,
Chairman.

GEORGE L. HOODENTYL, of Long Beach. Mr. Secretary, ladies, and gentlemen, there are two reasons for my appearing before you and before the Secretary this afternoon. I represent the municipal administration of the city of Long Beach, and there was a representative also here from the chamber of commerce. It had been reported that the chamber of commerce and the city of Long Beach were divided as to what should be done in this matter, but in view of the suggestions made by the honorable Secretary and by the Reclamation Director, those difficulties have been compromised, and it is with pleasure that the city of Long Beach unanimously commends the views taken by the Secretary and approves the report as modified by the Director of Reclamation. May I add this, Mr. Secretary; the city of Long Beach is somewhat typical of other cities of southern California relative to the power situation, and this is exceedingly vital to us.

The city of Los Angeles has been favored by the construction of its aqueducts for water and by the development of power municipally. The result has been that in the city of Los Angeles, also in the city of Pasadena and the city of Riverside, there are less rates for power than in the city of Long Beach, and I believe in all the balance of the municipalities in the southland. The city of Long Beach, an industrial district, particularly, is just across the line from the industrial district of the city of Los Angeles. We are friendly rivals for industries and friendly rivals for tourists. The rate charged in the city of Los Angeles, domestic rate, is 5½ cents per kilowatt hour, while the rate we are compelled to pay to the private utility, or the Edison company, is 9 cents per kilowatt hour. The rates for energy for manufacturing and industrial plants are proportionately the same.

I can not give you the definite rate fixed for manufacture, because there are so many variations of this rate that it is impossible for me to detail them, but the rates for industries in the city of Los Angeles are less than those in the city of Long Beach.

Now, you can imagine, Mr. Secretary, what a handicap that has been upon the city of Long Beach, which has this industrial section just across the line from the industrial section of the city of Los Angeles. Both of us have municipal water and we can meet their price on water, but we can not meet their price on power. Most everything else being equal, of course, most of the industries go to Los Angeles, and I want to say, Mr. Secretary, while we all glory, even those who do not live in the city of Los Angeles, in the wonderful growth of this great city—I want to say that it is in no little degree due to the privileges you obtain in Los Angeles with power and with light that we do not have in the other cities of southern California.

We believe that by the development of power by the Government this can be overcome. We know that the public-utility companies generally pay approximately 8 per cent for their borrowed money; we are satisfied that the Federal Government will not have to pay over 5 per cent and in that way would save the 3 per cent. We know also that the power companies pay dividends of 8 per cent or more. There would be no dividends to pay for this development by the Federal Government. We also know that the power companies pay very high salaries to their high officials, and that their overhead is exceedingly high. We know that will not be true under development by the Federal Government. In order to meet this the legislature has passed an act authorizing municipalities to join together in contracts for construction of power plants and the transmission of electric energy and other matters in common. If the Federal Government should construct a dam, and should so desire, it is possible for municipalities—and that includes rural districts, counties, and other political subdivisions—to join together in the construction of power plants and the transmission of energy and the distribution of it. We believe in that way that we can come up on a fair footing with the balance of southern California and that we will be then in such a position as to attract industries because of the fact that we will have cheap power as well as an all-year climate to work in. We think that that is an advantage, and that is the reason this matter is of such vital importance and interest to the municipalities of southern California. We certainly thank the Secretary and the reclamation director for coming here and we are glad—I know that the city of Long Beach is, and I think it is true of all the other cities—that we can indorse unreservedly the program that has been outlined. I thank you. [Applause.]

IMPERIAL SOUTHSIDE WATER CO.,
Holtville, Calif., December 7, 1921.

Know ye by these presents, that W. R. Waldrop, vice president, is the accredited delegate of Imperial Southside Water Co. at conferences participated in by the Secretary of the Interior, held at Riverside and San Diego, December 8–12, 1921, and duly empowered and commissioned to represent said company in all matters considered at these conferences.

By order of the board of directors.

Attest:

ROBERT HAYS, *Secretary.*

Fred L. Johnston, city manager of Santa Barbara, filed the following exhibit:

U. S. GRANT HOTEL,
San Diego, Calif., December 12, 1921.

Hon. A. B. FALL,
Secretary of the Interior, at the public hearing in the city of San Diego, December 12, 1921.

Fred L. Johnston, representing the city of Santa Barbara, Calif., by appointment of its city council; Owen H. O'Neill, representing the county of Santa Barbara, by appointment of the board of supervisors; and A. Grant Evans, representing the Rotary Club of Santa Barbara, desire to express what they believe to be the prevailing sentiment of their community as to the matters under consideration at this hearing.

We most heartily approve of the line of action recommended in the report of the Chief of the Reclamation Service and his publicly stated modifications of the same. We earnestly hope that the United States Government may be able to carry out the comprehensive plan suggested for the development of the Colorado River without unnecessary delay, and we further hope that, in common with other municipalities of the State, we may be placed in a position, without the intervention of any private individual or corporation, to purchase at cost the hydroelectrc power which may be developed under this plan.

Yours, very respectfully,

FRED L. JOHNSTON.
OWEN H. O'NEILL.
A. GRANT EVANS.

WILLIAM M. TOMPKINS, secretary of the San Diego Chamber of Commerce. The San Diego Chamber of Commerce is giving a dinner to Secretary Fall and Director Davis and the heads of delegations attending this hearing at 6.30 o'clock to-night at the San Diego Hotel, at Broadway and State Street. The chamber would like to invite all of those present to-day, but because of a limited seating space has been forced to invite only a small portion as named on the following list, all of whom it is hoped will be present at the time and place given. This seems to be the only opportunity of imparting the word to these guests.

(Mr. Tompkins reads list of invited guests.)

Mr. FALL. I did not hear the name of any of our lady friends on this list. I do not know whether it would be possible for the chairman to invite them.

The next speaker, I believe, is Mayor Bacon, the mayor of San Diego, and to be preceded by Mr. Sly, whose name is handed to me, as entitled to two minutes in addition to the six, I believe.

Mr. SLY. Mr. Chairman, ladies, and gentlemen; I am taking up some of Mr. Peters's time. I represent the San Diego County Farm Bureau and I wish to say to you that they are 100 per cent for Government ownership, Government building, and Government control of the power. [Applause.]

If a privately owned concern can buy this power and sell it to the farmers and make money, let's have it ourselves. Thank you.

JOHN L. BACON, mayor of San Diego. Mr. Secretary, ladies, and gentlemen, I want to say at the outset that Imperial Valley can voice our sentiments exactly; in order not to becloud the issue, we will simply say what they say we say too. [Applause.] That is what we believe.

We want a fair share of these benefits, and we believe that the Federal Government can fairly allocate them. We are willing to take whatever they say we should have, perfectly willing to rest our case in their hands and depend on their decisions.

There are two reasons why we are so firmly in favor of this. Principally this, that the ultimate development of the Colorado River means that hydroelectric energy will be put into existence equal to two-thirds that which is now developed in the entire United States. It is a national asset, not a local asset. Furthermore, that the Colorado River to-day is rising in its bed, depositing mud on its bed so that the river is rising, rising each year at the rate of 1 foot a year. The bottom of the Imperial Valley is 300 feet below sea level. That means that it is easier for the water to run from the Colorado River into the Imperial Valley than it is through its present mouth. A break in those banks means the flooding of the valley; that is why this flood prevention is so necessary. It means that some parts of Imperial Valley—if the Colorado River should go on a rampage and break over, as it has done before—would be over 100 feet below the top of that flood as it came through; there would be spots in the Imperial Valley, away on the edge not ordinarily thought of, that would be 50 feet under water. That is one reason why we are anxious to have the Federal Government take just as immediate action as possibly can be taken to prevent this impending disaster, and that is why we are perfectly willing that Imperial Valley shall speak for San Diego. We are with them, and we believe that their benefits will be our benefits. [Applause.]

RESOLUTION 27118.

Whereas the mayor and common council of the city of San Diego are informed that the League of the Southwest, an organization composed of people desirous of promoting the interests of the great seven States of the Southwest, is to hold a meeting in Riverside, Calif., commencing December 8, 1921, for the purpose of discussing the development of Boulder Canyon, on the boundary line between the States of Nevada and Arizona, to provide for the storage and impounding of waters of the Colorado River; and

Whereas the mayor and common council of this city are of the opinion that said Boulder Canyon should be developed under the direct supervision and control of the United States Government, and that the actual construction of such improvement should be carried on by the United States Reclamation Service, and that no private corporation or individual, city, or group of cities should be permitted to carry on such work or receive the major portion of the benefits to be derived from such construction work, but that the people at large throughout the Southwest should receive such benefit, and will receive the same if the United States Government itself carries on and completes said improvement; and

Whereas this mayor and common council are desirous of having the attitude of the present administration of the city government presented to the League of the Southwest at its meeting in Riverside. Now, therefore, be it

Resolved by the Common Council of the City of San Diego, as follows: That the mayor and common council of the City of San Diego respectfully urge the League of the Southwest, at its meeting to be held in Riverside, Calif., on December 8, 1921, to adopt a resolution favoring the development of Boulder Canyon by the United States Government, and urging the United States Government, through its Reclamation Service, to carry on and complete the work of constructing the dam in Boulder Canyon on the boundary line between the States of Nevada and Arizona, for the purpose of the storage and impounding of water and the development of electrical energy: And be it further

Resolved, That this mayor and common council respectfully request the League of the Southwest to adopt a resolution protesting against any plan of development of said Boulder Canyon which will result in any private corporation, private interests, individuals, city, or group of cities receiving any preference right in either the water to be stored behind said dam or the power to be developed thereby, or any plan that will result in denying to the people living in the southwest portion of the United States the benefits they are justly entitled to receive from said development work: And be it further

Resolved, That the mayor of the city of San Diego be, and he is hereby, authorized and directed to present to the League of the Southwest, at its meeting in Riverside, Calif., on December 8, 1921, a certified copy of this resolution.

I hereby certify the above to be a full, true, and correct copy of resolution 27118 of the common council of the city of San Diego, as adopted by said council December 7, 1921.

ALLEN H. WRIGHT, *City Clerk.*
FRED W. SICK, *Deputy.*

Mr. FALL. Ladies and gentlemen, by a mistake which is not entirely that of the chairman, the name of Mr. Wesener, of Yuma Valley, was not called in the proper order. Mr. Wesener will be recognized.

Mr. WESENER. Mr. Secretary, fellow water users, I do not really know why I am here, only that I came with the other boys. I was sent from Iowa down to Arizona to die, and I fooled them. I lived.

I have come over to California occasionally—to Long Beach or Los Angeles—and in talking with some of the boys over there they would say, "Where are you from?" And when I said "Yuma" they laughed. And I want to tell you, ladies and gentlemen—

YUMA.

I come from a real fairy land,
Whose children are sure a happy band,
Who when they reach our fertile shore
Seldom leave it. They weep no more.
It's where the feathery palm trees rise,
Where the dates grow ripe under sunny skies;
Where the alfalfa blooms and the mesquite trees
Attract in swarms the honey bees.
Where the maiden fair in khaki gay,
Like sweet Maud Muller, rakes the hay.
Three hundred feet above the sea,
Where the heart beats fast and the blood runs free,
Where you live like a live one, and when you die
They plant you under the alkali.
Drink to your soul in a whisky straight,
And shake for the drinks at the graveyard gate.

You may laugh at that, but to us it is home, sweet home, and we might tell you this afternoon, that we have the most green, the most fertile land on earth. We might tell you it was the old original Garden of Eden. We might tell you that it is the new Garden of Eden to-day, but we will not do that owing to the fact that it might hurt some of our neighbors over on the west from Imperial Valley. We might tell you that we have soil that is 6 feet deep; we are not going to tell you that, but I will tell you, you people that have not been down to Yuma Valley, that the old man here started six mowers to-day, cutting his hay in December. It is a wonderful land. Your problems in the Imperial Valley are our problems, and we can simply O. K. what you have said. I have been in the Imperial Valley, and in case I beat you fellows—I might tell you of the time when you took us over there and showed us—I asked you "What did you have here, how long a water supply have you," and you said, "Three weeks," and here you were, as one of the gentlemen told you, 150 feet below sea level, and that Colorado threatening every moment to come in on you, and every year we have that little trouble about giving you fellows some more water, by letting you put a dam in the Colorado down at Hanlon heading—you know how you come over each year with tears in your eyes and say—"This is the last year"—and the next year you are again over for the last year. You know, some of you gentlemen within sound of my voice—I have seen the water 4 feet deep in the main street of Yuma in the hotel; I have seen boats come down there, and we had a flood which was caused by the dam at Hanlon's heading, to give you fellows an intake. I have said within sound of some of your voices one night if our directors considered you gentlemen putting another pound of rock in the river, or if they consented even to a dam, and it happened again as I have seen my neighbors go out there with their men, women, and children, and all the stock been drowned, that while I am a law-abiding citizen and would not lead a mob, I'd go with a mob to help hang the fellow that did it.

Now, gentlemen, we want to bury the hatchet. You are neighbors of ours. You are only unfortunate when you went into the Imperial Valley and settled there in place of coming down into Yuma Valley. You did not know any better and we forgive you for what you did not know. We want to help you out. I have seen that old Colorado, as I said, in the streets of Yuma when it was 4 feet deep in the hotel, in the post office, and in the bank, and I have lain down in the month of July, last July, on the banks there, trying to encourage some fellows to put up a levee there to keep the Colorado from overflowing 15,000 acres of the best land that God Almighty ever made. Seventy-two hours we were there without sleep. Men, women, and children—white, black, yellow, red, brindled, and roan—were there. We are here to-day to help give you fellows relief, and we are playing the part of the Good Samaritan. You may say that the old man always works on his own interest, and we also need relief. We had our worthy Secretary down there the other day. We fired telegrams on him; we fired letters on him and we got him down here; we wanted to see him. Gentlemen, you can attempt to paint the lily and perfume the rose, but you can not do it. You have got to see these beauties of nature, and you have got to smell these by means of the nostrils, detect the odors, so we found it would be impossible for us to tell the Secretary what we had, and we took him down there and showed him the seventeen-mile post. There is that accursed Colorado ready to come in next June, and as sure as I am standing here, gentlemen, we will have it in next June again unless the river changes. Three feet has that bed risen in the last two years, and the banks are getting so high. We only have a narrow shoe string of a valley there, but it is very fertile, and we have some 15 or 20 miles of levee to keep up, and while we are not broke, we are financially embarrassed, and very badly twisted and bent. We say that our firm hope is to get the Government to take charge of that levee.

There are other things that we want. We have 60,000 acres that we are now irrigating just as I told you, of the richest land that ever crow flew over; then we have 60,000 acres as my friend Col. Fly's beloved mesa—the frostless belt. It will grow almost anything that grows if you will just get the water on. We want the water on that, and we want the power to put it on, and the Government can give it to us when that dam is put in up at Boulder Canyon. I have walked dry-shod across the Colorado down below Hanlon's Heading. You gentlemen from Imperial Valley never tell the fellows over there when we come over to buy real estate what is wrong with your crops, but we know. Every once in a while, in the months of July and August, down on the border, we know what is wrong with the crops; you can not get water enough even with the dam. Then you have numerous other acres there ready to bring in which are almost as fertile as ours—not quite. When you get the water it will be all right, and that water is going to waste—millions of feet down the Colorado, and it can be controlled—these things we are after. One gentleman said, "What is the use of being here this afternoon?" We seem to be unanimous. While I am not a Methodist, they run in the family a little bit, and some of the other family was afflicted with it, and I have gone occasionally to some of the Methodist camp meetings and some of these experience meetings, and I sort of believe we are giving in our experiences this afternoon; we are all of the same opinion so far, and I trust there will be no dissenting voice. We are assuring the Secretary of something I think that he already knew, that, Mr. Secretary, we are with you, body and soul. In the war times, when the Government called, the old Imperial Valley, together with the Yuma Valley, responded. We bought baby bonds. We bought thrift stamps. We contributed to the Red Cross. We contributed to the Knights of Columbus. We contributed to the Salvation Army. We did everything that they asked of us. Well, I want to tell you some of the greatest things that some of us fellows did was to send our sons, our first born, over across the water to fight the common enemy; they went and they fought like men; some of the boys are sleeping over in the Argonne Forest, where the south winds sing a soft requiem over the bodies lying there, and the wandering dove coos gently to its mate a soft requiem, and we who sent our sons and who died, say it was not in vain—it was our Government. Gentlemen, it is your Government. It is my Government. It is our Government, and we never yet have doubted that our Government is just.

I remember when a school-teacher of teaching my boys the old story of Washington. After the war was over and the trouble occurred, these fellows were hard up; they did not know what to do; they advised rash measures. The old man took out his glasses, he wiped them, and said:

"Mine eyes have grown dim in the service of my country, but I have never doubted her justice," and I want to tell you gentlemen. I came here this afternoon to represent the Yuma Water Users' Association, but I want to tell you, as has been told by some of the others, that every man, every woman, and every child, regardless of their color, is behind the Government. It is our Government. We do not doubt its justice. We want our Government to construct that dam, and we want them to control the dam, and we want them to apportion out the cost to us, and what we get in the way of power, water, etc., and we will be perfectly satisfied. We feel that the Government is just. One thing more, the eyes of some of us are not just quite as bright as they used to be; we are just a little bit more uncertain on our limbs. To-day is my natal day—53 summers and winters, too, have passed over this old head, which is getting bald, and I would like to live long enough to see that dam completed. All that we are asking is for the Government to take hold of it, and in these times when there are so many fellows looking for work, I think it would be a good opportunity to go ahead, build the dam first and apportion the results afterwards. The Yuma Valley will be satisfied, and we want to once again assure our Secretary that we stand with Imperial Valley—nothing except the Government in charge of this, to build it and control it and apportion out the results.

Lucius K. Chase. Mr. Secretary, ladies, and gentlemen, for some three years it has been my good fortune to be chairman of the reclamation committee of the Los Angeles Chamber of Commerce, and during all of that time the Los Angeles Chamber of Commerce has worked in harmony with the Imperial Valley in an effort to solve their problem. We have been with you in everything that you have undertaken to do for the development of your valley. Some of you gentlemen may not know it, but your representatives do—the representatives that we have had in Los Angeles know that we have been with you from start to finish. We were with you in the beginning. We are with you now, and we are going to be with you until the end. And, gentlemen, that our position may be accurate and brief, I have taken the liberty to reduce to writing the position of the Los Angeles Chamber of Commerce, which I will read. [Reads:]

1. The Los Angeles Chamber of Commerce considers that the preservation of the Imperial Valley and other lands adjacent to the Colorado River from flood destruction is at this time paramount, and that this valley should be given protection at the earliest possible moment.

2. That the conservation of lands in the lower Colorado Basin and their development for the benefit primarily of the veterans of the late war is a matter of national and immediate importance.

3. That an impounding dam should be promptly constructed by the Government at such point as its officials may deem desirable, and that if this should be Boulder Canyon we most heartily support such location.

4. That all remaining questions should be harmoniously and equitably solved with due regard to the interests of all, and that with the wisdom and good judgment of the Secretary of the Interior and the director this can be accomplished.

[Applause.]

Mr. Davis, of the Long Beach Chamber of Commerce. Mr. Secretary, I came here to-day representing the Chamber of Commerce of the City of Long Beach. You have already heard from the attorney of the city of Long Beach, but I represent that great booster body which has made it possible to build up one of the fastest growing cities on the Pacific coast and has achieved such wonderful success during the past few years in the accomplishment of building from a small beginning to what is now a metropolitan city in the great southwestern territory.

We are rapidly coming along to the point, Mr. Secretary, where, due to the fact that factories are coming in, we are going to need power in larger quantities. We have considered the reports passed around at different times, and recently the report we heard read at the Riverside meeting a few days ago, and I have since been instructed to say to you that on the basis of the reports made by your able assistant, Director Davis, of the Reclamation Service, having confidence in your integrity, in your fairness of treatment, in your wisdom, in the wisdom of your able assistant, feeling that you will give all a square deal in this great territory, without attempting to give you any advice or any instruction in regard to the way, the manner that we think this plan should be carried out, we extend to you our hearty support and assure you at any time in the future that we can be of any assistance we will be glad to be called on. The Chamber of Commerce of Long Beach, representing a body of 75,000 people, will do the best we can to assist you. Thank you, sir. [Applause.]

Judge HUGH H. CRAIG, representing the Chamber of Commerce of Riverside. Mr. Secretary, ladies, and gentlemen, knowing that I was to be here upon another mission, I was asked by the officials of the Chamber of Commerce of Riverside to bear to the honorable Secretary a letter—a very brief message—and that message was this: That the Chamber of Commerce of Riverside favors the comprehensive development of the Colorado River, to the end, first, that there shall be flood protection; second, that there shall be development of the arid lands by irrigation; and, third, that there shall be development of hydroelectric power. That the method and the means which are favored by that body are that method and means which shall prove most speedy, most efficient, and most economical. Thank you. [Applause.]

Mr. R. H. BALLARD, vice president of the Southern California Edison Co. Mr. Secretary, ladies, and gentlemen: In the interests of brevity, and with your permission, Mr. Secretary, I will read a statement briefly outlining the position of the Southern California Edison Co. in this matter. The Southern California Edison Co. has filed applications with the Federal Power Commission for the development of the power possibilities of the Colorado River. [Reads:]

The Southern California Edison Co. has filed applications with the Federal Power Commission for the development of the power possibilities of the Colorado River. It was stated in those applications that the company recognizes that its power developments can be made under such conditions only as will first provide for flood control and irrigation and that the company will submit to such modification of its plans and to such regulations of its operations as may be imposed by the Federal Power Commission or other Federal authority in the interests of flood control and irrigation.

We are willing that any license or permit granted us by the United States Government or the States shall contain a provision that the existence and operation of our power structures in the river at points below the Utah-Arizona line shall not operate to confer any preferred right to the waters of the river as against full potential uses for irrigation and other beneficial purposes in the upper basin. We acquiesce furthermore in principle that the States within which power is developed have first right to its use.

Our investigations indicate, in agreement with those of Director Davis, that there is water enough in the river, if it is properly conserved, to supply all possible demands for irrigation and domestic use and still leave an abundance for power, and that there is power enough to meet the need of all the States tributary to the river.

The company's plans for financing the project are along the same lines as those which it has successfully followed in its California developments. The company's credit position in the financial world is such that we are assured that bonds can be marketed to cover two-thirds of construction costs through investment bankers to the investing public throughout the country, and that stock can be sold directly to the people to supply the remaining one-third. Immediately upon securing the necessary Federal and State authority we are prepared to undertake and finance construction work at the rate of from $30,000,000 to $40,000,000 per year.

Under the Federal water power act, power rights are not granted in perpetuity but are limited to 50 years, at the end of which time the Government has the right to take the property over by paying the net investment therein. The act specifically prohibits the capitalization of water rights in any amount in excess of actual costs. The company will be strictly regulated furthermore by governmental authority in the matter of the issuance and sale of its stocks and bonds and the use of money derived therefrom, and will also be under strict regulation as to its plans of construction and operation and its rates and service.

Secretary FALL. Hugh H. Craig, of Riverside, spoke for the chamber of commerce. Does Judge Craig desire to speak for the Southern Sierras Power Co.?

HUGH H. CRAIG. Mr. Secretary, ladies, and gentlemen, the companies which I represent are serving a territory composed of the mining territory. [Reads letter:]

THE SOUTHERN SIERRAS POWER CO.,
Riverside, Calif., December 12, 1921.

Hon. A. B. FALL,
Secretary of the Interior,
San Diego, Calif.

SIR: On behalf of the undersigned companies we have the honor to hand you duplicate copies of exhibits named below:

Exhibit I. Territorial map of the system of these companies.
Exhibit II. Small map of same territory.
Exhibit III. Table showing generating plants.
Exhibit IV. Commercial statistics of the system.
Exhibit V. Summary of lands within territory served which will eventually be irrigated, mostly by pumping.

These operating companies, while they are separate entities, are owned and operated by the same people as one system; their interests are therefore identical.

Reference to the territorial map, Exhibit I, shows that some 52,000 square miles of territory are dependent, almost exclusively, upon this system for electric service.

Its hydro plants are located in Mono and Inyo Counties, Calif., with a steam stand-by plant at San Bernardino, Calif., and a few small plants as shown in the table.

The territory served comprises the mining territory of Mineral, Nye, and Esmeralda Counties, Nev.; the mining, industrial, and agricultural interests of Inyo, Kern, San Bernardino, Riverside, and Imperial Counties, Calif.; Yuma County, Ariz.; Baja, Calif., between Calexico, Calif., and Yuma, Ariz., together with the towns and cities located therein.

It is to be noted that there are no large cities in this territory; the electric energy is needed and used for irrigation, for industries, and for mining. The great Imperial Valley, which has been converted from a barren desert by use of Colorado River water for irrigation, into one of the greatest producers of cotton, melons, alfalfa, fruit, and live stock, has no source of supply for electricity, of which the demand is ever increasing, than these companies.

With the opening of new mines, cultivation of new areas, and the building of new industries, the potential demand for electric service of this territory is very great. In a few years we will have exhausted our present available supply of water power and must look to the Colorado River in the interest of the territory we serve.

We hold that the continued growth and prosperity of the great Southwest is entirely dependent upon an adequate supply of electricity at reasonable cost.

That the Colorado River is the only source of large supply.

That it is urgently necessary that the Colorado River be controlled and developed promptly and effectively and at the lowest possible cost.

First. For the protection of the Imperial Valley through proper flood control.

Second. For the reclamation of thousands of other acres of present desert lands, which may be made among the most productive on the continent.

Third. To make possible the fullest economical development and widest distribution of all the potential power possibilities of the river.

We believe that this can best be done through the agency of private capital, and favor the plan proposed by the Southern California Edison Co. as being the best adapted to accomplish the desired results. If that is done and the final engineering reports demonstrate the feasibility of the project, as now seems probable, we expect to share with them in proportion to the needs of the territory we serve both in the capital investment and in the utilization of the power.

We believe that the second best agency is for the United States Government to build all that part of the works having to do with land reclamation, such as dams, reservoirs, head gates, flumes, etc., the generating plants to be built by private capital, effecting a proper distribution by sale through the great privately owned, regulated public utilities, which alone, with their network of transmission and distribution lines already reaching into all parts of those States entitled to and which can by reason of location participate in the use of this electric power, can provide a proper and adequate distribution.

We are firmly against the delivery of this great natural resource into the hands of any city or group of cities for development or distribution, for the principal reason that it would effectually prevent the participation therein by those towns and cities, mines, and ranches, which are not financially able, or as individuals are too remote, to build their own transmission lines. Such a plan would confine the benefits to the few congested centers, which by such preference could and would build up and fatten on the needs of those less fortunately situated.

We respectfully submit our claim on behalf of and as representing that great territory looking to and depending upon us for service to a proper direct participation in the power development to be undertaken.

We respectfully urge the importance of the greatest possible promptness and speed in placing the river under control and in developing the power as rapidly as the participating States can absorb it.

Respectfully submitted.

THE NEVADA-CALIFORNIA POWER CO.,
THE SOUTHERN SIERRAS POWER CO.,
HOLTON POWER CO.,
By A. B. WEST,
Vice President and General Manager.

[Applause.]

R. B. PETERS (representing the farm bureaus). Mr. Secretary, ladies and gentlemen, lest there be any misunderstanding as to whom I represent and whom I do not represent, I will say that I am here to represent, primarily, about some 10,000 farmers in the southern group of counties in California, members of the farm bureaus of these respective counties. I also represent, somewhat, the State organization. I do not as a national director represent the national farm bureau organization. The San Diego farm bureau has presented their ideas very forcibly to the Secretary, and we concur in these in every respect. [Reads:]

Farmers in California are decidedly interested in the development of the Colorado River for flood protection, for irrigation, and for power development.

I will touch briefly on these three, as they seem to me to affect the farmers of this State.

Part of these views are purely personal, but the larger number are arrived at from intimate contact I have had with ranchers all over our own State and recently with farmers in the Eastern and Middle Western States, who met together last month at the national farm bureau convention in Atlanta.

I do not officially present a yes or no vote on specific matters, but rather a decided trend of opinion among farmers.

The organized agricultural movement in America is based upon the idea of mutual help, not alone for agriculture but for all the people. Therefore, I think there is no argument as to the fact that all American agriculture is behind flood protection for the farmers of Imperial Valley, or the Mississippi Valley, or wherever it may be needed, and that it will use its influence toward that end.

The second point, irrigation, is very important to the farmers and to the public especially, for these two reasons: The immediate development of the lower Colorado is necessary, first, because it has a much higher production per unit of land than any other part of the basin. This is largerly due to its longer growing season.

Second. Because a very important part of production in the lower Colorado basin is of nation-wide importance, because it is an off-season producer.

It supplies no inconsiderable part of the vegetables for our entire country when they can be had from no other locality. The destruction of Imperial Valley will be a national calamity.

There are two factors only that stand in the way of fresh vegetables in the winter for all the families of America, and not for the rich only, and these two factors are: Excessive cost of rail transportation and inefficient retail distribution in our large cities.

Organized agricultural marketing hopes to correct both of these factors in time. When they are corrected, the whole of the lower basin of the Colorado may one day be a great winter garden, furnishing winter vegetables for the whole Nation, produced economically, for the benefit of all, and not in serious competition with any other agriculture in the country.

The development of the lower Colorado will produce the greatest good, per acre, to the greatest number.

A third reason which makes irrigation so important a point in the development of the lower Colorado is this:

Under our present system of irrigated agriculture, in regions of less than 15 inches annual rainfall, we have to bring in continually new and higher lands to offset the alkali accumulations in the older irrigated districts in order to maintain production.

At this point I wish to consider for a moment a question that is uppermost in the minds of a number of the States, especially those in whose boundaries the waters of the great Rio Colorado rise.

There seems to be an undercurrent of feeling that the lower region of the Colorado may receive some rights to water that may deprive the upper regions of water they consider justly theirs.

As to the matter of legal rights I know nothing, but I am very positive of one thing, and that is that as irrigation is now practiced, the loss from alkali and rising water tables will tend to balance new lands coming in, and I doubt if for generations to come a serious inroad will ever be made on the total waters of the Colorado by all the irrigated districts combined.

Also a no inconsiderable quantity of water as now dumped upon land goes into that great underground reservoir to become available later in augmenting the available gravity supply that now exists.

To return to this matter of alkali, which renders useless land that has long been irrigated; to reclaim the ever-increasing alkali wastes of our irrigated districts will require pumping and the disposal of that water in order to lower the water tables.

Some engineers will disagree with this theory of pumping and will point to drainage as the solution.

The reason I am discussing alkali and the problem of lowering the water levels, which question seems irrelevant to the subject of the development of the Colorado, is this: It is important in relation to power development which I mentioned as the third point of interest to farmers.

Drainage, to be successful in our irrigated districts where alkali is plentiful, must be very deep; too deep in many types of soil to be practiced economically either by tiling or ditching; pumping, therefore, must be resorted to.

And, therefore, in order that irrigated agriculture may be maintained, cheap power is necessary.

The ranchers of California are, I believe, very generally of the opinion that the development of the Colorado should be by the Government and not for private gain. That this statement may not seem too dogmatic, I wish to point to two or three things upon which I base it.

The farmers of California believe in cooperation.

At the present time, through cooperative nonprofit agricultural organizations, they are handling agricultural products to exceed $300,000,000 per year, and I believe they are about the only group of farmers in the entire United States this year that have marketed their crop so as to return even anything approaching a fair price to the producer.

Also the farmers in this State largely own and distribute irrigation water through mutual nonprofit water companies, and they have no thought in the world of turning them over to private companies to handle under State commission control.

It has been established beyond question that the private production of electricity under commission control has gone on to a cost-plus basis, which paternalism can be about as badly abused as can any mutual or district project under the most inefficient handling.

The farmer in California, outside of the Colorado basin, in those districts irrigated solely by pumping, is facing a continually falling water table and lately also a falling price for produce, and at the same time is facing a continually rising price curve for power.

Electricity under this plan of private development in our State is not cheap power.

The farmer will be a decided factor in using power developed from the Colorado. He has had ample experience in community undertakings to establish power districts; in fact, has several under consideration at present.

Eventually the farmers will be a big factor in purchasing collectively Colorado River power, provided it can be turned to him at a reasonabe price, which is not being done under private development at present in other parts of the State.

The Calfornia State Farm Bureau at its annual meeting November 10, 1921, expressed itself as being in favor of Government development for the Colorado, and at Atlanta, Ga., on November 21, the American Farm Bureau Federation. in its program of work for the year 1922, adopted this: "We urge congressional action to the end that public resources of all kinds be conserved and reserved to the end that special interests may not exploit them for private gain, but that the public receive the full benefit of their development."

This is a flat stand for public development of public resources made by a group representing nearly 2,000,000 farmers.

The board of directors of the San Bernardino County Farm Bureau on December 6 passed unanimously the following, which may fairly be taken as representing the majority sentiment of the farmers of the county, and the farmers of this county use, roughly, from ten to fifteen thousand horsepower for pumping. This principally refers to conditions which will arise if the Colorado is developed by private corporations.

R. B. Peters,
President San Bernardino County Farm Bureau.

Resolved, That in the matter of the proposed Colorado River development, in view of the welfare of the peoples of many States and of the Republic of Mexico, and in consideration of the vital importance of the flood control and possibilities of irrigation of arid lands and development of power, the San Bernardino County Farm Bureau hereby adopts as its policy the three principles following:

1. Any project for the development of the Colorado River should be by and under the control of the National Government and any dam built, whether for flood control, reservoir purposes, or power development, should be declared to be a Government dam within the definition of the Federal water power act.
2. That before any permit, whether temporary or permanent, shall be granted by the Federal Power Commission, the agricultural interests of the State of California and the representatives of the State itself should be given an opportunity to propose and a hearing to present conditions to be incorporated in such a permit, not in conflict with the Federal water power act.
3. That before any permit, whether temporary or permanent, shall be granted the agricultural interests of the State of California and the representatives of the State itself should be notified of the terms proposed by the applicant for the permit and the form of any conditions suggested by or on behalf of the applicant to be incorporated in the permit, to the end that said farmers of California and the State through their respective representatives may protest and be given hearing to urge before the Federal Power Commission reasons in support of their protests against such terms and conditions as they may be advised are detrimental to the interests of the farmers and the State of California.

As I said, I do not represent the farm bureau sentiment or organized agricultural sentiment in the East. I believe, for the benefit of the development of the Colorado River, it is not policy at this time to emphasize the fact that great quantities of land are going to be brought into production. I simply bring this point out so that we can say that the development of the Lower Colorado River Basin is primarily for these things that do not come into direct competition with territory of overproduced agricultural conditions in the United States to-day. [Applause.]

Mr. FALL. Mr. Peters, do I understand that the farm organizations which you represent object to the development by irrigation or otherwise of land outside of the Imperial Valley and California? I want to understand—I may have misunderstood your statement—you thought it was not proper, possibly, to voice sentiments in favor of general reclamation at this time because of antagonism which might be encountered; but that because of the peculiar conditions in the Imperial Valley in the raising of crops which do not come in competition with other productive portions of the United States, this project might be encouraged. Well, is it your attitude, or that of the organizations which you represent, to discourage development of other projects because they might come in competition with some undeveloped——

Mr. PETERS. The organization as such, understand, has made no statement to that effect. I believe the public sentiment—the public agricultural sentiment in America to-day, as a whole, is opposed to the bringing in at this time any large, great increase of areas under production.

Mr. FALL. Then you can not very well expect the people of the United States to favor one particular section of the country by the use of public moneys, can you, unless it is along that same comprehensive program?

Mr. PETERS. I believe as long as they do not introduce the factor of direct competition that there will be no objection raised whatsoever.

Mr. FALL. Do you think there is any competition between the products of the average irrigated farm and those of the corn States and of the middle country or of the Northwest?

Mr. PETERS. At the present time there is a limited amount—not so much in the Southwest, but over the middle and further north.

Mr. FALL. Then under your program, as I understand it, you think that the development of the projects which are now under construction, and which will involve for their completion approximately sixteen to twenty-one millions of dollars, should be stopped because there is an overproduction in farm products?

Mr. PETERS. I do not believe anything personally. I possibly should not express a personal opinion. I believe the sentiment is absolutely not in favor of starting or stopping anything that is started. I simply refer to the sentiment that is true if the national state of mind of agriculture is known. If there is an overproduction of agricultural products in the United States, and very serious depressed conditions at the present time, any very large developments that are made conspicuous by their size, as such, might not receive the entire support of the agricultural communities of this country.

Mr. FALL. I was interested, Mr. Peters, for the reason that the President of the United States has just, in a message to Congress, advocated the reclamation of all the remaining public domain which may be reclaimed by irrigation, and the completion of the present projects which have been commenced, and also the reclamation by drainage or otherwise of all the waste lands in the United States, and has asked Congress to adopt a comprehensive program for that purpose. Now you do not approve, as I understand, of that program?

Mr. PETERS. I question whether that program will be enthusiastically adopted by agriculture as a whole.

Mr. FALL. Thank you very much.

Before proceeding to the call of the list of those representing specifically the several States, some one called my attention to the fact that Mr. Brown, I believe, of Arizona, desired to be heard as representing some farm organization or water users' organization. Am I correct?

Mr. C. S. BROWN, of Tucson, Ariz. Ladies and gentlemen, I thought once that since people were expressing my exact sentiments I'd forego this privilege; but it seems to have resolved itself into a handshaking party with the good Secretary, and I was afraid I would not get this opportunity to shake his hand if I did not embrace it. I can say that I represent the farmer people, and to a large extent the stock growers of Arizona, and when I went down into Riverside to attend the League of the Southwest, I found that, starting with the good mayor, most of all the speakers on that occasion referred to some passage of Scripture that had impressed them, and I was reminded of a passage of Scripture when I landed in this fair State, which read: "A certain man fell among thieves." [Applause.]

I have lost that impression. It seems to me that this body has disabused our minds of anything of that nature. When I came into this body it seemed to have such a dignity that it seemed to restore us to a spirit of normalcy, and I just wanted to say this, that I am of the opinion that the good Secretary has misunderstood Mr. Peters, or else Mr. Peters has misunderstood the Secretary. While I was not sent here to represent the National Farm Bureau, I have had the privilege of associating with that National Farm Bureau as a member of its executive committee for a short time, and while it is true that there are a few States who disapprove of any expensive reclamation that involves irrigation, I have had the privilege of disabusing their minds in the last few months to some modest degree for the reason that they had misunderstood what that reclamation meant. I have just come from a national concern where every State in the Union was represented but two, and those people with divergent views have been able to get together to the extent that they had formed a resolution involving reclamation that was a unanimity of purpose from every one of these States but two. We got together and I had said to those people that the people in the West were the biggest minded, most broad-gaged folks in the world—and I made them believe it, because I believe it myself—and I was about to have to conclude that I was mistaken the other day in Riverside, but now my assurance is reestablished. I do believe that if we could not have gotten together it seems to me that it would have been a disgrace. I remember not long ago going by the grounds of the institution for feeble-minded when I saw a group of folks under one man's protection. The fellow that was with me asked that guard "Aren't you afraid to be with these irresponsible people?" "No." He says: "I can take care of myself with any one of them, I think." Well, but he says: "What if they would go together and unite in double teams on you?" "Well," said the guard, "if they could do that they would not be here." [Applause.]

I can say this, that the Farm Bureau of Arizona indorses very heartily and completely the sentiments that have been uttered here with reference to the Government having full control of the building, the distribution, and all that pertains to the construction of this great reservoir system throughout the Colorado mesa.

I could not help but think of a passage of Scripture when these good people that seemed to own the upper reaches of the Colorado River were contending for their priority. Utah seems to own all the Green River shed; Colorado, the Grand River shed, but since we have for Secretary one who is versed in the law, I think he will agree with me when I say that referring to an ancient court record that antedates the early Egyptian land grants I read this, "That the earth is the Lord's and the fullness thereof." And in looking over some of the abstracts of title I have never seen where the property changed hands.

I believe that anyone with good reasoning powers can understand the erection of this great system of water storage and dam sites, and referring to the dam sites that have been referred to by men of eloquence, I just wish to state that in the last two years the farmers and stockmen of Arizona have not been able to make a living by a damn sight. If we overlook the agricultural idea, my friends, we have overlooked the greatest industry in the world.

Just referring to the pages of history very briefly, and asking you to look back over those pages for a few minutes, you will remember that all the way down the civilized nations from Babylon, Assyria, across to Rome, nations have risen to the zenith of their power and then crumbled. Our school teachers have told us that the prime cause of the crumbling, of its disintegration, was immorality. Granting that this is true, I think that you will agree with me that back of that immorality there was a more fundamental reason. That reason was that they forgot their agriculture.

Not long ago in an investigation in Washington one farm bureau was asked to create an agricultural program. In order to create that program sanely, and without prejudice and without malice and in safety, we asked that certain specialists be brought before us to interrogate, and one of these specialists was Mr. Hoover. This question was asked Mr. Hoover: "Is it not a fact that all the cities, with their wealth and all that pertains to cities—is it not a fact, Mr. Hoover, that those cities are builded and maintained on the difference between what the producer got for his product and what the consumer paid for it?" And after a moment's hesitation Mr. Hoover admitted that was a fact.

Ladies and gentlemen, if that is a fact in the fundamental laws of economy, it would be a violation of every elemental law of economy to overlook the agricultural interests of this great project. I just want to say in conclusion and in defense of brevity that the Farm Bureau of Arizona wishes to do what the little boy did when he committed his prayer to memory, in order to save time and in defense of brevity he had it printed, and every night as he slipped between his blankets he would point to that prayer and say, "Lord, those are my sentiments, too." [Applause.]

Gov. R. E. Sloane (of Arizona). Mr. Secretary, ladies, and gentlemen, I have been commissioned to speak for the State of Arizona. I know the Secretary will be glad to know, however, that my commission does not require that I shall consume the full 20 minutes allotted to my State.

The State of Arizona would, indeed, be lacking in gratitude if she did not always recognize the debt she owes to the Government of the United States and the aid and assistance we have received in the development of our water resources.

I want to say, furthermore, that as a State we are not committed to any definite plan as to the method by which the money needed to build the Boulder Creek Dam or to do the other work contemplated shall be raised. I want to say, however, that the State of Arizona is committeed to any policy and any program that shall meet with the approval of the Secretary of the Interior. [Applause.]

Now, I represent the State. I am not here to cite a discordant note in this general chorus of approval, but I have a duty to perform. Now, gentlemen, I am not here to raise any issue on State rights; that has long since been relegated to the limbo of forgotten controversies, I hope, but I want to call attention to one fact, and it is a fact, a glance at this map will show you—if you do not already know it—that these great dam sites and power sites are located within the confines of the State of Arizona. [Applause.]

We stand with southern California in this position. We belong to the lower reaches of the Colorado River, but while that is true, we recognize and appreciate fully the justice of the position assumed by the States to the north of us within the Colorado River Basin. We not only recognize that, but we stand ready to pledge by legislative enactment, if necessary, that no adverse rights to the use of water may be permitted to be developed to the prejudice of the people of these Northern States pending the solution of the question of the equitable distribution of the waters of the Colorado by the Colorado River Commission. [Applause.]

I want to say another thing, gentlemen, and I say it to you because you are here listening, and I have no doubt but what your future attitude toward this matter may be affected somewhat by what is said. I refer my remarks particularly, of course, to the Secretary of the Interior, but, secondly, to the gentlemen here representing other interests. We are a young State. Our resources are not yet developed. We have great natural resources. We locally look upon the power sites and these dam sites within these borders as naturally belonging to our own natural resources. Not selfishly do we look upon them; we are not here to urge that we should not forego—if we have a right—the right of receiving something in the way of taxation from these great plants; we are willing to forego that, but there are some other things that we can not in justice to ourselves forego. Now, it is all right, and I voice the sentiments expressed by fellow citizens from my State with respect to the agricultural interests alone; but agriculture is not our only interest. We have other interests and great interests. To illustrate, in 1919 we produced two-fifths of all the copper that was produced in all the world [applause], and that industry is still in its infancy, if not in the production of the raw material, in the utilization of that raw material into matters of utility—things that may be marketed, such as wire and other things of that kind.

Agriculturally speaking, we are yet in our infancy. We have hundreds of thousands of acres of land that are capable of being reclaimed and irrigated by means of water pumped from the underground waters of the earth. We are an interior people, and like all inland people we are dependent upon two factors for our future growth and prosperity. One is transportation, and the other is an abundance of cheap power. We have the means of transportation. We have 1,000 miles of transcontinental railroad, but we do not have cheap transportation. As I said, our industries are yet in their infancy. If the copper business is to prosper, we must be able in our State to produce copper at a low price, because copper is not likely to go back to the price it had before the European war; we must produce at a low cost. Labor cost may be reduced, and is reduced, but we do not want to shift the burden of cheapness upon the shoulders of the laboring man below. [Applause.]

We want cheap power, as well. We do not have oil in our State, gentlemen; at least, we have not yet discovered oil in paying quantities. We have copper. We have coal mines in our State, but geographically they are so located as not to be available for us in the central and southern parts of the State. We are dependent wholly upon power, and the only source of power in any great abundance lies, not in the Grand Canyon of the Colorado but in the Grand Canyon of Arizona. Now, that is what I am getting at, Mr. Secretary. We believe that we have a preferential right to that power to the extent of our needs [applause], and we do not measure our needs by our present necessities. As a young and growing State, we are looking to the future.

Now, then, if the plan suggested by the director be adopted—and I am not here to criticize that plan or to object to it—I want to make this suggestion: If the money to build the dam at Boulder Creek be contributed by municipalities, cities, and counties, and water-users' associations, they must be largely found in southern California. We are a poor State; we are a new State, and we have not the capital that you have; we can not contribute much in the way of money toward the building of this dam. However, I suggest that this matter must ultimately be regulated by contract between the contributors of this money and the Government, and that in any contract of that sort our preferential right to the use of such power as we may legitimately use and need shall be safeguarded, so that when we do want it we will be able to get it.

Now, that is an important detail on which I have no suggestion to make, but I think, and we think, that we should be safeguarded in some contract. That is about all I have to say, Mr. Secretary. We are related closely to southern California. We delight in the prosperity of the cities of California; we are deeply interested in our friends in the Imperial Valley; we want to see them protect their rights—their rights protected, their future protected—and we want to see them prosper; but charity, as we have always heard, in a measure begins at home, and we are simply here to-day to voice these thoughts that in all the plans that may be adopted, in all the plans that may be considered first and that ultimately will be adopted, our—what we regard as our—natural right to the use and enjoyment of the product of one of our natural resources shall not be forgotten. Thank you. [Applause.]

Engineer McClure (of the State of California). Mr. Secretary, speaking for and on behalf of the State of California, we congratulate ourselves that you are now within our borders. We congratulate you that there is a California to which you may come and within which you are now at this time. We congratulate you also that California and the other States of the Southwest have a problem for solution which we anticipate may occupy the best thought of not only ourselves but of your good self and your Cabinet of the administration at Washington. We are delighted, more than I can express in my unfitting words, with the attitude of mind which you have already expressed, and we thank you, sir, for that sympathetic expression: "Words might be multiplied but conversation may not be underwritten to profit."

An emergency exists, if you please, and that is the reason we are here.

I speak now on behalf of the irrigation district in the Imperial Valley. My official connection with it places me in a position where I know the strict manifest necessity of early action. An emergency exists, first, because once a year we have too much water. I do not share the idea of a great number of people that because the Colorado River may at some time again, as it did in 1905, find the avenue of the Salton Sea, therefore they should overnight have to take flight. That fear cuts but slight figure in my mind, but no one standing by the banks of the Rio Colorado, as I did during last June at the high-water period and watching this turbulent element finding its unimpeded progress at that time toward the ocean—unimpeded, but with a few inches only between the level of the top of the levees and the top of the water—will deny that an emergency exists, because at periods we have too little water.

Now, we want the best, the happy medium, and we believe that medium may be found in the storage of water at some good point above the Imperial Valley. Personally, I am pleased, Mr. Secretary, that it is neither before you nor me this afternoon to attempt to make an allocation of all of the water, or of all of the power that water may produce. That will remain for us to report on hereafter. An emergency exists at the present time because of the bungling mode of diversion that has to be resorted to. That has been clearly referred to here by my friend from Yuma district. It certainly must appeal to every business man, and especially to every engineer, that that mode of lifting water to a point where it may flow onto the valley should not be permitted longer than is absolutely necessary.

An emergency exists, if you please, because the moneys of the valley are at this time spent in a foreign country for protection works. Of necessity that must remain so, and we are grateful, indeed, to our sister Republic below there for the spirit of generosity which has been extended to us, and that spirit of generosity has been voiced here to-day by their representative.

As an officer of the State, a peculiar interest attaches. The irrigation district is interested in the matter not only from the viewpoint of getting this water there but before it gets there the bonds are issued. State securities are issued, and it is a very delicate matter, as you know, to place a security where a hazard exists, such as is manifest—as is present every year in the Imperial Valley.

I might appeal to you, as I do, for the claims of Wyoming. Their interests and the interests of others down the line will not be neglected. We believe, sir, that you already have this matter firmly fixed in your mind and that you will deal justly with us, but we need speed, because an emergency exists. [Applause.]

Mr. FALL. It is now 5 o'clock; I do not know how you feel, but I am tired. A recess is taken until 8 p. m.

EVENING SESSION.

Mr. FALL. I owe you my apologies in being late. The next speaker on the program is Mr. George Brewington, of New Mexico.

GEORGE BREWINGTON. Ladies and gentlemen, as has been announced, I am from New Mexico. Some of you are more or less familiar with the State. I have been, or rather the State has been allotted 20 minutes, most of which time we will not require. The time can be used to advantage, I presume, by some of the other States. I wish only to incorporate a few remarks into the record of the proceedings. [Reading:]

Though New Mexico is one of the oldest States in the Union as to its settlement, it is perhaps the youngest in point of development.

Long before there was any other civilized population west of the Alleghany Mountains, the valleys of New Mexico were filled with a prosperous people, who grew their crops and supported themselves in comfort by taking waters from the ever-flowing rivers and applying them to fruitful lands.

Long before irrigation had been heard of in Colorado or Arizona or California, it was an ancient art in New Mexico and it has lost none of its importance to-day.

There are vast areas of our State where bountiful crops are raised under ordinary rainfall, but there are still greater stretches where water brought by the hand of man is absolutely essential.

In the San Juan Valley there are hundreds of thousands of acres of arid lands waiting only for water to change to fertility, and water in plentiful quantity to-day runs by them unused. Only lack of funds and lack of development prevents their appropriation and use, and we look forward to the day and hope it may not be too far distant, when these conditions will cease and we can apply our own waters for the purpose for which Providence doubtless intended them.

I bear to you of our sister States no message of conflict or ill will.

Our best wishes go with your plans for development.

Your speakers have said, and the representatives of the Federal Government have promised, that in your present plans, to which your good fortune entitles you, the rights of the upper States will not be forgotten.

There is water in the Colorado River for all. The time will come when we will have desperate need for the share to which our situation entitles us.

Meanwhile, and under full assurance as to our protection as to future needs, and with the understanding that there is no intent to interfere with our own natural resources, we wish you Godspeed and assure you of our cooperation.

J. A. MARSH, of the State of Colorado. Mr. Secretary, ladies, and gentlemen, we appreciate very much the opportunity of Colorado to present what the Secretary referred to in his opening remarks as "observations" regarding the development of the Colorado River. We appreciate what the Federal Government has already done for Colorado, and we are very grateful that the development of the Colorado River is to be at least under the supervision and guiding hand of the United States Government, because I am satisfied that if it is under the guiding hand of Uncle Sam all of the children of Uncle Sam will be protected.

Now, we are not here, friends from Lower California, southern California, and the Southwest, to criticize your ambition. We do not blame you for wanting to protect yourselves against flood control. We wish you Godspeed in the development of the Colorado River. But in the development of the Colorado River, we hope that the interests of the upper States will not be neglected.

Now, in the State of Colorado, for instance, water rights rank first—domestic purposes, irrigation, and then power—and if we were developing the Colorado River alone we would develop it with that order in view.

The domestic purposes being necessary to protect human life, irrigation to make profitable the soil, and, of course, power being the third or the least important of the three. And so, in the development of the Colorado River, we are not here to attempt to dictate or even suggest under what particular plan the Colorado River is to be developed—that is, as to where the funds are to be obtained by the Federal Government, if it is to be done under the Federal Government, as I understand from the Secretary it is to be—neither are we here for the purpose of attempting to dictate at what particular site the dam or dams should be constructed.

Mining engineers, Mr. Secretary, have spent a great deal of time in an examination of this river, and they doubtless know where and at what place or places the dams could best be constructed.

But in the development of this river we are very much interested that our rights for domestic and irrigation purposes up in Colorado shall not be jeopardized, and it is our understanding that if these dams are constructed, Mr. Secretary, our rights will be protected and that no reservoir rights will be vested which will deprive us of our domestic and irrigation rights in the Colorado River.

Now, as we understand, the greatest efficiency can be gained from the water by its application to a beneficial use at the point where the river rises—that is, high up on the river—and by using it constantly, and letting the seepage go back to the river on down to its mouth.

Now, this particular river, 1,700 miles in length, produces in the State of Colorado 11,000,000 acre-feet of water, and Colorado has lands which it desires to develop and reclaim as well as the other States lower down the river.

I was glad to hear to-day the Secretary state that the President of the United States had announced that he was in favor of reclaiming all of the arid lands which it was possible to reclaim under the supervision of the Federal Government, and it will mean a great deal to the State of Colorado. There are within this river basin, inside of Colorado, 1,300,000 acres yet to be developed out of this river.

And the city of Denver, for which I desire to speak especially, also has a vital interest in this water supply. The city of Denver is a growing municipality, closely approaching 300,000 people, and its supply for domestic purposes is now almost up to the limit, and it must have some of this water in order that the people may live. It is absolutely necessary for domestic purposes that the people must have it to live, and if you people down in the Imperial Valley must have it controlled in order that you may not die, we must have it controlled in order that we may live, and we simply want a supply so that we may consume some that will make less for you to have down in that Imperial Valley, and in order to do this it is necessary that we have a transmountain diversion of between three hundred and five hundred thousand acre-feet per annum. This is a relatively small amount as compared with the amount that goes down the Colorado River to the sea, only I think about 1½ per cent of the total supply of the Colorado River. Now, then, this is not a new thing. Some 20,000 acre-feet of water are now being diverted out of the watershed for private enterprises.

The Reclamation Service is watering some 45,000 acres in the great Salt Lake Basin known as the Strawberry Valley project, and the water that goes into the Imperial Valley, something over 2,000,000 acre-feet per year does not get back into the watershed; and if all of the developments are made out of the Colorado River which are now under contemplation, almost one-third of the water within the Colorado Basin will come out of the Colorado Basin for the development of lands and for beneficial purposes.

So, Mr. Secretary, it is absolutely essential that the people of Denver have this quantity of water in order that they may live and in order that Denver may grow. Denver is having a phenomenal growth; there is more building in the city of Denver to-day than there has been for many years, and it is necessary that the people of Colorado and the city look forward to an efficient water supply for that city in its domestic phase and the interests of normality, and so I say in developing these projects down here whether you build one, two, or three or a series of dams, due regard should always be had for the upper rights and especially those rights for the higher purposes.

As I say, we wish you Godspeed in the development of Imperial Valley. We wish you protection. We wish all of these States to have the beneficial use of these waters so far as they may have them consistent with the interests of every other State.

Under the decision of the Supreme Court of the United States in the Kansas-Colorado case, the Supreme Court said: "We are entitled to, and all the States are entitled to, an equitable distribution of the water," and that is all Colorado is asking, that in your development you see that no interests vest so that Colorado can not have its equitable distribution of this water.

Now, as to this question of development we, of course, are anxious that the development shall not take place in such a way that all of the funds available from the Federal Government shall be applied toward the construction of any one dam, and that any development below shall not retard any development above which will protect the States in the upper regions. In other words, the development in the upper States, necessary as it will be some time in the early future, should not be retarded because all the funds appropriated by the Federal Government are used for the construction of the Boulder or some dam lower down the river.

Now, on this question of the water supply, and as the Secretary told us this morning, the several States in this Nation have named commissioners—each one has named a commissioner and the Federal Government will name a commissioner in a very short time, and we are perfectly willing to leave the matter of the distribution of these rights with these commissioners, feeling sure that each State will get all to which it is entitled under the award of the commission.

And another thing on this question of power. The Colorado River is undoubtedly capable of developing an exceedingly large amount of power, and in power development we hope that the Government will see that the power is developed, not simply for one State, not simply for certain of the States, but that it will be so developed, either at this point known as the Boulder Canyon or at other points, so that all of the States in this basin, comprising 244,000 square miles, will get the benefit of that power.

While the necessity of Colorado to-day is greater for the water to be used for domestic and irrigation purposes, yet it will also become, as the years go by, more and more interested in the question of power, and this question of hydroelectric power is of increasing importance, as is shown by the anxiety of the Colorado municipalities to obtain this power. And we hope, and we are sure, that in the development of this power the Federal Government will see that the dam is located at such a point either that the power can be transmitted to all of these States contributing to this basin or else that other dams will be constructed which will contribute a sufficient amount of power, and as I say, this question of the hydroelectric power is becoming constantly of increasing importance.

We find that coal is being used less and less for furnishing power for locomotives. I notice here in California that your engines are propelled by the use of oil—by burning oil. On the Atlantic coast many trains are being electrified, and while I am not a prophet or the son of a prophet, I predict that if all the power which could be generated, not simply by one dam but by a series of dams in the Colorado River, and which might be developed by cheap coal in many of the States, in the course of a very few years all of the railroads from the city of Denver west to the Pacific coast will be electrified. It will be a very comparatively short period of time before that very thing takes place.

And another thing, when hydroelectric power is reduced in cost, as it will be when it is developed in this river and by cheap coal, then it will be used for heating purposes in our homes and in public places such as this.

And so it is of increasing importance, and we are interested, Mr. Secretary, in the future development of power, and hope that when it is developed it will be equitably distributed, as the water must be equitably distributed, among the various States in this Nation.

Now, on the subject of irrigation, which, as I say, we hope will not be jeopardized, Colorado has irrigated from this basin now 750,000 acres.

Mr. Fall. You have both the Uncompahgre and the Grand Valley projects already on the headwaters of the stream constructed by the Government?

Mr. Marsh. Yes, sir; constructed by the Government, and then we could reclaim under the waters from the stream, which will not materially reduce the supply, an area of 1,300,000 acres.

Mr. Fall. Does that mean without taking the waters across the Divide and into——

Mr. MARSH. Yes, sir; it does, right in the same basin. The only waters which we are proposing to divert by the transmountain diversion are those which are absolutely essential for the preservation of human life for the purposes of the city and county of Denver.

Mr. FALL. Does that mean that you must have both the headwaters of the Rio Grande and the headwaters of the Colorado for the benefit of Denver?

Mr. MARSH. No, sir. The headwaters of the Rio Grande we are not getting for the benefit of Denver; no, sir, we are not. The waters which we are requesting for the benefit of Denver are the branches of the Colorado, the Fraser, the Williams, Forbes, and the Blue——

Mr. FALL. I beg your pardon?

Mr. MARSH. No, sir; we are not at all. The projects which you refer to are in the southern part of the State.

Mr. FALL. I heard one of the speakers from Colorado refer to the arbitrary act of the Reclamation Service in preventing the people of Colorado from obtaining the waters of the upper Rio Grande.

Mr. MARSH. I have not heard that. We make no criticisms; on the other hand, we are very grateful to the Federal Government for what it has done for us. I speak of the importance of this to Denver, because it is absolutely essential for the preservation of human life. As I say, the matter has been taken under consideration. I think it has been up before the Los Angeles Chamber of Commerce, and I know a very prominent consulting engineer from Los Angeles, Mr. Lippincott, who has gone over our situation; he agrees and has said in his report that it is necessary for the preservation of Denver and its future that we should have this diversion of this comparatively small amount.

Mr. FALL. I am very much interested in that because I have just had a proposition before me calling for official action with reference to a certain water application. The city of Denver allowed a certain time to elapse and a private individual to obtain the water rights there within the last month.

Mr. MARSH. Mr. Secretary, I am quite familiar with that situation.

Mr. FALL. I knew you would be.

Mr. MARSH. I will be very glad to go into that.

Mr. FALL. I do not care to go into it now.

Mr. MARSH. But the city of Denver did not—if you will permit me to make a statement—permit it to lapse. It was withdrawn by the President of the United States for the benefit of the water supply within the lower reservoir on the big river which does not [several words inaudible to reporter]—it does produce some small amount of water, too; it was withdrawn for the benefit of Denver, and it seems on the recommendation of the department it was withdrawn.

Mr. FALL. Now just what was the condition there with reference to that water application?

Mr. MARSH. Mr. Secretary, there had been an outstanding application for a reservoir site on a site known as Eagle Rock for 20 years—more than 20 years—since 1900; it was made by a gentleman of Denver on behalf of a private company. He had not been able to make the necessary expenditures for the purpose of retaining the reservoir, and the Department of the Interior had granted extensions from time to time for the purpose of permitting him to make the necessary expenditures. His last extension expired some time the latter part of last year or the first part of this year. The city of Denver had itself had an application filed for a permit to construct the reservoir on that site and we had asked the Department of the Interior to ask the Attorney General to bring a suit to forfeit it because he had not made the expenditure. The department handed down an opinion about three months ago, in which they said that his application should be rejected and that they would ask the Department of the Interior to have his application judicially forfeited, which as I understand is your practice and is necessary to be done. Your department stated in the same opinion that the city of Denver's application would not then be permitted to be filed, although the lands had been withdrawn for the benefit of the State, because the State had not then made financial provision for the construction of the reservoir, which cost several million dollars.

Mr. FALL. Didn't the city in that statement say that they did not need the water at that time?

Mr. MARSH. No, sir; I think not. Because we have always wanted to proceed to construct it so as to supplement this wholly inadequate supply which we have. Then, recently, and without your knowing anything about it, an order of the President withdrawing the site from entry for the benefit of Denver was canceled, and the gentleman who had previously made the application for a reservoir site reapplied, and his application was permitted to be filed without any notice to the city whatever; so we feel like we have done everything we could, Mr. Secretary, and we are hoping sometime to take it up with you further when the time arises.

Mr. FALL. Well, it has been taken up recently, and I for that reason was rather——

Mr. MARSH. Yes; I could not have gone into this explanation if you had not asked me.

Mr. FALL. I am glad to have it made public, because there has been some question about the action of the department in this matter; and while the action, as it happens, of the department in this particular matter was taken during my absence from Washington, still I am responsible for it, and it was based upon the statement contained in a written application of the city of Denver that at that time Denver was not prepared to go ahead with the application for the water; that Denver wanted the order withdrawn and held for her for future action.

Mr. MARSH. Would that mean, Mr. Secretary—it of course would—that we had not even voted the bond——

Mr. FALL. Yes; you were not prepared to go ahead with your construction.

Mr. MARSH. Yes; I guess we would have voted bonds at any time.

Mr. FALL. However, that was water on the——

Mr. MARSH. Water on the Platte watershed, and has no connection whatever——

Mr. FALL. On the Denver side, so there was that supply of water on that side available for Denver?

Mr. MARSH. A comparatively small amount, which was mostly an elevation reservoir, for the purpose of catching up above when that reservoir was cleaned. The point I want to emphasize, if we should have two other years in Denver like we had in 1902 and 1903, the population approaching 300,000, as it now is, and constantly growing, that that supply for domestic purposes would be short, and we would have a very serious situation in Denver; and that is the reason we are trying to supply—and the only other supply we can get is that supply out of the headwaters of the Colorado River, and no one need feel any apprehension about us taking any amount which is going to injury anybody below, because we have to take this water out at an elevation of some 10,000 feet, and the only time of the year that the water is not frozen there when it could be taken out is between about the middle of April and the middle of October; and the total amount which could be taken out, as we now figure it, is not to exceed 300,000 feet, and it is taken at the time of year when there is not any necessity, when the floods are on, and when it would be missed least of all; and, as I say, it would simply amount to about 1½ per cent of the total stream—a mere bagatelle—and not injure anyone below, but it is of infinite importance to the city and county of Denver and its welfare. I thank you. [Applause.]

L. WARD BANNISTER (of Colorado). Mr. Secretary, ladies and gentlemen, I had thought, until I heard a certain announcement made by the Secretary at Riverside, followed by a similar announcement by Mr. Davis, of the Reclamation Service, that there could be no peace between the people of Colorado as an upper State and the people of California. We have had experiences in our State with projects on the lower rivers supplied by waters which arise in our mountains, and we have found that invariably the claim has been made by those who have taken these waters below that they had a right to the continuance of that flow, and that any projects of ours which we established later in our own State could not be operated, if the effect of the operation would be to deplete in any degree the supply below; but Secretary Fall announced and Director Davis seconded the announcement, a principle which I thinks cuts the Gordian knot and makes it possible for peace to be established between the people of the upper States, like Colorado, and the people of the lower ones, like California. In other words, both officials stated that they believed in the principle of an equitable division of the waters of the interstate streams and of the waters of the Colorado River, and I take it, Mr. Secretary, that an equitable division of the waters of the stream means that prior users, whether they be in higher State or in the lower, are to count for nothing upon the ground of priority, but that the waters of the interstate stream are to be equitably divided, and then that upper State will do with its portion that which it may have the right to do, and the lower State with its portion the same thing.

I think that principle, when applied to the Colorado River, will bring about a condition under which it will be possible for the different States in this watershed to be satisfied, and not to be at war with each other. Of course, if there is plenty of water there can be no war anyway, but I have in mind the possibility of scarcity, and in that event I see in the principle which the Secretary has advocated a method of preserving the peace.

Now, Mr. Secretary, the remarks which I want to make go to the method by which I think it possible to protect an upper State like Colorado, and there are seven points which I wish to make as to the method of protection. The first three are to be found in the resolutions which were passed by the harmony committee at Riverside, but which, unfortunately, through the adjournment of that convention, were not presented to that body.

The first point was that where the development is to be by a private enterprise acting under the Federal Power Commission, there should be included in the license and permit granted to the holding company a provision whereby the water used in connection with the project should be considered subject to the right of equitable division on the part of other States upon that same stream, and in that way, as a matter of law, I take it that no matter what the will of the private company might be, no encroachment could be made upon the water of the other State.

Again if the development, instead of being carried on by a private company, should be carried on by the Government itself, I think that the rights of other States can be fully protected if, in the statute passed by Congress, and if in the regulations made by the department appropriating the money and authorizing the enterprise, there were inserted a provision similar to that which I have mentioned as being appropriate to license and permits granted to private parties by the Federal Power Commission.

The third point, which was also to be found in the harmony resolution, was this: It was not believed by any of us right that in supplying a project in a lower State the administrative department of Government should hold up projects in the upper State.

The Federal Government is, as you know, the owner of many thousands of acres of land in the upper States, and it controls a right of way across these lands. The agencies within our State, for instance, which wish to develop water projects, must apply to the Federal Government for a right of way across the public lands. Now, if the Federal Government denies that application, as it has done in numerous instances heretofore under administrations prior to your own, Mr. Secretary, then it becomes possible to prevent the development of our State, and it would seem to us that it is not right or fair to withhold consent to these applications, since the water which will be represented by those applications would be an encroachment upon that equitable share which ought to go to the lower State. If that encroachment be made then it seems that it would be fair for the Federal Government to withhold rights of way for projects in the upper State. But, merely to withhold because of the possibility that the supply in the lower State would be affected, without encroaching upon its equitable share, does not appear to us to be just.

The fourth point, Mr. Secretary, which I wish to make is this: For 15 years the people of Colorado have felt that they have been oppressed by your predecessors in office in this one respect. This is the only point on which we make complaint, and that is in the withholding of these permits or consents to guard our own projects.

I have in my pocket here an order to which I referred at Riverside, and in respect of which I think that Mr. Davis will concede that he was in error. I had said, referring to the interstate stream of the Rio Grande, that development in Colorado had been held up by the Reclamation Service, and I recall that you, Mr. Secretary, recalled that an order had been entered at one time—at about the time the Government of Mexico complained of America's use of the waters of that stream—and I recall that Mr. Davis thought that the order to which I referred, and which held up the projects in our State, was an order which was entered before the Reclamation Service was born, and, therefore, for which the Reclamation Service could not be held. Now, the order which I have here in my hand is one for which Mr. Davis is not responsible, because it was not entered until after, as I believe, he became connected with the service, or at any rate he was not then the responsible head, but it is an order dated April 25, 1907. It is signed by Mr. Newell, who was then the head of the service, and this is the reading:

I therefore recommend that the department lay down the general policy that until the development of irrigation on the upper Rio Grande in the State of Colorado and the Territory of New Mexico shall furnish sufficient data to determine the effect of the storage and diversion of water in that vicinity upon the water supply for the Engle Reservoir of the Rio Grande project, no further rights of way be approved which involve a storage or diversion of the waters of the upper Rio Grande and its tributaries, except applications of two kinds; first, those in connection with which there is a showing that the rights of the parties were initiated prior to the begining of active operations by the Reclamation Service for the Rio Grande project, namely, March 1, 1903; second, applications which involve the diversion or storage of not exceeding 1,000 acre-feet of water per annum.

That, of course, Mr. Secretary, would be an exception; it would be the law anyway.

Mr. FALL. That had particular reference to one particular project?

Mr. BANNISTER. It did. That is, there was an application for a project—it was the application of Antone Jacob for a right of way for a reservoir in Colorado.

Mr. FALL. I mean the order had reference to one particular project and not to the beginning of the activities of the Reclamation Service?

Mr. BANNISTER. Well, as I understand it, the order referred to the Engle (Elephant Butte) Reservoir; that is, the purpose was to protect—the order followed a decision of the Supreme Court of the United States in the Rio Grande Dam case and the treaty between Mexico and the United States and an act of Congress of 1907 following that treaty, and appropriating $1,000,000 to start the Elephant Butte Reservoir.

Mr. FALL. That is the history?

Mr. BANNISTER. Well, now, as I understand it, Mr. Secretary, under the treaty Mexico was given 60,000 acre-feet, and that would leave the rest of the stream to be equitably divided between the native States, and the only point I wish to make, and that, too, in the way I most respectfully can, is this, that, after first deducting from the stream the 60,000 acre-feet going to Mexico, we then would apply the doctrine of equitable division to the remainder, and the mere fact of Colorado holding back part of the water, namely that portion which otherwise would go into Texas or into lower New Mexico would not constitute an unlawful act on the part of Colorado since it encroached upon the equitable portion belonging to Texas or to New Mexico.

Mr. FALL. I had not intended to get into any controversy with you. When you get through I will feel inclined to give a little history connected with this particular transaction.

Mr. BANNISTER. I do not doubt you know more about the history and the facts than I do—I speak of the principle.

Mr. FALL. Yes.

Mr. BANNISTER. Of the principle, which I figure is simply this, that the mere fact that the lower project has its supply somewhat diminished is not conclusive of the case unless the upper State is encroaching upon the equitable portion of the lower. And I am informed, Mr. Secretary, reliably by the engineer's office of our State, that there have been numerous instances where rights of way have been refused, not only in respect to the headwaters of the Rio Grande, which flow southward through New Mexico, but also upon the headwaters of the Platte, which rises up in the State of Colorado and flows northeasterly into the Pathfinder Reservoir in Wyoming, whence it is used for irrigation in eastern Wyoming and western Nebraska, and I feel satisfied, Mr. Secretary, that if you should find that it would be a just thing between the States, that the present embargo upon Colorado in respect to the headwaters of those rivers could be lifted, you would find that 1,000,000 people in the State of Colorado, who in this respect feel wronged, would rally to the support of the development of the Colorado River, whereas otherwise we feel, in the light of past experience, we must meet the men of California upon the floor of Congress and through our Senators and Representatives oppose absolutely their plans for the development of the lower part of this river, a thing which we do not want to do and which we hope we may be spared from doing under this doctrine of equitable division which you announced yesterday.

Again, in respect to power, it seems to me proper not only to have an equitable division of the waters of the streams between the States, but there should be a distribution of the power generated at the Boulder Canyon Dam. That is a major project, and when power is developed there it is not likely that there will be another major project of that kind and magnitude for a good many years to come. The project which is first established will be the one which will supply the towns and cities of California, and there will be no market for another enterprise for a good many years, and therefore it becomes a matter of great importance that the other States—I can not speak for them except for Colorado—but it becomes a matter of importance to Colorado, at least the southern portion, which is in the same position as New Mexico and Nevada and Utah, that in the distribution of power they be recognized.

And next, in what way can they be recognized?

Several plans of development have been proposed. If the Government were to defray the entire expense of building the dam and the building of the power plant, it would be then in a position to distribute that power as it may be deemed best among customers in these different States, but the same thing would be true, Mr. Secretary if this development instead of being borne by the United States were borne by a private company acting under the supervision of the United States. We care not by which method the development is made if only we are guaranteed something in the way of distribution of power.

There is one plan, Mr. Secretary, which I very much fear, and that is the plan by which the Government constructs the project but reimburses itself through an allocation of costs between different persons or different communities. That plan we fear, and for this reason, it makes the project the property of those communities, and unless, which would seem to be hardly possible, some provision be made by which these other States like Colorado need not take all of their power now, need not subscribe now, but when they are more fully developed take it, it would seem that they would have to go without their fair distribution of power. If it be that municipalities are to supply the money or reimburse the United States for the money, it would seem to us that some arrangement could be made whereby these other upper States less developed now than California, but to which power is just as important, may come in at a later time, and if that could be arranged I do not see that the upper States can have any objection.

That is all, Mr. Secretary, except for a single point.

I have not met on my western trip any finer gentleman than Governor Sloane of Arizona, and I heard the governor this afternoon advocate the preferential right in power in favor of the State of Arizona. He advocated it upon the ground that Arizona owned the land or would own part of it upon which the dam is to be built, and he said that his fellow statesman—later he corrected the word to "associates," agreed with him in that respect. He said that he was willing that the legislature of his State should pass an act whereby any development on this lower river should be without prejudice to that equitable division of the water, and I think that was a statesmanlike view, and he need not have changed the name of his Arizona associates, but it seems to me that the thing should be carried just one step further, that just as there is to be an equitable division of water, so there should be an equitable division of power and without preference, for while Arizona may furnish the land upon which the dam stands, yet Colorado and the other upper States furnish the water, and while it is true that there can be no project without the ground upon which the dam stands it is equally true there can be no project without the water furnished by the upper States, and, furthermore, California, furnishing neither land nor water, nevertheless, does furnish a trough or river bed through which the water may make its clearance and constitute a stream instead of a lake, and therefore California ought to be entitled to a distribution of this power along with the upper States and with Arizona, but without preference for any.

Secretary A. B. Fall. Ladies and gentlemen, I am going to pursue rather an irregular course just at this moment. There is no controversy of any character when the facts are understood, as they should be between the speakers for the State of Colorado and those of some of the other States. There has been some misunderstanding and possibly some blame to be attached to the Reclamation Service or the bureau for not having acted more promptly in making a report upon certain phases of the diversion of the waters of the Rio Grande.

The opposition, if any, to the proposed construction of a reservoir upon the Rio Colorado hinges, in so far as the State of Colorado and other States are concerned, as I understand, upon their past experience with reference to a reservoir constructed upon the Rio Grande.

Now the situation is this, if you will allow me for a moment to recall a little history.

The present States of New Mexico, Arizona, California, a portion of the State of Colorado, and other territory of the United States were acquired by the treaty of 1848 from the Republic of Mexico. The headwaters of the Rio Grande in Colorado were obtained by these treaties. That portion of the territory in which all of the tributaries of the Colorado in the State of Colorado are concerned was obtained by the same treaty through which the lower portion of the Rio Grande from the headwaters in Colorado to the mouth in the Gulf of Mexico was obtained.

The same treaty provisions in 1848 and 1853–54, the Gadsden treaty that applied to the Rio Grande, applied exactly to the Rio Colorado. Therefore our friends think that because of the fact that in 1907 a reservoir was commenced upon the Rio Grande for the purpose of enabling the United States to carry out a treaty provision with the Republic of Mexico and under or following that treaty an order was entered by which they were deprived of the right to acquire any more waters temporarily upon the Rio Grande above this reservoir, therefore they might anticipate the same difficulty with reference to the proposed structure upon the Rio Colorado. As I understand, that is the whole objection.

Now, under the treaty of 1848–1854, both the Rio Grande and the Rio Colorado were declared navigable streams and international streams, and the faith of both Nations, Mexico and the United States of America, was pledged to maintain them in that condition, each pledged to respect the streams as international streams forming a portion of the boundary line of the two countries, and to respect the navigability of the two streams.

Mexico brought various claims against the United States for damages aggregating $35,000,000 upon the ground that the taking out of waters from the Rio Grande in the United States entirely within the territory of the United States had so depleted the amount of water flowing past south of the boundary line of the United States and into that portion of the stream or of the bed of the stream where the Rio Grande became an international stream, that the 20,000 acres, more or less, upon the Mexican side had been deprived of irrigation water to which it was entitled.

The Attorney General of the United States in passing upon this claim decided that it was not one which made the United States liable in a court of law, or liable for damages, but in considering the equities of the matter the two Governments arrived at this decision, that the Government of the United States would construct a reservoir within its own boundary, 160 miles north of its southern boundary line of New Mexico, and that through that reservoir they would give or deliver to the Republic of Mexico water for 20,000 acres of land free forever; 60,000 acre-feet of water. The matter had been in the courts for years. A private enterprise had sought to construct what was known as the Rio Grande Dam at the present site of the Elephant Butte Reservoir. After several years the United States Government instituted through its Department of Justice a suit against the Rio Grande Dam and Irrigation Co., upon the ground that if they constructed the reservoir, as it is now constructed by the Government, it would impede navigation in the Rio Grande and would be a violation of the treaty with Mexico.

The lower courts decided against the contention of the Government. The case was appealed and was finally reversed by the Supreme Court of the United States upon technicalities, was tried again, and the case was again decided against the contention of the United States and again appealed. Finally the great court—the Supreme Court of the United States of America—decided that irrespective of the question of impairing navigability, if the structure was calculated to or might impair the navigable capacity of the stream at some point, it was to be prohibited by the power of the United States. And that ended the controversy. The company lost and was deprived of its property.

Finally, or later, after entering into a treaty with Mexico, the United States in compliance with the terms of that treaty, the Congress of the United States—not the Reclamation Service, but the Congress of the United States—provided for the construction of the Rio Grande Reservoir. It was not a Reclamation Service project at all; it was a congressional project, for the purpose of enabling the people of the United States to keep faith with the people of their sister Republic and to comply with their treaty obligations. [Applause.] It was turned over to the Reclamation Service for construction, and I may say that the act providing for this construction and appropriation of this money was passed by the Congress of the United States at the insistence of that American who never forgot the honor of America, Theodore Roosevelt. [Applause.]

Now, my friends, the situation was this: We were obligated, first, by virtue of the decision of the Supreme Court of the United States, and second, by the terms of a solemn treaty with Mexico to protect the waters that we might give the 20,000 acre-feet to Mexico which we had decided or agreed with her belonged to her, and for that purpose. and that purpose alone, the Reclamation Service, to which this project had been turned over by the act of Congress, under the recommendation of the then Director Newell, withdrew, through the Interior Department, the public lands of the United States in Colorado, upon which a diversion of the waters of that stream might have been made, solely for the purpose of enabling us to perform our obligations, and to keep our national good faith, and in obedience to the terms of the Supreme Court decision, against the people of New Mexico and not the people of Colorado. The people of New Mexico were building, or proposing to build, this Rio Grande Dam, not the people of Colorado. The decision of the Supreme Court of the United States was against the Rio Grande Dam & Irrigation Co. of New Mexico and did not mention the people of the State of Colorado—did not involve them except that the decision of the United States Supreme Court was to the effect that the Rio Grande was a navigable stream, an international stream, and belonged to the United States of America from the head springing in the Rocky Mountains to its mouth in the Gulf of Mexico; and the same law, the same rule, applies to the waters of the basin and the land of the Rio Colorado. [Applause.]

Now, those are the legal questions involved, and those are the facts.

Now, I want to say—I said a moment ago that possibly the Reclamation Service was at fault—I am frank to say that I have criticized them myself, sir; I have agreed with you in this criticism.

Director Newell suggested that these withdrawals of these rights of way upon the public lands be continued until it was ascertained that they could be released for entry, and still these international obligations performed, and only that long and no longer. And it may be that the Reclamation Service has been dilatory in not having ascertained and reported heretofore that there was sufficient water falling within that basin to fill the Elephant Butte Reservoir, and to enable us to perform our international obligations, and our obligations to the prior users below that reservoir and yet to release certain of the waters in the State of Colorado—it may be that they have been dilatory, as I say, in the performance of that duty. I have suggested as much myself, and it shall be my pleasure to see that at an early date a report is made upon this proposition. [Applause.]

But I want to make the point again, that this action was founded, first, upon the opinion of the Supreme Court of the United States; second, that it was based upon the solemn treaty obligation with the Republic of Mexico, and we have nothing to apologize for, except possibly the Reclamation Service may have been a little dilatory in finding exactly how much water should be allowed to go into the reservoir known as the Elephant Butte.

Now, the same situation will inevitably arise with reference to the waters of the Colorado. The waters of the Colorado are equally solemnly pledged under exactly the same treaty by identically the same words to Mexico and the United States reciprocally.

Questions have arisen between the two countries heretofore, and in 1911, in the early part of the year, Henry L. Wilson, the ambassador to Mexico, entered into negotiations with the then Government of Mexico for a convention, the signing of a convention and the appointment of delegates for the settling of the questions which might arise and had then arisen between the people of the United States and the people of Mexico touching the waters of the Rio Colorado. After the interchange of several notes the form of the convention was agreed upon, and the final draft of the convention was communicated to the ambassador of the United States, Henry L. Wilson, in the City of Mexico for the signing of both parties, and for the agreement of Mexico, the naming by Mexico, of her commissioners to represent her under agreement to be entered into under that convention. And the revolution broke out in Mexico and the convention was never signed, and the convention is pending between the two countries to-day for that settlement. Exactly a similar course must be pursued as was pursued with reference to the waters of the Rio Grande. The agreement must be entered into finally, and pending that, if Mexico, unfortunately, is not in a condition legally to enter into that convention for the time being, and we are considering the distribution of the waters of the Rio Grande or the Rio Colorado, one power and one power alone can protect the waters of the United States and protect the Mexican interests in justice to that country, and that is the United States of America. [Applause.] And the United States will protect these interests, and will hold Mexico's interests intact and protect her interests, to be delivered to her whenever a government in Mexico is recognized, and enter into a contract for such delivery. Now those are the facts. [Applause.]

I intended to make no speech. You will pardon me. This is not my time for making a talk, but I felt that my friends from Colorado did not exactly understand the action of the Reclamation Service with reference to the waters of the Rio Grande, and I want to call your attention to the fact that you already have upon your tributaries to the Rio Colorado large rights in your State as you suggested, or as I suggested to you—reclamation projects now built for you by the Government of the United States. You have your rights, your certain rights, and when your right to any equable distribution of the waters of the Rio Colorado is to be ascertained, of course you will be debited by such rights as have already been accorded you. You are not being deprived of anything, as you thought you were, on the Rio Grande.

And now, my friends, let me ask one thing more, and I hope that this will end our little controversy about Colorado—because I love Colorado—I said a few moments ago that all this territory including Colorado was obtained from Mexico by a treaty and purchase. I want you to bear that in mind for a moment. Now I say as an historical fact that the waters which are being used in the Elephant Butte project in New Mexico and Texas were beneficially used 250 years before an irrigation ditch was ever taken out in the State of Colorado—that when Coronado came into New Mexico in 1595 he found the Mesilla Valley and the lower territory below El Paso, the Zuni settlements, and others in a high state of cultivation, and his Spanish followers located there, and from that day down to the present day they and their descendants have irrigated these same lands with the same waters, and I say it to you, my friends from Colorado, that for 10 years, living as I did as a citizen of the Territory of New Mexico, with my hands tied because a Territory can not enter the Supreme Court of the United States and sue the sovereign State, we submitted to have you take the waters from the head streams in Colorado [applause], praying in every State—praying for the intervention of the United States of America—if we had been a State, Colorado would have been sued for the diversion of the waters and the depredation and the use of the waters, and the people of the Mesilla Valley and the Colorado possibly might have been summoned to answer the complaint of Mexico in $35,000,000 damages rather than the United States of America. [Applause.]

You will pardon me, I know, but I wanted to set this matter right in the minds of some of our friends, and to emphasize to them, by setting it right, my determination, if possible, to see that no such disagreements or controversies may arise in the future as have arisen in the past touching the waters of the Rio Grande. [Applause.]

J. G. Scrugham (of Nevada). Mr. Secretary, I think I voice the sentiments of the majority of those present in thanking you for the clear-cut statement of your views on the Colorado River. You certainly have helped us to crystallize our views in a more thorough manner than would otherwise have been done. On behalf of the State of Nevada, I will say that we will unitedly support the Federal Government or any other competent agency decided upon as the proper one to construct the Boulder Canyon Dam and Reservoir. [Applause.]

However, we believe that the upper States should be given some satisfactory or adequate assurance that their constitutional rights and privileges will be adequately safeguarded. I do not think this even the time or the place to discuss what those rights should be. We believe that may properly be left to the recently constituted interstate Colorado River commission.

However, Mr. Secretary, the point we wish to emphasize is that this commission should be made to function as soon as possible, and we ask of you to present this thought to the President, if you deem it proper. The situation is urgent and we believe that the deliberations of this commission will do a great deal toward clearing the decks for a proper and clean-cut understanding of all parties concerned. Thank you.

Mr. FALL. Col. Scrugham, I want to say to you that I can assure you that in the delay in the appointment of the national commission the President of the United States has not been at fault. He understands the necessity for urgency in this matter, as we all do, but he has been requested by Representatives of seven States, or at least a majority of the seven States interested, not to announce the appointment of his commission, and he has delayed it on that account and on that account alone. [Applause.]

I understand that two other citizens of Nevada desire to be heard.

Mr. SQUIRES. Mr. Secretary, ladies, and gentlemen of the conference, we of Las Vegas, Nev., have a very vital and live interest in the Boulder Canyon project.

My friend, Gov. Sloane, of Arizona, mentioned the fact that the dams which would be built upon the Colorado River were located within the State of Arizona. He evidently forgot that any dam which is located in Boulder Canyon must have at least one end upon the soil of Nevada. [Applause.]

Now, we from Las Vegas, are inclined to be a little bit selfish, just the same as the rest of you, but not so very selfish; all we wish, ladies and gentlemen, and Mr. Secretary, is the privilege of sitting in the shade of our end of that great dam in Boulder Canyon and receiving a few of the little splashes and sprinkles of that great river of benefit which is to flow out of that project.

Las Vegas is located closer to the site of this Boulder Canyon Dam than any other city, and is connected to that site by a road some 39 miles in lengh, which is now being made by the county of Clark.

The benefits which we expect to receive out of the Boulder Canyon are somewhat extended beyond the pay roll of construction days. We expect that, located in the strategic position in which Las Vegas is, it will be the base from which much of the activity of construction will be carried on.

We have in that territory immediately about Las Vegas some very valuable and immense bodies of metallic and nonmetallic minerals. We have recently discovered within a very few miles of Boulder

Canyon the largest deposit of borax known in the world. It is being opened up and worked to-day. We have immense deposits of gypsum, manganese, and magnesite. We are waiting only for cheap power that they may be turned into riches.

We have surrounding the city of Las Vegas quite a large area of fertile lands, which needs only the waters to be secured from the subsurface water by pumping with cheap power to become as valuable and as productive as that of the Imperial Valley. We, you will see, are interested in this project in a way quite as definite, and although our interests may be smaller than those of some of the communities, they are quite as important and as precious to us.

We, gentlemen, wish to impress the importance of one thing—we are anxious to have that project built by whatever agency, provided it is best adapted to that purpose, in the shortest time possible.

I thank you, Mr. Secretary. [Applause.]

Mr. Harmon (of Nevada). Mr. Secretary, ladies and gentlemen of the conference, I wish to congratulate the gentleman from Colorado. I am frank to say that up till the time that the gentleman from Colorado brought up the question he did I had begun to think that this was somewhat of a boosting society for each and every district—about all that we heard was what and how the benefits to our district were going to be. I left home almost a week ago, went to Riverside, and thought I was in a good, old-fashioned Democratic convention—with all the fights going on—came down here, and concluded that we were going to have a little peace offering; and I want to thank you, Colorado. I learned more this evening, Mr. Secretary, when he roused you up, than I had known in a long time about the waters of this country. [Applause.] And that is the way I like to see conferences conducted.

Now, we in Nevada have other things besides divorces. We have an empire there that is undeveloped, and I am not overstretching the matter, Mr. Secretary, when I say that in the southern counties of Nevada, in which I reside—of which Las Vegas is my home—if you give us Boulder Canyon Dam and give us power in there we will increase the valuation of that county from ten million to fifty million. [Applause.]

We have some of the greatest and richest deposits in the West in our State, paying all due respect to the rest of them. As I sometimes tell my friends from California, Arizona, and Utah, if it was not for the southern end of Nevada your States might amount to something. All we want is action. You give us action and we are with you. I thank you. [Applause.]

R. E. Caldwell (of Utah). Mr. Secretary, ladies, and gentlemen, inasmuch as the last speaker saw fit not to boost for Nevada it would not be becoming in me to speak other than modestly of Utah, though if I do not say a fine thing about Utah it won't be because she does not possess the quality.

I have been thinking and thinking and thinking what would be proper for me to say, Mr. Secretary, and I have thought one thing more than all the other things; so I will say that one thing and trust to luck.

I happened to be appointed by the State of Utah a member of what we have come to call the compact commission.

I believe in the Government functioning, and when the Government of the United States—the Congress of the United States—passed legislation requesting and permitting the President to appoint a member of that compact commission, I believed that the United States was in earnest, and I believe it now.

I believe the intent of the United States is to bring about a cooperation in the matter of the development of the Colorado River with the States in that basin.

When I left Salt Lake City to come down here I had a very good understanding, I thought, of the Imperial Valley question, and I was convinced that the Imperial Valley situation was acute and must be attended to with all speed consistent with the circumstances surrounding the case. No Californian, since I have been down here, has said anything to convince me to the contrary, so I still hold to the view, and I am glad that—not that the Imperial Valley is in the imminent danger that we have heard of—but I am very glad that something has furnished the impetus which compels us to consider the development of the Colorado River. Now, Mr. Secretary, I am anxious on behalf of the State of Utah to learn what are the rights of the State of Utah—and by my official duties I expect to learn what the rights are—and I have no doubt that if the Secretary of the Interior soon does not tell us what our rights in the Colorado River are, it will not be because he does not have a pretty clear understanding of what they are. I do not anticipate a lot of trouble. I believe that our problems are common and I am very sure that our interests are common. I do want to have this development of the Colorado River undertaken, as far as I am concerned, cooperatively, and for the benefit of all the people living in the Colorado basin as if there were no State lines at all whatever.

Thank you. [Applause.]

Mr. Emerson (of Wyoming). Mr. Secretary, ladies, and gentlemen, Wyoming seems to have the last word, at least I am advised that is our program, and that is the only word we have had in open conference. At Riverside we seemed to have no place on the program. In the League of the Southwest we have no place in the constitution, therefore we must be some kind of a side issue.

At Riverside last week I had the privilege of hearing some of my friends from Colorado claim the major percentage of the water of the Colorado River arose in Colorado. Then came my friend Caldwell, of Utah; he took the rest of it, then he intimated to you that the only thing that came out of Wyoming was wind, but now Caldwell forgot to tell you how they would like a little of that wind to lift the fog and smoke off Salt Lake City at times.

Despite the statements of Colorado and of Utah of the source of the water of the Colorado River, the records of measurements of many years in my office show that past Green River City of Wyoming goes a very material contribution to the flow of the Colorado River. Upon the map you will see that Wyoming is at the top of the deck and about one-fifth of this great State is within the drainage area of the Colorado River. It happened about 17 years ago I alighted from a Union Pacific train at the flourishing station of Old Pal. You probably know it not, and after a two days' stage north I landed away at the back of the Colorado watershed in a metropolis called Coral, Wyo. There I hibernated for one winter. Now, we did not have the balmy winters of California at Coral; we had a good old-fashioned Wyoming winter, and that is some winter, but during that winter I noticed great herds of fine white-faced cattle were living upon the forage crops that are raised in abundance upon the Green River watershed. Next summer in the growing season I saw the fine meadows in the upper regions. In the past 17 years that have elapsed I have become well acquainted with the wonderful Green River country, one of the greatest cow countries of the West, and one that can raise forage crops, the hardier grains, the equal of any in the Temperate Zone. I know that Green River and I wish you knew it, for I believe that the people of this section need to appreciate what the interests of the other sections may be.

Wyoming is a State of wonderful natural resources. Until the recent disaster of two years ago Wyoming led all the United States in the production of wool and mutton. She is a leader in the raising of cattle. She is crowding the leaders in oil. The greatest of all, in my opinion, is her agriculture and her agricultural possibilities, and we can raise fine crops of different kinds in different parts of the State. The Green River Basin is high, from 6,000 to 7,000 feet; that also has wonderful crops.

Now, the Green River is not the only part of the Colorado; I believe you all know that. While acquainted with the Green River, I felt I would like to know something else of the Colorado River Basin. I had heard something of Imperial, and even California, so last week I made it a matter of my business to get down on the lower Colorado, and I had the great pleasure of being attached to the Secretary's party and being able to get a very good knowledge of the situation—see the great dam at Laguna—a really remarkable engineering structure. I went down to mile post 17, below Yuma, that Mr. Wesener talked about; there I could plainly see the evidences of what took place there in the first of last June; when that mighty river tore at its leash and succeeded, to a certain extent, in spite of the great force of men and teams, which had thrown loads of solid rock, in tearing into that levee, inundating 2,000 acres of land, and doing much damage. Then I went with the party to the other side of the river at the heading of the Imperial Valley Canal; saw the problems there, the great dredges that are needed to keep that canal free from sediment; followed its course down into Mexico, back to the Imperial Valley; there saw its wonders, both as to the lands now under cultivation and those which we hope to have brought in.

I believe I have a thorough understanding of the situation on the lower river, and I wanted to have it, because it is a spirit of cooperation that is going to work this situation out for us. I think the advantage of cooperation is shown to some extent in the passage, in the seven States, of similar legislation in regard to the Colorado River Commission and, following that, by the passage by the Congress of the United States of the Federal act providing for a commissioner by the United States. A Federal bill was fathered by Mr. Mondell, of Wyoming, and went through in jig time, went through above many other measures, and this was facilitated because Mr. Mondell was satisfied that here was something that was working for the good of Wyoming. I was certainly surprised in the many speakers who spoke for California this afternoon; to my memory not one mentioned anything about the river commission. You spoke about the powerful support of the Secretary and about the support of Director Davis, but, as far as I know, no allusion was made to the Colorado River Commission, or compact commission, as Mr. Caldwell referred to it. To my mind this is a wonderful agency to solve these problems, for it is going to take the men of seven States standing united, rather than six together and one or two alone—it is going to take the seven—and this commission in my mind will form a clearing house to perform this work.

I have had considerable experience in our interstate problems of Wyoming since I have been in the State engineer's office. In that State we had a situation on the North Platte River that shows to me the value of cooperation; in this case the North Platte did not run into Mexico, Mr. Secretary, so I won't get into an argument, I hope, because we can slip a little bit into Nebraska and have a good fight among ourselves without interference from the United States. We had a reservoir by the name of Pathfinder built in Wyoming. There was a contention on the part of persons—one, that this reservoir controlled the river and owned the water of the river, and for many years certain things were held up in Wyoming; rights of way were affected. Finally a cooperative investigation was undertaken and the whole problem has been solved, or is rapidly approaching solution, and that situation has been overcome by cooperation.

In the same way it seems to me that this situation on the Colorado River will be very largely solved, as far as the different States are concerned, by cooperation, and the compact commission provides the proper machinery to function through and to get this understanding between States, for, as Director Davis's report states, it will take enactments of Congress to put this thing over and we want a united front; we want a united front of seven States, and I doubt if Wyoming would get behind it with any good grace unless Wyoming knew its own interests were protected. They are anxious to see Wyoming's rights preserved and protected, and if I should leave the meeting that is designed to consider the problems such as the Colorado River, which affect Wyoming along with other States, and go home without pointing to something of our side of the controversy—I will not call it a controversy, because in my opinion it is not—if I should not perform my due function upon the commission and see that Wyoming's rights were recognized and protected by agreement as far as the same can be put in tangible form, when I got back to Cheyenne I'd be about as popular as a polecat at a picnic, and at Green River and Rock Springs I'd be about the same. But I see no reason why we can not get together, based upon the fact that there is an ample water supply for all, and that there are reservoirs, more than one, for the conservation of this great water supply. I see no reason why we should have any controversy over this matter, and I am glad the spirit manifested here is entirely different from that which seemed to come out of the Riverside meeting, and our differences should be buried; it is a case of bury the hatchet, it is a case of get together, and I am sure that the compact will be worked out, and the plan will have the ardent support of the Secretary and of Director Davis and others—that we get together on the main ground and that we will all be protected and this great work may go on.

Mr. FALL. Ladies and gentlemen, this completes the list lying before me of those who desire to be heard.

A VOICE. MacAldare, of Imperial, would like to be heard.

Mr. FALL. The program is completed, gentlemen. I will make the announcement that, unless there is some other new point that some one desires to call attention to with direct reference to the report under consideration, we will conclude the proceeding.

I thank you very much, all of you, for the information which you have given me, and which will be of very material assistance when I undertake to consider the reports which the director and myself will be compelled to prepare and transmit to the Congress of the United States. I regard this as one of the most serious questions, one of the most important questions which are before the public for consideration, as far as our interior policies are concerned. I regard it as part of the great development program of the President of the United States, as he has announced, and for which he is asking the assistance of the Congress of the United States. You may be assured I will give this matter mature consideration before making recommendations to the Congress, and I will bear in mind the advice which I have had here to-day from the different members and different parties who have spoken. Thank you. That is all.

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