THE COLORADO RIVER

HISTORY
SEVEN-STATES COMPACT
AND
FUTURE DEVELOPMENT

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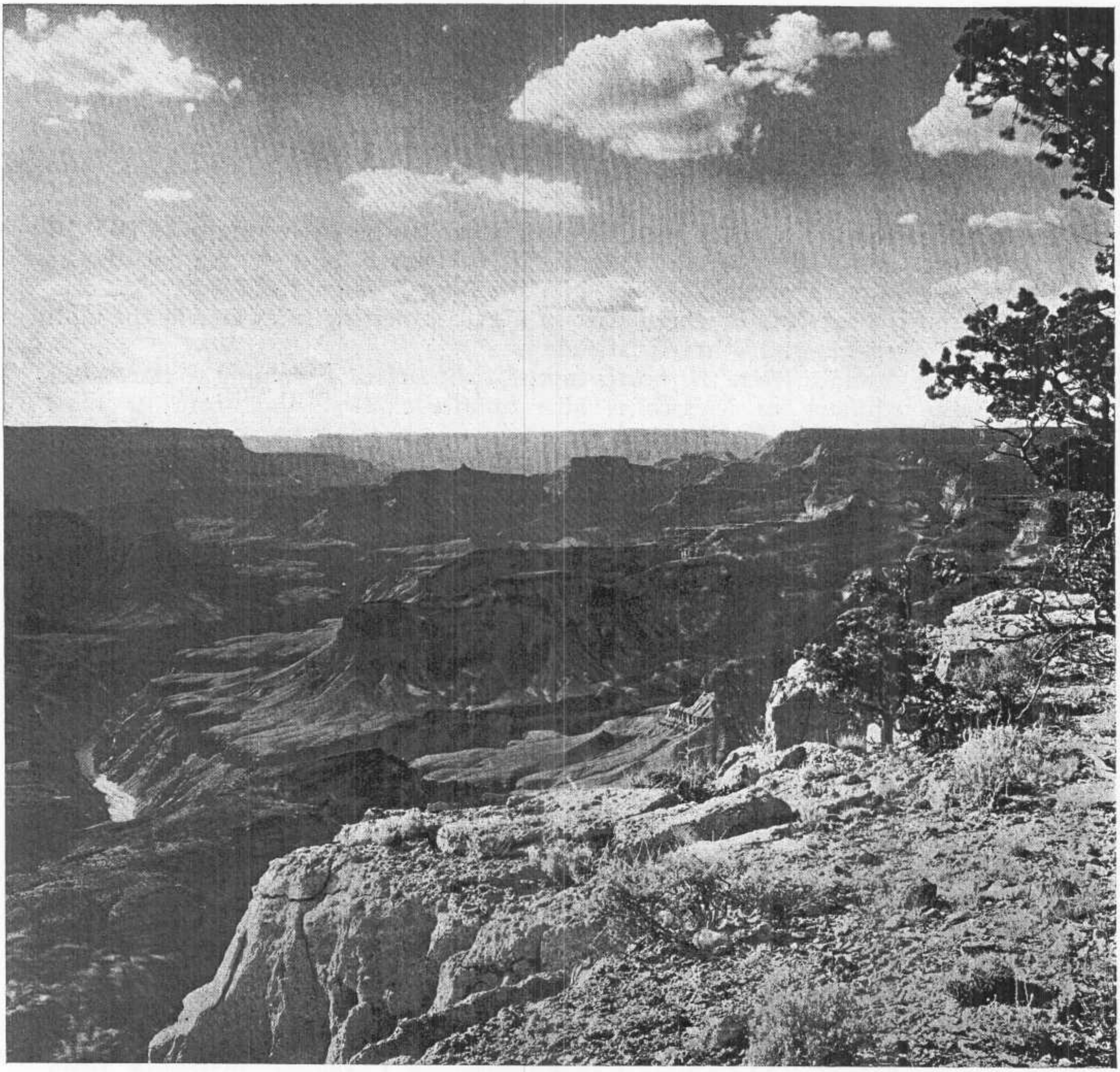
INDEX



A Section of the Grand Canyon from the Rim Showing Extensive Erosion.

The Colorado River

THE drainage basin of the Colorado River lies between longitude 105°30′ west and 116° west and latitude 30°40′ north and 43°30′ north, in Wyoming, Colorado, Utah, Nevada, New Mexico, California, Arizona, and the extreme northern part of Mexico, meeting tidewater in the Gulf of California at 32°15′ north latitude.

The distance from the northernmost tributary in Wyoming to the southernmost tributary in Mexico is nine hundred miles; and from its most easterly tributary in Colorado to its most westerly tributary in Nevada is five hundred and fifty.

Its source of greatest elevation is in Colorado at Chiefs Head, on the westerly slope of the Rocky Mountains at 13,579 feet.

Its most northerly tributary is the Green River which rises in Wyoming; the most westerly the Muddy, a small tributary of the Virgin flowing out of the southern part of Nevada on the easterly slope of the Muddy Mountains.

The most easterly tributaries are the headwaters of the Grand, which flows west from Colorado, and by its junction with the Green in Utah, above the northerly end of the Grand Canyon, forms the main stream of the Colorado.

The most southerly tributary is the San Pedro which rises in Mexico and flows north into the Gila, which in turn flows westward through Arizona and joins the Colorado near the southern boundary of that state.

The river channel is the boundary line between northwestern Arizona and southeastern Nevada, and between western Arizona and eastern California.

HISTORY

The Colorado River was discovered by the Spaniards in 1540, the second year after they entered Arizona. Hernando de Alarco co-operating with F. V. de Coronado, explored with ships the Gulf of California and sailed up the lower river; Melchior Diaz, marching along the shores of the gulf likewise reached the river; and Captain Gárcia López de Cardenas, marching from Zuñi, reached the Grand Canyon, but could not descend its walls. In 1604 Juan de Oñata crossed Arizona from New Mexico and descended the Santa Maria, Bill Williams and Colorado to the Gulf. The name Colorado was first applied to the present Colorado Chiquito (Little Colorado), and probably about 1630 to the Colorado of today.

Parties of the Mexican Boundary Commission Survey reached the river at points near the Gila and to the southward in the years 1849, 1854 and 1855. The latitude and longitude of the junction of the Gila and the Colorado was, for the first time determined by Lieutenant Whipple of the Topographical Engineers; and that part of the boundary from this locality to a point on the river twenty miles to the southward was determined, as also the latitude of the latter by the zenith telescope, by Lieutenant Michler, of the Corps of Topographical Engineers, in 1854.

The expedition of Lieutenant Ives, which took the field in 1857, was the most important expedition fitted out up to that time for the direct and positive exploration and examination of the river from its mouth toward its source.

The work was in many respects most admirably done; and although he failed to reach the highest point to which navigation could be directed in case of a commercial necessity, still, for the first time, he developed an understanding of the geographical position, topographical accessories, and the hydrographic peculiarities of nearly six hundred miles of this hitherto almost unknown great river.

The source of the Grand River, one of the main tributaries, was discovered by Lieutenant Pike in his expedition of 1805 and 1806; that of the Green River (the main fork or continuation of the Colorado proper), by Captain Bonneville in his explorations of the years 1832 and 1833.*

The early pioneers in 1860-65 started a settlement at the junction of Callville Wash with the river, and brought supplies up the river to this point in boats and canoes on tow lines, using Indians as motive power. From Callville the supplies were moved by pack train and wagon into Utah as far north as Salt Lake City.

*James White, formerly a resident of Kenosha, Wis., left Fort Dodge, April 13, 1867, and with a party under Captain Baker, made a prospecting tour of the San Juan region. Captain Baker was killed in a side canyon of the Green River, August 24th, and White, accompanied by one Henry Strole, commenced the descent of the river on a rude raft, exploring the junction of the Green and Grand and the mouths of the San Juan and Little Colorado. Strole was washed overboard and drowned on the fourth day. White then lashed himself to the raft and continued on the perilous journey, securing, by the barter of his arms to Indians, enough mesquit bread to sustain life until he reached Callville on the Colorado, September 8th, 1867.

So far as is known he is the first white man who passed through the wall of any part of the Grand Canyon.*

Major John W. Powell in 1867 commenced a series of expeditions to the Rocky Mountains and the Canyons of the Green and Colorado Rivers, during the course of which (1869) he made a daring boat journey of three months through the Grand Canyon, that part of the river channel not having previously been explored. On account of high water he was compelled to leave the river at Kanab Creek. In these travels he gathered much valuable information on the geology, and he also made a special study of the Indians and their languages. His able work led to the establishment under the United States Gov-

* U. S. Geographical Surveys West of 100th Meridian.

ernment of the geographical and geological survey of the Rocky Mountain region with which he was occupied from 1870-1879.

*In the reconnaissance of 1869, Capt. Geo. M. Wheeler reached, with parties under his charge, the Colorado at the mouth of the Virgin, and traveled along its northern and western banks as far to the south as Eldorado Canyon. In 1871 a regular boat party was organized by men selected from the expedition of 1869, and the ascent of the river made from Camp Mohave through the Black, Boulder, Iceberg, Virgin Canyons, and the transit of a portion of the Grand Canyon, making a total distance of two hundred and five miles, along which two hundred and twenty-five rapids and falls were noted. In 1872 the river was traversed along its northern banks from the foot of the Grand Canyon to the mouth of the Virgin by Captain Wheeler and party. The river was approached by parties of the expedition of that year in the heart of the Grand Canyon at the mouth of the Paria and at the crossing of the "Fathers." (El Vado de los Padres.)

In 1873 the river was crossed at the mouth of the Paria by a party under Lieutenant Hoxie. In 1875 and 1876 Lieutenant Bergland, of the expeditions of those years, approached the river, making certain topographic and hydrographic examinations and surveys at points at and between Camp Mohave and Fort Yuma.*

RIVER CHARACTERISTICS AND FORMATIONS

The river from its source, at an elevation of 13,579 feet to sea level at the Gulf of California about one hundred miles south of Yuma, Arizona, is eighteen hundred miles in length.

It is probable that Lake Bonneville, which at one time occupied a portion of Utah, Nevada and Idaho, found its first outlet through a northwesterly course to the Columbia River. Later the easterly portion of this vast body of water was probably drained by the Colorado River as it cut the Colorado Canyon.

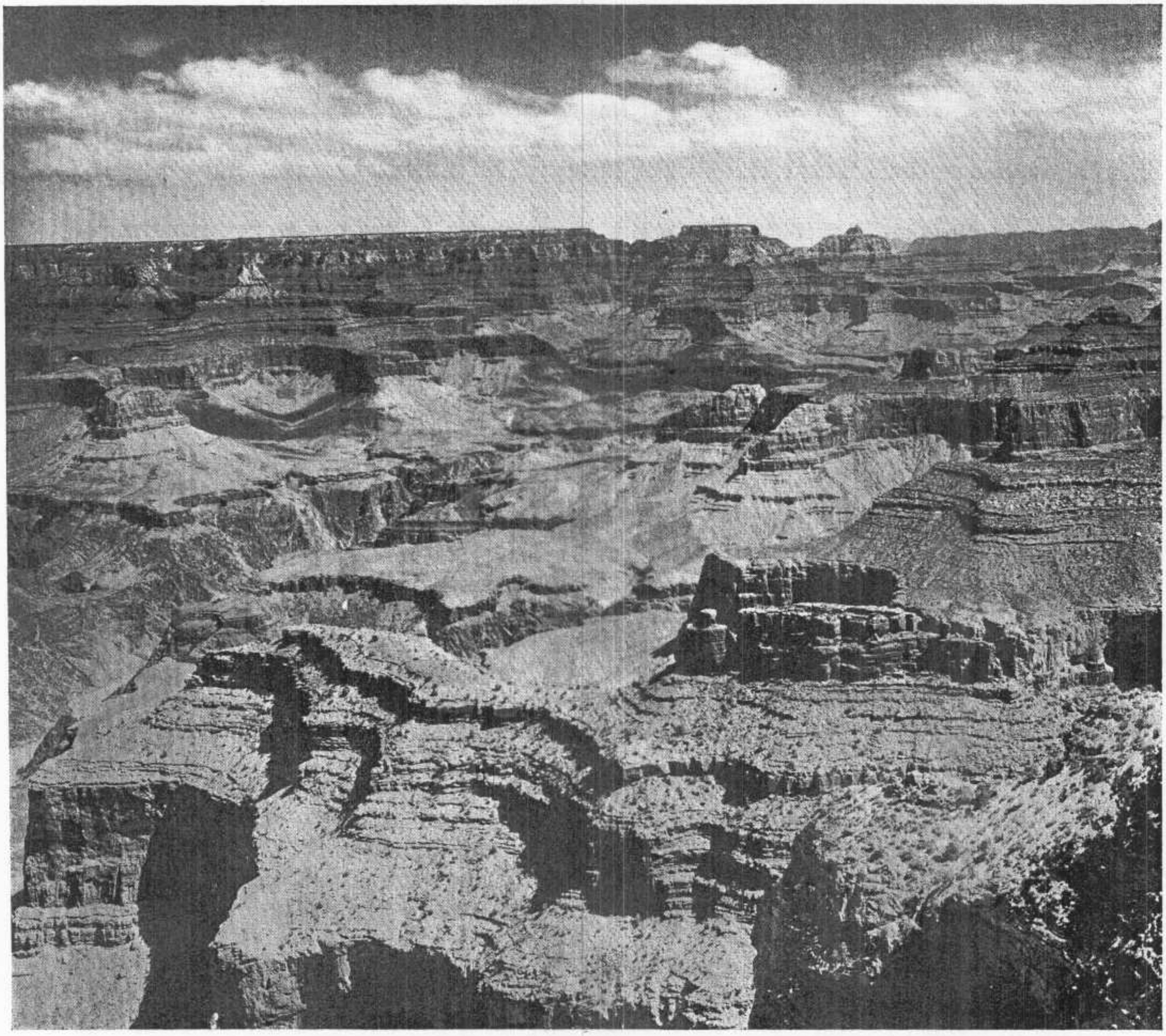
The high Uintah Range, in Utah, separated the drainage basin of the Colorado from the great westerly basin, and Great Salt Lake in Utah and the dry lakes of Utah and Nevada are the remaining evidence of that portion of Lake Bonneville which was denied an outlet to the sea.

Due to the sharp gradient, the river has transported a vast amount of detritus and it is evident that the channel has been closed at intervals by flows of lava which have caused the stream to deposit its burden and formed great plateaus of sedimentaries.

In the course of time the river cut new channels, which are evidenced by the vast canyons cut through the sedimentaries, part of which at least have been deposited by the river itself.

The formation from the junction with the Virgin north and east is largely sedimentaries; shale, sandstone (red, white and yellow) and natural concrete or pudding stone. Some limestone and occasional intrusions of volcanic

* U. S. Geographical Surveys West of 100th Meridian.



A Resting Place for Sedimentaries
The Eroded Material is now in the Imperial Valley and the Delta of the River.

rock are found between the westerly end of the Grand Canyon and the junction of the Green and the Grand Rivers, but the river does not find a granite bed of any considerable length until it leaves the Grand Canyon.

West of the Grand Canyon it has cut through an extensive area of granite which reaches its maximum elevation at Boulder Canyon. Here the river flows between almost vertical walls of syenite or hornblend granite more than a thousand feet high.

After leaving the granite walls of Boulder Canyon the formation for about twenty-five miles, to Black Canyon, is again sedimentary—largely pudding stone or natural concrete of recent origin—lying in benches which form the sidewalls of two extensive washes (Callville Wash and Las Vegas Wash) to the north of the river channel.

Below this open country the river again enters a series of canyons cut through volcanic rock of comparatively recent origin. These are the Black, Pyramid and Mohave Canyons. From the foot of Pyramid Canyon to Mohave Canyon, a distance of fifty to sixty miles, the formation is sedimentary and the country flat and open. At Mohave Canyon, fifteen miles south of the town of Needles, California, the river has cut a canyon through a dike of schist, quartzite, and limestone.

From the south end of Mohave Canyon the river flows, with but few exceptions, between banks of gravel and cemented material deposited in recent times by the river; and the lower one hundred and fifty miles is a continuous delta much of which has been deposited since the arrival of the white man.

Here the windblown sands have at times filled the channel during periods of low water and forced the river to find a new channel during the next period of flood.

The fine sediment deposited by the river in the lower delta is lighter than the blown sand, it is practically free of binding material and, when wet, has so little supporting power that stones will at times sink into it at the rate of ten feet per hour. This silt is practically the only material available on the delta with which to build protective dikes, and it is one of the reasons why a break means disaster.

At present the silt delivered by the Colorado River to the delta is 100,000 acre feet per year, or an area of 100 acres covered 1,000 feet deep annually. This in terms of cubic yards means that 161,334,000 cubic yards,—an amount equal to two-thirds of the total material (240,000,000 cubic yards) excavated by the Americans in the construction of the Panama Canal,—is carried to its delta by the Colorado River each year.

GEOGRAPHICAL CHANGES CAUSED BY THE DEPOSIT OF RIVER DETRITUS

At some time in the past the San Diego Mountains along the western coast and the San Bernardino Mountains to the eastward, partially enclosed a deep tidal basin connected with the ocean through what is now the Gulf of California. At that time the delta of the Colorado spread its fan westward into the southern end of this valley, depositing the heavier detritus along the course of the stream while the lighter material settled in the north end of the basin, now the Imperial Valley.

The formation of this delta in a southwesterly direction finally constructed a barrier to an elevation above high tide, closing the northerly end of the basin from access to tidewater and shifting the course of the river to the eastward until it finally flowed almost due south into the present Gulf of California.

The upper part of this valley, (Imperial Valley) cut off from its supply of water,—both the Colorado River and the tide,—and located in an exceedingly arid basin, gradually lost its water by evaporation, and left a valley the floor of which is two hundred and seventy-eight feet below sea level.

Floods each year formed a channel to the Gulf, then as they subsided the silt settled into the channel and the succeeding year's flood was forced to find a new path to tidewater.

The tidal variation at the extreme north end of the Gulf of California is from twelve to twenty-five feet, depending upon the season, and the river delta at this point is limited by the high mesas to the east and to the west so it has been unable to spread out as have the deltas of the Mississippi and the Nile. These facts, in conjunction with the immense burden of silt delivered annually by the river, has rapidly built up a high delta.

DEVELOPMENT OF THE IMPERIAL VALLEY

With the advent of modern irrigation engineering, dams were constructed in the Colorado River channel and canals were excavated through the river detritus and blown sand hills, to convey water to the irrigable lands; much of the area lying below sea level.

A ridge of high ground between the Imperial Valley and the Colorado made it possible to locate a diversion dam on the river north of the Mexican boundary line, but the same high ground made it advisable from an economic angle to construct the irrigation canal southwesterly across the boundary line into Mexico around the high land, then northwesterly back across the boundary line into California, to the distributing canals around the Imperial basin.

A private corporation was organized for the purpose of constructing the dam and irrigation system to provide water for the Imperial Valley lands in California.

This company acquired from the owners of the Mexican lands a right of way for the canal through Mexican territory and in exchange therefor gave a contract under which they agreed to supply water from the canal for the irrigation of lands in Mexico at a specified rate per acre per year.

Under these conditions a large area in Mexico and five hundred thousand acres in the Imperial Valley in California have been brought under cultivation. Here men and women of vision have by hard work won a battle with the desert, established homes, and converted this sunbaked lake bottom into gardens.

The original irrigation company failed and to insure a continuous supply of water it became necessary for the Imperial Valley land owners to organize a company to take over and maintain the water system. The Mexican land owners did not join in this mutualization plan but continued to purchase water under the terms of the original contract.

The encroachment of agricultural development on the natural delta of the river restricted the spread of its waters and concentrated the deposition of silt. This and the sand blown from the mesas to the east of the river forced the river out of its old channel into a much longer course to the north and west and made necessary the construction of a series of dikes to prevent the water from flooding both the Mexican and the American lands, and to safeguard against the possibility of the waters of the river, which at that point flow at an elevation of eighty feet above sea level, breaking through into the Imperial Valley lying two hundred feet below sea level.

During each flood season the accumulation of silt in the channels reduced their capacity and increased the flood menace. The farmers met this by adding to the height of the existing embankments and constructing additional levees to confine the stream within definite limits. This meant that the river and the farmers had entered into a continuous contest; for the annual deposit of silt made it necessary to raise the levees a corresponding amount before each succeeding flood.

To protect the American lands it was necessary that these levees and dikes,—paid for by the American farmers,—be constructed on the Mexican side of the boundary line.

In 1905 the river broke through the controlling embankments on the Mexican side of the boundary and flowed into the lowest part of the Imperial Valley, the Salton Sea in California. The uncontrolled stream rapidly cut a channel from the Salton Basin through the soft alluvial soil toward the river channel. This cut, fifty or sixty feet in depth, rapidly assumed alarming dimensions and threatened to form a new channel for the river, diverting its course from the Gulf of California into the Imperial Valley.

It was only after herculean efforts, in which the resources of the Southern Pacific Railway were called into service by President Roosevelt, that the break was finally closed and the Imperial Valley, with its fifty thousand people and half million acres of highly developed farms, was saved from permanent inundation.

Since this break still greater efforts have been put forward by the residents of the valley to maintain an adequate system of levees and compel the flood waters to continue to flow into the Gulf of California.

This task is now a difficult one and it is easy to foresee that the time is not far distant when, if present methods are continued, the river will become the master, will again flow uncontrolled into the Imperial Basin and make a lake of this now fertile valley with railways, cities, farms and improvements, valued at more than five hundred millions of dollars.

The construction of a dam and reservoir with sufficient capacity to regulate the flow of the river and provide storage for the silt is the only permanent assurance of safety.

APPROPRIATION OF WATERS

While considering the needs of the people of the Lower Colorado, it has been necessary to take into consideration the requirements of the people of the upper river and its tributaries.

In the eastern part of the United States, where the rainfall is sufficient to produce crops without irrigation, ownership of water in the streams is held under the rule of riparian rights of the abutting property owners.

In the western states where it is necessary to utilize the flow of the streams for irrigation, the right to the waters of the streams is acquired by those who first put them to beneficial use, known as the rule of right of prior appropriation.

This right of acquisition by appropriating the water and making use of it, whether for mining or agricultural purposes, has been confirmed by the courts and is now generally recognized as the law throughout the arid states west of the Rocky Mountains.

Under the decisions rendered waters appropriated and put to beneficial use on one part of a stream may not at a later date be depleted by appropriations made above.

Due to the operation of this prior rights doctrine residents on the upper river and its tributaries have opposed developments on the Lower Colorado which would acquire and put to use waters which might at a later date be required for irrigation or domestic purposes on the upper river or on streams tributary to the Colorado.

THE COLORADO RIVER COMPACT

In recognition of the possibility of conflict between the states and to avoid possible litigation, the Congress of the United States on August 19th, 1921, invited each of the seven states interested in the waters of the Colorado River to appoint a representative to confer and if possible—

> "to provide for the equitable division and apportionment of the use of the waters of the Colorado River system; to establish the relative importance of different beneficial uses of water; to promote interstate comity; to remove causes of present and future controversies; and to secure the expeditious agricultural and industrial development of the Colorado River basin, the storage of its waters and the protection of life and property from floods."

The Hon. Herbert Hoover, Secretary of Commerce, was appointed by the President to act as Chairman of this Commission, which was designated as the Colorado River Commission.

Each of the states interested responded by appointing a representative, and after a number of conferences the Commission met in Santa Fe, New Mexico, on November 24th, 1922, all of the members of the Commission being present, the Hon. Herbert Hoover, presiding.

It was at that time thought to be impracticable to attempt to bring all of the states into agreement on the question of the actual division of water as between the states. It was also recognized that the deep gorge (the Grand Canyon) through which the Colorado River flows between the southern boundary of Utah and the Arizona-Nevada boundary line, divided the territory tributary to the Colorado River into two natural basins, and the Commission agreed to allocate the waters to these basins which were designated as the Upper Basin and the Lower Basin.

The Upper Basin to comprise:—

> "those parts of the States of Arizona, Colorado, New Mexico, Utah and Wyoming within and from which waters naturally drain into the Colorado River system above Lee Ferry, and also all parts of said States located without the drainage area of the Colorado River system which are now or shall hereafter be beneficially served by waters diverted from the system above Lee Ferry."

The Lower Basin to comprise:—

> "those parts of the States of Arizona, California, Nevada, New Mexico and Utah within and from which waters naturally drain into the Colorado River System below Lee Ferry, and also all parts of said States located without the drainage area of the Colorado River System which are now or shall hereafter be beneficially served by waters diverted from the System below Lee Ferry."

The dividing line between the upper and the lower basins was determined upon by agreement at Lee Ferry, one mile below the mouth of Paria River in northern Arizona, a short distance above the entrance to the Grand Canyon. This division was recognized in the compact which was drawn, and the territory thereafter was referred to as the Upper Basin and the Lower Basin.

After due deliberation the representatives agreed:

> "Article 3 (a) There is hereby apportioned from the Colorado River system in perpetuity to the Upper Basin and to the Lower Basin respectively, the exclusive beneficial consumptive use of 7,500,000 acre feet of water per annum, which shall include all water necessary for the supply of any rights which may now exist."

This appropriated 15,000,000 acre feet of water per annum but the discharge records over a period of twenty-two years show that the average annual discharge of the river was in excess of 16,000,000 acre feet, so an additional paragraph was added:

> "(b) In addition to the apportionment in paragraph (a) the lower basin is hereby given the right to increase its beneficial consumptive use of such waters by 1,000,000 acre feet per annum."

This in effect gave to the upper basin 7,500,000 acre feet of water per annum, and to the lower basin 8,500,000 acre feet of water per annum. The same discharge records show, however, that occasionally the total discharge of the river is not sufficient to satisfy the specific apportionments, so this was covered by a paragraph providing that:

> "(d) The States of the upper division (basin) will not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75,000,000 acre feet for any period of ten consecutive years reckoned in continuing progressive series beginning the first day of October next succeeding the ratification of this compact."

This paragraph is important as it clearly gives to the upper basin the right to the water flowing in the stream up to 7,500,000 acre feet annually, provided 75,000,000 acre feet is allowed to pass to the lower basin during any consecutive period of ten years.

This puts the lower basin states on notice that they must provide storage to accumulate this water for beneficial use.

The natural discharge of the river at Boulder Canyon has exceeded 27,-000,000 acre feet and has dropped as low as 11,000,000 acre feet per year. So, if a series of flood years should be followed by a series of very dry years it would be possible for the upper basin to claim credit under the terms of this paragraph for the floods which had passed down the river and then to use the entire flow if it did not exceed 7,500,000 acre feet during the following years. Under these conditions the upper basin would still deliver the 75,000,000 acre feet over the ten-year period.

It is clear that the lower basin to put to beneficial use the water allocated to it must store the flood water for use during periods of drouth. The compact uses the term "beneficial consumptive use" in connection with the apportionment of the 7,500,000 acre feet to the upper basin and the 8,500,000 acre feet to the lower basin, but does not refer specifically to water lost by evaporation.

Under the provision that 75,000,000 acre feet shall be allowed to pass to the lower basin during any period of ten consecutive years, the loss by evaporation in the upper basin must, if necessary to assure delivery of this amount, be charged against the water allocated to the upper basin.

It is clearly the intent that the water lost by evaporation below Lee Ferry is chargeable against the allocation to the lower basin for it is included in the 75,000,000 acre feet to be delivered to the lower basin over the ten-year period.

It is only equitable to assume that all losses by evaporation from reservoirs in the upper basin are chargeable to that allocation, for there are a great number of favorable sites in the upper basin for impounding reservoirs and if all of these are utilized, without restriction, the total evaporated therefrom would be so great that it might interfere with the delivery of the amount allocated to the lower basin.

The compact further charges the lower basin with the duty of storing water for its own consumption by stating in Article 8:

> "Present perfected rights to the beneficial use of waters of the Colorado River system are unimpaired by this compact. Whenever storage capacity of 5,000,000 acre feet shall have been provided on the main Colorado River within or for the benefit of the Lower Basin, then claims of such rights, if any, by appropriators or users of waters in the Lower Basin against appropriators or users of waters in the Upper Basin shall attach to and be satisfied from water that may be stored not in conflict with Article 3."

DISTRIBUTION OF WATER TO THE STATES IN THE RESPECTIVE BASINS

The compact allocates the water to the two basins but leaves to the states the distribution of the water among the states comprising the basins.

The waters allocated to the upper basin must be equitably apportioned to the states in the upper basin under agreements to be entered into between those states.

The states comprising the lower basin to distribute in the same manner the water allocated to the lower basin.

Prior to the signing of the Compact a water controversy in the upper basin between Colorado and Wyoming had been settled by a Federal Court decision; and a threatened controversy between Colorado and New Mexico over the division of the waters of the San Juan River was settled by agreement between these states.

There still exists the possibility of controversy over the distribution of water between Colorado and Utah, and Wyoming and Utah. But after the adoption of the compact if these controversies arise they will be limited to the question of participation in the water allocated to the upper basin under the terms of the compact.

In the lower basin Arizona occupies a central position geographically. Waters from New Mexico, Utah and Nevada enter the Colorado within or on the boundaries of the State of Arizona.

The waters of the Little Colorado and the Gila Rivers rise in New Mexico but flow into and can be used advantageously in Arizona. The waters of the Virgin rise in Utah and flow into Arizona where an area of bottom land can be irrigated from this stream.

One small stream, the Muddy River, rises in Nevada and flows into the Virgin which in turn flows into the Colorado below the point where the river becomes the boundary between Nevada and Arizona.

California makes no contribution to the waters of the Colorado but the stream forms her western boundary, and on account of the low lying lands within her borders can use advantageously the greater part of the water allocated to the lower basin.

The states of the lower basin have not up to the present (May, 1924) entered into any agreements distributing the waters allocated to this basin, but after the compact is ratified if any controversy should arise over the distribution of waters to these states it will be limited to the lower basin by the compact.

The courts of western states have in most cases held that waters diverted from a stream must not be delivered into another watershed but must be used within the watershed of the stream system from which it was taken. Exceptions have been made when the water was required for domestic purposes or when it could be shown that the water would be of little or no value within its own watershed and could be put to beneficial use by diverting it to another watershed.

The Colorado River Compact contains no provision intended to limit or control diversions from the waters allocated to either basin, so it is possible for Colorado to divert to the Mississippi watershed the water required for domestic purposes in the vicinity of Denver, and for Utah to continue to divert to the Salt Lake basin the waters diverted to the Strawberry Valley irrigation project.

The framers of the compact recognized, however, that on account of physical conditions the upper basin states could not divert any great quantity of water out of the Colorado watershed and that the return flow from a high percentage of the water allocated to this basin would always pass on to the lower basin.

In the lower basin most of the water allocated must be diverted from the watershed before it can be put to beneficial consumptive use. In Nevada a limited area in the valley of the Muddy and a small area on the Colorado known as Cottonwood Valley, is all of the irrigable land within the Colorado watershed in that state. But, if the City of Los Angeles should construct an aqueduct from Boulder dam in a direct line to Los Angeles, it would enable Nevada to participate and bring under cultivation 60,000 acres outside of the Colorado watershed. The waters diverted to Los Angeles and vicinity for domestic purposes will be taken away from the Colorado watershed, and all waters diverted to the Imperial Valley will be delivered into the Salton Sea drainage area.

Arizona will be able to use a small part of the waters of the Little Colorado and all of the waters of the Gila before they reach the Colorado; and the Mohave Valley and the Yuma Valley in Arizona can be irrigated from the Colorado: all of these are within the Colorado drainage basin. But the total consumptive use within that state will be small as compared with the amount which will be diverted to California.

Due to the rapidly increasing population in the southwest the agricultural areas in the lower basin can be rapidly brought under cultivation, while the development of irrigation projects which will use the waters of the Colorado River and its tributaries in the upper basin will progress slowly and, in all probability, will not utilize all of the waters allocated to that basin until near to the end of the present century.

The Colorado River Compact will, however, when ratified, definitely establish the right of the people of the upper basin states to the use of the waters apportioned to the upper basin without regard to time of appropriation by the individual user and will protect these states against any appropriations made by residents in the lower basin states in excess of the amount allocated by the compact to the lower basin.

THE COMPACT AND POWER

The Colorado River Compact dealt entirely with the division of the waters of the river between the upper basin and the lower basin, the only reference to power being:

> "Subject to the provisions of this compact, water of the Colorado River system may be impounded and used for the generation of electrical power, but such impounding and use shall be subservient to the use and consumption of such water for agricultural and domestic purposes and shall not interfere with or prevent use for such dominant purposes."

No consideration was given to the allocation of electric power which could or might be developed, even though the power so developed was used exclusively for pumping water for irrigation.

ARIZONA AND THE COMPACT

The Colorado River Compact was signed by the representatives of each of the several states and by the Chairman, to become effective when ratified by the legislatures of the several states and by the Congress of the United States; and as signed it was promptly ratified by the legislatures of all the states except Arizona.

In the State of Arizona the question of ratification came up just prior to a state election and was made a campaign issue. One political party opposed it on the ground that the lower basin should receive a greater percentage of the total flow of the river and that a definite allocation of water should be given to Arizona.

After the election, the newly elected governor opposed the ratification of the compact and it failed in the Arizona legislature by one vote. Since that time Arizona has made continuous efforts to demonstrate that the state could put to beneficial use one-half of the flow discharged from the upper basin, but engineering investigations have demonstrated that due to the elevation of most of the lands in the state it would be exceedingly expensive and not financially feasible to lift the waters of the river to a sufficient height to irrigate an area which would utilize the amount of water asked for.

PRESENT AND ULTIMATE IRRIGATION DEMAND IN THE UPPER BASIN

At present (1924) the upper basin is using 2,800,000 acre feet of water, including the diversion to the Salt Lake Basin.

The survey made by the Reclamation Service shows

that eventually	4,073,000 acres
will be cultivated and will require	1.5 acre feet
of water per acre per annum, or a total of	6,110,000 acre feet
To this must be added	440,000 acre feet
which will be the total eventually diverted in the vicinity of Denver to the Mississippi watershed, and in Utah to the Great Salt Lake Basin, making a total of	6,550,000 acre feet
out of the	7,500,000 acre feet
apportioned to the upper basin, leaving	950,000 acre feet

to supply reservoir evaporation losses and still keep within the allocation.

Tests indicate that the probable loss by evaporation from the surface of a reservoir at the elevation of the upper basin is four feet per year. At this rate the 950,000 acre feet available will supply the loss from 237,000 acres of reservoir surface, or 371 square miles.

To develop all of the possible power on the upper river between Lee Ferry power site at an elevation of 3,110 feet, and the Kremling power site at

7,500 feet without loss of head, will require seventeen to twenty dams and power plants under average heads of 220 to 250 feet.

The location and capacity of the principal storage reservoirs will be determined by the demands of agriculture, but it is probable that under proper supervision the water available under the allocation will be ample to supply all irrigation demands and evaporation losses and that a surplus within the allocation will continue to flow to the lower basin.

PRESENT AND ULTIMATE IRRIGATION DEMANDS IN THE LOWER BASIN

It is evident under the terms of the compact that the lower basin must depend upon stored water to carry through a period when the demands of the upper basin deplete the stream below the required annual flow.

At present the lower basin is using 3,900,000 acre feet of water annually. * (This includes 780,000 acre feet used in Mexico.)

The survey made by the Reclamation Service shows that eventually	2,020,000 acres
will be cultivated * (this includes 800,000 acres in Mexico) and will require	4.1 acre feet
of water per acre per annum, or a total of	8,282,000 acre feet
Available records show that the probable annual average flow at Boulder Canyon, after subtracting the allocation to the upper basin, will be	11,420,000 acre feet
leaving	3,138,000 acre feet
to supply all losses.	

Experience has shown that drouths over the Colorado River watershed occasionally run in three-year cycles, so it is necessary to consider evaporation losses from the reservoirs over these periods. It is also necessary to give consideration to spillway losses due to insufficient reservoir capacity. These conditions must balance against each other.

If the surface area of the reservoir is too great, the evaporation losses will exceed the gain, but if the capacity is too small, the spillway losses become excessive.

The ideal reservoir would be one of great capacity and small surface area, similar to a bottle, but the nearest approach to this is a reservoir with sides as near to the perpendicular as possible. For a given storage capacity this would give a deep reservoir, so the water would be warmed to a less degree, and if the reservoir is located in a canyon the surface is to some extent protected from the

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* The agreement under which the Imperial Valley irrigation canal was constructed through Mexican territory provided that the Mexican land owners were entitled to receive water from the Colorado up to one-half of the minimum natural flow of the river at the international boundary.

The compact does not, however, recognize this agreement but provides that "If, as a matter of international comity, the United States of America shall hereafter recognize in the United States of Mexico any right to the use of any waters of the Colorado River System, such waters shall be supplied first from the waters which are surplus over and above the aggregate of the quantities . . ." allocated to the two basins and that any allocation to Mexico in excess of this surplus . . . "shall be equally borne by the Upper Basin and the Lower Basin."

wind and the evaporation is less than it would be if the same quantity of water was stored in a broad flat reservoir on the desert subject to the unrestricted action of sun and wind.

The evaporation loss from the surface of a reservoir in the lower basin is 5 feet per year, so if there were no spillway losses the 3,138,000 acre feet would supply the evaporation loss for a surface area of 628,000 acres, or 980 square miles.

There is, however, a natural and unavoidable loss between the Colorado River Canyon and the present irrigation intake at Laguna Dam amounting to 1,080,000 acre feet per annum. This loss, partly sub-surface flow, occurs whether the water is stored or not, so after deducting this from the 3,138,000 acre feet there remains 2,058,000 acre feet to supply evaporation losses from the reservoir, which allows 412,000 acres or 640 square miles, for the surface of the reservoir for one year's evaporation losses and no spillway losses.

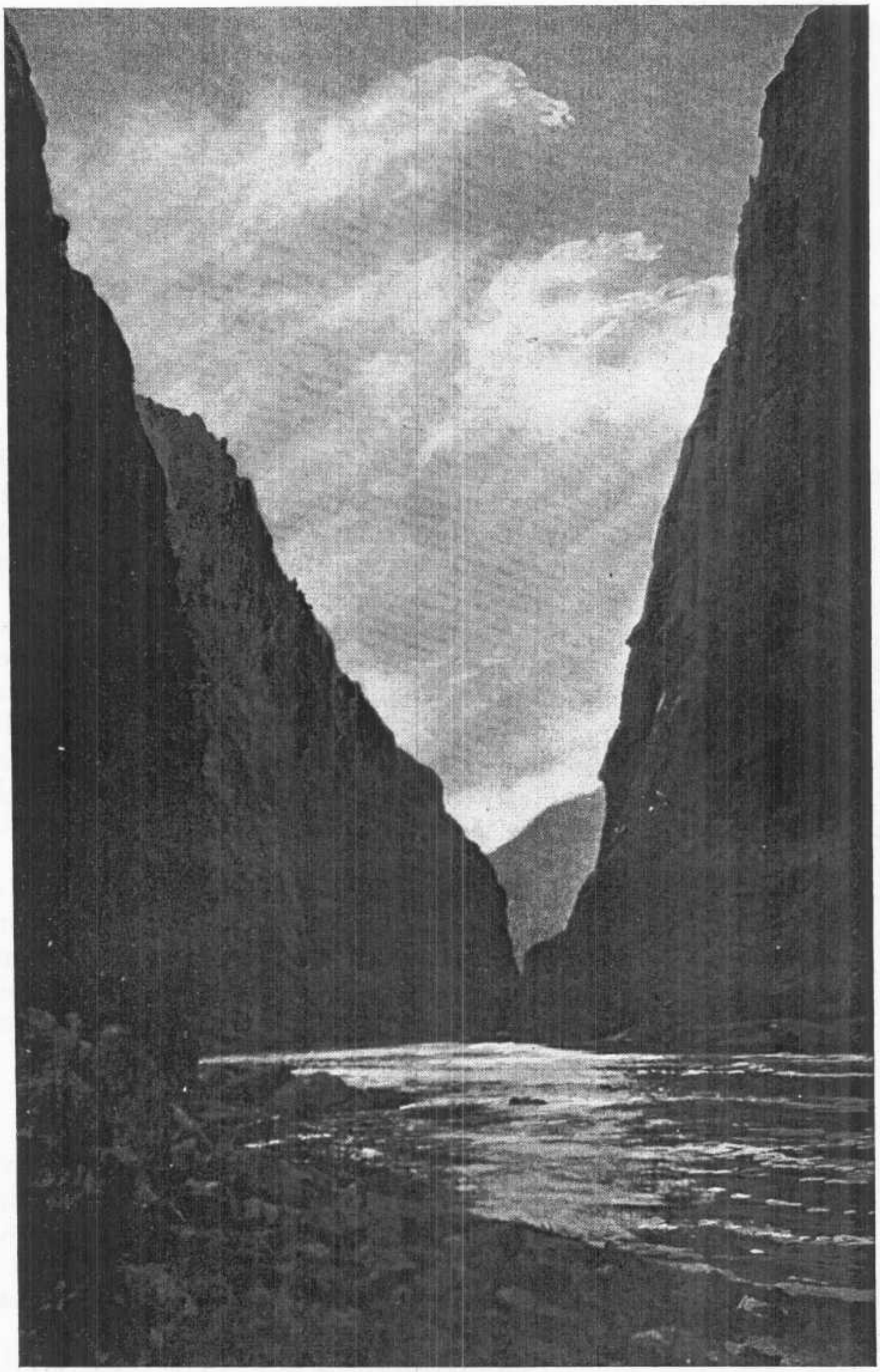
With a three-year period of drouth similar to 1902-3-4, and the upper basin using its full allocation, the total amount of water discharged into the lower basin during the three years would be		14,240,000 acre feet
The total required for irrigation in the lower basin would be	24,846,000 acre feet	
River losses to Laguna Dam	3,240,000 acre feet	
Evaporation losses, 3 years	450,000 acre feet	
Total		28,536,000 acre feet
Or a shortage of		14,296,000 acre feet

which, without any reserve for safety, would have to be in storage at the beginning of the drouth, and the reservoir would be empty at the end of the period.

To allow a margin of safety the storage for irrigation should be at least	16,000,000 acre feet
and if silt is to be stored for 300 years must be allowed.	30,000,000 acre feet
Pending depletion by use in the upper basin must be provided for flood control.	5,000,000 acre feet
A total of of storage to be provided.	51,000,000 acre feet

REDUCED DEMAND AFTER CULTIVATION

It is probable that the per acre demand for irrigation will decrease as the lands are brought under cultivation. Experience has shown that after lands



BETWEEN THE GRANITE WALLS OF BOULDER CANYON.

At this Point the Large Amount of Rock of Good Quality Available Without Rehandling Makes Possible the Construction of a Rock Fill Dam.

have been under cultivation for a time the accumulation of humus in the soil and the covering of vegetable matter conserves moisture and continued irrigation brings the sub-surface water plane nearer to the surface.

In the upper basin some alfalfa lands when first brought under cultivation required one and three-quarter acre feet of water per year; now, fifteen years later, they require but three-quarters of an acre foot per year. Lands in California which when first brought under cultivation required six feet of water per year, now require but four feet.

This condition of decreased demand will affect both of the Colorado River basins and in the future the margin of available supply over actual demand will probably increase rather than decrease.

AVAILABLE DAMSITES IN LOWER BASIN

Beginning at the lower end of the Colorado River the first feasible damsite for storage is the "Parker Site," five miles above the town of Parker. Here it will be possible, at a reasonable cost, to construct a dam 100 feet high which will impound 1,500,000 acre feet of water with but very little flood damage.

The second site is at Mohave Canyon where a dam 165 feet high will impound 10,000,000 acre feet. A dam at this location would, however, submerge the town of Needles, California, about thirty miles of the main line of the Santa Fé Railroad, the shops and yards of this company, and about 24,000 acres of irrigable and productive lands. The flood damage here will probably exceed $5,000,000.00 and the area exposed to evaporation will be excessive.

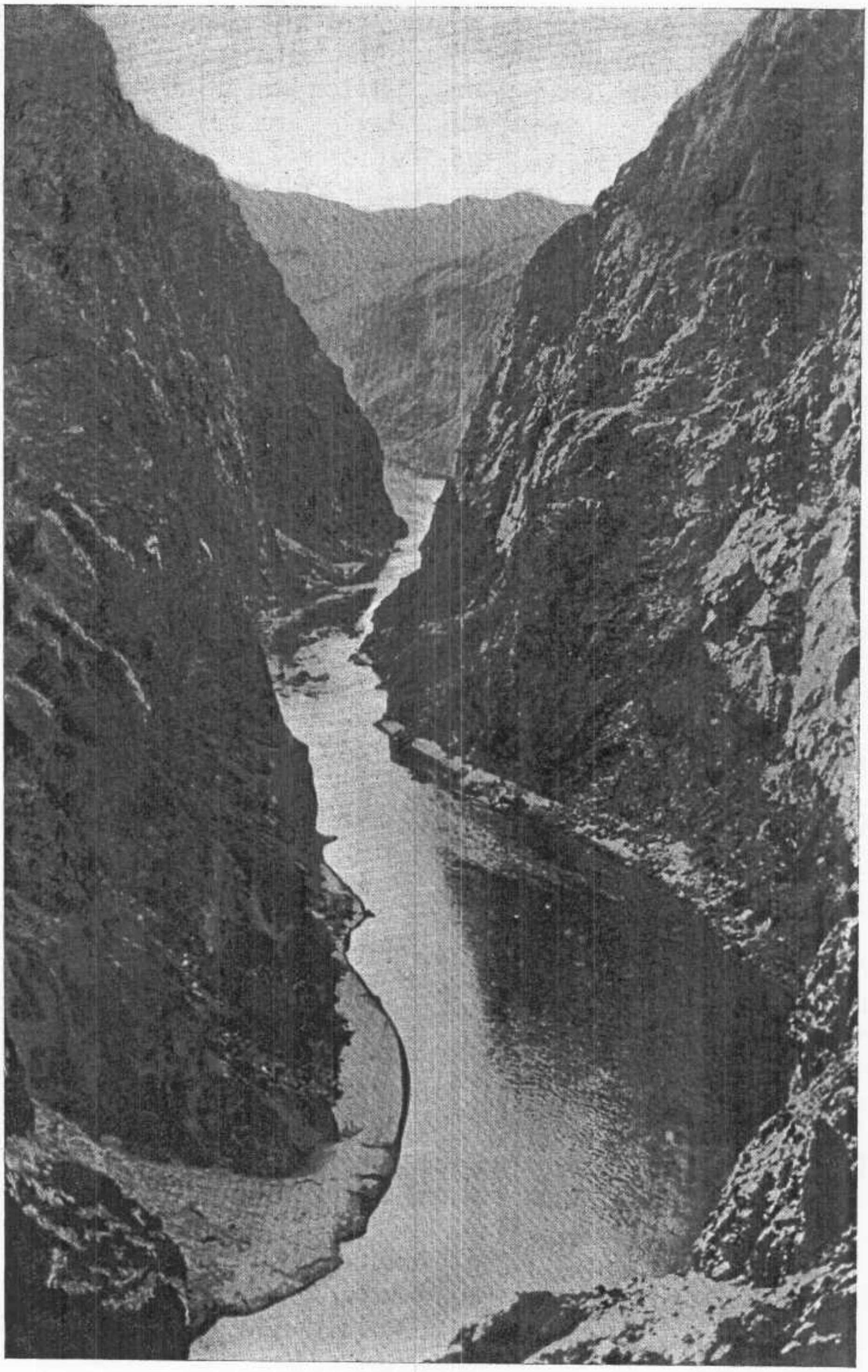
The third site is at Bulls Head Rock where a dam 115 feet high can, at a reasonable cost and with but little flood damage, be constructed to impound 1,800,000 acre feet of water.

The fourth location is at Black Canyon where a concrete dam 600 feet in height to impound 34,000,000 acre feet can be constructed in a favorable basalt formation. The location here is favorable except for flood damage. The reservoir would flood and destroy a gold bearing placer area containing gold to an estimated value of $64,000,000.00, which can probably be recovered at a profit of $30,000,000.00.

THE BOULDER DAMSITE

The next location is at Boulder Canyon where conditions are favorable for the construction of a concrete dam up to 600 feet in height, or a rockfill dam up to 860 feet in height. Here the sidewalls are of granite, and a reservoir of minimum area per unit of capacity can be constructed. A dam 860 feet above present low water will make possible the storage of 32,000,000 acre feet of water on top of 50,000,000 acre feet of silt storage.

The flood damage will be small and the water can be made available for the development of power at a higher head. The extra power which can be developed will pay much more than the entire cost of the higher dam out of the unused water discharged from the upper basin, pending the development of the agricultural areas in that basin.



Aeroplane View
Looking into Boulder Canyon at the Damsite

Complete flood control can be secured and the maximum of power can be generated near to the market. An economic balance can be secured between spillway loss, evaporation loss, power generated and flood damage cost.

The Boulder Canyon damsite has been carefully studied, surveyed and drilled to bedrock. The large volume of granite of good quality available at this point makes possible the construction of a rockfill type of dam at a high safety factor up to a height of 860 feet above present low water.

The comparative cost of storage, the evaporation loss, the spillway loss, and the power generating capacity for three heights of dams at this location are shown in the following comparison.

	600 ft. Dam	*715 ft. Dam*	*860 ft. Dam*
Silt storage, acre feet	5,000,000	18,000,000	48,000,000
	50 years	180 years	480 years
Storage for power and irrigation, acre feet	22,400,000	28,300,000	29,400,000
Total storage, acre feet	32,400,000	41,300,000	82,400,000
Cost per acre foot of storage	$1.17	$0.84	$0.66
Average annual evaporation before full depletion in the upper basin	588,000	840,000	1,136,000
Average annual spillway loss before full depletion in the upper basin	1,149,000	467,000	112,000
Total losses before depletion	1,737,000	1,307,000	1,248,000
Average annual evaporation after full depletion in the upper basin	587,000	797,000	1,137,000
Average annual spillway loss after full depletion in the upper basin	513,000	72,000	57,000
Total losses after depletion	1,100,000	869,000	1,194,000
Power installed (H. P.)	890,000	1,100,000	1,370,000
Firm power before depletion "	550,000	830,000	1,050,000
Additional power for irrigation "	85,000	115,000	215,000
Firm power after depletion "	390,000	630,000	880,000
Cost of dam per firm H. P.	$69.00	$52.00	$51.00

Note: Heights of dams given above present low water.

1 acre foot is the amount of water that will cover 1 acre to a depth of 1 foot.

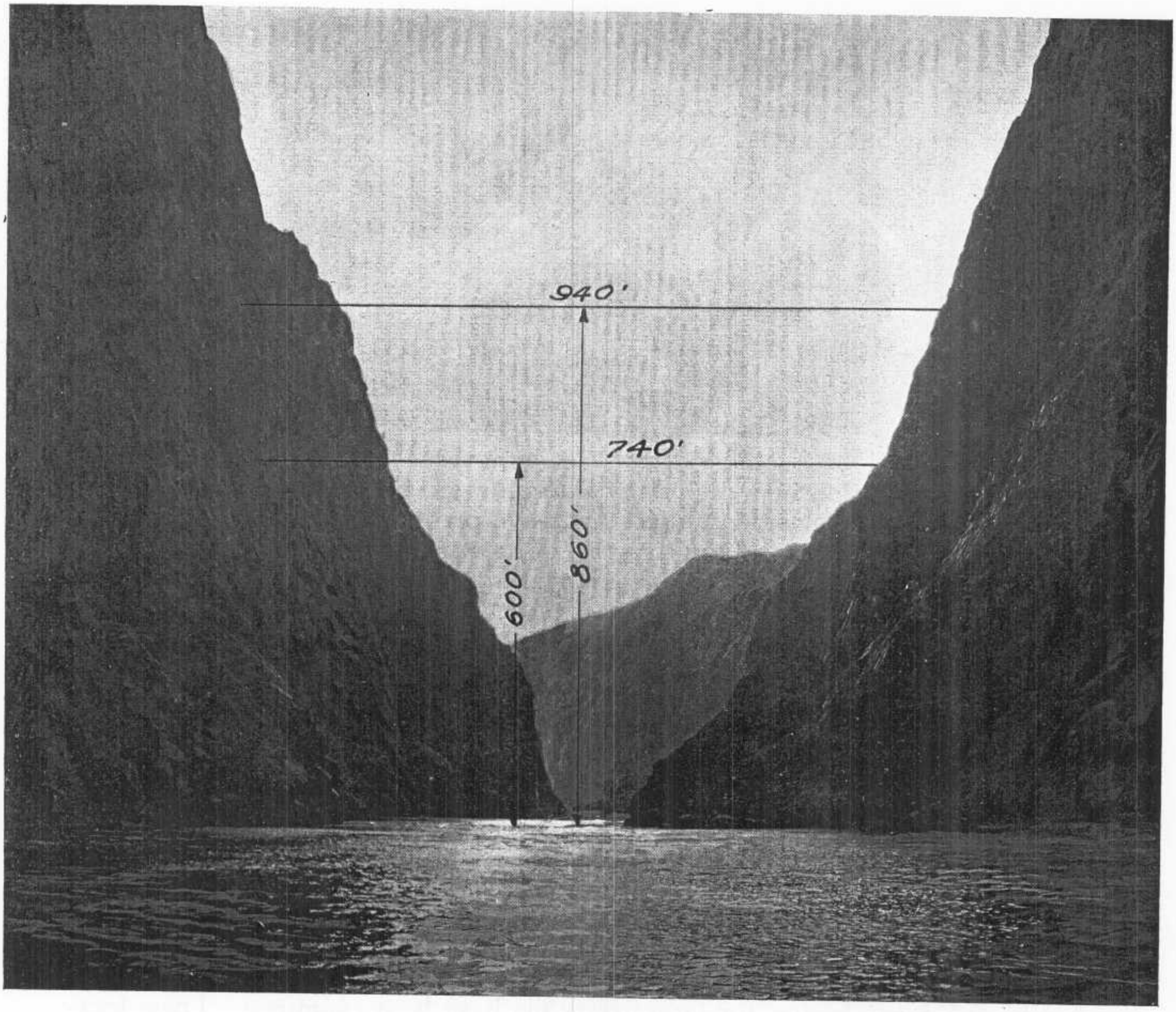
1 second foot equals a flow of 1 cubic foot per second.

1 second foot for one year is equal to 724 acre feet.

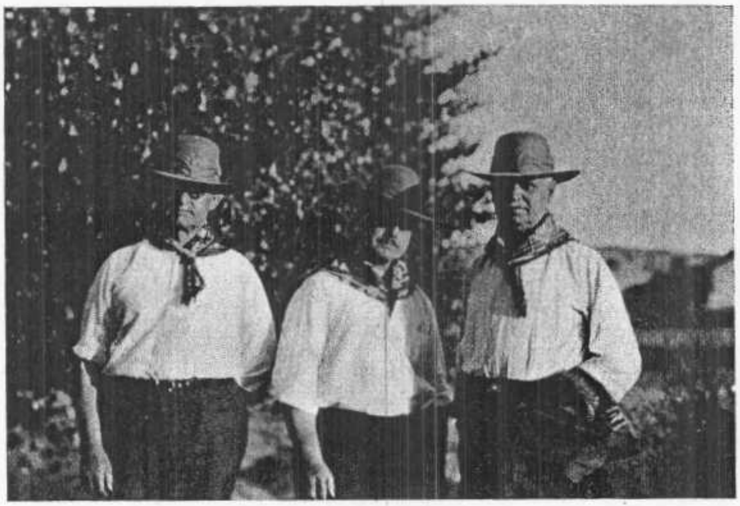
1,000,000 acre feet is equal to 1,380 second feet for a period of one year.

ROCKFILL TYPE OF DAM

The rockfill type of dam which can be economically constructed here on account of the quality and quantity of material available without rehandling, would be excessively expensive at any other location on the lower river.



The Damsite in Boulder Canyon Looking Downstream



The foundation of a rockfill type of dam can be extended as its height is raised; so it will be possible without excessive preliminary cost, to construct a rockfill dam at Boulder Canyon to a part of its ultimate height and at a later date increase the capacity and the head available for power by adding to the height of the dam.

For a concrete or a masonry dam it is necessary at the beginning to design and construct the foundation to the full dimension which will be required when the dam is completed to its ultimate height, so the preliminary saving on partial construction for these dams would be much less than for a rockfill.

DAMSITES ABOVE BOULDER CANYON

The damsites above Boulder Canyon at Spencer Canyon, Diamond Creek and Bridge Canyon, are not so favorable for reservoirs of large capacity, and if consolidated with the Boulder location under one high dam will not only provide the required storage but will consolidate the generation of power economically at a point very much nearer to the market for the power generated.

At Glen Canyon and at Cataract Canyon, both in the upper basin (above Lee Ferry) possible sites for large reservoirs have been examined. These locations are in soft sedimentary formations and due to this are not, from a construction point of view, so satisfactory as the Boulder Canyon location. The control of the irrigation demand in the lower basin would be remote, and the transmission distance to the present power market unnecessarily long.

DAMS BELOW BOULDER CANYON

After the installation of a dam in Boulder Canyon it will be feasible to construct a dam 75 feet high at a point called the Portals, near the lower end of Black Canyon immediately above Giant Wash. This will not interfere with the recovery of gold in the gravel deposits between Boulder Canyon and Black Canyon, and without exposing any great area of water to evaporation, will permit the regulated flow of the river between the Boulder power house and the Bulls Head reservoir to be utilized in the development of an additional 100,000 horse power.

A dam 115 feet high can be constructed at Bulls Head Rock which will back the water up to the Portals power house location, and utilize the regulated flow of the river in the development of an additional 150,000 horse power. Below Bulls Head Rock the extensive area of river bottom agricultural land can then be irrigated from the Bulls Head reservoir.

Leaving the Mohave Canyon damsite undeveloped will make possible the irrigation of 27,000 acres of river bottom land and avoid flooding the town of Needles, and the Santa Fé Railroad.

BALANCING RESERVOIR

After the full development and utilization of the water allocated to the upper basin it will be advisable to provide a balancing reservoir to balance between the maximum demand for power in the winter and the maximum demand for water for irrigation in the summer. This balancing reservoir can best be provided at the Parker location, where a dam 100 feet high can be economically constructed, and, will with the Bulls Head reservoir, impound a sufficient quantity of water to enable the power plant at Boulder Canyon to operate at full demand during the winter and still conserve the water for irrigation during the summer months.

SUMMER SEASON POWER FOR IRRIGATION

The summer season power which can be generated at Boulder is of great importance to Southern Nevada, Arizona, and Southern California where extensive areas are underlain with water at a depth of from thirty to eighty feet below the surface. The stored water at Boulder will provide power at a low cost for pumping from these subterranean sources and will bring a large area of fertile land under cultivation.

EQUITABLE DISTRIBUTION OF COST

The development of the Lower Colorado River is an economic problem in which the demands of the water users are paramount. The primary necessity for the development is the urgently needed protection from floods and the possible inundation and permanent destruction of the cities and homes in the Imperial Valley.

The development of power is incidental but it can be made to eventually pay the cost of the entire development. To be equitable, however, the cost of the dam should be pro-rated to the power and the lands for which the water is provided.

To make the flood protection complete the silt should be retained in the reservoirs. This will relieve the lands now under cultivation from a large part of the very considerable sum expended annually for the removal of silt from canals and ditches. It, therefore, appears but equitable that these lands should bear some portion of the cost of the dam, at least to the extent of a part of their annual saving. This can be covered by a small charge per acre or per acre foot paid annually to the Federal Government or the state for the water delivered.

The lands which will be brought under cultivation through the construction of the dam and storage of water will appreciate in value. It is only just, therefore, that a portion of this appreciation should be applied to the cost of the dam and be paid as an annual charge for the stored water as delivered.

Clear water free of silt, as required by the Los Angeles water district, can be taken from the Boulder Canyon reservoir at an elevation which, insofar as altitude is concerned, would make possible the delivery of water to Los Angeles by gravity. This water should be paid for at a rate which will represent its proper participation in the investment in the dam and control works.

The power generated and used for lighting, railway and industrial purposes, should be sold at a rate which will enable it to pay all of the operating charges, interest, amortization and taxes on the power installation and transmission lines, and an equitable part of the interest and all of the amortization of the cost of the dam.

The extra power generated during the irrigation season and available for pumping for irrigation should be relieved of all water charge. The rate to the farmer should be as low as possible, based on the investment in the generating and transmission equipment only. His operating charges will even then be higher than the water charge to the farmer who receives gravity water.

FEDERAL OWNERSHIP OF WATER

The Colorado River flows through a number of states so it, and all of its branches—should be considered as an interstate stream. The breaking of a dam located within one state might prove disastrous to agricultural and power developments located in a state further down the stream. The water evaporated from reservoirs of excessive area in the upper basin might deplete the flow of the lower river below the minimum to which the lower basin is justly entitled. These conditions indicate the necessity for Federal control.

Part of the responsibility for the silt originating in the upper basin should be assumed by the upper basin and reasonable silt storage capacity should be provided in each reservoir constructed. This capacity, and the silt storage in the lower basin reservoirs will meet the silt problem for a number of centuries.

The water will be used for domestic purposes by the people in the lower basin. Therefore, the upper stream should be protected against contamination and if proper legislation is enacted now, before cities are developed along the streams, it will be possible to assure potable water to those in the lower basin who must depend upon this stream for their domestic supply.

All impounding dams, lands under the reservoirs, and the shore lines of the streams and reservoirs, should be transferred to the jurisdiction of the Federal Government.

The Reclamation Service should control the flow and distribution of the water for domestic and agricultural purposes, and the Federal Power Commission should assure the safety of all structures erected for the purpose of impounding waters.

Water, being an element of common necessity more or less equally used by all, essential to the maintenance of life, subject to contamination and destructive of life and property when not properly controlled, should be held firmly in the control of the Federal Government and administered for the benefit of all without discrimination.

FEDERAL OWNERSHIP OF POWER

Electric power, unlike water, is not a universal necessity. It is not equally used by all. Many citizens use little or none. There are available substitutes in competition both for light and for power.

Its principal use is as a profit earning commodity; the profits earned by many manufacturers being dependent upon their ability to secure a supply of electric power at a low cost.

If the power is supplied by the Federal Government at a rate below cost then the non-using taxpayer will be indirectly paying the profit of the manufacturer who makes his profit out of the use of power. If it were supplied by a private corporation the other users of electric power would be paying the profit of this manufacturer.

The transmission and distribution of water is as old as civilization, but the generation and transmission of electric power is a new industry. Its continued development is dependent very largely upon the incentive promoted through competition. Covering this industry with governmental control and political preferment instead of competitive selection would stifle the industry.

If the Federal Government undertook the installation of equipment for the generation of power on the Colorado River it would of necessity have to distribute this power to states in which state public service commissions fix the rates. The rates fixed by the state commissions would have to be equitable to the competing private power corporations then in business within the states.

It is hardly to be expected that such rates would just balance the Government's cost. If the installation had been excessively expensive, as frequently occurs under government administration, then a rate which would be profitable to a private corporation might be unprofitable to the Government, and through taxation, burdensome to the non-user of power. If the reverse happened to be the case, and the Government generating plant, on account of its size, freedom from taxes, or other conditions, was able to produce power at a lower cost than the private corporation, then the rate fixed by the state commission would earn a profit accruing to the non-user of power. Either case would be inequitable.

A fair consideration of all the facts indicates that the generation and distribution of electric power is a specialized industry which can best be handled under private ownership with public or governmental supervision over rates.

FEDERAL POWER COMMISSION CONTROL

The power generated on the Colorado River should be allocated to the several states by the Federal Power Commission. The Federal Water Power Act, under which the Commission derives its authority, is, however, deficient in that it does not specifically authorize the Commission to allocate power to states interested in interstate streams.

The act provides that the Commission may exercise jurisdiction over the investment, or at least the question as to whether, or not, the investment proposed is adequate for the purpose. But the commission is not empowered to determine rates. This is left to the public service commissions of the states.

If the Federal Power Commission allocated power to a state without the authority to control the rate the state public service commission could fix a rate which would be confiscatory; or the rates for power to adjoining states, if left to the commissions of the several states, might be so at variance as to be entirely inequitable.

This situation would not arise if the Federal Power Commission and the state commissions could at all times agree. But the more certain way would be to amend the Federal Water Power Act and empower the Federal Power Commission to fix rates and allocate power to the states at interest in all streams under the jurisdiction of the Federal Power Commission.

PRESENT AND FUTURE DEMAND FOR POWER

The Colorado River from its sources to the Mexican boundary line has sufficient flow and fall, if fully regulated and utilized, to develop between six and seven million horse power.

At present within transmission distance of the Lower Colorado River fuel is being used to generate about 250,000 horse power, requiring approximately 8,000,000 barrels, or 400,000,000 gallons, of oil per year. This is equivalent to a continuous discharge of the full capacity of a pipe 17½ inches in diameter at the rate of one foot per second, or an 8-inch pipe discharging at the rate of five feet per second.

If a pipe line was discharging this stream of oil into the ocean it would be regarded as a waste which would not be tolerated. Yet this would be but the equivalent of the present actual waste on the Colorado River and, in addition thereto, the farmers are suffering a heavy annual loss due to floods and are paying the cost of maintaining levees and of removing the accumulating silt from the irrigation canals and laterals.

The Colorado River below Boulder Canyon can, under full development, generate 1,225,000 horse power without wasting any of the water required for irrigation. The present rate of increase in demand for electric power within transmission distance is approximately 90,000 horse power per year, and the rapidly increasing population indicates that for a number of years this rate will be maintained.

But other water powers are in course of development and the present market for power in this territory, with the probable unsatisfied increase in demand up to the completion of the necessary dam and control works, will not warrant a first installation of more than 500,000 horse power. This generating capacity will not justify the investment which is needed for a dam to meet the requirements of irrigation, and if the entire interest, amortization and maintenance charge of such a dam is charged against the revenue derived from this first power installation, the rate charged for power will have to be high enough to pay it, and will preclude the possibility of establishing a low rate until the demand for power permits the distribution of this charge over a much greater output.

If a corporation owning undeveloped water powers in California controlled the Colorado River development it could turn this situation to its own advantage. The necessary high rate would permit the development of its other water powers at unit costs in excess of the ultimate unit cost of the Colorado River development. The California demand could be supplied from these sources at rates justified by the investment. The Colorado River power market would then be limited to the demand outside of California, and the final development of the Colorado would be deferred until the increased demand justified the already established high rates.

Anticipating the increase in demand for power some of the generating companies now serving the southwestern territory with hydro-electric power have acquired the water power rights on the important streams in California within transmission distance of the markets. The projects which could be developed at a low cost per horse power were developed first, and it is now necessary for them to develop the more expensive projects at costs which (according to published figures) in many instances will exceed the cost per horse power of the completed Lower Colorado River development.

If the future demands for power are for a time supplied from the Colorado, the investment of these companies in some of their undeveloped water powers will have to be carried as an expense until the demand exceeds the supply available from the Colorado and the price advances enough to justify the development of their more expensive projects.

It would no doubt be to the advantage of these companies to defer the development of the Colorado until they had developed all of their own projects. The state public service commissions would then be under the necessity of maintaining rates high enough to give them a fair return on their total investment even if power from the Colorado could be delivered at a lower cost.

Such a plan would not, however, be to the best interests of the people of the states of the southwest. It would not encourage the development of mining and other industries and would delay the reclamation of thousands of acres of land in Arizona, Nevada and California, which can be irrigated by pumping if power is made available at a moderate cost.

Duplication of investment should be avoided and existing transmission and distributing companies should be protected against destructive competition, given a fair return on their investment, and compensation for the risk taken by their investors in the development of the industry. This, however, should not be permitted to delay the development of power on the Colorado River.

The corporation installing and operating the power development in connection with the proposed lower basin reservoir should be independent of any existing power distributing corporation. The company should be a generating company delivering the power only to political divisions, distributing companies, and railways. Seasonal or irrigation power should be delivered to mutual associations, communities or groups, organized for the purpose of acquiring power and distributing it to their memberships for irrigation purposes.

The generating company should not be or become a competitor of any using or distributing company or association; and the requirements of states, counties and municipalities, should be given preference over those of private distributing corporations.

The rates at which the power is sold by the generating company should be fixed by the Federal Power Board, or by agreement between the Federal Power Board and the state boards at interest. The interest charge on the cost of the dam should be borne by the Government, or the states, or the lands benefited, until the demand for power is sufficient to enable the power company to assume this charge without increasing the rate charged for power. The amortization of the cost of the dam can be deferred until it can be assumed and paid by the power company.

This plan would deliver the power at a uniform rate into the jurisdiction of the several states for distribution at the rates there fixed by the state boards. It would avoid duplication of investment and automatically limit future developments to projects which could deliver power at a cost as low as the rates established for Colorado River power.

The principal market for power in the lower basin is in Southern California and Southern Arizona, so it will be advantageous to serve this market from a development as far south on the river channel as the local conditions and the demands of agriculture will permit.

The firm power available throughout the year, which under these conditions can be generated at Boulder, the Portals, and Bulls Head Rock, will be generated much nearer to the market for power than would be possible with developments above Boulder Canyon.

From Boulder Canyon to Los Angeles (the principal market), the distance is 250 miles; to San Diego approximately 300 miles; to Yuma, Arizona, 250 miles; the mining districts in southeastern Arizona, 250 to 300 miles; and the principal mining district in Nevada, 250 miles.

The principal market for power in the upper basin is in Utah in the vicinity of Salt Lake City, so this market can best be served from one of the favorable locations in the upper basin.