

The
Verde River Water
Project
of the City of
Phoenix, Arizona



A
vast accomplishment of
lasting importance

Verde River Water Project

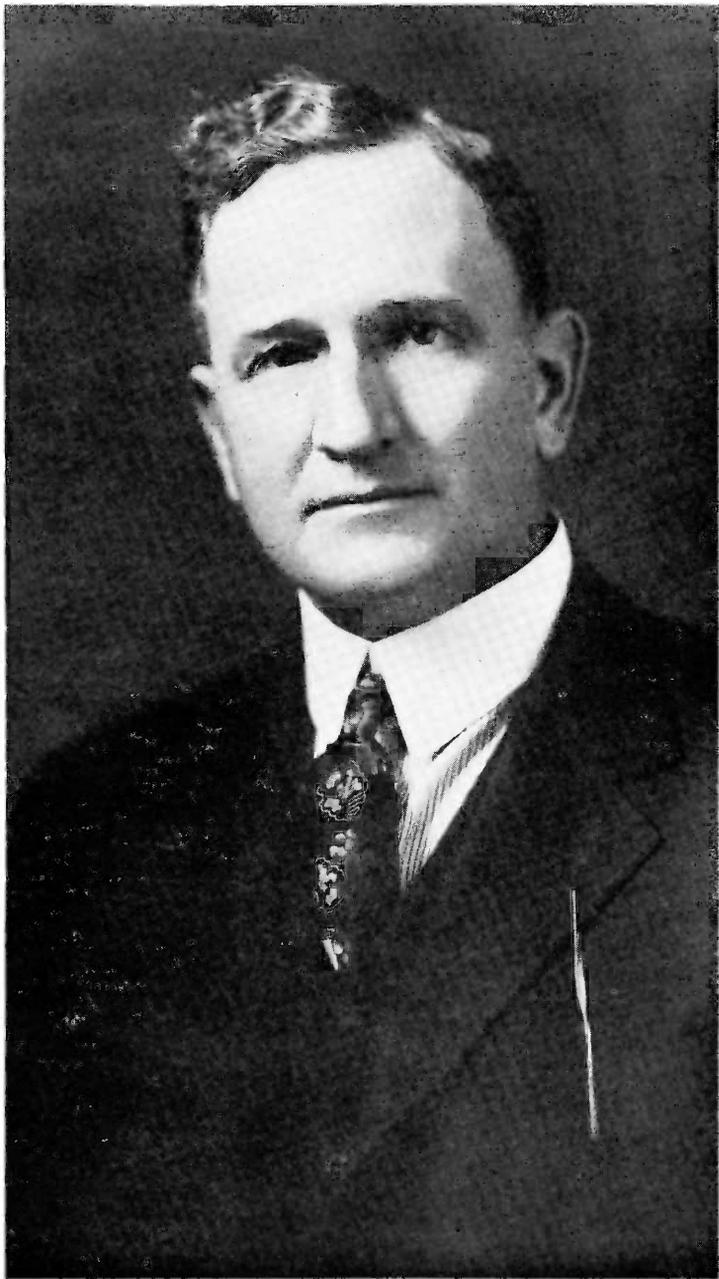
of the City of

Phoenix, Arizona



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BY
UNITED STATES SENATOR
CARL HAYDEN
1968

A
*vast accomplishment of
lasting importance*



V. A. THOMPSON
City Manager

His vision, determination and knowledge
made the Verde River Project a reality.

VERDE RIVER WATER PROJECT OF THE CITY OF PHOENIX, ARIZONA



PURITY AND PERMANENCE OF VERDE WATER SUPPLY MEANS MUCH TO PHOENIX

WITH the completion of the Verde Gravity Water System there now is no city in the United States that has better water than Phoenix. by all of the scientific tests which are applied to the determination of the purity of water. This fact has been fully confirmed by the analyses of the water made by laboratories in various sections of the country. A chemist of paramount authority said in his report on the Verde water that he did not recall that it was materially surpassed by any supply within his knowledge elsewhere throughout the country. A famous Consulting Engineer, who was Assistant Chief Engineer during the construction of the Owens River Aqueduct, recently stated that the Verde water was unusually pure; of about the same quality as that obtained by the City of Los Angeles from the Sierra Nevadas; somewhat better than that used in San Francisco and much similar to the supply of Pasadena.

Phoenix' pure, soft, clear water is taken from the sub-surface flow of the Verde River, at a point near historic Fort McDowell, 32 miles Northeast of the City. Although the flow of the Verde is normally clear and practically free from impurities at the point of intake, the water is thoroughly filtered through sand, gravel and boulders before entering the delivery conduit. At no point is the water taken direct from the river, as the concrete pipe through the infiltration galleries is laid parallel to and at some distance from the river.

The Verde River has its source in the Santa Maria and Sierra Prieta mountains of Yavapai County, at an elevation of 7,750 feet. Included in the flow of the stream are tributaries from the snow-clad San Francisco Peaks, which rear their heads to an elevation of 12,794 feet in the far stretches of Coconino County. On down through the practically virgin areas of the Tusyan, Coconino, Prescott and Tonto National Forest Reserves, the flow is still further augmented by the melted snow and rains from the mountain plateaus, all contributing to the inexhaustible source of supply.

“With the coming of the Verde water the last faint cause for fault finding, so far as Phoenix is concerned, has been eliminated.

“This may sound rather a broad statement, but the facts will bear investigation,” said the editorial writer who penned the above paragraph, when the water from the Verde River was first turned into the city mains.

“What,” he queried, “does the city now lack which would make it a better place in which to live? The climate is incomparable. For at least nine months in the year it could not be improved upon, and within a few hours ride there is comfort even in the heated period of Summer. The air, remarkably free from humidity, is life-giving and pure and invigorating. The fertility of the valley is so amazing, the soil so productive and capable of such variety of product, that no other spot can compare to it in agricultural advantages. The Arizona sunshine, on the job day in and day out with only rare instances of obscurity throughout the year, is famed the world over for its health-giving qualities. Add to these things the fact that Phoenix, a beautiful, clean, well ordered and

well governed city, boasts every modern, up-to-date institution necessary to the happiness and convenience of mankind, and I submit that the case is complete.”

There is also the added fact that the possibilities of Phoenix as a manufacturing center have been greatly enhanced by the adequate supply of pure, soft water from the Verde. The water leaves no sediment or scales when used in boilers, thereby ensuring to the manufacturer economy in fuel costs. During the construction work Verde water was used in the boilers of the excavating machines and no compound whatever was necessary.

Direct savings are assured to every water user, in the decrease of plumbing bills, economy in the use of soaps and water softeners and in the increased life of household linen, wearing apparel and the finer fabrics, which are not injured by the water.

Increased fire protection will be given, by the equalization of pressure in all parts of town. Extension of fire and service lines to the sub-divisions taken into the city within the past few years, gives them practically the same protection which is accorded the business building or the residence a few blocks from the heart of the city.



L. V. HITCHCOCK

City Engineer

Who made a most enviable record in the construction work.

THOROUGH INVESTIGATIONS PRECEDE LAUNCHING OF PROJECT

Pioneer investigations for a pure water supply for the city were begun in 1906. At that time Lincoln Fowler, Chairman of the City Water Works Board, secured the services of Alexander Potter, a New York Consulting Engineer, to investigate and prepare plans for a pure water supply.

Alexander Potter

Mr. Potter did not confine his investigations to a water supply which could be constructed for the sum of \$300,000, the amount of money available at that time. He said:

"I have considered it proper not to limit my investigations to the sources which are, strictly speaking, available, but I have examined sources of supply which Phoenix may with profit look to when the population has increased from 100% to 500% of what it is at present. At that time a much greater sum than \$300,000 will undoubtedly be easily available for water supply. In fact, when we consider that with a gravity supply all pumping expenses are eliminated, it will not be long before your city will be able to look seriously and even favorably at a proposition involving a very much larger amount of money than is at present available.

"Water which will be soft and free from salt can be brought from a distance to Phoenix by a gravity system. The value of securing soft water is of course very great, especially in the event of Phoenix becoming a manufacturing center, as the effect of hard or saline water upon boilers is very serious and attended with increased expenses of operation, thus reducing fuel economies.

“The most attractive of the propositions for a water supply is that of conveying the waters of the Verde River to the City of Phoenix by gravity.”

V. A. Thompson

After personal investigations, covering a period of many months, V. A. Thompson, then Superintendent of the Water Works, addressed a communication to the City Council under date of November 13, 1913, urging that a survey be made of a gravity line to the Verde River, in order that an estimate could be made of the cost of the proposed project. His conclusions were summarized as follows:

“First. It is necessary to secure a new water supply if the development of the city is to be continued.

“Second. The Verde River is the only source that promises a supply that will be sufficient.

“Third. There is an ample supply for our needs, and the quality is satisfactory.

“Fourth. There are no difficult engineering problems presented in building the conduit needed. It is a large but simple undertaking.

“Fifth. While there may be more or less litigation, as in all enterprises of this character, I believe that the rights sought to be acquired by the city can be successfully maintained and defended.”

At the suggestion of Mr. Thompson, the City Council engaged Hiram Phillips of St. Louis, Mo., a noted Water Works and Consulting Engineer, to investigate the proposed sources of supply. Mr. Phillips recommended that the City employ some local engineer to make further investigations and compile statistics on all the proposed sources from which

water might be secured. Howard S. Reed, of Phoenix, was engaged to do this work.

Howard S. Reed

In his report Mr. Reed stated that in his investigations of a source of supply no consideration had been given any of the supposed supplies from wells, as a careful perusal of Mr. Willis T. Lee's report of the underground waters of the Salt River Valley, convinced him that "was the amount of water sufficient, the quality would be such that it could not be used to any advantage for manufacturing purposes, and we would still have the expense of pumping, etc." He made examinations of sources of supply from Seven Springs, Cave Creek, Queen Creek, Hassayampa River, Agua Fria River and Verde River. It was the opinion of Mr. Reed that the Verde River was the most practical source from which the City could secure an adequate and desirable water supply.

Hiram Phillips

"A glance at the analysis of the city's present water supply, showing such a large percent of total solids, especially salt, condemns it for domestic and manufacturing use," said Hiram Phillips of St. Louis, in the opening paragraph of his report. As regarded the facts to be considered in connection with a water supply for the city he wrote:

"The first consideration in selecting a water supply is its quality, second, quantity, and third, cost. However, cost is relative,—the writer contends that a pure, wholesome and clear water, adequate and safe, is worth to a city just what it will cost. A city is handicapped which has bad water or an inadequate supply." After checking all previous reports and



WILLIS H. PLUNKETT

Mayor

1920-1921



PETER CORPSTEIN

Mayor

1919-1920

conducting extensive personal investigations of the proposed sources of supply, Mr. Phillips summarized as follows:

"The writer has given careful consideration to the merits of the various sources and is decidedly of the opinion that a supply from the Verde River has so many elements of merit in its favor as compared with the other sources, that the project should be accurately developed before expending further time or money on the other projects mentioned. The project commends itself to me:

"1st. The quality is good.

"2nd. There will be no storage required. Gauging over a long period of time gives us reliable data.

"3rd. The City now has a title to water in this stream.

"4th. There will be no valuable lands or reservoir site to condemn.

"5th. There is a feasible location for a gravity pipe line with no hazardous construction, which can deliver the water under fire or domestic pressure, no pumping being required.

"6th. It is believed that an accurate survey will demonstrate that the system can be constructed for a sum that would be a fine investment for the city."

Despite the recommendation of Mr. Phillips that the Verde Project should be developed before expending further time or money, no further action was taken until early in 1916. At that time the City Commission authorized the employment of William L. Church, a Consulting Engineer of New York City, to make further investigations of the proposed water supply for the city. Previous to the coming of Mr. Church, City Manager Craig and City Engineer Gi-

rand conducted investigations coverings practical tests as to the quantity and quality of the Verde water. A notice of the appropriation by the city of 1100 miners inches of the waters of the Verde River was filed at this time. It was expressly provided in the location notice that the filing was not intended as a waiver of any prior rights enjoyed by the city.

William L. Church

The conclusions reached by William L. Church, Consulting Engineer of New York City, were as follows:

“The only practical source of a water supply for Phoenix is a gravity supply taken from the sub-surface flow of the Verde River.

“The consideration which may blanket all others is that you already have a clear title to an adequate supply from the Verde. A corresponding title to a supply from the Hassayampa or Agua Fria would involve long and costly litigation.

“A primary governing consideration is the quality of the water. I do not recall that the Verde water is materially surpassed by any supply within my knowledge elsewhere throughout the country. Various analyses of the Verde water are before you and are further confirmed by the analysis made on this date by John C. Sparks, Consulting Chemist. Mr. Sparks is of paramount authority on this subject, and I may add is the official chemist for the Board of Water Supply of the City of New York and of many other cities.

“A third governing consideration is the available quantity of water. In this respect the Verde rates with or above the other proposed sources of supply. Specifically, the basis of my estimate of an adequate

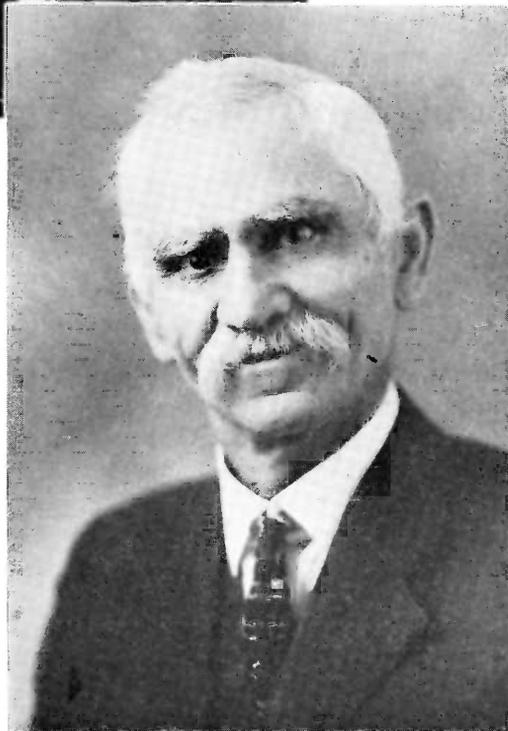
supply is the fact that your single test well about 10 feet square and penetrating into, but not through the water stratum, supplied a six-inch centrifugal pump having a measured discharge of 1400 gallons per minute for a period of several weeks continuously. At this rate of pumping it was impossible to lower the water level.

“As a counter check I have estimated back from your proposed supply of 15,000,000 gallons per day and find that on the total catchment area of approximately 4,000 square miles tributary to the intake point it represents a unit flow of only .006 cubic feet per second per square mile. The lowest recorded minimum in the semi-arid countries is usually .15 square feet per square mile. You will see therefore that your proposed draft is almost negligibly small when related to the catchment area which will supply it. Since you will draw from ground water and from a constant flow far in excess of hourly consumption, no impounding reservoir will be required. This will prevent not only extraneous contamination, but the steady although slow concentration of soluble impurities by evaporation.

“In my judgment there is no question as to the desirability of a wooden pipe line. This recommendation does not rest by any means upon the favorable difference in cost, considerable as that is. It rests mainly upon the fact that the varying capacity of a wooden pipe line does not diminish with age. The old objection to the deterioration and ultimate decay of a wooden pipe line, which at one time had some authority has now wholly disappeared in the light of intelligent practice. A pipe line of Redwood or Cypress, properly selected and carefully built, and above all kept constantly saturated with water, is as permanent as any other material. Wooden pipe lines



C. W. BARNETT
Commissioner
1918-1922



J. A. R. IRVINE
Commissioner
1918-1922

have unquestionably passed into the realm of accepted material with all engineers and may be adopted by you without fear of disappointment."

Craig and Girand

Investigations in 1916 by R. A. Craig, City Manager, and J. B. Girand, City Engineer, covered practical tests to determine the quantity of water available and the quality of the water to be had when used in large volumes, and included a preliminary survey of a pipe line location from the intake site on the Verde River to Phoenix. In their judgment the quantity of water developed was sufficient, the quality was satisfactory and the survey demonstrated that the building of a pipe line from the Verde River to Phoenix was entirely feasible.

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THOMPSON SECURES DEFINITE ACTION

Early in 1919 the situation as concerned the city's water supply had become acute. It was obvious that more water would have to be developed to meet the demands of a rapidly growing population. City Manager V. A. Thompson placed all of the facts before Mayor Peter Corpstein and City Commissioners J. A. R. Irvine, Chas. W. Barnett, Geo. N. MacBean and Chas. H. Dunlap. He urged that immediate action be taken toward the development of the Verde River Project. Through previous personal investigations and a careful study of the reports of the eminent engineers who had theretofore examined the sources of a water supply for Phoenix, Manager Thompson was convinced that water from the Verde River was the most logical source of supply. He argued that it was better business to develop the Verde River Project and secure an adequate quantity of pure, soft water, than to add to the existing supply of hard, alkali tainted water by sinking more wells and providing more pumping equipment. In March, 1919, he recommended that the City Engineer be instructed to prepare and submit at the earliest possible date an estimate of the cost of installation of a gravity water supply system from the Verde River; with authority to secure such assistance as he deemed advisable. The Mayor and City Commissioners, on the same day it was presented, unanimously approved the recommendation of City Manager Thompson and the City Engineer was instructed to prepare and submit the estimates at the earliest possible time.

Estimates and Financing

In May, 1919, City Engineer L. B. Hitchcock presented the estimates of the cost of a Gravity Water

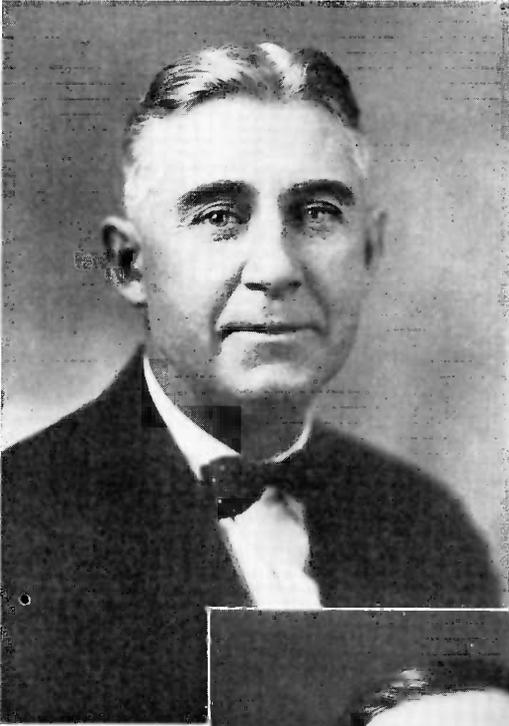
Supply System from the Verde River. The estimates were made with the assistance and approval of Hiram Phillips, Consulting Engineer of St. Louis, Mo. The total estimated cost was \$1,315,242.50, which included the following items: 25,000,000 gallon capacity reinforced concrete reservoir, \$250,000.00; 157,700 feet 42" wood stave pipe at \$4.00 per foot laid, \$630,800.00; 11 miles extra strength pipe, additional cost, \$58,000.00; 15,000 feet 42" concrete pipe at \$12.00 per foot, \$180,000.00; hauling 825 tons cement and 5,125 tons wood pipe, \$33,875.00; valves and gates, \$10,000.00; air vents, \$3,000.00; arroya crossings, \$30,000.00; engineering, legal services and incidentals, \$119,567.50.

Plans for Financing

At the suggestion of City Manager Thompson, the City Commission on May 28, 1919, instructed the City Attorney to draft and submit an ordinance calling an election to vote on a bond issue to provide funds for the construction of the Verde River Project. Previous to this time the personnel of the City Commission had been changed by the election of Luke W. Henderson and Fred O. Adams. These two Commissioners entered heartily into the plans for construction of the new water system. When the ordinance was presented, calling a special election for July 26, 1919, to vote on bonds in the sum of \$1,300,000.00, the measure was passed by the unanimous vote of Mayor Peter Corpstein and City Commissioners J. A. R. Irvine, Chas. W. Barnett, Luke W. Henderson and Fred O. Adams.

Taxpayers Support Officials

Enthusiastic endorsement of the plans of their Mayor, Commissioners, and City Manager, was evi-



LUKE W. HENDERSON
Commissioner
1919-1922



FRED O. ADAMS
Commissioner
1919-1922

denced in the vote of the taxpayers at the special election. The proposal for the issuance of bonds in the sum of \$1,300,000.00 for construction of the Verde Project was carried by a vote of 810 to 33. On September 20, 1919, the bonds were sold to a syndicate of Chicago and Denver buyers.

Material Prices Soar

Shortly after the bonds were sold bids were called for on the Redwood pipe to be used in the construction of the line. The prices of all classes of construction material had been rapidly advancing, and when the proposals for the Redwood pipe were opened in January, 1920, the bids were found to exceed the quotations furnished the city in April, 1919, by approximately \$281,000.00. The prices of other material to be used in the construction of the project had also advanced since the estimates were made, and labor was scarce and high.

Plans are Revised.

City Engineer Hitchcock, at this time, recommended that the proposed reinforced concrete reservoir be eliminated from the plans for the Project, and the city proceed with the construction. His suggestion had the entire approval of Hiram Phillips, of St. Louis, Mo., who had been employed as Consulting Engineer, and had assisted in preparing the preliminary estimates. Before favorable action was taken on this suggestion, the Mayor and City Commissioners conferred with a large group of representative taxpayers, who recommended that the City immediately proceed with the construction of the Project under the revised plans.

Development of Plans and Construction

It was originally planned to contract for practically all of the construction on the intake and pipe line. Almost at the beginning of the work it was demonstrated that with few exceptions it was practically impossible to secure satisfactory bids from reliable contractors, due to unsettled labor conditions. This fact was illustrated in the default on a contract let for the excavations for the 38-inch Redwood pipe. City Engineer Hitchcock and Consulting Engineer Phillips recommended that all future work on the Project be done under force account by the city. With the approval of City Manager Thompson, the City Commission, on June 18, 1920, authorized the adoption of this plan.

With the exception of a portion of the backfill, which was done under an informal contract, all of the construction connected with the installation of the Intake System was completed by city forces. This work included excavations, backfill, right of way, sand trap, laying pipe, concrete facing on river bank, road work, etc. The concrete pipe for the intake was furnished by B. B. Boyd.

The contract for the excavations, backfill and right of way for the 36-inch Redwood line had been let before the city adopted the force account plan. This work was completed by the contractors, Morgan Ford & Co. Some extra work was done by the city forces, due to the flooding of a part of the contract work. All of the trestles, bents, stand pipes and concrete portions of the saddles were put in by the city. The Redwood pipe was furnished and installed by the Pacific Tank & Pipe Co., and the Redwood Manufacturers Co.

The excavations, backfill and right of way for the 38-inch Redwood pipe line were only partially

completed when the contractor defaulted on his contract. The work was completed by the city under force account, with the exception of the backfill and steam shovel work, which was done under contract. All of the Redwood pipe for this line was furnished and installed by the Redwood Manufacturers Co.

Infiltration Intake System

The simple method employed to tap the underground filtrated waters of the river, is the feature of the Intake System for the Verde water supply. It amounts to nothing more than offering the water a path of least resistance through a big concrete pipe, instead of through the soil strata. The excavations for the Intake were made in the water-bearing strata, consisting of sand, gravel and boulders, to a maximum depth of 28 feet below the ground surface and about 15 feet below the underground water surface.

Water Not Taken From River

At no point in the Intake System is the water taken direct from the river. The big concrete pipe line lies parallel to the river and some distance back from the bank.

Open Joints in Pipe

Approximately 12,000 feet of concrete pipe, five feet in diameter, is included in the underground Intake System. At the extreme northern end, 4210 feet of the pipe is laid with an open joint every four feet, to give ingress to the water from the water-bearing sand, gravel and boulders.

Much Excavating

In digging the trench for the intake pipe the banks continued to crumble away, necessitating the



LOUIS B. WHITNEY

Mayor

1922

extra removal of thousands of yards of sand and gravel. At times during the work it was necessary to make the trench more than sixty feet wide at the top, in order to provide sufficient space at the bottom for the reception of the five-foot intake pipe. It was necessary at all times to operate pumps to keep the water low enough for the men to work.

Wets and Drys Divided

The excavations were under water constantly and the workmen were compelled to remain in the water to complete their task. It was necessary in this construction to divide the eight-hour working day into two shifts—four hours wet and four hours dry. Despite the fact that a dragline machine was used to swing the pipe into place, the work was difficult and dangerous as each joint of pipe weighed approximately two and one-half tons. On an average, only about five lengths were laid in a day, or a total of twenty in each eight-hour shift.

Pipe Made On Ground

Realizing the almost prohibitive expense and work involved in hauling pipe for the Intake System from Phoenix, or in shipping it from an outside point, the city contracted with B. B. Boyd, of San Diego, to make the pipe on the ground. This was no small undertaking. The pipe is made of concrete, heavily reinforced with steel, and is five feet in diameter and six inches thick from outer to inner circumference. It was cast in four-foot lengths, each of which weighed over 5,000 pounds. A total of 2,974 lengths, weighing 15,415,450 pounds, were required to complete the intake. Motor trucks were used in hauling the cement and reinforcing steel from Phoenix to the intake site.

MATERIAL AND LABOR INVOLVED

Approximately 12,000 feet of concrete pipe, five feet in diameter, was used in building the Intake System. The contract price for making this pipe was \$115,196.77, which did not include the installation. It required 102,773 cubic feet of concrete to make the pipe. In mixing the concrete, it was necessary to use 21,731 sacks of cement, 45,225 cubic feet of sand and 90,126 cubic feet of stone. The pipe was heavily reinforced, approximately 395,000 pounds of steel being used in its construction. To install the intake pipe it is estimated that it was necessary to move about 504,750 tons of material.

Sand Trap

The water is carried through the intake pipe to a sand trap, at which point it is delivered to the Redwood pipe line, through which it flows by gravity a distance of 28.7 miles, to the junction point with the city water mains.

The sand trap is a concrete building twenty feet square and twelve feet high. The floor is laid two feet below the flow line of the Redwood pipe, with a sluice gate on the side toward the river. Any sand that may be carried through the intake line by the water is deposited on the concrete floor of the sand trap and is disposed of at infrequent intervals by opening the sluice gate and forcing it into the river.

VERDE RIVER WATER

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CARL J. BARDEN of
1968

THE BIG REDWOOD LINE

The total length of the Redwood pipe line is 28.7 miles, which covers the distance from the Sand Trap to Twelfth Street and McDowell Road, where it connects with the city water mains. From the Sand Trap to the reservoir site, a distance of 22.6 miles, the line is 36 inches in diameter. The 38-inch pipe is laid from the reservoir site to the connection with the city mains, a distance of 6.1 miles.

The Redwood line was laid under ground where practical, but there were stretches where it was not feasible to excavate because of the hard, rock formation. At other points a path had to be blasted through the solid rock, where cliffs rear on one side and the outside walls are steep banks that drop away to the Verde River. As an extreme example of the difficulties encountered, six miles before the line reaches the intake, workmen had to blast a mile of road and path for the pipe through almost solid rock. A small crew of Indian workmen were six months in completing this one mile.

Construction Details

There was 119,162 lineal feet of 36-inch and 32,289 lineal feet of 38-inch Redwood pipe, used in building the big gravity line from the Verde River to Phoenix. A total of \$792,764.84 was paid for the finished pipe, which did not include the cost of digging the trenches for its reception nor the expense of hauling the material from Phoenix.

The Redwood pipe is made of staves, cut in the form of an arc, 1 9/16 inches thick and approximately 5½ inches wide, and varying in length from 12 to 18 feet. The staves are held in the form of a circle

[Twenty-five]



L A Y I N G S E C T I O N O F R E D W O O D P I P E

by steel bands $\frac{1}{2}$ inch in diameter, which are spaced from $2\frac{1}{4}$ to 10 inches apart, varying according to the internal water pressure. A total of 2,802,218 pounds of steel is included in the bands, shoes, nuts, washers and clips used to tie the pipe securely and provide the necessary reinforcement.

One hundred and eighteen freight cars were required to haul the Redwood staves to Phoenix. There was also thirty-nine car loads of reinforcement material and two carloads of valves and fittings.

General Direction

The 36-inch Redwood line runs in a Southerly direction from the Sand Trap to Granite Reef, practically paralleling the Verde River. At this point it takes a Westerly course, following the Arizona Canal on the North side, to a point about 4,000 feet East of the Fort McDowell bridge. From here it takes a Southwesterly direction, crossing the Arizona Canal and continuing thence across the desert to a point on the Thomas Road approximately five miles East of Scottsdale. It then follows Thomas Road, in a Westerly direction, to the reservoir site, six miles East of Central Avenue. Here the 36-inch line connects with the 38-inch pipe, which continues on to Sixteenth Street, where it turns South to McDowell Road, then West on McDowell Road to Twelfth Street, where it connects with the city mains.

Tracing the Line

Leaving the Sand Trap, the pipe is laid underground for two and one-half miles until it reaches the Gauging Station on the Verde River, where it runs on the surface for a distance of half a mile, then drops out of sight for the next half-mile, to emerge

and cross a rocky stretch one-half mile in length. Another plunge and the line is carried underground for approximately two miles and then breaks out to sweep around Granite Reef Hill for half a mile. From here, with the exception of where it crosses the Arizona Canal on a trestle, the line is hidden from view for more than seven miles. Then comes an exposed stretch of half a mile, where the line rears its head in the climb to a mesa thirty feet above. Here it sinks into the ground for a mile, to again emerge and pursue its course across another rocky stretch of two and one-half miles. In the final lap of its course, through Thomas Road, Sixteenth Street and McDowell Road, the line is carried underground for a distance of eleven miles, to join with the city distribution system at Twelfth Street. In this last stretch the line runs under the New Cross Cut, Grand and Little Maricopa Canals, and over the Old Cross Cut Canal on a trestle.

QUALITY OF VERDE WATER

The most recent report on the quality of the water being delivered to Phoenix by the Verde River Gravity System is that of J. B. Lippincott of Los Angeles, under date of July 12, 1922. Mr. Lippincott was Assistant Chief Engineer of the famous Owens River Aqueduct, and is a recognized authority on water and water systems. In his report on the supply from the Verde River, he presents analyses of the water shown in earlier reports, together with the analysis of samples taken by himself, and summarizes as follows:

“Numerous chemical and sanitary analyses have been made of the water of both the Verde River and of the infiltration galleries of the gravity system. Both of these waters contain approximately 30 parts mineral salts per 100,000 parts of water. This is an unusually pure water for the arid regions of the Southwest, and is well within general standards accepted by water works authorities. It is of about the same quality as that obtained by the City of Los Angeles from the Sierra Nevadas, through their aqueduct, somewhat better than that used in San Francisco and much similar to the supply of Pasadena. The well water formerly used by the City of Phoenix contains about four times the amount of mineral matter as does that of the Verde.

“The drainage basin of the Verde River is situated in the Tonto, Prescott, Coconino and Tussayan National Forest Reserves and hence the sanitary quality of the water is above the average. While this subject has previously been extensively discussed, it is gratifying to note that the water being delivered is as predicted.



T H R O U G H T H E C U L T I V A T E D F E R T I L E F A R M L A N D S

VERDE RIVER WATER PROJECT *of*

“The following comparative analyses are interesting, instructive and conclusive:

(Analyses made on parts per 100,000)

	Reed Report 1913	Church Report 1919	Path. Lab. Nov. 30, 1921	Goss Lab. May 29, 1922
Appearance		Clear	Clear	
Odor		None	None	
Calcium Carbonate	Faint Trace	13.23	13.41	1.5
Magnesium Carbonate....	Mod- erate	7.22	7.02	Trace
Sodium Sulphate	Mod- erate	3.97	4.88	0.2
Sodium Chloride	5.4	4.83	3.51	4.0
Aluminum & Iron Oxide		.47	.65	0.04
Silica		3.53		0.05
Total Mineral.....		30.25	30.1	5.79
Free Ammonia0081	.008	
Albuminoid Ammonia....		.0088	.0096	
Nitrogen as Nitrates072	.0065	
Nitrogen as Nitrites.....		Trace	None	
Total Organic & Volatile		3.04	3.3	1.75
Total Solids.....	40.8	33.29	33.4	7.54

“Analyses were made of the city water supply and the Verde River water on November 30, 1921. A comparison of these is interesting and the two analyses are shown below:—

(Parts per 100,000)

	City Water	Verde Water
Appearance	Clear	Clear
Odor	None	None
Calcium Carbonate.....	27.93	13.41
Magnesium Carbonate.....	4.95	7.02
Sodium Sulphate	13.69	4.88

THE CITY of PHOENIX, ARIZONA

Sodium Chloride.....	95.29	3.51
Aluminum & Iron Oxide.....	.28	.65
Total Mineral.....	144.3	30.1
Free Ammonia.....	.005	.008
Albuminoid Ammonia.....	.003	.0096
Nitrates.....	.005	.0065
Nitrites.....	None	None
Total Organic and Volatile....	21.4	3.3
Total Solids.....	165.7	33.4

VERDE RIVER WATER PROJECT of

TOTAL COST OF PROJECT

As shown in the report of the Auditor, employed by the City Commission in 1922, the total expenditures chargeable to the construction of the Project amounted to \$1,525,282.62.

A tabulation of the total expenditures together with a classification of costs is shown below:

Total Costs

Intake System (including pipe on hand)	\$ 424,029.43
36-inch Redwood Pipe Line.....	792,666.75
38-inch Redwood Pipe Line.....	296,416.42
Reservoir Site	9,000.00
Chlorination Plant	3,170.02
Total Cost to June 30, 1922.....	\$1,525,282.62

Intake Cost Segregated

11,896 ft. 60" Concrete Pipe.....	\$ 115,196.77
Laying 11,316 ft. of above Pipe	22,542.97
Excavating, Backfilling and Right of Way	185,215.69
Well Drilling and Tests.....	1,570.02
Sand Trap	3,958.95
Transportation	7,998.61
Roads	14,878.99
Camp Construction.....	4,319.63
Equipment (including 2 Dragline Excavators)	28,089.51
Engineering and General Costs.....	34,392.86
Commissary and Mess Loss	5,865.43
Total.....	\$ 424,029.43



BIG PIPE CROSSES IRRIGATION CANAL

36" Redwood Pipe Line

119,162 ft. Redwood Pipe, installed in Trenches	\$ 581,084.47
Structures (trestles, stand pipes, and concrete portions of saddles).....	10,074.83
Valves and Fittings.....	4,681.00
Redwood Portion of Saddles.....	4,506.85
Excavation, backfill and right of way	83,437.50
Transportation and Material Yard expense	35,689.37
Engineering and General Expense	69,267.61
Pipe Fitting and Adjustments.....	2,817.27
Commissary and Mess Loss.....	1,107.85
Total.....	\$ 792,666.75

38" Redwood Pipe Line

32,287 ft. Redwood Pipe, installed in Trenches	\$ 211,680.37
Structures (trestles, stand pipes, and concrete portions of Saddles)	4,419.47
Valves and Fittings.....	411.00
Excavations, backfill and right of way	36,612.46
Transportation and Material Yard expense	12,187.17
Engineering and General Expense	26,006.31
Settlement due to abandonment of part of work	4,069.29
Pipe Testing	460.88
Commissary and Mess Loss.....	569.47
Total.....	\$ 296,416.42

VERDE RIVER WATER PROJECT *of*

Chlorination Plant

Total Cost\$ 3,170.02

Reservoir Site

Total Cost\$ 9,000.00

The foregoing figures are all taken from the report of the special accountant employed by the last City Commission to audit the accounts of the Verde River Project. The audit covers the period from the first expenditure to June 30, 1922.

MEN BEHIND THE GUN

V. A. Thompson, City Manager, was the executive head of the entire organization and responsible to the Mayor and City Commissioners for construction of the Project. All vital problems were subject to his approval.

The actual construction work on the Project was under the direction of City Engineer L. B. Hitchcock. His entire time was devoted to the Project during the period of its construction, and he exercised direct supervision over all details connected with the undertaking.

Hiram Phillips of St. Louis, Mo., was the Consulting Engineer engaged by the city during the planning and construction periods, and gave much valuable time to the Project.

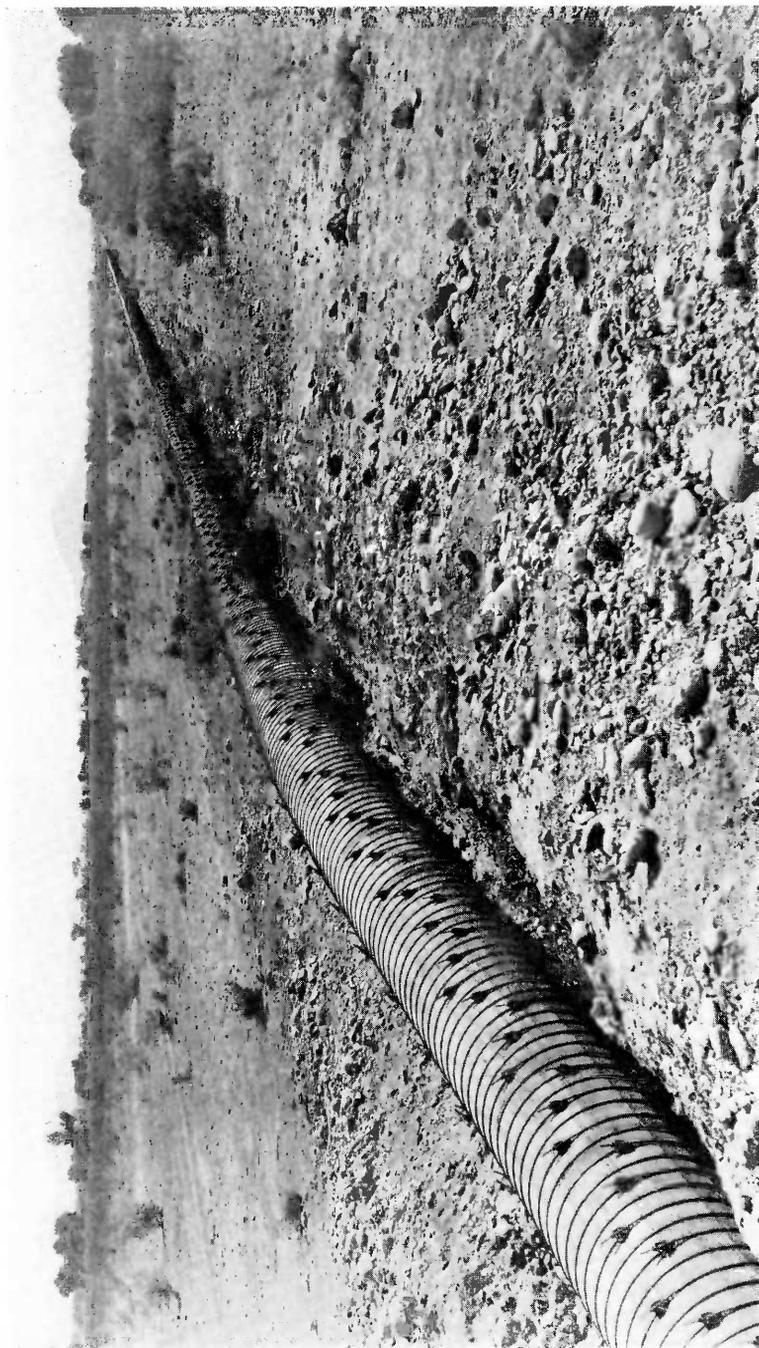
The following officials were directing the affairs of the City of Phoenix during the periods covering the inauguration, construction and completion of the Verde River Gravity Water System:

1918-19

Mayor, Peter Corpstein
Commissioner, J. A. R. Irvine
Commissioner, Chas. W. Barnett
Commissioner, Chas. H. Dunlap
Commissioner, Geo. N. McBean

1919-20

Mayor, Peter Corpstein
Commissioner, Luke W. Henderson
Commissioner, J. A. R. Irvine
Commissioner, Chas. W. Barnett
Commissioner, Fred O. Adams



ON ITS WAY OVER THE DESERT SANDS

VERDE RIVER WATER PROJECT *of*

1920-21

Mayor, Willis H. Plunkett
Commissioner, Chas. W. Barnett
Commissioner, Fred O. Adams
Commissioner, J. A. R. Irvine
Commissioner, Luke W. Henderson

1921-22

Mayor, Willis H. Plunkett
Commissioner, Fred O. Adams
Commissioner, Luke W. Henderson
Commissioner, J. A. R. Irvine
Commissioner, Chas. W. Barnett

PHILLIPS MEETS SAD END

The only happening to mar the final completion of the Project occurred on December 22, 1921, when Hiram Phillips, of St. Louis, Mo., met his death in an automobile accident near the Intake System. Mr. Phillips had been engaged as Consulting Engineer when the Project was first inaugurated, and had previously made exhaustive examinations of the sources of a water supply for the city. He was a man of national prominence in the engineering world, having been associated in an advisory capacity with some of the biggest municipal works in the country.

The accident which ended fatally for Mr. Phillips occurred when an automobile in which he was riding turned over and pinned him beneath the car. The accident was unavoidable and no blame could be attached to anyone.

At the time this distressing accident occurred, the Project had been practically completed, and the trip had been planned for a final inspection of the work, before turning the water into the big main.

No fatality, accident or mishap of any kind occurred during the actual construction of the Project. A remarkable record, when the hazardous nature of the work is taken into consideration. Excavations were made in cuts of caving quicksands, and pipes laid in deep water where the banks were constantly caving. Paths were blasted through solid rock formation and roads built along mountain sides. Many thousand tons of material had to be handled over desert and mountain roads and thousands of tons of rock and earth had to be moved.

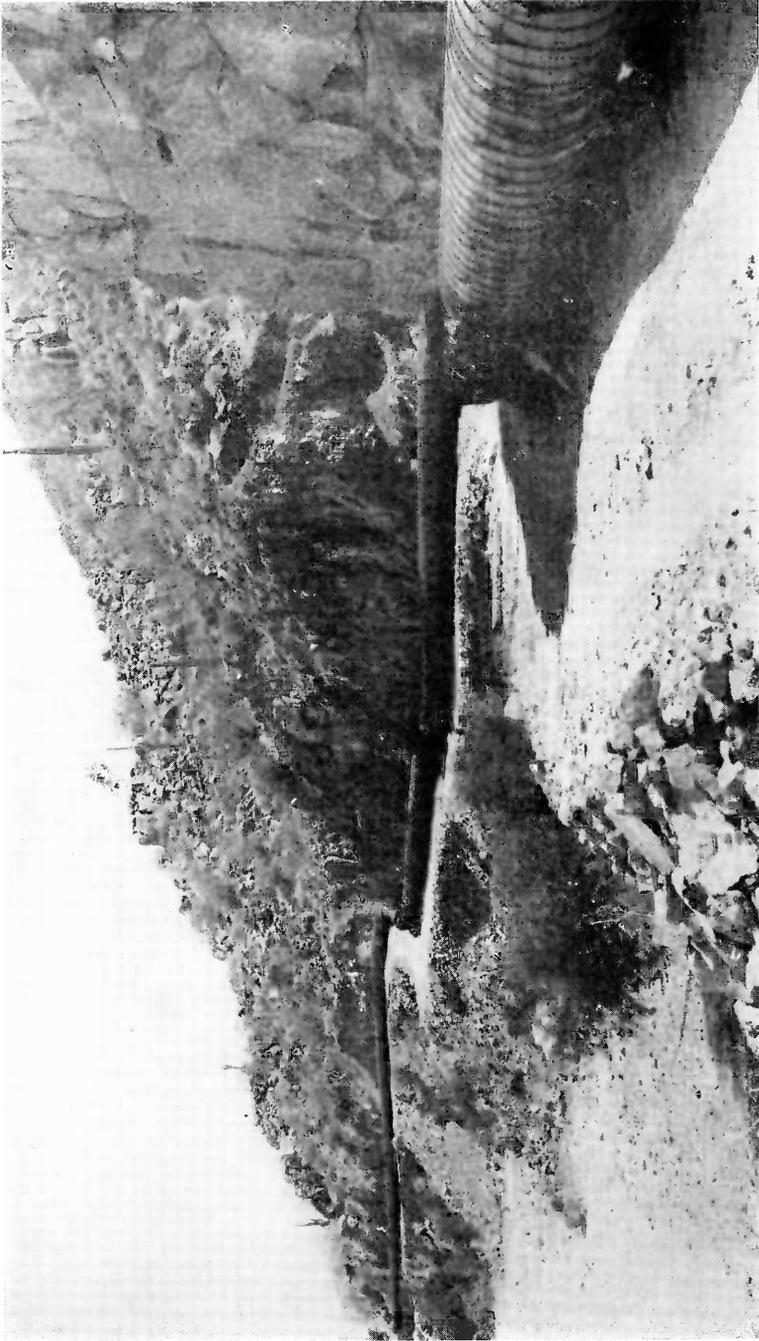
The records will show that no workman was killed, seriously crippled or maimed during the period

of construction; not a horse or mule was killed or crippled; there were no premature blasts in the use of powder; no trucks or motor cars were wrecked, and there was not a single case of serious illness in the construction camps.



FLUCTUATION RESERVOIR

A service or fluctuation reservoir has been constructed on the 15-acre tract owned by the City on Thomas Road. It has a capacity of approximately 5,000,000 gallons. This is not intended as a storage reservoir, but is to provide sufficient water to care for the peak load on the days of heaviest consumption. It is not planned to impound the water at any time for a period of more than 24 hours. However, the reservoir is covered with a substantial roof and the air spaces are protected by copper screening.



A TORTUOUS PATH AROUND THE HILLS

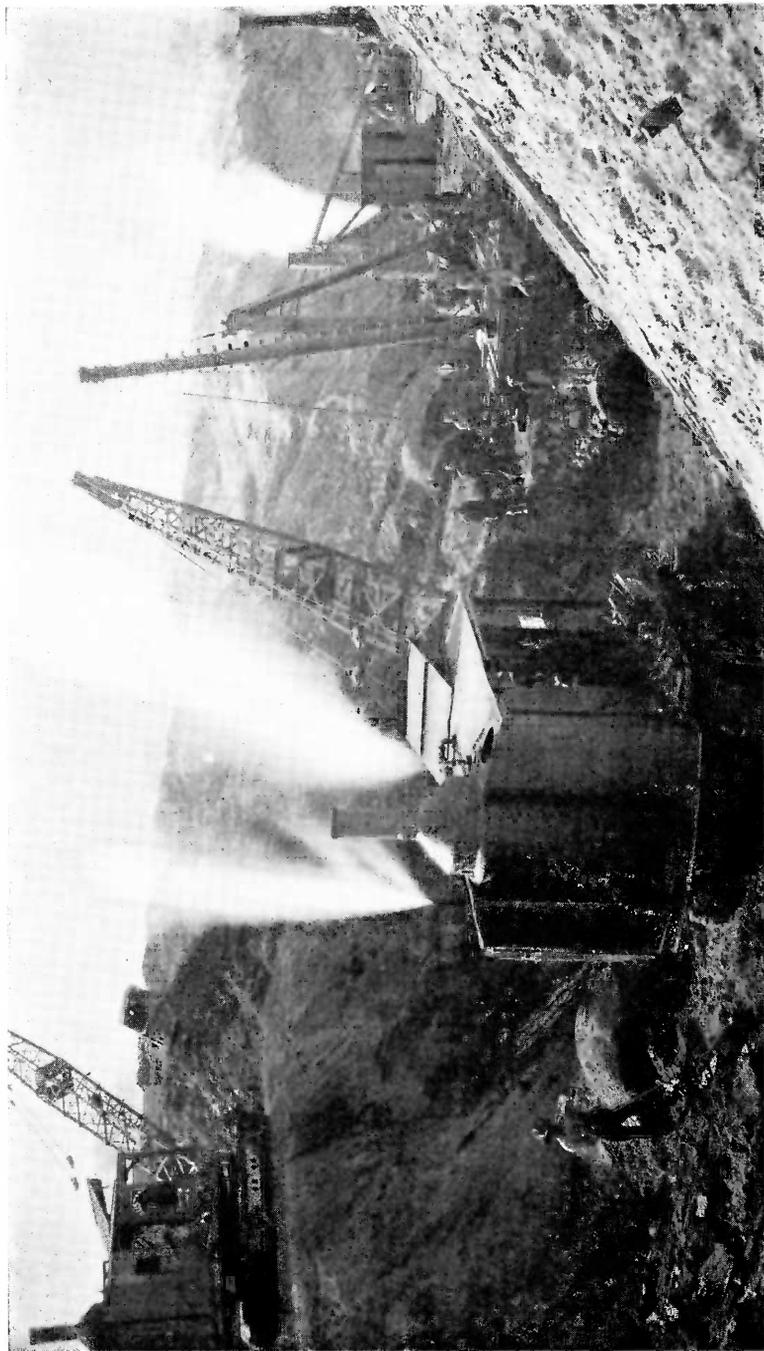
WELL DONE — IS VERDICT

In May, 1922, immediately after the accession to office of the newly elected Mayor and Commissioners, a resolution was introduced authorizing the employment of J. B. Lippincott, as Consulting Engineer on the Verde Project; with instructions to report conclusions relative to the system, both as to construction and operation. The resolution had the hearty support of the two hold-over Commissioners, Luke W. Henderson and Fred O. Adams, and was passed unanimously.

Referring to the general plans and construction work on the Project, Mr. Lippincott said in his report:

“The Redwood pipe line and also the infiltration galleries at the intake of the system have been thoroughly inspected. The general character of the work is satisfactory and is a credit to the city.”

Mr. Lippincott is an engineer of national prominence, and was Assistant Chief Engineer during the planning and construction of the Owens River Aqueduct, the water project which cost the City of Los Angeles \$25,000,000. Mr. Lippincott's report on the quality of the Verde water is given elsewhere in this report.



DIFFICULT CONSTRUCTION OF INTAKE SYSTEM

LOCAL NEWSPAPER COMMENT

Arizona Republican

The turning of the new water into the "iron veins" of the city marks a step ahead, which gave the State's metropolis a supply of the "greatest necessity of life" which is second to none in the United States.

Aside from quality, the quantity of the water is also an important feature, for the supply will care for a population of more than twice the city's present size.

The completion of the Verde River Gravity water system overshadows all other civic improvements in the history of the city of Phoenix.

The new water system and its rapid construction will stand as an engineering feat for the city.

Arizona Gazette

Exceeds in lasting importance anything heretofore done for Phoenix.

Stands out with pronounced prominence as a public work for the benefit of the entire community.

A vast undertaking fraught with many difficulties. Obstacles have been met and overcome without undue fuss or disturbance.

To the men who first worked out the plan, to the Mayor, City Commissioners and their City Manager and Engineer, and to those who have had a hand in this achievement we extend our congratulations for a task well done, and the thanks of the people for a boon almost beyond price.

[Forty-five]

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