REPORT OF THE CHIEF ENGINEER

Chas. Hermany,

TO THE

Water-Works and Sewerage Commissioners

UPON A

PUBLIC WATER SUPPLY

AND A

SYSTEM OF DRAINAGE

FOR

THE CITY OF MEMPHIS.

SECOND EDITION.

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REPORT.

LOUISVILLE, July 15, 1868.

W. RICHARDSON HUNT, ESQ., *Chairman of the Board of Water-Works and Sewerage Commissioners for the City of Memphis, Tennessee:*

SIR—One of the first and leading considerations in the selection of abiding places for man, whether it be the cave of the savage, the hut of the barbarian, the cottage of the peasant, the camp of the soldier, the residence of the man of wealth, or the site of a large city, is the supply of an ample quantity of pure and wholesome water.

Self-evident is this fact, and should be so completely within the comprehension of all persons as to render it superfluous to attempt any elucidation of the subject.

Nature, however liberal, does not always make ample provision for supplying the wants of man, inasmuch as springs, brooks and rivers are not sufficiently numerous to furnish water of suitable quality *everywhere* where man chooses abiding places; hence his ingenuity or constructive ability is called into action, and wells are formed by excavations in the earth, from which water is obtained for limited numbers in localities more or less remote from natural water courses.

In cities where large populations dwell upon comparatively small areas of land, this mode of obtaining water fails, both as regards quantity and quality. Upon the sites of many towns and cities, wells wholly fail to furnish water of suitable quality; hence rain-water cisterns, constructed under ground, and located in streets, courts, alleys, yards, basements, etc., into which that portion of rain falling upon the roofs of the houses, and not evaporated or absorbed, is conducted and stored for use. These modes of water supply are very expensive, considering the limited quantity and deteriorated quality furnished.

Take, for instance, the city of Memphis, with a population of 50,000, within the reach of an efficient public water supply; within this limit the present mode of supply is by means of wells and rain-water cisterns, principally the latter; the money invested in wells, cisterns, pumps, pipes and fixtures-with the attending annual repairs, at a very moderate esti, mate, cannot represent less capital than $300 for each and every house; and estimating twelve persons as the average number to each house, the capital represented by the present water supply of Memphis would be $25 *per capita*, or $1,250,-000 for a population of 50,000; while the quantity furnished is limited to the minimum, and the quality in every respect inferior.

The city is, in this respect, situated similarly to all the other principal cities of the United States prior to their being provided with public water supplies, the sources of which being pure and far beyond the reach of the contaminating influences incident to densely populated districts. These cities, like your own, in times of sickness or epidemics, had the *prevailing diseases* to much greater extent and much more aggravated cases, by virtue of the fact that limited quantities of indifferent or bad water aided climatic causes in developing and prolonging epidemics. In the city of New York, as early as 1798, while the necessity of a supply of pure water was already severely felt, Dr. Brown, in a report upon the subject in the same year, "exhibits circumstantially the consumption of water as of a very small quantity (on account of the difficulty of procuring it), and subordinate quality; he considers this as the cause of a variety of diseases and contagious disorders, *especially the yellow fever, which had recently made great ravages there.* Further, he blames highly the preference given by the inhabitants to the water in the Collect* and some wells, which by its freshness and the intermixture of carbonic acid pleases the taste, although partaking of the filth of men and animals, which sinks into the ground in streets, yards and stables, and then drains through the cemeteries before it reaches the pond. Thus the water in the Collect, as also in the wells, was rendered in a high degree unwholesome, in spite of its agreeable taste. He also considers the state of health of a populous city as depending

* A pond supplied by a fine (?) spring.

more upon the purity of its water than the quality of all the rest of its provisions together."

In the city of Philadelphia, as early as 1793 or 1794, Benjamin Franklin was, it is believed, the first who publicly called the attention of the citizens to the very important subject of watering the city from some other source than the wells then universally used; urging that the afflictions from the ravages of contagious diseases rendered it necessary that a more copious supply of water should be procured, to insure the health, comfort and preservation of the citizens. This was just after the city had been visited by *yellow fever.* And in Franklin's will, dated June 23, 1789, is the following clause: "And having considered that the covering of the ground plot of the city with buildings and pavements which carry off most of the rain and prevent it soaking into the earth, and renewing and purifying the springs, whence the waters of the wells must gradually grow worse, and in time be unfit for use, as I find has happened in all old cities, I recommend that at the end of the first hundred years, if not done before, the corporation of the city employ a part of the hundred thousand pounds in bringing by pipes the water of Wissahiccon Creek into the town, so as to supply the inhabitants."

Thus we perceive that the leading men of the cities of New York and Philadelphia (the latter now one of the healthiest cities on the face of the globe) were, three-quarters of a century ago, engaged upon the solution of problems exactly similar to the one now before the citizens of Memphis, and long before the founder of Memphis had visited the Chickasaw Bluffs. And were the histories of other cities in this particular accessible to us, they would no doubt be similar to the cases named. There are, however, many towns and cities in the United States which have not waited until dire necessity compelled the establishment of public water supplies; but which, by a laudable enterprise, have established water-works as a means of enhancing their growth, offering inducements to capital, artisans and manufacturers to locate in their midst, and thus secure an increase of permanent wealth and population by fostering habits of cleanliness, health, industry and enterprise. View the subject in any light you will, it is full of interest and importance, and one in which the citizens should take the deepest interest; and it must be also self-evident to every property owner that the introduction of an ample supply of pure and healthful water into Memphis will do more toward building up the town and enhancing the value of property than any other improvement now contemplated.

To sum up all the advantages from a properly devised public water supply, would require a lengthy dissertation upon the subject; we will therefore briefly enumerate some of the principal ones only.

1. It furnishes a better quality of water than is possible from wells and rain-water cisterns, and at a much cheaper rate for the same quantity than can be obtained by private or individual means of supply.

2. It encourages a liberal use of wholesome water by all classes, and thereby induces habits of cleanliness and comfort, diminishes sickness, and in times of epidemics it has proved by the experience of other cities to be the greatest protection to densely populated districts.

3. By the constant command, at all hours of the day and night, of an unlimited quantity for protection against the ravages of fire, it reduces the risks for insurance companies, and with that the rates of insurance, and in this way perhaps more than in any other is a well-regulated public water supply productive of pecuniary advantages, which annually amount to a very liberal percentage on the capital invested.

4. It invites settlement, and encourages the investment of capital in manufacturing enterprises, which by fostering productive industry tends to build up the city in the elements constituting permanent wealth and independence.

As the congregation of large numbers of human beings upon comparatively small areas has been shown to defile the spring and well-water, as also the rain-water, by causing it to absorb in its fall the noxious gases which constantly arise from populous cities, as well as from the washings of the roofs, consisting of an almost endless catalogue of articles prejudicial to health, thereby compelling a supply being obtained from a source beyond the reach of city defilement, it must not be concluded that with the procurement of pure water the evil is remedied; not by any means; it is only one of the effects which is obviated, for the evil itself continues to grow with the increase of population, until the earth or subsoil of the city is so thoroughly permeated with human excreta as to render a removal an absolute necessity; to accomplish which end capital and industry, under the direction of the civil engineer, have constructed systems of sewers, through which, with the water from public water supplies and rains as vehicles, the refuse, etc., from dense populations is carried to running streams and rivers, to be diluted to an extent which makes it harmless. Hence a system of thorough drainage, through the medium of sewers, is next in importance to a public water supply for a city as a means of preserving the health of its inhabitants. This is a subject upon the investigation, development and perfection of which the ablest statesmen, scientists and engineers of Great Britain and the continent of Europe have been engaged for years; and in the United States, also, much attention has been given to the subject, although the literature or written experience in relation to it is quite meager. In a late publication* upon this subject the author truthfully remarks: "The general standard of public morals always corresponds with the state of public health, the latter depending again upon abundance of food combined with a pure atmosphere and an unlimited supply of undefiled water."

And further: "In nothing is the superior wisdom of the present Emperor of the French so manifest as in the undivided attention he, like the founder of his dynasty, pays to the sanitary, agricultural, industrial and commercial interests of his people, which thus manifestly proves that true statesmanship finds its best allies in agriculture and public health."

This much, as prefatory, has been deemed pertinent to the subject under investigation; and the results of an extended

* Krepp's London Sewerage.

survey and examination for a public water supply and a system of sewerage for the city of Memphis are herewith respectfully submitted.

Upon the first visit to your city and its surrounding country, it was evident that a water-works and system of drainage, comparing favorably with similar enterprises in neighboring cities, was neither a simple problem in engineering nor pecuniarily an insignificant undertaking for the city of Memphis, with its present population and wealth. Convinced in the outset of these facts, the duty of a thorough and extended investigation of the subject could not be confounded with hasty and ill-digested plans, however popular for the time being they might have proved. As to water-works, there are three general plans which present themselves as worthy of investigation and development.

1. A supply from Wolf River, taken at the most available point above the town of Raleigh.

2. A supply from the Mississippi River, drawn at the first suitable point above the city.

3. A supply from the Mississippi River, taken in the vicinity of Hatchie Lake.

These different plans will be described in the order in which they have been named, with accompanying estimates of cost. First, however, it is deemed necessary to briefly state what have been regarded as the governing points in projecting a public water supply for a city. These were, first, the quality of the water, depending, of course, upon the natural facilities enjoyed by the city to be supplied; second, the quantity required in a given time, depending upon present population and the prospective growth of the city, modified by climate and the business pursuits of its inhabitants; and lastly, the projection of the works on a general plan which will admit of being commenced and carried out in such a manner as to steadily grow with the growth of the city, causing at no time an investment of capital greatly disproportionate to the wealth of the city; nor containing any branch the functions of which are limited by any cause, except the durability of the materials of which it is composed. The compliance with this latter condition (next in importance to the quality of the water) the interests of Memphis rigidly demand; for no new project, of as much importance as a public water supply to a city, is worthy of consideration, unless it is so designed as to admit of a systematic development with the growth of the city, and this is particularly the case in the present undertaking, where everything remains to be done; and consequently there can be no excuse for commencing any scheme which the present state of hydraulic engineering does not pronounce nearest perfection.

In commencing the surveys, the center line of Front Street was taken as a base line, from which the surveys were extended as represented upon the maps, the measurements being made with 100 foot chains, with that degree of accuracy practicable by this manner of determining distances; and in balancing the surveys, by calculation of latitudes and departures, they were proven to have been carefully made. The angles were measured with the transit, checked by the needle.

For the levels, the plane of reference or datum line adopted is the same as the one established by the City Engineer Department of Memphis, and is an assumed plane, one hundred feet below high water in the Mississippi at this point. Referring to this plane, the top of the stone water table at south-east corner of the rope-walk in Navy Yard, reads 111.85* feet; the top of the stone water table at south-west corner of Exchange Building, reads 148.65 feet; and the center of Court Square, in center of inclosure around Jackson's monument, reads 151.8 feet. To this plane all the figures representing elevations or difference of level upon the maps and plans refer. The levels made use of in drawing the maps and making the calculations were proven by repeated tests to have been accurately taken; and the elevations given upon the maps and plans all read *plus plane of reference*, the expression adopted for which is, plus P. R., and so used throughout this report. Court Square being a locality well fixed in the minds of all citizens, it has been assumed as a point of reference in describing the different localities referred to in the following report.

* Reads in Mississippi Delta Survey, 46.26 feet.

Upon the commencement of these examinations, the opinion that the Mississippi River was the only source from which the city could obtain water of suitable quality was generally prevailing. Wolf River was looked upon by most of the citizens as being entirely out of the question, both as regards the quality and quantity of water available from that stream.

To determine the question intelligently, specimens of water from these streams were taken in the months of June, July, August, September, and October, securing as great a variation in these specimens as the changes in the rivers made practicable during this interval of time; also two specimens from Hatchie Lake, and one from a well in the longest settled portion of the city. These specimens were numbered from one up to ten, and, with these numbers as the only distinguishing marks, sent to Prof. J. M. Locke, of Dayton, O., who analyzed them, and whose able and lengthy report upon the analyses is herewith presented.

REPORT OF THE ANALYSES OF CERTAIN SPECIMENS OF WATER.

LABORATORY OF THE WESTERN MILITARY INSTITUTE, NEAR DAYTON, OHIO,
February 25, 1868.

To CHARLES HERMANY, ESQ.,

Chief Engineer of the City Water-works, Memphis, Tenn.:

SIR—Having had placed in our hands several specimens of water marked Nos. 1 to 10, inclusive, with the request that we analyze the same and report to you the results; permit us to submit the following report:

Scientifically the analyses are important as showing the relation between the waters of springs and rivers, and the geological strata through which they pass. It is evident that water taken from a river or other running stream will vary in its composition according to the different stages of the stream from high to low water; but, as sometimes happens, one tributary will be locally in flood while the other streams are low, when it is evident that the composition of the water in the main stream will approximate that of the tributary furnishing the greater amount; but at the lowest stages of summer drought it may be assumed that the conditions are nearly uniform and constant, and that the results in different years will be nearly identical. Hence, when the work of analysis has been once performed under these conditions, it can forever afterward be referred to as a standard of comparison.

WATER AS A SOLVENT.

We rarely think of water as an active chemical agent, while in fact its powers as a solvent are very extensive over all forms of matter, whether solid, liquid or gaseous.

In some cases pure water dissolves a substance directly, as in the case of gypsum, while in other cases, in order to become a solvent, water must first combine with some other substance, as in the solution of limestone by first combining with carbonic acid. Pure water scarcely acts upon limestone, but that which has first absorbed fixed air (carbonic acid) will then dissolve one per cent. of limestone, and become what is called "limestone water." As heat will expel this *absorbed* carbonic acid, the limestone water when boiled loses one portion of its acid, and with it the power of any longer holding the lime in solution; it thus becomes milky, and the lime is deposited as a crust upon the inside of the vessel in which it is heated, as the tea-kettle or steam-boiler. As lime is a very common ingredient of waters in a limestone country, it becomes an inquiry how the water acquires the carbonic acid by virtue of which it dissolves the lime of limestone? It derives it in part from the atmosphere, but mostly from the soil, especially from the black mould formed by the rotting of leaves, wood, etc. Water passing through the decaying substance in the soil acquires carbonic acid, and then dissolves the first lime it meets with, holding it in solution as bicarbonate of lime, or lime with a double portion of carbonic acid. Cold springs are often abundant in this dissolved limestone, but as soon as the water is discharged to the open air and becomes warm, as in the sun, bubbles of gas escape, and the water becomes milky by deposited lime. The streams in which this action goes on deposit a crust on the pebbles over which they run, and often cement the pebbles together.

From the above it will be perceived that when the property called *hardness* of water is owing to the presence of bicarbonate of lime, it can be remedied by boiling the water, which dispels one-half of the carbonic acid, and the lime will then settle as a proto-carbonate of lime. When this hardness is owing to the presence of sulphate of lime (gypsum), an addition of the carbonate of soda will precipitate the lime as a proto-carbonate of lime. The sulphuric acid, which was united with the lime, combines with the soda, whose carbonic acid has united with the lime.

This property of water, to dissolve and become impregnated with various substances, giving to the natural waters of different localities different and characteristic properties, is the foundation of the following

CLASSIFICATION OF NATURAL WATERS.

First—Aqua Atmospherica, or atmospheric water, including rain, hail, snow, dew and frost. These are the nearest pure forms in which natural waters can be obtained, still they often contain foreign matter, derived from the atmosphere and whatever may be floating in it.

Second—Aqua Fluviatalis, river-water. The impurities of this vary much, according to circumstances, especially by the nature of the soils and rocks whence it is derived.

Third—Aqua Fontana, spring and well waters. These are the chief sources of rivers; but as the waters are supplied to them immediately from the rocks, the clays, the sands, and the soils where they are located, they are less pure than river-waters; for, in their course, the waters of rivers deposit much of the foreign matter which they receive at their fountains.

Fourth—Aqua Medicinales, medicinal or mineral waters. This name is given to such waters as are charged with such ingredients, and to such an extent as to produce peculiar effects on the human system. Sometimes they have a temperature unusually elevated, when they are termed thermal waters.

Mineral springs have ever attracted great attention, and their analyses have been studiously preserved; but authors are faulty in not recording more of the analyses of river-waters in common domestic use.

Fifth—Aqua Oceanica, sea-water. As all the saline matter contained in springs and rivers is carried more or less to the ocean, whence the water is evaporated or distilled into the atmosphere, to be precipitated at the heads of rivers in a pure state, leaving always the saline matter behind, the ocean may be supposed to be continually becoming more and more saline and concentrated. In some small seas or lakes having no outlet, and around which the earth is charged with saline matter, the water becomes highly impregnated, even to saturation, as in the case of some lakes in Persia, the Dead Sea, and the Great Salt Lake of America.

From this view it appears that the dry land of earth is undergoing a perpetual washing and freshening by atmospheric waters; and the materials carried into the ocean mechanically and chemically are, according to the doctrines of geology, settled and crystallized into strata, ultimately to be raised up by some force of nature unknown to us, and to form, in their turn, dry and habitable land.

This land would, of course, emerge saturated with all the oceanic salts, which must be dissolved slowly away by the streams and rivers which must be formed. By this upheaval of strata from the depths of the ocean it is that the continued contribution of the land to the sea is restored, and that action which seemed to tend constantly to an ultimate extreme becomes a revolution returning into itself, and preserving an equilibrium which would otherwise unbalance the present condition of things. We have not yet discovered the laws of this revolution as we have astronomical periods, but no doubt those laws exist.

SOME SPECIAL CIRCUMSTANCES WHICH MODIFY WATERS.

Well and spring-waters from large cities generally contain nitrates, which arise from the rapid oxidation of the nitrogenized organic matter. These nitrates in the water prevent the formation of any vegetable matter, the presence of which cannot be detected by the microscope, even after it has been long kept.

According to Heinrich Rose, of Berlin, "the silicic acid (flint) which exists in water is probably, in most cases, one of the constituents of the organic substances, and it is partially owing to animalculæ with silicious (flinty) coats (*Bacillaræ and Naviculæ*)."

But some of the silica (flint) is most undoubtedly derived from the burning of vegetable matter on farms: the potassa and silica of the ash, fusing in combustion, become soluble, and are carried by rain-water precolating the soil into the springs, and thence into the rivers.

In obtaining the results embodied in the following tables, the course pursued was to take a measured quantity of water (one quart) of each specimen, the solid matter held, mechanically suspended, was separated by filtration, dried and weighed, giving the amount of *sediment* to one quart.

The clear filtered water was then carefully evaporated to dryness, leaving the mineral ingredients, which were collected and weighed, and reserved for future examination. In most of the cases separate portions of water were taken from which to determine the amount of some one ingredient, as one portion for the determination of the lime, another for the magnesia, a third for the sulphuric acid, etc. This course avoided any accumulative error which might arise from any slight impurities in one or more of the tests employed.

This, in general, would have been the process most desirable to have employed in all cases, but a limited supply of several of the specimens required a different and more usual process to be pursued, that of determining several constituents from the same portion of water; but the system of checks and counter-checks employed we deem sufficient to prevent any erroneous results, the employment of these checks being as essential to the conscientious analyst as to those who make the results of his labors the foundation of their own.

As most substances combine in *known proportions* ONLY, it is unnecessary to separate them in analysis in order to know the quantity of each of the constituents, these last being ascertained by calculation. Thus, when we obtain a given weight of proto-carbonate of lime, we know that the carbonic acid and the lime exist in the proportion of 22 to 28, and whatever may be the weight obtained, we separate it into two quantities by calculation, which shall have the above proportion, calling one carbonic acid and the other lime. With regard to lime it is a little more than one-half of the compound from which we estimate it, or in the ratio of 0.562 to 1.

Silica, or flint, we procure in a pure state. Alumina, or clay, we also procure free from all combination. The magnesia in these examinations was determined in a compound of which is formed about only a quarter; *i. e.*, the magnesia was in proportion of 0.253 to 1.

The chlorine from a compound of which is constituted less than one-fourth.

The sulphuric acid was estimated from a precipitate of sulphate of baryta, which is slightly over one-third sulphuric acid.

From this view of the subject it is evident that we can determine accurately a result imperceptible by the most delicate balance; as in the case of magnesia, if the precipitate be the *one-thousandth* of a grain, which is weighable, then the pure magnesia which it contains will be in the proportion of 1 to 0.253, or in the one-thousandth of a grain of precipitate there would be but twenty-five hundred-thousandths of a grain of magnesia, an amount not weighable.

The balances employed by us were made by Robinson, of London, and the celebrated Oertling, of Berlin, both delicately suspended on jeweled suspensions and turning decidedly with the one-thousandth of a grain. To give some idea of the weight of this denomination, let a person take a *fine* human hair, cut off a piece an inch in length, and divide it into four pieces, each piece will weigh slightly less than the one-thousandth of a grain.

ON THE USE OF LEAD FOR PIPES, CISTERNS, ETC.

As the use of lead for pipes, cisterns, etc., in connection with water, is a subject of general interest, we beg leave to introduce some remarks and practical suggestions upon the use of this metal.

We find the use of lead for conducting water condemned by the Roman architect Vitruvius, who flourished in the age of Augustus, to whom his works on architecture were dedicated. Vitruvius says "ceruse is formed, which is hurtful to the human body."

Galen also censures the use of lead pipes. There is but little more than repetition of the above statements till the close of the last and the commencement of the present century, since which time science has unraveled the laws that regulate the actions of lead and water.

Spring and river-waters which contain minute portions of neutral salts, form insoluble compounds with the lead, which would coat a cistern; pure water dissolves the oxide of the metal which remains in solution until it is precipitated by the carbonic acid of the air as a carbonate of lead, but lead is not dissolved by pure water when the atmosphere is excluded, as it furnishes the oxygen to form the lead into an oxide previous to the solution.

The acetate of soda but imperfectly prevents the formation of the solution of the oxide of lead. When a hundredth part of the acetate of soda is dissolved in water, lead placed therein loses about one-fourth of what it would in distilled water in the same length of time. On the contrary, assenite of soda is a complete preservative when dissolved in the proportion of a twelve-thousandth part. Phosphate of soda and hydriodate of potassa are almost as effectual preservatives in the proportion of a thirty-thousandth part only of the water. It requires a two-thousandth of chloride of sodium (common salt) and a four-thousandth of sulphate of lime. Nitrate of potassa (nitre) is but little superior to the acetate of soda. When water contains a hundredth part of this nitrate, it almost entirely prevents any action; but if the quantity be reduced to a hundred-and-sixtieth, the loss sustained by the lead is fully a third of that dissolved in distilled water.

Christison makes the statement that water, which contains a ten-thousandth or a twelve-thousandth of salts, may be safely conveyed in lead pipes, if the salts in the water be chiefly carbonate and sulphate; that lead pipes cannot be safely used when it contains a four-thousandth of saline matter, if this consists chiefly of muriates (chlorides).

Water in leaden vessels is sometimes contaminated by the effects of the galvanic current, which generally requires the presence of two metals, viz., lead and the solder which is used to unite it. This is probably a source of galvanic action in cisterns; also, the iron, copper, and brass rods and wires which are used therein.

This electrical action may take place, even without the presence of another metal, by parts of the same pieces of lead, for example, being of a different quality, caused by more or less impurities, and thus acting as different metals. This will explain why sheet lead corrodes sometimes in spots when exposed to the air or water. Lead-lined cisterns, to contain water for culinary purposes, should always be filled nearly up to the top, and should not have lead covers; for the water is slowly evaporated and then condensed on the metal, thus covering it with distilled water, which dissolves the oxide, and, accumulating, drops into the cistern, carrying the dissolved lead with it. The equilibrium of the water can be easily maintained, where the cistern is supplied by a pipe, by using the common automatic ball and stop-cock. A remarkable instance of the above mode of poisoning is mentioned by the Compte de Milly, in a paper read by him before the Academy of Sciences at Paris. About a year after having two leaden cisterns placed in his house to hold the water of the Seine for domestic purposes, he was attacked with severe and obstinate colic. This led him to examine his cisterns. He found that the sides, when they were occasionally left exposed by the subsidence of the water, and more especially the tops, were covered with a white liquid, which was constantly dropping into the water of the cistern, which gave decided evidences of lead. But the Seine contains such an amount of salts that it will not dissolve lead placed within it.

Rain and snow-waters should never be retained in leaden cisterns, as such waters are of sufficient purity to dissolve the coating; nor should water collected from buildings covered with lead be used for general domestic purposes. This was forcibly illustrated at Amsterdam, at the time such roofs were substituted for tiled ones in that city. The lead colic became general and committed great ravages. This was undoubtedly caused by the water which was collected from the roofs for culinary purposes; the same is mentioned as having occurred at Harlem.

REMARKS ON THE SPECIMENS ANALYZED.

As the various specimens previous to analysis were known to and distinguished by us only by the numbers attached to each package, we have so designated them in the various tables.

No. 1.—This specimen of water contained a large amount of yellowish brown colored sediment, the greater portion of which readily separated from the liquid by settling, but leaving the water of a yellowish tinge even after standing a long time. After filtration the water remained opalescent and of a yellowish green cast. The entire amount of sediment contained in one gallon, 20.31117 grains.

No. 2.—This water contains a yellowish sediment amounting in a gallon to 3.55892 grains. After filtration it remains slightly opalescent.

No. 3.—This specimen contained a gray sediment, a portion of which was very light and flocculent, but readily separated by filtration; the water remained of a yellowish tinge, but perfectly clear.

The sediment from this water was largely composed of alumina (clay), and the weight from one gallon=101.613 grains troy weight.

No. 4.—This specimen was clear, with a dark brown sediment which was very flocculent, filtered freely, the filtrate being clear, but of a decided yellowish tinge. The sediment was small in quantity, there being in a gallon but 1.2602 grains.

No. 5.—Upon opening the package containing this specimen there was a decided odor of vegetable matter, which passed off in a short time. The water itself, however, was entirely free from all woody taste. When filtered, it was very clear and of a bluish tinge; the weight of sediment from one gallon=0.73633 grains.

No. 6.—This specimen, on evaporation, yielded a residuum of a light brown color, readily darkening by a slight elevation of temperature. The amount of sediment contained in one gallon=2.83214 grains.

No. 7.—On opening the bottle containing this specimen there was a strong odor of sulphureted hydrogen, but after a short time all appearance of the presence of this substance disappeared.

The water was very clear, containing but a small amount of sediment, there being but 0.1234 of grains to the gallon. After removing the sediment the water has a decided yellowish tinge.

No. 8.—This specimen contained but enough sediment to render it slightly turbid, and is really made perfectly clear by filtering as it passes through the filter freely. The amount of sediment to the gallon being equal to 0.38893 grains. This specimen, it will be seen by reference to the tables, contains a smaller quantity of mineral or foreign matter than any other specimen examined, the amount not being greater, and the substances such as will be found constituting the impurities of the contents of many rain-water cisterns.

No. 9.—On opening the bottle containing this specimen there was a decided smell of woody or vegetable matter. It contains sufficient sediment to render it turbid.

The sediment in one gallon=0.9877 grains was very minutely divided, and easily suspended, giving a whitish gray appearance to the water.

No. 10.—This specimen was very clear, having a peculiar brilliancy that to the eye of the inexperienced would have indicated it as the purest, brightest water of the entire series examined, while in fact it contained the greatest number of mineral substances of all the specimens.

OF THE TABLES.

For the convenience of reference and comparison we have presented the result of our analysis in the form of the accompanying tables.

The table marked No. 1 contains the results of the analysis of one quart of water of each specimen expressed in the decimal weights of the French. These are the actual weights obtained. This table is the basis from which have been deduced by calculation or combination Tables Nos. 2 and 3.

Table No. 2, deduced by calculation from No. 1, presents the quantity in troy grains of each substance in one gallon of water.

Table No. 3.—After having determined by analysis the number and quantity, or "what and how much," of the various ingredients are contained in a given specimen, the analyst has gone as far as he can with *absolute positive* certainty; but as these substances in many cases combine with one another, it becomes a question, in what manner are they combined in the natural water? In doing this, although the analyst cannot assert that he is positively correct, yet guided by the chemical affinities of the various substances his combinations will most probably be correct. In Table No. 3 we have presented the substances combined according to the best authorities, and our knowledge obtained during their examination.

JOSEPH M. LOCKE,
JOHN LOCKE, M.D.

TABLE No. 1.

Contains the weight of substances in Grammes (1 Gramme=15.43402 Troy Grains) Found in one American Quart (1593.05 Grains) of each Specimen.

	1	2	3	4	5	6	7	8	9	10	REMARKS.
Solid Matter..........	0.04500	0.07100	0.22950	0.20003	0.04370	0.17650	0.23035	0.03875	0.15640	1.24260	
Lime....................	0.00444	0.00834	0.05639	0.04968	0.00810	0.05111	0.09215	0.00472	0.02953	0.02932	No. 1, Wolf River
Calcium..............	....	....	....	....	....	....	....	....	....	0.04230	No. 2, Wolf River
Magnesia..............	....	....	0.00650	0.00778	....	....	....	....	0.00342	0.14254	No. 3, Miss. River
Soda	....	....	....	....	....	0.01822	....	....	0.03540	....	No. 4, Hatchie Lake
Sodium	....	....	0.01645	0.01663	....	....	....	....	....	0.17559	No. 5, Wolf River
Alumina	0.01075	0.02078	0.00584	0.00636	0.00457	0.00852	0.00547	0.00613	0.00805	0.04800	No. 6, Miss. River
Iron.....................	Trace.	Trace.	Trace.	Trace.	Trace.	....	....	....	....	....	No. 7, Hatchie Lake
Silicic Acid (Flint)..	0.02550	0.03446	0.03033	0.01732	0.01931	0.00750	0.01794	0.01267	0.00468	0.03552	No. 8, Wolf River
Sulphuric Acid.......	....	....	Trace.	....	....	....	....	....	....	0.05497	No. 9, Miss. River
Carbonic Acid........	0.00348	0.00655	0.05145	0.04758	0.00637	0.05312	0.07240	0.00371	0.05205	0.14805	No. 10, Well in City
Chlorine	....	....	0.02468	0.02504	....	....	....	....	....	0.34609	
Organic Matter	....	....	0.02919	0.02257	0.00535	0.03748	0.04222	0.01112	0.02264	0.21195	
Loss......................	0.00083	0.00087	0.00867	0.00707	....	0.00055	0.00017	0.00040	0.00063	0.00857	
Total..................	0.04500	0.07100	0.22950	0.20003	0.04370	0.17650	0.23035	0.03875	0.15640	1.24260	

ANALYZED BY JOHN LOCKE, M.D.

TABLE No. 2.

Showing the Quantity in Grains of the substances contained in an American Gallon (58,372 Grains) of each of the Specimens.

	1	2	3	4	5	6	7	8	9	10	REMARKS.
Solid Matter..........	2.778124	4.383262	14.168435	12.349070	2.697867	10.896420	14.220909	2.392273	9.655525	7.671327	
Lime	0.275108	0.514879	3.481299	3.067049	0.500062	3.155332	5.688981	0.291394	1.822894	0.181010	No. 1, Wolf River
Calcium.	....	....	....	....	....	....	....	....	....	0.261144	No. 2, Wolf River
Magnesia...............	....	....	0.401285	0.480307	....	....	....	....	0.211165	0.880000	No. 3, Miss. River
Soda....................	....	....	....	....	....	1.124831	....	....	2.185254	....	No. 4, Hatchie Lake
Sodium..	....	....	1.015559	1.026671	....	....	....	....	....	1.084024	No. 5, Wolf River
Alumina	0.663663	1.282876	0.360539	0.392642	0.282134	0.525991	0.337697	0.378442	0.497067	0.296333	No. 6, Miss. River
Iron....................	Trace.	Trace.	Trace.	Trace.	Trace.	....	....	....	....	....	No. 7, Hatchie Lake
Silicic Acid (Flint)..	1.574271	2.127426	1.872456	1.069269	1.192124	0.463021	1.107545	0.782196	0.288920	0.217435	No. 8, Wolf River
Sulphuric Acid.......	....	....	Trace.	....	....	....	....	....	....	0.339363	No. 9, Miss. River
Carbonic Acid.......	0.214841	0.404371	3.176322	2.937403	0.393259	3.279421	4.469693	0.229041	3.213080	0.913989	No. 10, Well in City
Chlorine	....	....	1.523647	1.545872	....	....	....	....	....	2.136624	
Organic Matter.......	....	....	1.802076	1.393383	0.330288	2.313869	2.606497	0.686505	1.398001	1.308496	
Loss.....................	0.051241	0.053710	0.535252	0.436474	....	0.033955	0.010496	0.024695	0.039144	0.052909	
Total..	2.778124	4.383262	14.168435	12.349070	2.697867	10.893420	14.220909	2.392273	9.655525	7.671327	

ANALYZED BY JOHN LOCKE, M.D.

TABLE No. 3.

Showing the Quantity in Grains of the compound ingredients contained in an American Gallon (58,372 Grains) of each of the Specimens.

	1	2	3	4	5	6	7	8	9	10	REMARKS.
Chloride of Sodium.	...	...	2.539206	2.572543	...	...	...	...	...	2.757188	
Chloride Calcium....	...	...	...	...	...	...	...	...	...	0.724604	No. 1, Wolf River
Sulphate of Lime....	...	...	Trace.	...	...	...	...	...	...	0.439596	No. 2, Wolf River
Sulphate Magnesia..	...	...	...	...	...	...	...	...	...	0.121569	No. 3, Miss. River
Carbonate of Soda...	...	...	...	...	...	1.925063	...	...	3.736055	...	No. 4, Hatchie Lake
Carbonate of Lime..	0.488949	0.919250	6.216605	5.476869	0.893321	5.634521	10.158674	0.520435	3.255215	...	No. 5, Wolf River
Carbonate Magnesia	...	...	0.842301	1.007890	...	...	...	...	0.441123	1.753197	No. 6, Miss. River
Carbonate of Iron...	Trace.	Trace.	Trace.	Trace.	Trace.	...	...	...	...	...	No. 7, Hatchie Lake
Alumina (Clay).......	0.663663	1.282876	0.360539	0.392642	0.282134	0.525991	0.337697	0.378442	0.497067	0.296333	No. 8, Wolf River
Silicic Acid (Flint)..	1.574271	2.127426	1.872456	1.069269	1.192124	0.463021	1.107545	0.782196	0.288920	0.217435	No. 9, Miss. River
Organic Matter.......	...	...	1.802076	1.393383	0.330288	2.313869	2.606497	0.686505	1.398001	1.308496	No. 10, Well in City
Loss and Soda Salts.	0.051241	0.053710	0.535252	0.436474	...	0.033955	0.010496	0.024695	0.031944	0.052909	
Total Solid Matter...	2.778124	4.383262	14.168435	12.349070	2.697867	10.896420	14.220909	2.392273	9.655525	7.671327	

ANALYZED BY JOHN LOCKE, M.D.

The analyses have demonstrated the fact that the universally prevailing opinion with reference to the superiority of the Mississippi water over that of Wolf River is fallacious; and that instead of the water from Wolf River being inferior in quality to that of the Mississippi, it is proved not only far superior to it, but equal in purity to any public water supply in the United States.

The following table, taken from Mr. E. S. Chesbrough's report to the water commissioners of Chicago in 1861 (to which the analyses of the Mississippi and Wolf River waters with several others are added), will show the relative purity of waters supplied to or proposed for different cities. The table gives the quantity of solid matter in a wine gallon (equal to the United States standard gallon) held chemically in solution by the respective waters, and shows that Wolf River water stands *third* in degree of purity, Lake Cochituate and the Long Island streams alone being superior; whilst the Mississippi water stands No. 16 in the order of purity, limiting the comparisons to the public water supplies in the United States.

Table No. 1.

City Supplied	Source	Grains of solid matter in one U. S. gallon	Order of Purity	Analyzed: By Whom	Analyzed: When	Analyzed: By Whom Repeated and Remarks
Boston	Lake Cochituate on surf.	1.85	1	Silliman	......	Jervis & Johnson.
Boston	Lake Cochituate 62 ft. bel.	3.37	5	Silliman	......	Jervis & Johnson.
New York	Croton Lake	4.16	6	Chilton	1852	W. J. McAlpine.
Brooklyn	Long Island Streams	1.97	2	Chilton	1852	W. J. McAlpine.
Albany	Patroon's Creek	4.72	8	......	......	H. P. M. Birkinbine.
Jersey City	Passaic River	7.44	14	......	......	H. P. M. Birkinbine.
Philadelphia	Schuylkill River	4.42	7	Boye	1860	H. P. M. Birkinbine.
Baltimore	Jones' Falls	5.85	11	......	1860	H. P. M. Birkinbine.
Washington	Potomac River	5.59	9	......	1859	Jacob Houghton.
Rochester	Genesee River	11.21	...	......	1860	H. P. M. Birkinbine.
Rochester	Lake Ontario	4.16	...	......	1859	Jacob Houghton.
Hamilton, C. W.	Burlington Bay	7.03	...	......	......	
Detroit	Detroit River	5.72	10	......	......	
Cincinnati	Ohio River	6.74	13	J. M. Locke	1852	
Quebec, average	St. Charles River	6.75	...	Silliman	1848	Geo. R. Baldwin.
London	Thames River	17.97	...	Taylor	......	
Paris	Seine River	10.60	...	......	......	
Edinburg	......	10.74	...	......	......	
(Switzerland)	Lake Geneva	10.64	...	......	......	
Dresden	Elbe	21.00	...	......	......	
	WELLS					
New York	Manhattan	104.00	...	......	......	
New York	Average of several others	49.00	...	......	......	
Albany	Lydius Street	19.24	...	......	......	
Albany	Capitol Park	65.20	...	......	......	
New Haven	Average of five	20.32	...	......	......	
Brooklyn	Average of several	48.83	...	......	......	
Boston	Longacre	56.80	...	......	......	
Boston	Tremont Street	26.60	...	......	......	
Rochester	Average of several	30.00	...	......	......	
Washington	Average of nine	16.00	...	......	......	
Detroit	Park Lots	116.46	...	......	......	
Cleveland, O.	Lake Erie	2.54	...	W. W. Mather	1852	
Cleveland, O.	Lake Erie, near shore	8.33	15	W. W. Mather	1852	Supplies Cleveland.
Cleveland, O.	Cuyahoga River	5.54	...	W. W. Mather	1852	
Cleveland, O.	Well near old Theatre	79.23	...	W. W. Mather	1852	
Cleveland, O.	Well on Euclid Street, (Prof Cassel)	1.56	...	W. W. Mather	1852	
Cleveland, O.	Average of 4 city wells	21.14	...	W. W. Mather	1852	
Charlestown, Ms.	Mystic Pond	3.22	4	Silliman	1862	
Charlestown, Ms.	Mystic Pond	4.08	...	Dr. Hayes	1859	
Boston, Mass.	Cochituate	5.00	...	Dr. Jackson	1845	
Cambridge, Mass.	Fresh Pond	6.32	12	......	......	
Memphis, Tenn.	Mississippi River	14.17	...	J. M. Locke	1868	Average 11.58.
Memphis, Tenn.	Mississippi River	10.90	16	J. M. Locke	1869	
Memphis, Tenn.	Mississippi River	9.66	...	J. M. Locke	1868	
Memphis, Tenn.	Hatchie Lake	12.35	...	J. M. Locke	1868	
Memphis, Tenn.	Hatchie Lake	14.22	...	J. M. Locke	1868	
Memphis, Tenn.	Wolf River	2.78	...	J. M. Locke	1868	Average 3.06.
Memphis, Tenn.	Wolf River	4.38	...	J. M. Locke	1868	
Memphis, Tenn.	Wolf River	2.70	3	J. M. Locke	1868	
Memphis, Tenn.	Wolf River	2.39	...	J. M. Locke	1868	
Memphis, Tenn.	Well	7.67	...	J. M. Locke	1868	

It is thus manifest that in every particular the water from Wolf River is better and more suitable for the uses of a public water supply than that which could be obtained from the Mississippi. There is but one consideration which justifies a moment's hesitation in making a choice from the two waters, and that is the fact that the Mississippi water will arrive at a desirable degree of clearness by subsidence in two days, whilst that from Wolf River will require eight days, caused by the greater quantity of alumina in the latter, and the almost total absence of lime and salts; which impurities in the Mississippi water, by chemical action, aid in producing a more speedy precipitation of its sediment. On this account a subsiding reservoir for clearing a given quantity of water from Wolf River, would have to be four times the capacity of one for clearing the same quantity of Mississippi water; making a difference in this particular in favor of the Mississippi water equal annually to the interest upon the difference in the costs of the respective reservoirs, which comparison will be rendered definite hereafter. To counterbalance this advantage possessed by the Mississippi water over that from Wolf River, we find, by referring to the analyses, that the maximum quantity of sediment per gallon contained in the Wolf River water is only 20 per cent. of the maximum quantity contained per gallon of the Mississippi water, and the average for the specimens taken 17 78-100 per cent. By sediment in the water is meant the impurities held *mechanically in suspension* independent of those held *chemically in solution*. The former can all be separated from the water before distributing it by subsidence or filtration, while the latter can never be disengaged from any water on a scale applicable to a public water supply, and must always go with the distribution and be consumed by the people. The analyses thus show that the average quantity of sedimentary matter contained by the Mississippi water is about six times the average quantity contained by the Wolf River water. The average quantity of sediment contained by the Mississippi water, as determined by these analyses, is 1-1661 of its own weight.

This quantity corresponds very closely with the observations and deductions of the Mississippi Delta Survey, from which the following table is compiled, with the addition of the quantities determined by Prof. J. M. Locke and Col. Henry Fladd.

PROPORTION OF SEDIMENT IN RIVER WATER.

River	Authority	WATER TO SEDIMENT By Weight as	WATER TO SEDIMENT By Bulk as	Measurements Made.
Miss. at Carrollton........	Miss. Delta Survey..	1,808 is to 1	*3,435 is to 1	For twelve months, 1851–1852.
Miss. at Carrollton........	Miss. Delta Survey..	1,449 is to 1	*2,753 is to 1	For twelve months, 1852–1853.
Miss. at Columbus	Miss. Delta Survey..	1,321 is to 1	*2,510 is to 1	For nine months, 1858.
Miss. at the mouth........	Mr. Meade............	1,256 is to 1	*2,386 is to 1	For two months, 1838.
Miss. at the mouth........	Mr. Sidell.......... ...	1,724 is to 1	*3,276 is to 1	For 1838.
Miss. at various places...	Prof. Riddle..........	1,245 is to 1	*2,366 is to 1	For fourteen days, summer 1843.
Miss. at New Orleans.....	Prof. Riddle..........	1,155 is to 1	3,000 is to 1	For thirty-five days, summer 1846.
Miss. at Natchez..........	Mr. Brown...........	....	528 is to 1	At irregular dates, 1846 and 1848.
Miss. at Memphis.........	Lieut. Marr..	596 is to 1	*1,132 is to 1	For three and a half flood mos., '49.
Miss. at Memphis.........	Lieut. Marr..........	....	2,950 is to 1	For twelve months, 1850–1851.
Miss. at Memphis.........	Water-works Survey	1,661 is to 1	*3,156 is to 1	Average of three specimens, taken July 15, Sep. 18, and Oct. 7, 1867.
Wolf River, five miles above Memphis......	Water-works Survey	10,000 is to 1	....	Average of four specimens, taken June 13, July 11, Sep. 18, and Oct. 7, 1867.
Miss. at St. Louis.........	Water-works Survey	368 is to 1	In the condition of dried mud.	
Miss. at St. Louis.........	Water-works Survey	94 is to 1	In the condition of soft mud.	

*Computed by assuming the specific gravity to be 1.9, which is nearly that of the natural deposit of the Mississippi River.

On page 148 of Mississippi Delta Survey Gen. Humphreys observes: "A comparison of these different results leads to the belief that no material error will result from assuming that the sediment of the Mississippi is to the water by weight nearly as 1 is to 1500, and by bulk nearly as 1 is to 2900, provided long periods of time be considered." Therefore, in this comparison between the two waters, it is proper to estimate the annual average quantity of sediment in the water from the Mississippi at this point at 1-1500 of its own weight, and that contained by the water from Wolf River at 1-9000 of its weight; and with these proportions, the deposits in the settling reservoirs, when the daily consumption reaches 6,000,000 gallons, would be 15 34-100 tons of mud from the Mississippi and 2 55-100 tons from Wolf River daily, which would require to be removed from the settling reservoirs periodically; and the difference between the respective quantities named (12 79-100 tons) is against the Mississippi water.

The manner of removing these deposits from the settling reservoirs will have to be determined by experience as well as the expense attending the removal. At St. Louis it eventuated in the filling up of the old reservoirs, and the building of a temporary one from which to supply the city while the old ones were being cleaned.

To determine the question of quantity available from Wolf River, the stream was carefully gauged in the month of October, when it was at its lowest stage for the season, and reported by the oldest residents along its banks to be at its lowest annual fall stage. The gaugings were made October 9, 10, and 12, 1867, at a point 4 54-100 miles above the town of Raleigh, directly opposite Station 447 of conduit line (see water-works map); and the average discharge during the time of these observations was found to be 8,636,775 U. S. gallons per hour, being equal to nearly eight times the minimum discharge of the Croton River supplying the City of New York. The sources of Wolf River are reported to be about sixty-five miles south-eastwardly from Memphis, and composed of a comparatively small number of springs, discharging great volumes of sandstone-water. These statements are corroborated by the fact that for three months last fall, during the driest weather, the stage of the river did not vary six inches; and also, by the analyses, showing comparatively a small quantity of lime and a large quantity of silicic acid held in solution by the water.

In deciding upon the scale or magnitude of the works, it has been assumed that simultaneously with the construction of water-works the city will also be provided with a system of thorough drainage or sewerage works; that the water supply should be liberal in quantity, and the use of it general; and that the growth and progress of the city of Memphis in the near future will be equal to that indicated as having prevailed heretofore. With these considerations as a guide, it is estimated that by the time the works can be put in successful operation a population of 75,000 would be within the limits of an efficient distribution; that two-thirds of this number would avail themselves of the use of the water; and that in this latitude, with the long periods of dry weather, with sewers to conveniently dispose of the water after having subserved the many uses and abuses to which public water supplies are generally subject, it would require sixty gallons *per capita* per twenty-four hours. At this rate of consumption, it would require for a water-consuming population of 50,000 inhabitants 3,000,000 gallons daily; and to project the works upon a scale of twice this quantity, or 6,000,000 gallons daily, is not believed to be making any too liberal provisions for the future. In the following table is given the data pertaining to this point in other cities. It gives the average daily quantity *per capita* in the measure of the total quantity of water in gallons distributed for all uses—viz., domestic, manufacturing, fire protection, dust laying, etc.—divided by the total population, and also that portion of the population who obtain their supply of water from the public water supply exclusively.

TABLE No. 2.

Year	Cities	Each inhabitant per day. Gallons.	Each consumer per day. Gallons.
1867	Charlestown, Mass	41.83	54.33
1867	Brooklyn, N. Y	......	*47.10
1866	Cleveland, Ohio	22.35	24.26
1867	Detroit, Mich.	48.46	54.47
	Chicago, Ill	50.00	......
	Cincinnati, Ohio	......	......
1864	St. Louis, Mo	......	* 54.1
1866	Louisville, Ky	16.81	73.96
1864	New York	62.00	

* Approximate.

With the above named considerations, and the data from the statistics of other works above tabulated as guides, the supply for Memphis is designed of a capacity in the commencement of 6,000,000 gallons in twenty-four hours.

Before describing any of the plans investigated, it will not be out of place to advert to the fact that a water supply for Memphis by means of artesian wells has been suggested heretofore, and found more or less favor with prominent men in the community. An artesian well, sending forth a constant stream of pure water, is a beautiful and interesting sight; and in the popular mind it is invested with a great degree of novelty. What is an artesian well? Historically, it is so called from a mode practiced in Artois, a province in France, by boring for water. Technically, an artesian well is a mode for obtaining a spontaneous flow of water at or above the surface of the earth through the medium of a tube perforation of the earth's crust, extending in depth until a body of water is reached, from which, by hydrostatic pressure, a portion is delivered through the tube at or above the surface of the earth. The most plausible theory explanatory of the flow ot water from artesian wells is their similarity to natural springs, there being in both contracted apertures from the surface of the earth to subterranean reservoirs full of water, and compressed by columns of this liquid. Through these apertures (natural fissures in the earth in the case of springs, and artificial borings in the case of artesian wells) the water escapes, seeking its level.

The history of artesian wells, so far as they have been resorted to as a means of supplying towns and cities with water, is not at all encouraging, whatever may be their merits as means of obtaining limited quantities of water for private or special uses. The City of New York having for a period of sixty-three years endeavored to solve the problem of procuring a public water supply, dating from July, 1774, with the proposition of Christopher Colles, to the incorporation of a fourth company in 1827, "called New York Well Company,"* finally endeavored to obtain a supply by means of artesian wells. "The company made several attempts to procure water, but being satisfied by their experiments of the impracticability of the undertaking, the enterprise was abandoned."

"The hope next embraced was that of artesian wells. Mr. Levi Disbrow had about this time succeeded, by boring to a great depth through earth and rock, in procuring a copious† supply of good water at the Manhattan Reservoir, corner of Bleecher and Mercer streets. The diameter of this perforation is eight inches; its depth 442 feet. A tube extends from the top to near the bottom in order to exclude the springs that may be met with in the descent, and of which the quality might impair that of the main supply. Mr. Disbrow made several other borings, varying from 72 to 250 feet in depth.

"Encouraged by his success, Mr. Disbrow proposed to supply the city by an artesian well and reservoir in each ward. But inasmuch as the product of these wells is limited, even supposing (what is by no means certain) that the multiplication of them in different levels would not diminish the supply and drain the sources of the more shallow to the deeper perforations, it seemed obvious that the cost of such an enterprise, taken in connection with the uncertainty of the result as to the adequate supply, forbade the undertaking. Nevertheless, the corporation caused various perforations to

*See King's Memoir on the Croton Aqueduct. †20,000 gallons in 24 hours.

be made in the public markets, and in Jacob Street in the swamp. In this last, at the depth of 128 feet, a mineral spring was obtained, unfit for domestic purposes, but which for a time was supposed or represented to possess valuable medicinal qualities."

During the interval above referred to in the history of the New York water supply, nearly every available means was resorted to, and all known mechanical expedients applied, all resulting, as did the artesian wells, in failing to meet the wants of the city; and it was not until a source of unquestionable purity, guaranteeing an unlimited quantity, was chosen and made available by one of the most reliable engineering works, that the wants of the city were supplied. The City of Liverpool was supplied up to the completion of the Rivington Pike scheme, a gravitation water supply put in successful operation in 1856 by means of seven wells, furnishing in 1849 an aggregate quantity of 3,903,075 gallons per day, at an average cost of $11.13,* in the pumping department alone, per million gallons elevated 100 feet; and in 1854, from the same wells, the cost was $9.29 per million gallons raised 100 feet high; in these costs, attendance or labor, coal, oil, tallow, etc., only are included, no allowance being made for wear and tear, depreciation of machinery, or interest on capital invested. Reduced to similar measures, (*i. e.*, the annual average cost at the pumping station in attendance, labor, fuel, oil, tallow, etc., per million United States gallons of water raised 100 feet high), the cost of pumping water at some of the principal pumping works in the United States is given in the following

*See Hughes's Treatise on Water-works, pages 146 and 147.

TABLE No. 3.

City	Year	Power	Different level betwe'n source and delivery	WHAT PORTION OF PUMPING CAPACITY DAILY REQUIRED.		Cost per million gallons elevated 100 feet	Order of economy
				Maximum	Average		
Cambridge, Massachusetts............	1866	Steam.	72½	....	....	$18 02	10
Charlestown, Massachusetts....	1865	Steam.	135	0.228	0.177	14 97	6
Hartford, Connecticut..................	1866	Steam.	120	....	....	16 34	8
Brooklyn, New York....................	1866	Steam.	161	0.440	0.380	12 84	4
Jersey City, New Jersey...............	1866	....	159	0.285	0.269	9 63	1
Fairmount, Philadelphia, Penn......	1866	Water	......	1.000	0.605	2 00	0
Schuylkill, Philadelphia, Penn.......	1866	Steam.	115	0.414	0.290	13 00	5
Delaware, Philadelphia, Penn.........	1866	Steam.	112	1.000	0.806	22 00	13
24th Ward, Philadelphia, Penn......	1866	Steam.	......	1.000	0.615	9 91	2
Germantown, Philadelphia, Penn...	1866	Steam.	......	0.272	0.215	23 10	14
Cleveland, Ohio..........................	1865	Steam.	158	0.200	0.154	17 55	9
Cincinnati, Ohio..........................	1866	Steam.	165	0.712	0.546	18 09	11
Louisville, Kentucky....................	1866	Steam.	144	0.200	0.123	16 14	7
Chicago, Illinois..........................	1865	....	125	0.540	0.354	12 20	3
Detroit, Michigan........	1867	....	75	0.410	0.360	18 20	12

The results in this table are not given as being exact comparisons between the cost of pumping water in the United States and the cost at the Liverpool wells, but simply as illustrative of the comparative cost between pumping water from wells and rivers or lakes. To make the comparison exact, there would .be required detailed knowledge of the cost of labor, fuel, etc., at each station, whereas the results in the table, as well as those for the wells, were calculated from annual aggregates.

The city of Liverpool was supplied with good water from these seven wells for many years. They were located within a circle of three miles radius, but the quantity available from them, although they were frequently deepened by borings, was gradually decreasing; and Mr. Stephenson, in a report in 1850 upon the Liverpool Water Supply, recommended an increase in the number of wells as the best means of permanently increasing the quantity. Notwithstanding Mr. Stephenson's clear and able treatment of the question, the well system of Liverpool has been abandoned, and the city supplied with water by the Rivington Pike scheme, apparently for no other reason than the greater security against a failure in the supply enjoyed by the latter plan.

In the following table are given the distinctive features of some of the most noted artesian wells :

TABLE No. 4.

Name	Location	Depth of Well Feet	Diameter of Bore at Bottom of Well Inch	Quantity of Water	Temp'ture of Water °Far	Length of Time in Boring Well Yrs.	Elevation of Discharge plus or min. Surface of Ground Feet	Discharge per 24 hours in U. S. gallons	Total Cost of Well	First Cost in measures of 1,000,000 gallons in 24 hours
FOREIGN—										
Grenelle.........	Paris	1,806	6	Fresh.....	82½	7	....	175,104	$70,180 00	$401,028 00
Passy	Paris	....	......	Fresh.....	......	......	plus 66	2,188,800	....	....
Kissengen.......	Bavaria.............	1,878	.....	Mineral..	66	......	plus 58	1,077,120	32,263 00	30,050 00
Aire...............	Artois, France.....	....	......	Fresh.....	......	......	plus 11	360,000	....	....
UNITED STATES—										
Charleston.......	South Carolina....	1,250	3	Salt.......	87	......	plus 10	30,000	20,000 00	666,666 66
Belcher's.........	St. Louis......	2,199	3½	Salt.......	73	5	min. 30	108,000	20,000 00	185,185 18
DuPont's.........	Louisville, Ky.....	2,086	3	Mineral..	......	1½	plus 170	330,000	10,000 00	30,303 03

This table illustrates the highly experimental nature of the process in obtaining water by means of artesian wells. Out of seven successful wells, four furnish water unsuitable for domestic use. As to cost, the statements concerning the costs of the wells named are too indefinite, and the number of wells too small, to form any comparison with ordinary pumping works.

Below are given extracts from a report* of the commission constituted in accordance with the proposition of the Senator Prefect of the Seine, by a decree of his Excellency "the Minister of Agriculture, Commerce, and Public Works," many of the observations and conclusions in which are as applicable to Memphis as they are to the city of Paris:

DATED OCTOBER 29, 1861.

Instructed to examine the question 'whether it be possible and expedient to provide exclusively by means of artesian wells for the supply and distribution of water for all public and private uses in the city of Paris.'

Monsieur the Minister—The commission that you have instituted to examine if it be possible and expedient to provide exclusively by means of artesian wells for the supply and distribution of water for all public and private uses in the city of Paris, after careful examination, reports to your Excellency that such is not its opinion.

The commission is unanimous. Among its members there are none who are unaware of the importance of artesian water drawn from the green sand for the use of Paris. But among those who base upon it the greatest expectations there are none who are of opinion that it would be advisable to exclude the employment of other resources that nature or art has placed at the disposal of the Parisian people. . . . .

CONCLUSIONS.

In conclusion, for the following reasons, the commission is of opinion that it is not best to provide exclusively by means of artesian wells for the distribution of water for all public and private services in the city of Paris.

1. The water-bearing stratum of green sand is not the exclusive property of the city of Paris. It can be operated upon at any distance or level by the proprietors of the soil. The works constructed by companies, associations, and indi-

*A copy of which was furnished by E. S. Chesbrough, Esq.

viduals, however great or indisputable may be the capabilities of this source, could absorb them and render them of very doubtful application to the municipal wants.

2. The phenomena and natural accidents, such as earthquakes, that exercise little influence upon canals through which flow surface water, could, on the contrary, produce on channels for the passage of water at great depths a derangement of their course.

Though such events may be rare, it is sufficient to know that once in twenty years their effect on the well of Grenelle has been observed, not to be willing to expose the city of Paris to receive suddenly and for entire months turbid water in all its reservoirs, or to submit to a diminution of one-half the product of its flowing wells, which, though it were but temporary, would not be the less serious.

3. The art of boring is not yet advanced enough by experience in tubing very deep wells of large diameter, especially in what concerns the green sand basis; tubes in iron do not last; copper tubes even, lined with tin, might fill the people with anxiety in times of epidemic; wooden tubes are uncertain; and wells not provided with tubes have not been thoroughly experimented with.

4. The water of the artesian source, which is of great purity, and which, so far as mineral substances are concerned, is better suited than all others for industrial and public use, is very slightly aerated and tepid. It would be necessary, therefore, to cool and aerate it to render it useful for domestic purposes; and for this reason it would be regretted that it is not a little richer in carbonic acid and carbonate of lime.

5. . . . .

6. . . . .

7. In conclusion, when we talk of supplying 2,000,000 inhabitants, it is prudent to assure ourselves of the simultaneous use of bodies of water taken from various sources, in order to be always ready to quiet the complaints of the people. Water, as we have said, ought never to be suspected; and, in case of the least doubt, the administration must be able to replace one water, though suspected without cause, by another which may possess the confidence of the consumers.

Such, M. the Minister, are the reasons that have determined the commissioners to recommend to your Excellency not to adopt the plan of supplying Paris exclusively by artesian water. Your Excellency, before making a final decision, will agree, perhaps, with the commission that it is best to leave to time the solving of questions that are not sufficiently clear at present.

I have the honor of being, with respect, M. the Minister, your Excellency's very devoted colleague,

V. DUMAS,
Senator Member of the Academy of Science.

It has also been suggested, and considerable importance given to it, that, as a means of obtaining clear water, large impounding reservoirs be formed in the Mississippi or Wolf River bottoms, which are subject to overflow from these rivers during flood stages of the Mississippi; that these reservoirs be made large enough to hold a year's water supply for the city of Memphis; and that they be annually filled during high water. It was further claimed that from these reservoirs the city could be supplied with clear water by pumping machinery elevating the water *but once*, and *that* through less height than by pumping directly from the Mississippi, from the fact that by the latter plan the actual lift would vary with the rise and fall in the river, whereas by the former plan the settling reservoirs would be filled at flood height, and consequently save an annual average lift of about twenty feet in elevating the water for distribution.

To determine the merits of this plan in a pecuniary point of view, a survey was made of a natural basin between Wolf River and the New Raleigh Road, upon Mr. K. G. B. L. Wynn's plantation, a location for which some natural advantages were justly claimed. The most economical plan for a settling reservoir upon this site is represented in outline on Details No. 7. It could be filled only during the highest stages of the Mississippi; occasionally, perhaps, from floods in Wolf River. When filled by backwater from the Mississippi it would be a mixture of Wolf River and Mississippi water. A reservoir containing a year's supply of water for Memphis, when the consumption reached 6,000,000 gallons daily, would have to hold 2,190,000,000 gallons, without any allowance for leakage or evaporation. It would have a water surface of 386¼ acres, and for which the earth-work alone in the locality surveyed would be—

Mucking, 479,305 cubic yards at 20 cents	$95,861 00
Excavation, 8,795,439 cubic yards at 20 cents	1,759,087 80
	$1,854,948 80

A sum quite out of proportion for a single branch of the proposed water-works; and that only for the earth-work, without any slope protection or influent and effluent chambers.

Supposing the existence near Memphis of a locality—a level plain—for a reservoir of this capacity, built in the most economical form, circular, where the excavation would just make the embankment; it would require a water surface of 381⅕ acres, with 18 feet depth. The work in this *conjectural* case would be

Real estate, 381⅕ acres at $300	$114,360 00
Mucking, 297,938 cubic yards at 20 cents	59,587 60
Excavation carried in embankment, 667,000 cubic yards at 30 cents	200,100 00
Slope paving, 19,000 cubic yards at $11	209,000 00
Influent and effluent chambers	50,000 00
	$633,047 60

It is thus manifest that pecuniarily a plan of this kind is inadmissible; and were this not the case, in a sanitary point of view, it is doubtful whether it would be prudent to attempt in this latitude to store a year's water supply in this manner; but were all these objections overcome, or proved to be groundless, can the city of Memphis depend upon the Mississippi's rising annually to a height at which an impounding reservoir of this kind could be filled? Or, in the event of accident to the reservoir, causing the water to escape (from which liability a reservoir in the Mississippi bottoms is not by any means exempt), where would then a supply of water be obtained, unless the pumping machinery is arranged for taking a supply directly from the river?

WOLF RIVER PLAN.

In looking to Wolf River as the source of supply, it is of course desirable to go beyond the backwater from the Mississippi, in order to obtain the water from the live stream uninfluenced by backwater. It is also important to avoid the impurities from the several branches of cypress and cane creeks, which drain an extent of territory of some 20,000 acres, nearly all of which is under cultivation, much of which will soon be suburbs to the city, and the drainage from which during low stages of Wolf River, in the latter part of summer and in the fall, would, and does now, prejudicially and seriously, affect the quality of the water. For these reasons it is deemed inexpedient to take the water from a point nearer the mouth of Wolf River than the town of Raleigh. At this point the surface of the water at ordinary summer stages is one foot and a half above high water in the Mississippi, and fifty feet below Court Square in the city of Memphis. To take the water here would require it to be elevated by pumping machinery at the start, as no dam of sufficient elevation can at this point be successfully constructed to bring the water near the city for being elevated and distributed. In fact, nowhere along Wolf River, from its mouth to a point two miles north-east of Ridgeway Station on the Memphis and Charleston Railroad, is it practicable to build a dam exceeding ten feet in height above low water, for the reason that a dam of greater elevation will bring the river out of its banks, and that the river with its bottom lands for eight miles above the town of Raleigh has a fall of only 33 48-100 inches to the mile, taking the general direction of the valley and the stream (course south 45° east), and by the exact meanderings* of the river, a fall of 15 44-100 inches to the mile; hence a dam of greater elevation than ten feet would have to extend entirely across the valley, which latter,

* The length of the river, measured upon its meanderings, which are confined with a strip of river bottom about 3350 feet in width, compared with the length measured upon the center line of said strip of land, is as $2\frac{17}{100}$ is to 1.

at the narrowest places, is three-quarters of a mile wide; and for every foot above ten feet such a dam would flood an area of 172 acres of timbered bottom lands densely filled with undergrowth, the clearing up of which for a suitable storing or settling reservoir, and the construction and preservation of a reliable dam of this extent would involve an expense wholly inadmissible. Consequently, in order to bring the water from Wolf River, it must either be elevated by pumping machinery at the source, or taken at a point sufficiently far up stream to secure an elevation which will permit its being brought by gravity to a suitable locality for constructing a subsiding reservoir. This latter plan is, under existing circumstances, the best and most economical. In deciding, however, upon this plan for obtaining a supply of water from Wolf River, the following general plan presented itself, viz: To locate the pumping station immediately upon the banks of Wolf River, at or near the site selected for the dam presently to be described; the settling reservoir on the high ground between this point and Ridgeway Station on the Memphis and Charleston Railroad; and to bring the water from the settling reservoir to the distributing reservoir through a brick conduit, located upon the dividing ridge between Wolf River and the Nonconnah Creek. This project was abandoned, however, without an instrumental survey of the route, and for three principal reasons. First, because the ground along the ridge is much more broken than in the valley where it is proposed to locate the conduit, causing the line to be more sinuous and the work heavier and more costly than in the valley, although the ridge line might prove a mile and a half shorter. Secondly, because this plan would reduce the elevation of the flow line in the distributing reservoir (not any too high, as it will hereafter be proposed) some twenty feet; for no conduit could be constructed at a reasonable cost which would admit of being submerged, as it were, to a depth of twenty feet below the flow lines of the settling and distributing reservoirs. Hence cast-iron pipes would have to be used, which, being of equal capacity with the proposed conduit, would be much more costly. And thirdly, because the locating of the pumping station upward of two miles from either railroad or water communication would involve an annual and constantly increasing expense for the delivery of fuel at the pumping works. For these reasons it was not deemed necessary to make surveys of this route, although several reconnoissances were made.

DAM.—The first suitable location above the town of Raleigh upon the river, where a dam ten feet in height will enable the water to be taken at the proper elevation for conducting it to the nearest site to the city, possessing the necessary natural features for constructing a subsiding reservoir, so located as to permit hereafter, whenever deemed necessary, to combine filtration with subsidence for rendering the water clear, is a point 7 3-10 miles above Raleigh, almost due east (S. 88° 36′ E.) from the center of Court Square in the city, and 11 87-100 miles distant from the latter point. At this point the river is seventy-six feet wide at extreme low water, and one hundred and twenty feet wide when bank-full. Upon its easterly bank the bottom land is, on an average, ten feet above low water, and upon its westerly bank the land is twenty feet feet above low water. The extreme fluctuation of the river, from low water to flood height, is fifteen feet at this point, as determined from the flood of July 28, 1867, which is reported by old residents along the river as having been the highest within their recollection. Here it is proposed to build a dam across Wolf River (being on the farm of Mr. Massey), with an elevation at the crest of 131.39 feet plus P. R., being 10 21-100 feet above low water in Wolf River, 31 39-100 feet above high water in the Mississippi at Memphis, and 20 4-10 feet below Court Square. The material of the river banks is clay, containing considerable fine sand, specific gravity about 2.1, firm and capable of retaining water in its natural condition. The bed of the river is sand, of a degree of coarseness suitable for mortar. The structure proposed is a dam with a weir or overfall of two hundred feet in length, composed of timber, concrete, and cut-stone masonry, built in the following manner: First, to drive four rows of piles transversely across the stream, the two outside rows to be squared sheet piles, and the inside rows round bearing piles. Upon these piles, as supports for the easterly portion of the dam, is to be placed a timber grillage, planked, for the commencement of the masonry, and for the westerly portion a timber crib, filled with concrete, upon which to commence the masonry of that portion of the dam facing the main channel of the river. The masonry is to commence six inches below low water, and be carried up to the elevation named. Behind the crib and grillage, in order to secure the joint between them and the piling, is to be driven sheet piling; and behind the entire structure there is to be an earth embankment, to make the dam perfectly water-tight. (For particulars see Details No. 1, Figs. 1, 2, and 3, herewith submitted.) Upon the easterly bank an embankment is to be raised four feet above extreme high water, and extending up and down stream, to prevent by-wash in times of high water. Above the dam the river banks are to be raised, wherever required, by levees, to compensate for the obstruction by the dam, and keep the river within its banks at all stages during which it now remains within banks.

Gate-house.—Immediately above the dam, and upon the westerly bank of the river, is to be located the gate-house for admitting and regulating the flow of water into the conduit. (See Details No. 1, Figs. 4, 5, 6 and 7.)

Conduit Line.—From this point, through a brick conduit, by the force of gravity, the water is to be brought from the river to the settling reservoir. The proposed line for the conduit commences at the portal in the dam, thirty-seven feet up stream from the overfall, with a grade elevation at the flow line or soffit of arch of 131.39 feet plus P. R., being on a level with the crest of the dam; thence S. 66½°, W. 111 feet to a point in the center of the westerly front of the gate-house; thence S. E. upon a curve of 380 feet radius, 339 feet to tangent; thence N. 62° 26′, W. 3911 feet on a tangent to beginning of curve; thence north-westerly, upon a curve to right of 5731.4 feet radius, 2000 feet to reverse curve, crossing Echols Creek 5251 feet from the beginning of conduit; thence north-westerly, upon a curve to left of 5731.4 feet radius, 3000 feet to reverse curve; thence north-westerly, upon a curve to right 5731.4 feet radius, 4500 feet to reverse curve; thence north-westerly, upon a curve to left of 5731.4 feet radius, 2500 feet to change of curvature near Mrs. Hamlet's residence; thence north-westerly, upon a curve to left (extending to a south-westerly direction) of 28,014 feet radius, to tangent 27,945 feet, crossing Big Creek at 17,836 feet, Macon Road at 22,901 feet, Cane Creek at 30,576 feet, Old Raleigh Road at 36,371 feet, and the Memphis and Ohio Railroad at 38,904 feet from the beginning of the conduit; thence S. 69°, 40′ W., upon a tangent 9300 feet to beginning of curve, crossing the several branches of Cypress Creek as designated upon the maps and profiles submitted; then south-westerly, upon a curve to the left of 7163 feet radius, to change of curvature, 3268 feet; thence south-westerly, upon a curve to the left of 1348 feet radius, to tangent, 1000 feet; thence due south 758 feet to the center of the north wall of influent gate-house to settling reservoir; making the total length of the conduit 58,632 feet, or 11 1-10 miles. The line thus described is the most eligible one of a number of lines surveyed, and from its commencement follows the contour of the ridges and depressions which extend north from the dividing ridge separating the rain-fall between Wolf River and Nonconnah Creek, at such an elevation as to make the work of excavation and embankment very light. (See Profiles Nos. 1 and 2.) The material through which the excavations are to be made is principally a mixture of clay and sand in the upper strata, merging into fine sand in the deepest excavations; all very compact, and will readily stand at a slope of ½ horizontal to 1 vertical in the excavations for the full length of time it would be required to stand for this purpose. The indications along the line are, that after the spring seasons little or no water would be encountered in the excavations. The prices in the estimates for the earth-work of the conduit are based upon the presumption that the excavations will be free from water. This presumption is justified by examinations of the wells along the line, in which the water-level was found below the line of the proposed work. The conduit is to be of brick, oval in section, 6 feet 3 inches in height and 5 feet in width. The lower portion is to be a semi-circle of 2½ feet radius, and the upper portion a semi-ellipse of 7½ feet major by 5 feet minor axis, inside measurements. The shell is to be of brick, 9 inches thick, laid in two rings with hydraulic cement. This size for the conduit was determined not so much by the present demand for water in the city as by the dimensions requisite for conveniently passing through it for inspection and repairs, which works of this kind frequently require, and for which there is generally but a brief space of time allotted. The conduit, where located in excavation of 5 feet depth or greater, is to be built in the natural earth, excavated to conform to the exterior form of it. Wherever the excavation is less than 5 feet, the conduit is to be supported laterally by brick-work, which, as the excavation diminishes, merges into a solid supporting wall, uniting under the conduit upon a bed of concrete as the conduit changes from excavation into embankment. Wherever the embankment exceeds 12 feet in height the supporting wall is changed from a solid to a cellular structure, consisting of inverted arches upon concrete, supporting brick piers thirteen inches thick, placed transversely with the conduit line and at intervals of 6 feet; these being again united by arches, upon which the conduit with its lateral supporting walls is to be built. (See Details Nos. 2 and 3.)

The embankments are to be 8 feet wide on top, and to have slopes of 1½ horizontal to 1 vertical; all the masonry to be of brick, and wherever exposed to be capped with stone coping.

The sectional area of the proposed conduit is 24 7-10 square feet; it is calculated for a fall of 1-2000 or 3 168-1000 inches to the mile, with which area and inclination, when running full, it will deliver 12,398,000 United States gallons of water per twenty-four hours. The conduit is to be provided with manholes, placed at intervals of half a mile, which are to facilitate inspection and repairs, and act as ventilators when needed; it is to be provided with two waste weirs, one located at Cane Creek, the other in the influent gate-house at the settling reservoir, which is also to serve as an overflow to the reservoir. In addition to the waste weirs there are to be built in the invert of the conduit, as often as deemed necessary, or as often as the culverts and topography along the line will permit, cast-iron drains, to facilitate the removal of deposits which may accumulate in it. The creeks and branches are to be crossed upon culverts and arches. At the Memphis and Ohio Railroad, in order to preserve the bottom grade of the conduit, the crossing is to be effected by means of two lines of 48-inch cast-iron pipes, the flow line of the conduit or soffit of the arch being one foot above the grade of the road at this point.

SETTLING RESERVOIR.—At the terminus of the conduit line, just described, the influent gate-house to the proposed settling reservoir is located; the center of the house is N. 67° 03′, E. 12,423 feet, or 2 35-100 miles from the center of Court Square in the city. The gate-house is so arranged as to discharge the water from the conduit into either compartment of the reservoir, discharge directly into the pipe-vault on the west side of the reservoir through a branch conduit through the dividing embankment, or divert the water when required, through a waste culvert into a branch of Cypress Creek. (See Details No. 4, Figs. 2, 3, 4 and 6.) The settling reservoir is located at the termination of the conduit line, upon the low ground on the westerly branch of Cypress Creek, between the Memphis and Ohio Railroad and the old Raleigh Road. The construction of it upon the site proposed is so arranged as adapt it to combining the process of filtration with that of subsidence, at any time hereafter at which the wants of the public will demand filtered water, and the means of the city enable it to furnish the same. For accomplishing this the elevation of the water surface, when the reservoir is full, has been fixed at 128½ feet plus P. R. (being 23.3 feet below Court Square), while the drainage through the channel of Cypress Creek can be secured at an elevation of 106 feet plus P. R., making a difference of 22½ feet between the flow line of the settling reservoir and the drainage elevation of the filter-beds, in which difference of elevation, subsidence and filtration can be readily effected. For the present and near future wants of the city, the settling reservoir alone without filter-beds is proposed, and is to be used for storing and settling the water from which to supply the city by means of pumping machinery.

It is to be an earthen embankment reservoir; the basins or compartments of it are to be two in number, and formed partly by excavations and partly by embankments; that portion of the storage capacity obtained by excavation compared with that obtained by embankment being as 1 is to 2, and all the earth required is contained within the area of the site. The embankments are to be made of earth, deposited in successive layers of such depths as the nature of the material and its condition at the time of working shall determine to be best. All the embankments are to have puddle-walls in the center, commencing two feet below the natural surface of the ground, and extending to within four feet of the top of the embankment; to be six feet wide on top, and increasing one foot in width for every ten feet in depth. The slopes of the embankments, inside and outside, are to be 3 horizontal to 1 vertical, to be protected on the inside with brick paving and on the outside with Bermuda grass. The dimensions of the reservoir were determined by the length of time required by the water from Wolf River to become clear by subsidence, which is about eight days during the winter and spring months of the year.

With a consumption of six million of gallons daily, there would be required a reservoir with two compartments of 48,000,000 gallons each, the city being supplied from one while the water in the other is becoming clear for distribution; and as the water in a reservoir of this kind never is *all* available for distribution, the capacity of each compartment has been fixed in round numbers at 52,000,000 United States gallons.

EFFLUENT CHAMBER.—In the division embankment, at its junction with the west embankment, is located the effluent chamber, to be built of stone, which is so designed as to permit the water to be drawn from the reservoir at any point from the surface to the bottom. From this chamber, by means of three 40-inch cast-iron pipes leading to the gate-house, to be located outside of the embankment, the water is to be drawn. These three lines of pipe, with their stop-gates, are so disposed as to admit of one of the three being used for draining and cleaning one compartment of the reservoir while the other two supply the city from the other compartment, and *vice versa*. (See Details No. 4).

PUMPING STATION.—From the gate-house on the west side of the reservoir, by the force of gravity through one line of 36-inch pipe, the water is to be brought to the pumping station, which latter is located near the Memphis and Ohio Railroad, N. 69½°, E. 9,880 feet, or 1 87-100 miles from the center of Court Square. At this point it is proposed to erect the buildings necessary to accommodate the pumping machinery, such as pump, engine, boiler, coal-houses, and chimney. The kind of pumping machinery recommended for this particular locality is Worthington's Duplex Pumping Engine.

This machine is strictly a steam pump, consisting of two steam cylinders and two water cylinders laid horizontally in pairs, the piston rod of each steam cylinder extending to its water cylinder and working a water displacement plunger; the steam and water cylinders being separated a sufficient distance to permit the requisite mechanical devices to be attached to each connecting rod between the steam piston and water plunger, for working the steam valves and air pumps; the connecting rod of the right hand engine working the steam valves and air pump of the left-hand engine, and *vice versa*.

The machine is self-contained and does not require expensive masonry foundations; it works horizontally; has the smallest mass of inert matter in the moving parts, being just sufficient for the safe transmission of the power; and thus, in conjunction with its moderate velocity, reduces its liability to accidents to a minimum. The valves are multiform vulcanized rubber disks, strengthened by perforated cast-iron disks, the rubber seating upon grated composition metal valve seats; the receiving and delivery valves are disposed in sets vertically one above the other, and rise and fall vertically. In the economical use of fuel this engine compares favorably with the best pumping engines in the country; and in its daily performance it will give moderately good results, with perhaps less attention from skillful enginemen than any other kind of pumping engine now in use, being nearly automatic in its operation. It has been in use for a number of years, and there are at present in successful operation as follows, to-wit: One pair at Harrisburg, Pennsylvania; one pair at Greenwood Cemetery, Long Island; two pairs at Cambridge, Massachusetts; two pairs at Charlestown, Massachusetts; one pair now being erected at Salem, Massachusetts; and one pair at Newark, New Jersey; the last four named being each capable of elevating 5,000,000 gallons water per twenty-four hours.

Wherever this pumping engine has been in use, it has given entire satisfaction, and, with the exception of the Cornish pumping engine, it has been duplicated a greater number of times than any other engine for water-works purposes, despite its recent origin.

The buildings proposed at the pumping station consists of one combined engine, and pump-room sufficiently large (53 by 60 feet) to accommodate two pairs of engines; one boiler-house (53 by 60 feet) to accommodate two batteries of boilers; one chimney equal in capacity to furnish draft for both batteries of boilers and coal-houses of dimensions suitable for the purpose. Two pairs of engines, forming two individual or separate pumping machines, each capable of elevating 250,000 gallons of water per hour, or 6,000,000 in twenty-four hours, are embraced in the estimates, and recommended for this locality.

Pump Main.—From the pumping station, by the power of the engines through one line of 24-inch cast-iron pipe, the water is to be delivered into the distributing reservoir. The line deemed best and proposed for the pipe is as follows: Commencing at the pumping station, thence southwardly to Winter Avenue, 308 feet; thence westwardly along Winter Avenue to Boundary Avenue, 5115 feet; thence westwardly along the line of Winter Avenue extended to its intersection with the Raleigh Road, 2015 feet; thence along the Raleigh

Road to its intersection with Third Street, 2129 feet; thence along Third Street to its intersection with Monroe Street, 3604 feet; thence along Monroe Street to its intersection with DeSoto Street, 606 feet; thence along DeSoto Street to its intersection with Elliott Street, 3508 feet; thence along Elliott Street to its intersection with the Hernando Road, 648 feet; thence along the Hernando Road to opposite the dividing embankment of the distributing reservoir, 8389 feet; thence into the reservoir, 125 feet; making a total distance of 26,447 feet, or 5 1-100 miles for this line of pipe, which is to perform the combined functions of pump main, supply main, and distributing main. As pump and supply main during the day, while the pumping engines are at work; as supply and distributing main during such times as the engines are not at work; or as pump and distributing and as supply and distributing main at such times as the consumption of water in the city is greater than the capacity of the pumps. Under the first of these conditions, some of the water in the pipe passing through the city on its way to the distributing reservoir is withdrawn by the branch or distributing pipes, and the city receives its supply direct from the pumps, whilst the remainder passes on to the reservoir; under the second condition, the engines being at rest, the current of water in the pipe is reversed, and the city draws its supply direct from the distributing reservoir; and under the third condition, the city may, by the united capacity of all the branches from the main being in excess of that of the main itself, draw all the water delivered by the pumps as well as an additional quantity equal to the capacity of the reservoir end of the pipe; having, in this particular case, the advantage of being supplied by two lines of pipe, which is an improvement incidental to this mode of distribution, arising from the pumping works being located on one side of the city while the distributing reservoir is located on the other; and it thus fully compensates for what is at first sight considered a more expensive arrangement than the usual plans, viz.: pumping works and reservoirs being both on one side of the city. To make the maximum capacity of the pipe fully available, the lowest practicable route through the city has been selected for it.

DISTRIBUTING RESERVOIR.—The site selected for the distributing reservoir is on the highest ground embraced within the limits of the surveys made, and will enable the maintenance of a greater head upon the distributing pipe than any other natural elevation within reach of the city or available for the purpose. (See record of elevations in Table No. — in Appendix.) It is located on the west side of the Hernando Road, between McLemore and Richmond Avenues, S. 27½°, E. 13,050 feet, or 2 47-100 miles from the center of Court Square. It is to be an earthen embankment structure in two compartments, the united storage capacity of which, when filled 20 feet deep, is equal to 43,332,500 United States gallons, making available a seven day's supply of water when the city's consumption is 6,000,000 gallons daily.

The flow line or water surface, when the reservoir is full, is 220 feet plus P. R., and 68 2-10 feet above Court Square. The capacity of the basins is formed nearly entirely by the retaining embankments, but a small portion being obtained by excavation; and the material or earth to form the embankments is not contained within the area of the site, but must be obtained outside. The embankments are to be built up in horizontal layers of uniform thickness, the thickness of the several layers to be determined by the nature of the earth and its condition at the time of depositing it. All the embankments are to have puddle-walls in the center of them, to be protected on the inside slopes with stone slope paving, and on the outside with Bermuda grass. Within the intersection of the easterly and division embankments is located the pipe-vault, which communicates with the joint influent and effluent chamber located in the division embankment. In this pipe-vault, by means of a four-way branch pipe containing a check-valve, the pump main (which terminates here, and by reversing the current becomes a supply main) is made to discharge water automatically through the influent chamber at the level of the flow line into the reservoir, or draw water from it, through the intervention of the effluent chamber, from any level, for the supply of the city. (See Details No. 6.)

The rhomboidal plan adopted for this reservoir, it will be perceived, is not the most favorable to obtaining a maximum

Memphis, Tenn., September 1, 1885.

SIR:

The following has been prepared in consequence of the numerous letters of inquiry which have been received, as to the working of the Waring system of Sewers in Memphis; and, it is believed, contains answers to all questions heretofore asked.

The city has a population of about 60,000, and occupies the summits and slopes on both sides of the valley, which is drained by a stream known as Bayou Gayoso.

The main sewers are located on each side of the bayou, and as near to it as was found practicable.

We have altogether about $40\frac{9}{10}$ miles of sewers, of which four miles are mains located along the bayou and discharging into the river by one outlet; the remainder are laterals draining into these mains, except about $4\frac{1}{10}$ miles of sewers constructed before the present system was adopted, and discharging into the Mississippi by other outlets.

The mains are ten, twelve, fifteen and twenty inches in diameter. Of the laterals, about 85 per cent. are six inches in diameter, and the remainder eight inches, except a few short lengths, which are ten inches. The mains for the most part are laid with a grade of two inches in one hundred feet, which is the minimum.

The minimum grade of six inch laterals is six inches in one hundred feet.

At the upper end of each lateral is located one of Rogers Field's Automatic Flush Tanks, which discharges one hundred and twelve gallons in about forty seconds. This tank discharges its contents as often as it is filled, but it is believed once in twenty-four hours is sufficient.

The system has man-holes, distributed on the mains.

No surface or roof water is permitted to enter the sewers, the system being designed and proportioned for house sewerage only.

The house drains are all four inches in diameter, and no trap is permitted on the main drain, each fixture being provided with a separate trap. The soil pipes are of cast iron, with lead joints, above the ground, and extend four inches in diameter above the roof. Each house drain is consequently a ventilator for the public sewer.

For the purpose of removing the subsoil water, agricultural drain tiles are laid in the trench with each lateral, on the grade of the sewer, or below it, which discharge, not into the sewers, but into the bayou. Additional lines of tile have been laid in streets in which no sewer is located. $35\frac{6}{10}$ miles of subsoil drains.

A large part of the trenching has been done by contract, but the pipes have been laid with hired labor.

The prices last paid for excavating and back-filling are as follows: Trenches $6\frac{1}{2}$ feet deep, 25c.; $6\frac{1}{2}$ to 9 feet, 30c.; 9 to 12 feet, 45c.; 12 to 15 feet, 75c., per lineal foot.

The pipe laying, including laying drain tile in the same trench, also the cost of the cement, sand, oakum and tile paper, is estimated to cost $7\frac{6}{10}$ cents per foot. The flush tanks cost complete about $45.00 each, including $10.00 royalty.

The six-inch pipes, although draining houses on both sides, in some cases for a distance of three thousand feet, have never been overcharged, and have seldom been found running half full.

No trouble has been caused by sewer gas, and the sewers are believed to be comparatively free from it.

Some of the six-inch pipes have occasionally been obstructed by sticks, bones, etc., becoming fixed across the diameter of the pipe, all of which have been promptly removed, at an average cost of $13.50 each.

Some deposits have been found in the mains, which have been rapidly and inexpensively removed by the passage of hollow metal balls through them. These balls are about three inches less in diameter than the sewers, and being lighter than water are pressed against the top of the sewer, and are rolled along by the force of the current. The velocity of the ball is less than that of the water, which in passing it is deflected against the bottom and sides of the sewer so as to thoroughly cleanse it.

A portion of the mains have been cleansed ten times since their construction; the laterals not at all.

Pipe laying was commenced about 20th January, 1880, and on July 1st of that year about twenty miles had been laid. The first house connections were made about March 1st of the same year.

Hourly observations in the twenty-inch main, on 30th April last, showed the greatest depth of flow, $12\frac{3}{4}$ inches at 10 a. m.; least depth, 8 inches at 2 a. m. On 13th of June greatest depth 14 inches at 11 a. m.; least depth, $10\frac{1}{4}$ inches at 4 a. m.

Floats in the same sewer gave a surface velocity of $2\frac{6}{10}$ feet per second, the depth being $12\frac{1}{4}$ inches.

The following is a statement of the connections made with the system to date, but does not include those made with old sewers discharging by other outlets:

Water Closets,	5,834	Bath Tubs,	472
Sinks,	3,968	Wash Basins,	423
Urinals,	424	Privy Sinks,	60
Cellar Drains,	66	Flush Tanks,	192
Man-holes,	54	Observation,	412

The system of sewers appears to give entire satisfaction both to the city government and citizens generally.

NILES MERIWETHER,

Engineer In Charge of Sewers.

storage capacity with the quantity of material in the embankments, the sides of it being made parallel with the streets between which it is located on account of the present and prospective value of the site.

Distributing Pipe.—The principal line of distributing pipes proposed are as follows, viz.: One line of 16-inch pipe from the intersection of Third and Poplar Streets; along Poplar Street to its intersection with Front Row; thence along Front Row and Chickasaw Street, one line of 8-inch pipe, to the county jail; and along Front Row and Shelby Street to the intersection of Beale Street, one line of 12-inch pipe; thence along Shelby street southwardly, one line of 10-inch pipe to near Butler Street. In addition to these principal lines, six (6) miles of 6-inch pipe and ten (10) miles of 4-inch pipe are proposed to be laid in such localities as will best accommodate the citizens. Also, one hundred (100) fire hydrants, and fifty (50) of the street cisterns now in use, are to be connected with the distributing pipe for supplying the fire department with water.

SUMMARY OF ESTIMATED COST OF WOLF RIVER PLAN.

For real estate, right of way, and land damages; grubbing, clearing, pumping, and bailing for Wolf River dam and conduit line	$18,400 00	
For Wolf River dam	75,166 60	
For gate-house at the dam	29,441 00	
For conduit line	709,041 50	
For gate-house at end of conduit	16,435 00	
For contingencies and omissions, 10 per cent	84,848 41—	$933,332 51
For settling reservoir (two basins)		373,327 90
For buildings at pumping station		67,872 60
For two pairs pumping engines		100,000 00
For pipe system		505,886 60
For distributing reservoir (two basins)		349,009 10
Total cost of Wolf River plan		$2,329,428 71
$287,424.50 of which need not immediately be provided, as in the beginning of the works one basin in the settling and one in the distributing reservoir can be omitted		287,424 50
		$2,042,004 21

MISSISSIPPI RIVER PLAN.

In taking water from the Mississippi, it has been assumed that it would be imprudent, unwise, and exhibiting great lack of forecast to propose taking water from the river below the city, where it is charged with the drainage from the latter and refuse from the steamboats at the landing, rendering the water unfit to be supplied to the city. When it is remembered that this evil must eventually, with the increase of population in the city, assume formidable proportions, it must become evident that no plan proposing to take water from the river below the city can be at all considered. Consequently, the examinations have been confined to the river above the city exclusively, and have resulted in proposing pumping works east of Wolf River, in the vicinity of the cotton factory, and to bring the water from the Mississippi by means of an inlet pipe, laid from the river through the alluvial deposits, and underneath Loosa Hatchie and Wolf Rivers, to the pumping station.

INLET PIPE.—In erecting and maintaining pumping works taking a supply of water from the Mississippi above the city, there are two physical conditions, the adaptation of the pump-works to which will be found very difficult.

The first of these conditions is the remoteness from the river at which reliable foundations for pumping machinery can be obtained, requiring a long conduit or inlet pipe for the purpose of bringing the water from the river to the pump well at the pumping station; and the second we find in the unstable nature of the material through which such conduit or inlet pipe will have to be built and maintained in position, as well as kept clear from the immense deposits left by the water from the Mississippi, whenever favorable conditions to this end prevail. To meet the last named condition, and obviate the many difficulties which present themselves the moment you study the subject, a great many schemes by different persons have been suggested, such as floating pumping works with flexible shore or land connection leading to reservoir or distribution, and thus obviate altogether the silting up or the constant removal by mechanical means of deposits to which an ordinary inlet pipe would be subject; to lay along the bed of Wolf River, from the Mississippi to the pumping station, a flexible conduit or inlet pipe, provided with a mouth or portal capable of being submerged or floated, and fitted with gates to exclude the water, for the purpose of removing at regular intervals the deposits constantly accumulating; or, having in view the constant changing of the river channel, and the cutting and caving of its banks, to construct a brick or stone masonry conduit which might, as it were, disintegrate piecemeal as the banks are washed away, and not permit an entire stoppage of a supply of water; this plan omits making provision for the growth of the conduit in the event of bars forming at its mouth. Again, to sink at such point in the river channel as may be considered the least liable to change, by pneumatic process, an inlet tower of wrought iron, reaching a depth that will insure a reliable foundation; the tower to be filled with concrete from its base to a point near the line of low water in the river; above that point to be hollow, and provided with gates at such intervals that will permit the water to be taken at all stages of the river near its surface. From the land side of this tower are to lead off two cast-iron inlet pipes, and extend through the alluvium to the pump wells at the pumping station, and to be fitted with alternate slip and flexible joints, so that, in the event of any of their supports being washed from under them, the pipes may adapt themselves to these changes by their flexibility and extensibility, or to make the pipes continuous tubes of boiler plate between the inlet tower and the pumping station, supporting and securing them against lateral forces by means of piers formed of screw piles, and reaching to a depth not subject to change by variations in the channel, and located at suitable intervals; the whole forming a double subaqueous conduit possessing a strength and stability capable of withstanding the current of the river in the event of the surrounding alluvium being washed away. To guard against the silting up of any of these pipes, it is proposed to secure a velocity of current through them while supplying the pump wells that will prevent deposits being made. In the case of the flexible and extensible pipes, it is to be obviated by making their diameters and the depths of the pump wells at the pumping station, at the lowest stage of the river, hold such relations one to the other as will permit a velocity of current at which no sediment can accumulate in the pipe. In the case of the fixed pipes, it is proposed to give them an inclination from the inlet tower to the pump wells that will insure sufficient velocity at the lowest stage of the river to prevent deposits. To make either of these expedients an effectual remedy against the silting up of the pipes, it would be necessary to provide each line with a stop-gate at the inlet tower, which being closed at intervals varying in the duration with the quantity of sediment in the water, and the pipes being drained by the pumping machinery, by then opening the gates, and flushing the pipes from the inlet tower to the pump wells, the deposit would be removed, and this operation, being frequently repeated, would keep the pipes free from sediment.

It will be perceived that in all these schemes there is an effort made to make the structures proposed independent of the changing alluvium in which they must be executed and preserved; and whatever merit any or all of them may possess as mechanical expedients, it is doubtful if any of them come within the province of practical engineering; at least they are here not so considered.

At this stage of the investigation of the subject, this question naturally presents itself: Why not eliminate from the problem one of the difficulties—the silting up of the inlet pipe—by locating the pumping machinery immediately upon the bank of the river, and dispensing with an inlet pipe all but an inconsiderable length, which could be kept clean by flushing, or which would keep clean by the action of the pumps, as is the case at the St. Louis pumping works? This plan is considered practicable upon the assumption that the unstable and ever-changing banks of the Mississippi can have stability imparted to them by artificial means, such as stone rip-rap. The question how far above and below the pump-


MAP OF THE
TAXING DISTRICT OF SHELBY COUNTY
SHOWING
CONSTRUCTION OF SEWERS
1885.
NEW SEWES
OLD
FLUSH TANKS
S.C. Toof & Co. Lith. Memphis Tenn.
MISSISSIPPI RIVER
WOLF RIVER
HIGH WATER OUTLET
LOW WATER OUTLET
TRANSFER FERRY
CUSTOM HOUSE
Court Square
(Prop'd) UNION DEPOT
MARKET SQ.
M&C SHOPS
M&C RR.
M&P RR.
M&L R RR.
MISSISSIPPI & TENNESSEE RR DEPOT
ST. AGNES ACADEMY
WINCHESTER CEMETERY
STORAGE CO.
BAYOU
GAYOSO
FOURTH
THIRD
SECOND
FRONT
MAIN
PROMENADE
CHICKASAW ST
AUCTION
CONCORD
OVERTON
JACKSON
WINCHESTER
MARKET
EXCHANGE
POPLAR
ADAMS
JEFFERSON
COURT
MADISON
MONROE
UNION
BEALE
LINDEN
VANCE
HERNANDO
PONTOTOC
DE SOTO
ST. MARTIN
MULBERRY
SHELBY
CLINTON
TENNESSEE
BUTLER
ELLIOT
CALHOUN
WEBSTER
GEORGIA
CLAY
LAUDERDALE
ORLEANS
WELLINGTON
TURLEY
MYRTLE
MANASSAS
CHAPIN AV.
MISSISSIPPI AV.
LA ROSE AVE
WRIGHT AVE
DAVIE AVE
CHELSEA
SEVENTH
SIXTH
FIFTH
EWING
MAXWELL
PEYTON AVE
N. WINCHESTER AVE
HILL ST
CARROLL AVE
CHARLESTON AVE
YATES
WASHINGTON
HIGH
POLK
ALABAMA
MOSEBY
ROBESON
JONES AVE
QUIMBY
RALEIGH ROAD
20" BRICK

ing station must the rip-rap protection extend then presents itself; which being satisfactorily answered, there is still another of no little importance to be answered, and that is the preservation of the pump mains through the alluvium between the pumping station and the bluff. This latter difficulty must ever be regarded as practically an insurmountable one by any means at the command of the city, from the fact that the main channel of the river has been (within the recollection of gentlemen now residing in Memphis) between the bluff and the line which forms the present river bank; and that this will be the case hereafter is not at all improbable, when it is remembered that opposite the southern terminus of the bluffs, upon the east bank of Hatchie Lake, the Mississippi is now only 1700 feet distant from said bluffs, and annually encroaching (reported at a rate of 100 yards per annum), whilst at the head of Hatchie Lake it is only 700 feet distant (see water-works map), Hatchie Lake having formerly evidently been the main channel of the Mississippi, and from present indications there are reasons to believe that it will again be its channel at a day not very far in the future. In such an event, the Mississippi would take a portion of the present channels of Loosa Hatchie and Wolf Rivers; and these streams, instead of discharging their waters through the common mouth opposite Commerce Street in the city, would debouch into the Mississippi at points respectively and approximately two and four miles above the present discharge. This would inevitably result in destroying at least a portion of the pump main, and leave the pumping works severed from the city in a condition which at this date baffles conjecture.

It is obvious, then, that any plan contemplating a supply of water from the Mississippi at this point must provide for the contingency which may arise from a partial or total destruction of, or rendering inoperative, its inlet conduit. It is, therefore, proposed to locate the pumping works at a point which, in the event of the inlet pipe from the Mississippi becoming obstructed from any cause, will permit a supply of water being drawn from Wolf River through an inlet especially provided for this purpose in the erection of the pumping works; and in case the Mississippi should hereafter assume its former course, this special inlet would then permit a supply being taken from it instead of from Wolf River.

For the mouth of the inlet, a point N. 24°, W. 5525 feet, or 1.046 miles from the center of Court Square, has been selected, being upon the present low-water margin of the Mississippi. From this point the inlet will extend N. 48° 30′, E. 3500 feet, through the alluvial deposits, and underneath Loosa Hatchie and Wolf Rivers, to the pumping station, located upon the bluff between the rolling-mill and cotton factory sites, being N. 3° 45′, E. 7475 feet, or 1.415 miles from the center of Court Square. The inlet pipe is to be a line of 48-inch cast-iron pipe; the individual pipes forming the line to be plain cast-iron cylinders, 48 inches inside diameter, 50½ inches outside diameter, 12 feet in length each, and to be jointed by means of cast-iron sleeves and lead packing; the sleeve joint in this place being preferred to the socket plan of joint, on account of the former rendering the pipe line more flexible.

The grade elevation for the top of the pipe has been fixed at 59 feet plus P. R., being one foot below what is reported, extreme low water, and 8¾ feet below the lowest water in 1867. To guard against irregular settling of the pipe line, it is proposed to lay it upon a timber foundation, prepared by forming a platform 8 feet wide, composed of twelve 8 by 8-inch timbers, laid side by side lengthwise with the pipe line, and fastened to each other by drift bolts; this platform to be built as the excavation for, and the laying of, the pipe progresses; upon the top of this platform, at intervals of five feet (making two to each pipe), are to be placed cross-timbers 8 by 8 inches and 8 feet long; these are to support the pipe and distribute the load. (See Details No. 11.)

At the mouth of the inlet pipe the river bank is to be graded, so as to make the slope of that portion of the bank which is *above* low water the same as the bed slope of the river *below* low water surface; to extend this up and down stream 250 feet each way from the inlet pipe, and cover the whole surface with rip-rap 2 feet in depth, commencing on the crest of the slope and extend it 300 feet into the river.

Upon this rip-rap as a support, the river-end or mouth of the inlet pipe is to be placed, terminating with a quarter circle curve extending down stream, the lower end of this curve to constitute the mouth of the inlet, to be enlarged to 6 feet in diameter, and be fitted with suitable strainer, to be attached in such a manner as to permit its being removed for cleaning and replaced after cleaning.

The inlet pipe is to be provided with two stop gates, one at the pumping station and the other near its mouth or river end; and at intervals of 100 feet throughout the entire line are to be placed T pipe, one end of which is to project vertically from the pipe, and be capped with suitable bonnets, containing each a manhole and cover; and surrounding and over each one of these T pipe there is to be built a well extending above high water in the Mississippi.

For the purpose of keeping the inlet pipe clear of deposits, it is proposed to connect it with the settling reservoirs, and, whenever found necessary, to flush it by sending a current of water back through it into the river, and thus keep it clean. In the event of this plan either failing or being neglected, it is then proposed to remove the deposit through the T pipe communications with the line by manual labor.

Against the closing up of the end of the inlet pipe by the formation of sand-bars there is of course no preventive; for the rapidity with which bars are reported to form will defy any effort on the part of the city of Memphis to prevent them. Should the changes in the current of the river cause the formation of a sand-bar in front and over the mouth of an inlet pipe in use for supplying the city with water, the supply must of course in such a contingency fail.

From the pumping station it is proposed to lay a second inlet pipe to Wolf River, for the reasons heretofore stated. The pipe is to be the same diameter, and laid in a similar manner through precisely the same material as the one to the Mississippi River; it will run due west from the pumping station 450 feet to Wolf River, and left in such condition as will enable it to be brought into service in case of accident to the one from the Mississippi.

Pumping Engines.—The pumping machinery is to consist of two Cornish pumping engines, each of sufficient capacity to elevate 250,000 gallons of water into the subsiding reservoirs and 250,000 gallons into the distributing reservoir per hour; each engine is to work two pumps, placed vertically one above the other, the plungers of which are to be suspended from the pump-end of the walking beam by one and the same connecting rod, so as to make the strokes of the two plungers simultaneous and of equal length. The lower pump is to take its supply from the pump well in the engine-house, which is fed directly from the Mississippi by the inlet-pipe, and is to deliver its water through the intervention of a stand pipe into the settling reservoir, whilst the upper pump is to draw its supply directly from the settling reservoirs by means of a supply pipe, and is to discharge its water also through a stand pipe into the pump and distributing main, and thence to the distributing reservoir. The lower of the two pumps is to be larger in diameter than the upper by a percentage which will compensate for the loss of water incidental to subsidence and filtration.

The stand pipe is to be a double standing column, *i. e.*, one inside of the other, with properly disposed branches and stop-gates for receiving and delivering the water in the manner designed; the annular space formed between the inner and outer pipe is to accommodate the lower pump, and the inner pipe the upper pump; the outer and inner pipe corresponding in elevation with the heights of the settling and distributing reservoirs respectively. This unusual design of pumps and stand pipes is proposed for the purpose of obviating the expense of two separate and distinct pumping works, which are ordinarily provided wherever the water has to be elevated, first for purification and afterward for distribution, which occurs wherever there are no elevations available possessing the requisite height to admit of building the subsiding reservoir, the filter-beds, and the distributing reservoir contiguously. This concentration of the pumping machinery at one pumping station admits of the whole being conveniently managed and supervised by one individual, greatly reduces the first cost, can be managed more economically, it promises in every way the most satisfactory results, and is confidently recommended as being preferable to the ordinary plan of two separate pumping stations.

SETTLING RESERVOIRS.—The settling reservoirs are located N. 8° 45′, E. 7,700 feet, or 1.458 miles from the center of Court Square, upon the high ground between the Big Creek Plank-road and the cotton factory; they are to be earthen embankment structures, comprising three equal and separate compartments, united by a combined influent and effluent chamber; the capacity of each compartment is 13,126,000 United States gallons.

The flow line, or water surface, when the reservoirs are full, is 146 feet plus P. R., and 5 8-10 feet below Court Square in the city; the capacity of the basins is formed by excavation and embankment, the material or earth for the latter being all found within the area of the site, and composed of clay containing a small percentage of sand. The earth excavated to form the lower part of the basins is to be carried into the embankments, which latter are to be built up in horizontal layers of uniform thickness. All the embankments are to have puddle-walls within the center of them, and are to be protected on the inside slopes with stone slope paving and on the outside with Bermuda grass. The ichnographical disposition of the compartments of these reservoirs forms two sides and one angle of a hollow square; this arrangement was induced by the topography of the site, and to enable the construction of an influent and effluent chamber, united with a pipe-vault, in the common center where the embankments of all the compartments unite. The design of this structure is such as will permit water from the Mississippi to be pumped into one compartment by the lower pumps; water to be drawn from another for supplying the upper pumps; whilst the third compartment, by means of the drain pipes, may be undergoing the process of cleaning; all passing simultaneously through one and the same structure. The three compartments of the reservoir can thus successively be brought, with the proper pipe arrangement, in communication with the inlet pipe for the purpose of flushing it; with the lower or upper pumps for receiving or supplying water; or with Wolf River for the purpose of disposing of the sediment accumulating from the water. (See Details Nos. 8 and 10.)

The three basins jointly are designed to furnish 6,000,000 gallons of clear water per twenty-four hours, by being used in the following manner: numbering the compartments 1, 2 and 3; then assuming that Nos. 1 and 2 are filled with water and No. 3 empty; and further, that the water in No. 1 has had time to become clear by subsidence, whilst that in No. 2 is undergoing subsidence; the pumping machinery is then started, delivering water from the Mississippi into compartment No. 3, and drawing it from No. 1 to deliver it in the city or distributing reservoir, until No 3 is full and No. 1 empty. By this time the water in compartment No. 2 has become clear or fit for distribution, and communication between the pumping machinery and compartments Nos. 2 and 1 being now established, the previous process will be repeated continually in maintaining a supply of water through the reservoirs. The settling reservoir and pumping machinery are relatively so located that in the event of its becoming necessary hereafter to filter the water in its passage between the two, all that is required is to construct the filter-beds, a site for which is especially left unoccupied.

PUMP MAIN.—From the stand pipe at the pumping station, through a line of 24-inch pipe, the water is to be delivered into the distributing reservoir. The line proposed for the pipe is as follows: Commencing at the stand pipe; thence southwardly to Bickford Street, 230 feet; thence eastwardly to the center of Second Street, 1055 feet; thence southwardly along Second Street to its intersection with Concord Street, 3515 feet; thence along Concord Street to its intersection with Third Street, 386 feet; thence along Third Street to its intersection with the Raleigh Road, 959 feet; thence the main and distributing pipes are to be the same as by the Wolf River plan.

HATCHIE LAKE PLAN.

So called because it contemplates locating the pumping machinery near Hatchie Lake.

The surveys and examinations made for this project were induced and completed in deference to the general belief that the Mississippi was the only suitable source from which water for the city could be obtained, and to ascertain whether or not an inlet conduit could here be constructed, subject to less danger and fewer contingencies than immediately above the city; also for the purpose of getting an accurate survey and map of the river above the city, so that hereafter any changes taking place upon the easterly bank of the Mississippi can be definitely determined. This is now practicable from Fort Pickering for nine miles due north from it, by the aid of the water-works map herewith presented.

By this plan it is proposed to take the water from the Mississippi at a point N. 18½°, W. 31,925 feet, or 6.046 miles from the center of Court Square, and thence conduct it north-eastwardly 1840 feet through the Mississippi bottom and underneath Hatchie Lake to the pumping station, to be located upon the easterly bank of Hatchie Lake. The banks and bottom land of the Mississippi at this point are the same as they are immediately above the city, with the exception of being covered with timber and dense undergrowth. The inlet conduit proposed for this locality is in every way similar to the one recommended for the Mississippi River plan, and is subject to the same dangers and contingencies as the latter, with the exception of its length, which, being less, it would be less expensive to remove deposits in the event of its having to be performed by manual labor.

Pumping Station.—The site selected for the pumping station is N. 15½°, W. 31,580 feet, or 5.981 miles from Court Square, upon the easterly shore of Hatchie Lake and at the southerly terminus of the third Chickasaw Bluff.

The design and construction of the machinery and buildings are in every way similar to those recommended for the pumping station near the cotton factory, with this exception: the machinery will have to be stronger, on account of the additional head due to the friction in 4.829 miles of pump main from the Hatchie Lake pumping station to where it meets the pump main from the pumping station of the Mississippi River plan, which additional head, with a velocity of three feet per second, equals forty-six feet.

Settling Reservoir.—The settling reservoirs are located in a valley, the sides of which form one-half of the retaining walls for the basins. They are N. 13° 25′, W. 33,000 feet, or 6¼ miles from Court Square.

Unlike the settling reservoirs near the cotton factory, it is proposed to construct these reservoirs in two compartments. The site favors this plan and permits the needed capacity for obtaining clear water more economically by the use of two compartments than by three, provided a number of years are considered.

The flow line or water surface of these reservoirs, when full, is 138 feet plus P. R., and $13\frac{8}{10}$ feet below Court Square in the city. The capacity of the basins is formed by three artificial embankments across the valley, the earth for the formation of which is to be taken from the side slopes forming the valley. The materials for and construction of embankments are similar to those for the reservoir proposed near the cotton factory.

The influent and effluent chamber for these reservoirs is to be similar in design and construction to that of the reservoirs proposed near the cotton factory.

The reservoirs are planned with a view to combining the process of filtration with subsidence whenever it may be desired. The united capacity of the basins is 144,000,000 gallons (see water-works map), which is large enough to furnish 9,000,000 gallons water daily.

Pump Main.—The pump main is to commence at the pumping station; thence in a southeasterly direction to the old

Randolph Road; thence along said road to its intersection with the Big Creek Plank-road; thence along the said plank-road to the intersection of Second and Bickford Streets in Chelsea, and thence to the city and the distributing reservoir by the same line as proposed in the Mississippi River plan.

The crossings at Loosa Hatchie and Wolf Rivers are to be made with inverted cast-iron syphons, supported on and secured to timber platforms sunk beneath the beds of the rivers.

SUMMARY OF ESTIMATED COST.

Inlet and river work	$191,862 66
Buildings at pumping station	230,135 20
Pumping machinery	260,000 00
Settling reservoir.	310,016 41
Pipe system	903,089 60
Distributing reservoir	349,009 10
	$2,244,112 97

SUMMARY OF THE ESTIMATED COST OF THE THREE DIFFERENT PLANS.

Branches of Work	Wolf River Plan	Miss. River Plan	Hatchie Lake Plan
Wolf River acqueduct	$933,332 51		
Inlet and river work		$342,231 78	$191,862 66
Buildings at pumping station	67,872 60	230,135 20	230,135 20
Pumping machinery	100,000 00	225,000 00	260,000 00
Settling reservoirs	373,327 90	280,533 00	310,016 41
Pipe system	505,886 60	483,339 60	903,089 60
Distributing reservoir	349,009 10	349,009 10	349,009 10
Totals	$2,329,428 71	$1,910,248 68	$2,244,112 97

Cost of Wolf River plan equals 1 22-100 times the cost of the Mississippi River plan.

CONCLUSION.

In deciding upon the plan to recommend for adoption, the following comparisons between the different plans have been instituted:

First. The quality of the water.

Second. The facility with which the works, according to any of the plans, can be, from time to time, enlarged or extended to meet the growth of the city.

Third. The economy with which any of the works planned can be maintained and managed annually, in measures of annual interest upon cost, and of supervision, labor, repairs, fuel, and wear and tear.

Fourth. The first cost of works according to the respective plans.

With reference to the quality of the water, nearly all that is deemed necessary has been said in the forepart of this report. It is, however, proper to add that the water in the Mississippi will never be any purer than it is found at present; but on the contrary, the tendency is, with the settlement of the country, the growth of present and future cities upon its banks and upon those of its tributaries, the drainage and filth from all of which will be carried by it to the Gulf of Mexico, to continually render more and more impure its water; whereas, the supply proposed from Wolf River is at present pure to a degree eminently satisfactory, and is beyond the reach of any existing cause threatening to defile or render impure the water. The supply is proposed to be taken within fifty or sixty miles of the extreme limits of the catchment basin discharging its rain-falls through Wolf River, so that by the time future population in the counties or towns along its banks will cause the water to become impure, the population and wealth of Memphis will make it practicable pecuniarily to extend the aqueduct to the head-waters of Wolf River, and be supplied from reservoirs receiving their water from small streams and gathering grounds so limited as to enable the preservation of their waters at almost rain-water purity.

This view of the subject may seem to look further toward providing for the future wants of Memphis than is at present necessary; but it is justified by the fact that all the natural water-courses in every country become more and more impure with the increase of population, and less suitable for distribution in densely populated cities; and the best practice of hydraulic engineering in its application to public water supplies, is to collect and store the water as near as practicable to the gathering grounds upon which it falls in the shape of snow and rain, and thence convey it artificially to the place of distribution. The truthfulness of this is illustrated by the following named examples of water supplies to towns and cities in the United States, where the water is collected and stored in reservoirs near the limits of the drainage areas supplying them, viz.: the Boston and Charlestown water supplies in Massachusetts; the Albany, Croton and Brooklyn water supplies in New York; and the Hartford, Ct., and Baltimore, Md., water supplies. The last two of these have changed within the last few years from taking their daily supplies from natural water-courses to storage reservoirs approaching the limits of the drainage areas supplying them with water. The Loch Katrine scheme, supplying the city of Glasgow; the Rivingtown Pike scheme, supplying Liverpool; the Birmingham water supply; and the contemplated change in the mode of supplying the city of London with water, are cases in point, and demonstrate the justice and propriety of this view of the subject.

As to the facility with which the respective plans can be developed and extended to meet the growth of the city, there is not much difference between the Wolf River and Hatchie Lake plans. The Mississippi River plan, on account of the restricted area suitable and available for settling reservoirs and filter-beds, and because of the fact that these latter will soon be within a built-up portion of the city, this plan is less adapted for extension than the other plans, which are not subject to restricted areas suitable and available for this purpose.

In economy of annual management there is considerable difference; the Wolf River plan being first in economy, the Mississippi River plan second, and the Hatchie Lake plan third.

The difference in the cost of carrying on works built according to the respective plans arises principally in the pumping department. The pumping machinery taking a supply from the Mississippi River must be constructed to adapt itself to a variation of the water level in the pump wells of 40 feet, the extreme variation in the stages of the river. This requires costly foundations, and the machinery requires to be more massive on account of having to elevate the water on an average 50 fifty feet higher than from the settling reservoirs of the Wolf River plan; also because the water from the Mississippi River will have to be elevated twice—first for purification, and second for distribution.

This difference of cost in the pumping departments of the respective plans resolves itself into interest upon the difference of capital invested in the pumping stations; difference of annual repairs; difference in attendance, labor, fuel, oil, etc., at the pumping stations; difference in the annual cost of removing the sediment left by the respective waters in the settling reservoirs, and the cost of elevating water for flushing the inlet pipes, which are approximately estimated as follows, based upon a daily consumption of 6,000,000 gallons:

	Wolf River	Miss. River	Hatchie Lake
Annual interest upon cost of pumping stations at 10 per cent.........	$16,787 26	$45,513 52	$49,013 52
Annual repairs 2½ per cent. of cost...	419 68	1,137 84	1,225 34
*Cost of elevating 6,000,000 gallons of water daily per annum........	29,700 00	43,772 83	57,081 60
Cost of removing sediment......... ...	765 00	4,602 00	4,602 00
Cost of elevating water for flushing...	....	500 00	500 00
Annual interest upon cost of remainder of works at 10 per cent.	216,155 61	146,511 35	175,397 78
Total an'al cost for maintaining works	$263,827 55	$242,037 54	$287,820 24

* In estimating the annual expenses in this branch of the projected works, the average cost for elevating water was determined from the data in Table No. 3, page 31 of this report.

From this comparison of the costs for maintaining works projected according to the respective plans, it appears that the Wolf River plan, although greatest in first cost, in the aggregate for maintaining it, it exceeds the Mississippi River plan only $22,000 annually, and in the pumping department it is much more economical. If to this difference in cost for maintaining the respective works the engineering difficulties in executing and preserving the inlet conduits of the plans contemplating a supply from the Mississippi, and the probability of having to clean these conduits frequently by manual labor, are added, the result, in a pecuniary point of view, is in favor of the Wolf River plan. Were this not the fact, however, the present and prospective difference in the quality of the respctive waters would alone constrain the recommendation of the Wolf River plan ; and it is recommended as being in every way the best for the city of Memphis.

Should the Mississippi River plan be deemed the best and be adopted, it is deemed proper to add here that before commencing the work examination by deep borings should be made, to ascertain whether a stratum of clay underlies the Mississippi River at this point, in which a work similar to the Chicago Lake Tunnel could be executed. If a stratum of clay were found, and a tunnel executed in it, such a work would be less liable to destruction than the inlet pipes, and would perhaps prove less costly; but would be more difficult to keep free from sediment either by flushing or by manual labor.

Contracts for borings to determine the practicability of this project were made with several parties, but owing to the want of suitable fixtures and experience in this business the work was never performed.

SEWERAGE.

The great diversity of opinion prevailing among eminent engineers, particularly among those who have made this branch of engineering a specialty, as to what constitutes a proper or the best system of drainage in given cases, must naturally cause considerable hesitancy before presenting a plan for artificially draining a city, the natural drainage of which is subject to such great variations and has become as objectionable as that of the city of Memphis.

Any attempt at a system of drainage is always an effort to modify, improve, or supersede the natural drainage of the district to which it is proposed to apply it to such an extent as will, for the time being, subserve the wants or necessities of the people inhabiting the district. To what extent any system of drainage should be a modification, an improvement, or a supersedure of the natural drainage, must of course be determined separately for each individual case. The expression *natural drainage* is here used in the following sense, viz.: the flowing off from the surface of a given district of urban and suburban territory by water carriage, available in natural streams of running water and occasional rain-falls flowing to these streams upon natural lines of outfall, a moderate portion of the constantly accumulating detritus, vegetable and animal matter, the refuse incident to population, and all cast-off matter whose specific gravity makes it practicable to rivers, lakes, bays, harbors, etc., where its offensiveness is mitigated by being mingled with large volumes of purer water. Hence it is manifest that as the topography, area, natural streams of running water, rain-fall, and population which obtain in different districts or cities vary, so should the system of drainage applied to them vary in the extent to which they are modifications, improvements, or supersedures of the natural drainage. The correctness of this principle is demonstrated in practice, inasmuch as the best existing systems of artificial drainage give evidence of having arrived at whatever degree of perfection they now possess by passing successively through the stages of modification, improvement, and at least partial supersedure of the originally existing natural drainage. In some of the most densely populated cities the only traces visible of the existence of a former natural drainage are the lines of the main outfalls, which, to a greater or less degree, coincide with the natural lines of rain-water outfalls. Therefore, it is evident that the tendency of all systems of artificial drainage is inevitably in the direction of the total supersedure of the *natural drainage*, in the sense in which the expression is here used; and whenever the design of a system of artificial drainage aims at or its development approaches a supersedure of the natural drainage, it has applied to it the distinctive term of sewerage or system of sewers.

As the topography of the sites of cities varies from almost unbroken plains to hills and valleys, so is the village or town population which forms the nucleus of the future city compelled to modify the natural drainage, in dedicating the land to public and private uses, by dividing it into lots, lanes, avenues, streets, and alleys. In this artificial division of the land, the controlling element is economy and the custom of endeavoring to make the figures of the lots, lanes, avenues, streets, or alleys similar to regular geometrical figures, which plan is generally applicable to limited areas only. This results in fixing the general direction of streets, etc., favorably to a limited area without reference to drainage or the future extension of the plan over the adjoining land, and when additions to the town are made, it is found pecuniarily impracticable to extend the plan first adopted. The additions are, therefore, laid out upon new plans, swung, as it were, from the salient hinging points of the original plan, and the ultimate plan of the city is systemless, in so far as it is applicable to an economical plan of sewerage. In the modifications of the natural drainage, by diverting the rain-fall from the roofs of the buildings and the lots into the lanes, streets, and alleys, and thence to the main lines of rain-water outfall or streams of running water, many of the smaller original lines of outfall are ignored and the water from rain-storms concentrated upon lines along which the water-way is inadequate, or along which the improvements will not permit the storm-waters to be discharged on the surface. Consequently, improvements in these main channels are required, which consist generally of underground masonry conduits for the disposal of storm-waters, and constitute the beginning of what is now termed sewerage. At this period in the city's growth or development, sanitary considerations render imperative the removal of fecal matter by other means than the ordinary privy or dry well system, which latter process so completely saturates the subsoil of a city with human excreta as to be productive of alarming evils. The original purity of running streams and spring and well-water is destroyed; and the joint or complicated questions of removing storm-water, fecal matter, house slops, and the refuse from manufactories, as well as the preventing of natural streams of water from becoming poisoned with these substances, are before the municipal government. At this juncture the problem is generally referred to scientific men for solution. The English solution of it thus far, as developed in their general systems of town drainage, and described in general terms, has been to construct underground, generally along the center lines of lanes, avenues, streets, and alleys traversing the districts to be relieved, conduits of stone or brick masonry; or lay stone-ware pipes, holding such relations to the areas to be drained and to one another in the elements of diameter and inclination as to form a regular system. Into these all excrement, house slops, refuse from manufactories, and all cast-off matter which can be floated, are conducted by means of house or branch drains and street gulleys, and by the aid of an ample public water supply and occasional rain-falls, through these conduits into natural water-courses, to be diluted so far as to be inoffensive. This manner of disposing of city sewerage is called the *water-carriage* system. It is, with some exceptions, the general practice in England; and, so far as sewerage works have been designed and constructed in the United States, the universal practice.

The mixing of fecal matter with water, and disposing of it through the sewers, was originally an incident to the London sewerage,* but has since become an important integral part of this as well as of other systems of sewerage. It finds, however, little favor in the cities on the continent of Europe, and is obliged to encounter much opposition from some of the ablest scientists and engineers in England. It is condemned on account of polluting the natural water-courses and depriving agriculture of a valuable fertilizer. The interest in agriculture increasing with population, and the progress in science, unmistakably indicate the ultimate abandonment of mixing human excrement with town sewage, and will sooner or later compel its general utilization in agriculture.

Thus the fact is evolved, that originally sewers were designed to carry off rain-water only, to which the contents of surcharged cess-pools (dry wells† in the United States) were in time added; and ultimately the refuse waters from dwellings and manufactories, as well as the contents of water-closets, which superseded privies, were discharged by direct and special branches into the sewers. At the present day, in densely populated cities, where ample public water supplies make the water-carriage system practicable without the aid of rain-water, the question of separating the sewage from the rain-water‡ is being discussed. Able and experienced engineers advocate the adoption of separate systems of drain-

* Mr. Bazalgette, in a paper read before the Institute of Civil Engineers, March 14, 1865, gives the following statistics, page 28: "Up to the year 1815 it was penal to discharge sewage or other offensive matter into the sewers; cess-pools were regarded as the proper receptacles for house drainage, and sewers as the legitimate channels for carrying off the surface waters only. Afterward it became permissive, and in the year 1847 the first act was obtained, making it compulsory to drain houses into sewers.

"As the population of London increased, the subsoil became thickly studded with cess-pools, improved household appliances were introduced, overflow drains from the cess-pools to the sewers were constructed; thus the sewers became polluted, and covered brick channels were necessarily substituted for existing open streams."

† What are termed dry wells in the United States differ from the London cess-pools in this particular: they consist of excavated pits in the subsoil, sustained by *pervious* masonry lining, and are not intended to be cleaned out until the surrounding earth fails to absorb their contents; while the London cess-pools were constructed with *impervious* masonry linings, and were designed to be cleaned out at proper intervals.

‡ See Mr. Bazalgette's paper before referred to, page 34: "Is the rainfall to be mixed with the sewage; in what manner and quantities does it flow into the sewers; and is it also to be carried off in the intercepting sewers; or how is it to be provided for?"

age for one and the same city; that is, one system for rain-water and the other for sewage. The transportation of sewage, at first the incidental function of artificial systems of drainage for towns, eventually, with the increase of population, seems to have become the principal function, and evidences that thus far most of the existing systems of artificial drainage, if long periods of time are considered, are resultants between expediency measures and scientific application of mechanical devices, combined with the technical knowledge evolved by experience in this branch of engineering. Without deeming it necessary at this point to advert to the general development of the various plans now under trial for meeting the wants of densely populated cities in this particular, and which are the subject of much earnest discussion in the scientific and engineer's societies and journals of the day, we will endeavor to devise the best application of the *water-carriage* system practicable in the present case, not ignoring, however, the value of a portion of the sewage as a fertilizer, nor the pollution of natural water-courses with sewage as being a great evil. The fact that here the land for agricultural purposes is too cheap, abundant and fertile, and the scope of agriculture too limited, to permit the expensive application of fecal matter as manure; that the further pollution of the Mississippi by the addition of the sewage from another city is a contingency altogether too remote for serious consideration; and that the *water-carriage* system is the only plan that has hitherto promptly relieved densely populated districts of a serious evil, constitute the principal reasons for deciding upon its application. It is but following natural examples, inasmuch as it is the order of nature to constantly refresh, wash, and drain the surface of the earth with pure rain-water, which, after the consummation of its many offices, is discharged through the natural water-courses, filled with impurities which it is destined to deposit in the ocean, from whence the water is again evaporated and returns to the earth in the shape of rain.

In the case before us, the drainage of the city of Memphis, there is an area of 5,033 acres, one-fifth of which may be considered urban and four-fifths suburban territory, for which a system of drainage is to be devised. The surface of this territory is undulating, varying in elevation from 75 feet plus P. R., the lowest point in the discharge of its rainfall through the main natural outfall, to 210 feet plus P. R., its highest point along the ridge forming the boundary of the water-shed or area to be drained. The greatest length of this district north and south is 22,000 feet, and its greatest width from east to west is 18,500 feet. The main channels through which the rain-falls are now discharged are Bayou Gayoso, Bayou Quimby, and Bayou De Soto, with their minor branches. All the main channels extend from the dividing ridge north-westerly in an opposite direction to the course of the Mississippi, and unite in one main channel at Concord Street; thence north-westerly to Wolf River. They serve for rain-water discharges principally, and during the longest droughts they become, it is reported, entirely dry; they were nearly dry in 1867. Ordinarily they discharge a small quantity of sipe and some spring-water, and are the receptacles of the entire drainage of the city. They are, as may be expected, offensive during the greater portion of the summer, and are annually becoming more so. In Bayou Gayoso the backwater from the Mississippi at its highest stage extends from its mouth at Wolf River up to Gayoso Street, and in Bayou Quimby from its junction with Bayou Gayoso up to Boundary Avenue—a distance of 9,650 feet in the former, and 6,300 feet in the latter, measured along their meanderings. The average annual length of time during which the backwater from the Mississippi fills Bayou Gayoso as far as Concord Street to a depth of 6 feet is 130 days,* as determined from the stages of the river recorded in General Humphrey's report. In 1867 it was 180 days. The inclinations of the beds of the bayous, measured upon their meanderings, are 0.0024444 for Bayou Gayoso, and 0.0025555 for Bayou Quimby. The total length of Bayou Gayoso, from Wolf River to its head, is 5 52-100 miles, with an inclination of 0.0056 to Gayoso Street, thence as above stated; the length of Bayou Quimby from its junction with

* In 1849, 116 days; in 1850, 139 days; in 1858, 130; in 1859, 135. Average 130.

Bayou Gayoso to its head is 4 41-100 miles, with an inclination of 0.00704 to Boundary Avenue. Bayou De Soto, from its junction with Bayou Gayoso to its head, is 2 84-100 miles, with an inclination of 0.007266. (See water-works map.)

These are the average inclinations of the respective bayous, rated by their lengths, measured upon the lines of their meanderings, and they afford a prompt and efficient natural drainage for the rain, spring, and sipe-water from all portions of the area above named, except those portions subject to backwater from the Mississippi. Excepting the pond of stagnant water south of Beale Street, between Main and Shelby Streets, which is caused by artificial obstructions to the natural drainage, there is not an acre of ground in the city which is not perfectly drained whenever the Mississippi is down to within 18 feet of low water. But despite this efficient and harmless removal of the rain-falls during part of the year, this system of drainage does no longer meet the wants of Memphis, for the reason that with the present population, the great quantity of vegetable and animal matter which finds its way into the bayous while full of backwater from the Mississippi, is gradually deposited upon the borders as the water recedes, and being thus exposed to the action of the atmosphere which, with the hot sun, produces rapid decomposition, becomes annually a fruitful source of sickness.

During the summer season, when there is little or no water in the bayous, the excrementitious matter, which, with other refuses, finds its way into them, there being no current of water to remove it, is collected in stagnant pools, reeking with deathly vapors. In addition to all this, the numerous privies in the city, all built in a perfectly retentive subsoil, during the summer season disseminate their poison among the population day and night, and call loudly for abolishment and sanitary reform.

The improvements needed in the drainage of Memphis, then, seem to divide themselves into two departments, viz.: the purification of the bayous, and the providing of expedients for the removal of house drainage and fecal matter. The plan which naturally presents itself first for accomplishing these objects, is to unite the two into one improvement by converting the different bayous into arched masonry conduits, and make them the main outfall sewers for the discharge of all sewage and water from rain-storms jointly; at the same time filling up with earth those meandering portions of the bayous which can not be occupied by the sewers.

In the consideration of this plan, the first question to be solved is the size of the sewers; to determine which three elements are indispensable: the areas to be drained, the inclination of the sewers, and the maximum quantity of sewage and rain-water discharged in a given time from said areas. The first two of these elements only are known; the latter remains to be determined, and is composed, in cities enjoying a public water supply, in connection with a general use of water-closets, of the refuse water after having subserved the uses of the population holding in suspension its excrement, and the rain-fall *discharge*. The former is found, in densely populated cities, to vary but inappreciably from the water supply in bulk; one-half of which, according to observations on the London sewers, finds its way to the sewer in six hours, and the other half in the eighteen remaining hours out of the twenty-four. Then, taking the water supply at 60 gallons or 8.0214 cubic feet per twenty-four hours *per capita*, and the resulting sewage as the same in bulk, one-half of which being discharged in six hours, and rating the ultimate population at seventy-eight persons to the acre, equivalent to fifty thousand per square mile, there will result 0.0144 cubic feet as the sewage per acre per second (equivalent to a rainfall 0.0143 inches in depth per hour), rated according to population and water supply, to which the maximum discharge from rain-storms is to be added.

This latter quantity depends upon the depth of rain falling in a given time, and the condition of the surface upon which it falls, whether dry, wet, frozen, paved, built over, or cultivated; modified by the declivity of the slopes along which the discharge takes place. For the territory under consideration, the determination of this quantity is at present an impossibility; first, because the proportion between the paved, built-over, and cultivated areas is continually varying; second, because maximum rain-falls take place only at long intervals of time; third, because maximum rain-falls, under conditions favorable to a maximum surface discharge, take place at still longer intervals of time; and fourth, because a great number of observations, under the named conditions, would be necessary to establish reliably the maximum rain-water discharge for this locality.* It would require a much longer

* See Mr. Bazalgette's paper on the London Main Drainage, page —: "Careful observations of the quantity of rain falling on the metropolis, within short periods of time, have been made by the author for many years. Taking an average of several years, it has been ascertained that there are about one hundred and fifty-five days per annum upon which rain falls; of these there are only about twenty-five upon which the quantity amounts to $\frac{1}{4}$ of an inch in depth in twenty-four hours, or the $\frac{1}{100}$ part of an inch per hour if spread over an entire day. Of such rain-falls a large portion is evaporated or absorbed, and either does not pass through the sewers, or does not reach them until long after the rain has ceased. In the report of Messrs. Bidder and Hawksley and the author, in 1858, on this subject, it is stated that continuous observations, and, as far as practicable, protected from disturbing influences, had been taken at the close of the preceding year, and that these observations, which are recorded in the Appendix to the above Report, had enabled them to arrive at some reliable conclusions, and that 'the results of these observations distinctly established the fact that the quantity of rain which flowed off by the sewers was, in all cases, much less than the quantity which fell on the ground; and although the variations of atmospheric phenomena are far too great to allow any philosophical proportions to be established between the rain-fall and the sewer-flow, yet we feel warranted in concluding, as a rule of averages, that $\frac{1}{4}$ of an inch of rain-fall will not contribute more than $\frac{1}{8}$ of an inch to the sewers, nor a fall of $\frac{4}{10}$ of an inch more than $\frac{1}{4}$ of an inch. Indeed, we have recently observed rain-falls of very sensible amounts failing to contribute any distinguishable quantity to the sewers.' But there are in almost every year exceptional cases of heavy and violent rain-storms, and these have measured 1 inch and sometimes even 2 inches in an hour.

"The observations of Mr. Bidder and Mr. Hawksley, in 1857, upon the Savoy Street sewer, showed that of a rain-fall of 2.90 inches in twenty-six hours, only 64½ per cent. was delivered into the sewers, all the rest being absorbed or evaporated. In the Radcliffe Highway sewer they found on the same occasion (which was an unusual rain-fall, it having rained, he believes, for twenty-six hours, without ceasing) that 52 per cent. of the total quantity only was discharged into the sewers. It so happened that, without any co-operation with the gentlemen named, he was at the same time engaged in gauging the flow of the London Bridge sewer, which drained 2250 acres, partly urban and partly suburban; it was necessary that this should be known, as the character of the surface much affected the quantity delivered into sewers in time of storms. Now, with the same rain-fall, or rather a fall of 2.75 inches instead of 2.90 inches, being the amount recorded by period of time than can be devoted to the present examination.

For the only record of rain-gauge observations made at Memphis, that could be found, we are indebted to Dr. R. W. Mitchell, who kindly furnished his rain-gauge observations, which are tabulated below. They are serviceable as a guide, but extend over too limited a period of time to be made the basis of proportioning works which are to meet the requirements of the city for the future.

RECORD OF RAIN-FALL OBSERVATIONS MADE BY DR. R. W. MITCHELL, MEMPHIS, TENNESSEE.

Month	1857	1858	1859	1860
January	....	4.91 inches	4.05 inches	7.20 inches
February	....	3.25 inches	7.10 inches	5.46 inches
March	....	4.75 inches	6.41 inches	1.00 inches
April	....	3.15 inches	6.40 inches	3.62 inches
May	....	7.56 inches	†4.03 inches	0.50 inches
June	....	5.00 inches	†5.30 inches	5.60 inches
July	....	9.64 inches	1.75 inches	*2.27 inches
August	....	3.37 inches	4.48 inches	1.09 inches
September	....	1.40 inches	4.76 inches	2.95 inches
October	1.47 inches	1.92 inches	1.48 inches	3.52 inches
November	4.82 inches	3.14 inches	3.77 inches	4.15 inches
December	4.91 inches	5.46 inches	3.47 inches	†4.61 inches
Total	11.20 inches	53.55 inches	53.00 inches	41.97 inches

* Of this quantity two inches is reported to have fallen, during an interval of one hour, on the 30th of the month.

† Interpolated.

From the extracts given from Mr. Bazalgette's paper, it appears that in the case of the London sewers, so far as observations have been made, the augmentation of sewage flow attributable to rain-storms varies from an imperceptible quan-

Mr. Glaisher on the occasion referred to, he found that in the London Bridge sewer 53 per cent. of the total quantity only ran off. On one occasion, in April, 1858, he had gaugings taken of the same sewer, when 0.24 of an inch of rain fell in an hour and a half; he there found that 74 per cent. of the total quantity ran off, leaving 26 per cent. absorbed and evaporated. Of a rain-storm of 0.54 of an inch in five hours, in June, 1858, there was delivered into the Irongate sewer, which drains an area entirely paved and built over, as much as 94½ per cent. of the total rain-fall, and that, of all the storm gaugings he had made was the greatest percentage of rain-fall he ever knew to be discharged by a sewer. In August, 1858, with a rain-fall of 0.48 of an inch in one hour and two-thirds, he found only 78 per cent. of the total quantity discharged into the Irongate sewer."

tity to 94½ per cent. of the total rainfall; but these results are only applicable to the cases for which the observations were made, and can by no means be made generally applicable in determining the sizes of main sewers.

Therefore, for the sake of determining the practicability of the plan under consideration, it is assumed that the maximum flow in the main sewers, which can result in extreme cases from rain-storms and ordinary sewage jointly, is equal to a discharge of two inches of rain per hour. Then, with the areas to be drained and the inclinations practicable, there would be required as main outfall sewers the lines and sizes given in the following table, which also includes the sizes required to carry off sewage equal in bulk to one inch and one-half inch rain-water per hour, respectively.

TABLE No. 5.

Areas drained (Acres)	Length of Sewer (Feet)	Grade elevation on invert plus P. R.	Inclination	In	From	Diameters of Sewers discharging Sewage equal in volume to: Two inches rain per hour (Feet)	One inch rain per hour (Feet)	One-half inch rain per hour (Feet)
5,033	9,380	75.2	.00244	Bayou Gayoso...	Wolf River to..................	31.1	23.6	18.0
4,767		84.0		Bayou Gayoso...	Bayou Quimby.	30.5	23.0	17.4
3,522		84.0		Bayou Gayoso...	Bayou Quimby to...............	27.0	20.5	15.5
3,259		92.1		Bayou Gayoso...	Adams Street to.................	26.2	20.0	15.0
2,922		98.4		Bayou Gayoso...	20 feet N. of Gayoso St.......	25.0	19.0	14.4
1,792	716	98.4	.00244	Bayou Gayoso...	20 feet N. of Gayoso St. to...	20.6	15.6	11.8
		100.1		Bayou Gayoso...	Gayoso Street Bridge..........	20.6	15.6	11.8
1,792	3,050	100.1	.00335	Bayou Gayoso..	Gayoso Street Bridge to.......	19.3	14.6	11.0
		110.2		Bayou Gayoso...	Elliott Street.................	19.3	14.6	11.0
1,039	550	110.2	.00782	Bayou Gayoso...	Elliott Street to..................	13.1	9.9	7.5
		114.5		Bayou Gayoso...	South Street (West)............	13.1	9.9	7.5
603	712	110.2	.0045	Bayou Gayoso...	Elliott Street to	11.8	8.9	6.7
		113.4		Bayou Gayoso...	South Street (East)............	11.8	8.9	6.7
1,130	2,966	98.4	.005	Bayou De Soto..	20 feet N. of Gayoso St. to...	13.0	10.0	7.5
		113.2		Bayou De Soto..	Wellington Street...............	13.0	10.0	7.5
302	1,500	99.8	.01	Lit. Betty Bayou	Bayou Desoto at Gayoso St. to	7.6	5.8	4.4
		114.8		Lit. Betty Bayou	Lauderdale Street...............	7.6	5.8	4.4
1,245	3,380	84.0	.0045	Bayou Quimby.	Bayou Gayoso to.............. ...	16.0	12.0	9.0
		99.2		Bayou Quimby.	Boundary Avenue...............	16.0	12.0	9.0

SUMMARY OF ESTIMATED COST.

	Two inches Rain	One inch Rain	One-half inch Rain
Bayou Gayoso from Wolf River to South Street..........................	$1,953,507 77	$1,295,373 86	$1,000,071 44
Bayou DeSoto from Bayou Gayoso to Wellington Street................	104,859 54	68,300 98	54,759 60
Little Betty Bayou from Bayou De-Soto to Lauderdale Street.........	25,741 59	14,899 11	12,151 98
Bayou Quimby from Bayou Gayoso to Boundary Avenue................	172,561 84	106,031 97	63,591 17
	$2,256,670 74	$1,484,605 92	$1,130,574 19

The estimates for this plan include the filling up of the main channel of Bayou Gayoso so far as it is filled with back-water from the Mississippi, and those portions of Bayou Quimby where its channel and the proposed sewer coincide, but in neither case the adjacent private lots.

This plan could be modified so as to have two main outfall sewers, both discharging their contents into the Mississippi instead of Wolf River, and the cost of it considerably reduced. Taking the center line of Adams Street as a dividing line, the territory lying north of it could be drained by one sewer, commencing near the intersection of Bayou Quimby and Boundary Avenue; thence westwardly through the valley of Bayou Quimby to the intersection of the center line of Concord Street produced, with Bayou Gayoso; thence westwardly along the center line of Concord Street, produced to a point in the old Navy Yard, 400 feet west of the east line of Chickasaw Street; thence upon a curve to left of 500 feet radius, 340 feet to a tangent; thence south-westerly upon said tangent to the Mississippi River.

The territory south of Adams Street could be drained by the sewers in the different bayous all uniting in one outfall leading into the Mississippi. The best route for this main outfall sewer is Gayoso Street, which has been selected, and in which, at its intersection with Bayou Gayoso, all the principal sewers south of Adams Street are to unite; thence through Gayoso Street, partly by an open cut and partly by tunneling, the main outfall sewer is to lead to the Mississippi.

With this subdivision of the areas to be drained, and the inclinations available, the lines of the main sewers required are given in the following table, with the diameters requisite for discharging sewage, equal in bulk to two inches, one inch, and one-half inch rain respectively per hour.

TABLE No. 6.

Areas Drained	Length of Sewers	Grade Elevation on Invert	Inclination	In	From	Diameters of Sewers dis-ch'rging Sewage equal in volume to		
						2 in. rain per hour	1 in. rain per hour	½ in. rain per hour
Acres	Feet	plus P.R.				Ft.	Ft.	Ft.
1,774	150	60.0	0.0747	Old Navy Yard	Mississippi River to.................. *	103	*7.8	*5.9
		71.4		"	150 ft. north-east of same.......... *	103	*7.8	*5.9
1,774	1,300	71.4	0.0082	"	150 ft. north-east of Mississippi to	160	12.2	9.25
		82.3		"	End of curve...............................	160	12.2	9.25
1,508	1,985	83.3	.00076	"	End of curve to...........................	243	18.4	14.0
		84.8		Concord Street.	Bayou Gayoso...............................	243	18.4	14.0
1,248	3,380	84.8	0.0045	Bayou Quimby.	Bayou Gayoso to..........................	160	12.0	9.0
		100.0		"	Boundary Avenue.........................	160	12.0	9.0
132	3,125	84.8	.00244	Bayou Gayoso...	70 ft. north of Adams Street to.....	72	5.5	4.2
		92.4		"	Bayou Quimby.............................	72	5.5	4.2
2,922	100	60.0	.01140	Gayoso Street...	Mississippi River to................. *	116	*8.8	*6.7
		71.4		"	700 ft. w. of e. line of Front St... *	116	*8.8	*6.7
2,922	200	71.4	0.0874	"	700 ft. w. of e. line of Front St. to...	198	14.7	11.1
		94.7		"	500 ft. w. of e. line of Front St......	198	14.7	11.1
2,922	1,400	94.7	0.0038	" tu'nel	500 ft. w. of e. line of Front St to..	230	17.4	13.2
		98.1		"	900 ft. e. of e. line of Front St......	230	17.4	13.2
2,922	500	98.1	0.0038	"	900 ft. e. of e. line of Front St. to.	230	17.4	13.2
		100.0		"	Bayou Gayoso..............................	230	17.4	13.2
1,130	900	100.0	0.0038	"	Bayou Gayoso to..........................	157	12.0	9.0
		103.4		"	Bayou DeSoto..............................	157	12.0	9.0
77	2,640	107.8	.00244	Bayou Gayoso...	70 ft. north of Adams St. to.........	58	4.4	3.4
		101.4		"	Gayoso Street..............................	58	4.4	3.4
1,792	3,050	100.0	.00335	"	Gayoso Street to..........................	193	14.6	11.0
		110.2		"	Elliott Street................................	193	14.6	11.0
1,039	550	110.2	.00782	"	Elliott Street to...........................	131	9.9	7.5
		114.5		"	South Street (west)......................	131	9.9	7.5
603	712	110.2	0.0045	"	Elliott Street to	118	8.9	6.7
		113.4		"	South Street (east)	118	8.9	6.7
1,130	2,690	103.4	0.2050	Bayou DeSoto...	Gayoso Street to..........................	140	10.5	8.0
		113.2		"	Wellington Street.........................	140	10.5	8.0
302	1,500	103.4	.00772	Lit. Bet. Bayou	Gayoso St. at Bayou DeSoto to.....	80	6.0	4.6
		115.0		"	Lauderdale Street.........................	80	6.0	4.6

* Or its equivalent in lines of cast-iron pipe with flexible joints.

SUMMARY OF ESTIMATED COST.

In	From	2 in. Rain	1 in. Rain	½ in. Rain
Concord Street.........	Mississippi to Bayou Gayoso......	$298,347 50	$203,334 01	$131,237 97
Bayou Quimby.........	Bayou Gayoso to Boundary Ave.	172,655 34	106,125 47	63,684 67
Bayou Gayoso.........	Adams Street to Concord Street.	96,110 08	75,820 36	72,150 76
Gayoso Street..........	Misssissippi to Bayou DeSoto	367,589 31	261,141 70	160,295 14
Bayou Gayoso.........	Adams Street to Gayoso Street...	40,658 75	36,651 45	32,904 19
Bayou Gayoso.........	Gayoso Street to South Street.....	226,870 44	147,174 61	98,149 64
Bayou DeSoto.........	Gayoso Street to Wellington St...	99,279 84	62,678 44	50,713 13
Little Betty Bayou...	Bayou DeSoto to Lauderdale St.	25,895 60	14,443 00	11,897 66
Bayou Fill from Con	cord Street to Wolf River...........	180,248 64	180,248 64	180,248 64
		$1,507,655 50	$1,087,617 68	$801,181 80

This latter plan is the preferable one, both on account of its being cheaper and because it provides for discharging all the sewage into the Mississippi instead of Wolf River. By discharging directly into the Mississippi, the sewage would be carried away as soon as it reached the river, and not become offensive; whereas, if it was discharged into Wolf River, it would, at certain seasons of the year, become very objectionable.

The branch sewers for Plan No. 2 are designed to be capable of discharging sewage equal in volume to one-half inch rain per hour. This is considered ample capacity, particularly with the great inclinations of the street grades toward the bayous, by means of which any excess of storm-water not passing through the sewers can harmlessly flow off on the surface. With the inclinations available, and the areas which they are to drain, none larger than 2 feet in diameter are required, which size it is proposed to build of brick 4½ inches or one ring in thickness. Wherever smaller sizes will answer it is proposed to use stone-ware pipe.

All along the lines of branch sewers, at or near the intersections of the streets, are to be built catch-basins, by means of which the surface water in the gutters is admitted into the sewers. The catch-basins are to be located under the line of the curb-stone, partly under the gutter and partly under the sidewalk. They are to be oval in plan, 4 by 6½ feet in diameter, 5½ feet below the gutter, built of brick, have trapped connections with the sewers, and are to be provided with movable cast-iron covers. The catch-basins are to perform the office of retaining all the heavier detritus from the streets, and prevent the entrance into the sewers of all matter that may cause obstructions and the formation of deposits in the branch and main sewers. They fill up rapidly and require frequent cleaning by hand unless the streets are kept very clean.

At all the junctions of the catch-basin discharges with the branch sewers, and at all changes in their alignments, there are to be constructed manholes, located in the center of the streets, and covered with cast-iron curbs, fitted with perforated covers. These manholes are to facilitate inspection, and the removal of deposits in the event of its forming; also as ventilators to the sewers. The experience upon the subject of ventilating sewers favors the plan of allowing the gases to escape through the perforated manhole covers at the intersections of the streets, wherever the streets are paved and kept sufficiently clean to prevent the perforations in the manhole covers from becoming clogged with mud. In Memphis, where many of the streets are unpaved, this mode of ventilation will be ineffectual, and it is therefore proposed to make a sufficient number of untrapped connections between the sewers and the rain-water pipes from the roofs, by which plan, if the pipes are kept in proper repair, the foul gases from the sewers are discharged above the roofs of the houses.

Intermediate of the manholes just described, at intervals of 100 feet, there are to be built manholes in every way similar, except that they are to terminate a foot or eighteen inches under the surface of the street, and are to be covered with stone flags or cast-iron covers, not subject to the wear and tear of street traffic, and can therefore be made cheaper. These latter manholes will be required only occasionally for determining the exact location and removal of obstructions, while the former are required for frequent inspection of the sewers and constant ventilation.

SUMMARY OF COST FOR BRANCH SEWERS—PLAN No. 2.

35,378	feet 15-inch sewers in unpaved streets, at *$3.309	$117,053 92
15,572	feet 15-inch sewers in streets partly paved, at $4.003	62,338 27
13,055	feet 2-feet sewers in unpaved streets, at $4.043	52,787 35
20,265	feet 2-feet sewers in streets partly paved, at $4.593	93,081 62
84,270	Total	$325,261 16

However desirable it may be to unite the two improvements into one—viz., the purification and the maintaining inoffensive of the bayous, and providing conduits for removing house soil-water and fecal matter jointly—the plans described and estimated for are regarded as being in many respects objectionable, and they are presented principally to

* Cost per running foot, including all labor, cost of material, etc. Ratio of unpaved to paved streets, estimated approximately. See detailed estimate.

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demonstrate that the generally prevailing public desire to have these unsightly bayous obliterated cannot be gratified except at great cost and risk.

The plans are considered objectionable for the following reasons: First, in a financial point of view; second, as engineering works; and third, as sanitary measures.

Financially, it is believed that the attempt to construct the main sewers upon this principle—*i. e.*, obliterating the bayous or main rain-water channels, and converting them into sewers of sufficient capacity to carry off all sewage and the maximum discharge from rain-storms jointly—will involve the expenditure of a sum of money entirely disproportionate to the present population and wealth of Memphis.

As engineering works, they must be regarded as being without precedent, inasmuch as they have to be, beyond a doubt, of sufficient capacity to meet the requirements of the districts for discharging the greatest flow from rain-storms which may hereafter take place; involving the anticipation of possible future conditions brought about by natural and artificial causes to an extent that would be marvelous; also for the reason that no city has heretofore attempted to dispose of the greatest flows from rain-storms by means of underground conduits alone; the best practice being to take care of a moderate quantity and allow the balance to flow off on the surface, except for very flat or limited districts.

The possibility of a failure in one or the other of the main outfall sewers, during a heavy rain-storm, after all the natural outlets are filled up and probably built over, is fraught with such dire consequences to a great portion of the city as to properly cause much hesitation before undertaking an improvement upon such a scale*.

As sanitary measures, large sewers are very objectionable, for the reason that the ordinary flow of sewage spreading upon the inverts of large sewers has not sufficient volume and scouring efficiency to remove promptly the heavier par-

JULY 24, 1868.

* The disastrous flooding of Jones' Falls Valley and a great portion of the city of Baltimore (two days after writing the above) fully illustrates the futility of attempting to constrain the flow from occasional extraordinary rain-storms.

ticles of undecomposed animal and vegetable matter constantly finding their way into them. The constant accumulation of such matter during the dry season of each year, when the flow of sewage does not keep the main sewers clean, would convert them, as it were, into "elongated" cess-pools, and thus originate or aid in prolonging epidemics to a fearful extent. To keep sewers of this magnitude clean, by flushing them with water from the public water supply, would involve an expense for elevating water for this purpose alone, which at present can not be estimated.

It is therefore concluded that the preferable plan would be to separate the two improvements, and devise a plan of sewage which will carry all sewage into the Mississippi, and take in addition but a small quantity of rain-water. This would, with proper sanitary regulations, keep offensive matter out of the bayous, and permit them to perform their natural office, viz.: the discharge of rain-water. Then, with proper State legislation defining the bounds of the bayous as channels for discharging rain-falls, and removing the encroachments upon said channels, the maximum rainfalls could be harmlessly discharged into Wolf River. The unsightliness of the bayous would be remedied by straightening and slope-paving them, from time to time, with the improvements along them and the increase of wealth in the city; and should the back-water from the Mississippi in Bayous Gayoso and Quimby be at any time in the future considered insufferable, it could be removed by building a dam and lock in Bayou Gayoso near its junction with Wolf River, and erecting suitable pumping machinery. This, during times of high water in the Mississippi, would enable the perfect draining of these bayous at a very moderate cost, by closing the lock-gates and operating the pumping machinery. The pumping machinery for this purpose need not be of greater capacity than equal to remove the ordinary flow in the bayous, since no sewage, under this arrangement, would be permitted to enter them; the occasional storm-water discharges would inconvenience no one, since they would occupy the channels of the bayous for short periods of time only. Or, should it be hereafter decided to obliterate the bayous, by converting them into masonry conduits for the discharge of rain-water, it would be at a time when, pecuniarily at least, the problem would be less difficult of solution.

The sewerage by this plan would consist in locating the main lines generally in the valleys of the bayous, and as near to them as practicable, with the lowest grade elevation of their inverts above ordinary high-water in the Mississippi. Where practicable, the main sewers are to be located above the flood lines of rain-water discharges in the bayous, so as to provide them with waste weirs, connecting with the bayous, to relieve the sewers of surplus water during excessive rainfalls. The main sewers in this case are designed of a capacity, when running full, equal to discharge three times the maximum quantity of sewage independent of rain-water, or three times 0.0144 cubic feet per acre per second, as heretofore determined; *i. e.*, the sewers are made sufficiently large to carry into the river sewage equal in volume to a discharge of one inch of rain in twenty-four hours.

The minimum inclination of the main sewers is to be 3 168-1000 feet per mile, which, in the case of a 3-foot sewer, when running half full, will produce a velocity of current equal to 2 6-10 feet per second, or 1 4-10 miles per hour, calculated by Prony's formula. The actual velocity, however, in a sewer of this size and inclination, when half filled, is greater from the fact that at every junction with its branches (provided the junctions are properly made) the volume of sewage flowing in the main sewer receives an increment of velocity arising from the greater inclinations of the branch sewers, and consequent greater velocity with which they discharge their contents into the mains; and in the city of Memphis, where all the branches will have great inclinations, this will be especially favorable to the main sewers in maintaining a self-cleansing velocity of flow. This plan divides the district to be drained into three principal divisions, viz.: into a northern, middle and southern division. The northern division consists of Chelsea, the valley of Bayou Quimby, and that portion of the valley of Bayou Gayoso which is too low to be drained by the main sewers of the middle and southern divisions. The main sewer for the northern division is to commence at the Mississippi River opposite Winchester Street; thence north-eastwardly through the old Navy Yard to the intersection of the alley north of Auction Street with Promenade Street; thence eastwardly along the alley north of Auction Street to the alley between Fourth and Fifth Streets in Chelsea; thence south-eastwardly through the valley of Bayou Quimby to the intersection of the old Raleigh Road with Winter Avenue extended westwardly from Boundary Avenue; thence along Winter Avenue extended to Boundary Avenue. The main sewer, draining the middle and southern divisions, is to be located in Beale Street, commencing at the Mississippi River; thence, partly by an open cut and partly by a tunnel, along Beale Street to Causey Street, where its principal branch is to extend southwardly along Causey Street. From Causey and Beale Streets eastwardly along Beale Street to DeSoto Street, at which point the main sewer is to be divided into two principal branches, one extending southwardly along Bayou DeSoto, as far as Wellington Street at present, and the other northwardly in the valley of Bayou Gayoso to the intersection of Concord Street with the alley between Main and Second Streets.

The branches in the valleys of Bayou Gayoso and Little Betty Bayou are to drain what is called the middle division, and those in Causey Street and the valley of Bayou DeSoto, the southern division.

In the following table will be found designated the locations, areas to be drained, diameters and inclinations of the main sewers required by this plan. They are of sufficient capacity to remove a quantity of sewage equal in volume to a discharge of one inch depth of rain from the areas per twenty-four hours.

TABLE No. 7.

Areas Drained Acres	Length of Sewer Feet	Grade Elevation on Invert plus P.R.	Inclination	In	From	Diameter in Feet
3,522	300	60.0 96.3	0.121	Beale Street "	Mississippi River to 542 ft. west of east line of Front St.	*3.0 3.0
3,522	242	96.3 96.4	0.0006	" "	542 ft. west of east line of Front St. to 300 ft. west of east line of Front St.	7.75 7.75
	1,400	96.4 97.3	0.0006	" " Tunnel	300 ft. west of east line of Front St. to 1,100 ft. east of east line of Front St.	7.75 7.75
	308	97.3 97.5	0.0006	" "	1,100 ft. east of east line of Front St. to Causey Street	7.75 7.75
1,730	666	97.5 97.9	0.0006	" "	Causey Street to DeSoto Street	5.75 5.75
910	516	97.9 98.2	0.0006	DeSoto Street "	Beale Street to Gayoso Street	4.5 4.5
600	3,354	98.2 100.2	0.0006	DeSoto, Madison, and Fourth Streets	Gayoso Street to Poplar Street	3.75 3.75
	3,644	100.2 102.4	0.0006	Poplar, New, Market, alley e. Third St., Winchester, alley e. Main	Fourth Street to Concord Street	3.0 3.0
820	320	97.9 98.1	0.0006	Beale Street "	Desoto Street to 320 ft. east of Desoto Street	4.25 4.25
820	31	98.1 110.0	0.384	Bayou DeSoto "	Center Beale Street to Tangent point of curve	....
820	2,330	110.0 118.5	0.0036	" "	Tangent point of curve to Wellington Street	3.0 3.0
302	31	98.2 109.0	0.348	Little Betty Bayou " "	Center DeSoto Street to Tangent point of curve	....
302	1,925	109.0 118.0	0.0046	" " " "	Tangent point of curve to Lauderdale Street	2.0 2.0
302	700	118.0 121.2	0.0046	" " " "	Lauderdale Street to Beale Street	2.0 2.0
1,792	31	97.5 111.0	0.435	Causey Street "	Center Beale Street to Tangent point of curve	....
1,792	2,705	111.0 116.5	0.002	" "	Tangent point of curve to South Street	3.0 3.0
1,611	150	60.0 75.0	0.1	Old Navy Yard "	Mississippi River to 150 ft. north-east of River	*2.0 2.0
1,611	1,970	75.0 97.0	0.01116	" "	150 ft. north-east of River to Promenade St. & alley n. of Auction St.	3.0 3.0
1,611	2,010	97.0 100.0	0.00149	Alley north of Auction St. " " "	Promenade Street to Alley east of Fourth Street	4.75 4.75
1,245	1,227	100.0 101.1	0.0009	Valley of Bayou Quimby. " " "	Alley east of Fourth Street to Old Raleigh Road and Winter Av. ext	4.75 4.75
1,245	2,020	101.1 102.9	0.0009	Winter Avenue extended " "	Old Raleigh Road to Boundary Avenue	4.75 4.75

* Or its equivalent in cast-iron pipe with flexible joints.

TABLE No. 8.—SUMMARY OF ESTIMATED COST—PLAN No. 3.

In Beale Street, from Mississippi River to Causey Street	$69,623 51
In Beale Street, from Causey Street to DeSoto Street	12,809 94
In DeSoto Street, from Beale Street to Gayoso Street	9,180 16
In DeSoto Street, etc., from Gayoso Street to Poplar Street	39,170 12
In Poplar Street, etc., from Fourth Street to Concord Street	29,872 04
In Beale Street, from Desoto Street to 320 feet east of same	4,978 60
Along Bayou DeSoto from Beale Street to Wellington Street	16,595 48
In Causey Street, from Beale Street to South Street	19,467 80
Along Little Betty Bayou from DeSoto Street to Beale Street	13,153 80
Sewer draining northern district from Mississippi River to Boundary Avenue	66,108 96
	$280,960 41

The outfall portions of all main sewers, for at least one hundred feet in length from the Mississippi, are to be cast-iron pipes with flexible joints. This will allow of a limited adaptation of the sewer lines to the changes constantly taking place at the shore.

The branch sewers to be used in Plan No. 3 are to be 36 inches, 27 inches, 24 inches, 18 inches, and 15 inches in diameter, and of the same drainage capacity as those proposed for Plan No. 2, with catch-basins and manholes of similar construction and arrangement.

For the branch sewers no table of locations, diameters, inclinations, etc., is given, for the reason that the construction of branch sewers is generally a piece-meal process, in which it is often the case that a much greater area is drained by a given line of sewer than if the entire plan was carried out at the beginning; and therefore any table of dimensions applicable to the whole system would, in all probability, lead to bad results, unless all the different sewers were built simultaneously, or at least approximately so. The dimensions of the branch sewers for the different subdistricts, being determined partly by the manner of carrying out the system, is therefore left for decision at the time of construction. Upon the sewerage map herewith submitted is drawn a general plan of the system devised, showing the location and direction of the main and branch sewers of Plan No. 3.

Summary of Cost for Branch Sewers—Plan No. 3.

2,025	lineal feet 36-inch sewers in paved streets, at *$6.852.........	$13,875 88
3,278	lineal feet 36-inch sewers in unpaved streets, at $5.693.......	18,662 10
1,999	lineal feet 27-inch sewers in unpaved streets, at $5.108.......	10,210 07
7,522	lineal feet 24-inch sewers in unpaved streets, at $4.695.......	35,317 54
8,355	lineal feet 18-inch sewers in paved streets, at $4.128..........	34,485 72
18,754	lineal feet 18-inch sewers in unpaved streets, at $3.835.......	71,920 70
12,366	lineal feet 15-inch sewers in paved streets, at $3.802..........	47,013 12
33,821	lineal feet 15-inch sewers in unpaved streets, at $3.601.......	121,802 18
88,120	Totals..	$353,287 31

* See detailed estimate in Appendix for mode of determining cost per lineal foot.

By this plan it is proposed not to connect the street gutters generally with the branch sewers, but only in the paved streets, and in such other localities where the accumulation of storm-water is too great to be readily discharged upon the surface. This will reduce the first cost by dispensing with many catch-basins, as well as the cost of keeping them clean; for so long as the streets are unpaved the catch-basins will be found very troublesome. The catch-basins thus omitted can be built as fast as the streets become paved. The inclinations of the streets of Memphis toward the respective bayous into which they drain are, as a general rule, so great as to promptly and harmlessly convey the water from rain-storms into the bayous; and there seems to be no good reason why this mode of disposing of the rain-water upon unpaved streets should not be continued for the present, particularly when it is accomplished so economically. The crossings of the bayous with the branch sewers is to be effected with cast-iron inverted syphons.

The plan, then, recommended for adoption is No. 3, the main outfall sewers of which are large enough to discharge sewage equal in volume to a discharge of one inch rain per twenty-four hours, and the branch sewers to a discharge equal in volume to one-half inch of rain per hour.

The main sewers are designed to carry off all sewage and sufficient rain-water to occasionally flush them, and the branch sewers all sewage, and as much storm-water as is necessary to relieve the streets from surface water.

Ordinarily the branch sewers are to discharge all their contents into the main sewers, and during heavy rain-storms partly into the main sewers, and the excess by means of overflows or waste weirs into the bayous. The duration of excessive rain-storms is generally very short, and the contents of the sewers nearly all rain-water, so that there can not be any harm in discharging the excess, which the main sewers can not pass, into the bayous and thence to Wolf River.

Below is given a resume of the estimated costs of the respective plans described.

TABLE No. 9.

Plans	Class	DISCHARGING SEWAGE EQUAL IN VOLUME TO			
		2 in. rain per hour	1 in. rain per hour	½ in. rain per hour	1 in. rain per 24 hours
No. 1..	Main Sewers....	$2,256,670 74	$1,484,605 92	$1,130,574 19	....
No. 1..	*Branch Sewers	....	....	....	....
No. 2..	Main Sewers....	1,507,655 50	1,087,617 68	801,281 80	....
No. 2..	Branch Sewers..	....	....	325,261 16	....
No. 3..	Main Sewers....	... .	....	....	$280,960 41
No. 3..	Branch Sewers..	....	....	353,287 31	....

* None estimated.

In order to determine the nature of the material in which the main sewers will have to be built, borings were made, which indicate that the excavations will be mostly in clay and loam, the greater portion of which was found dry and easily worked. The depth at which the tunnel proposed will have to be executed, indicates sand and water, perhaps quicksand in some localities. But in the construction of the tunnel (in Beale Street) the water and excavated material can both be removed by the force of gravity, and therefore more economically than if they had to be elevated.

The grade elevation of the inverts of the branch sewers is fixed at twelve feet below the door-sills or first floors of the houses. This will enable the drainage of all cellars of ordinary depth, excepting such as may be located near the bayou lines; these, if connected with the sewers, will be subject to flooding from backwater during heavy rain-storms, such as will fill the bayous to flood height. But the subsoil drainage incidental to a general system of sewers, will, it is believed, make it superfluous to make sewer connections to the cellars in Memphis; and wherever it is not absolutely necessary, the cellars had better remain unconnected with the sewers, for the most carefully designed and conducted plans of sewerage occasionally flood cellars if connected with the sewers.

The plan recommended for adoption is one of minimum dimensions, and therefore the least in first cost. By minimum dimensions is meant the dimensions which the latest experience has demonstrated to be ample, provided sewers are regarded (as artificial works must ever be regarded) as only approximately automatic in their functions, requiring constant inspection and the frequent removal of the many substances improperly endeavored to be passed through them.

In Great Britain and on the continent of Europe, experience has demonstrated that improper substances admitted into sewers will obstruct them, no matter what may be their dimensions, and must be removed by manual labor. To effectually meet this evil, the earlier practice was to make all the sewers large enough to conveniently admit men, and pass through them, removing matter which should never have found its way into them. Sewers constructed upon this plan are costly to build and keep clean; they induce the admission of refuse which can not be removed by water, but which could generally be carted away much more economically from the surface at the points of accumulation than by being first unwisely forced into sewers, thence exhumed by the tedious and life-destructive labor of the sewer-scavenger, and then carted away; calling into requisition a "description of labor which it is improper for human beings to perform, and which ought to be forbidden, as being false in principle, and belonging to a low state of art, and as being ignorant or interested excuses for the avoidance of the trouble and expense of practicable and efficient substitutes."

The later practice is founded upon the principle that it is more economical to *prevent* the admission of improper substances (such as will not pass by water-carriage) into the sewers, by the intervention of catch-basins and police regulations, by keeping clean streets, alleys, courts, yards, etc., and by carting away the refuse as fast as it accumulates, than to admit and force everything into large sewers until they are full, and then remove it by the same ignorant and debased service by which it was forced into the sewers.

The recorded experience of the English and American engineers upon this subject, during the last ten years, demonstrates the correctness and greater economy of the later practice in this branch of engineering.

In the Appendix are given detailed estimates of cost for the different plans for water-works and sewerage investigated.

In conclusion, it is just and proper—indeed, a pleasure—to state that to the assistant engineers, a list of whose names is hereto appended, the citizens of Memphis and the undersigned are greatly indebted for the efficient and faithful performance of their respective duties.

The undersigned also takes pleasure in acknowledging valuable aid from a number of public-spirited citizens, prominent among which were Wm. O. Lofland, Esq., Captain G. W. Grader, James B. Cook, Esq., Colonel Minor Meriwether, Colonel J. L. Meigs, Colonel M. B. Prichard, Francis Foster, Esq., J. H. Humphreys, Esq., Major D. Wintter, and others whose names do not at present recur to memory.

Respectfully submitted, CHAS. HERMANY,
Chief Engineer.

OFFICE OF THE BOARD OF PUBLIC WORKS,
CHICAGO, September 1, 1868.

COL. W. RICHARDSON HUNT,
Chairman of the Board of Water-Works and Sewerage Commissioners for the City of Memphis, Tenn.:

SIR—Having, by visits to Memphis and Louisville, and by much personal conversation and correspondence with Mr. Hermany, made myself familiar with what he has done from before the commencement of the surveys for your water and sewerage works to the preparation of his plans and estimates, I fully concur with him in the conclusions at which he has arrived and the recommendations he has made in the foregoing report.

Respectfully submitted, E. S. CHESBROUGH,
Consulting Engineer.

ENGINEER CORPS.

WATER-WORKS SURVEY.

A. W. GLOSTER, ... In charge of Party.
F. DE FUNIAK, ... Assistant.
J. M. WRIGHT, ... Assistant.
H. L. McCLUNG, ... Assistant.
J. M. COTTON, ... Rodman.

SEWERAGE SURVEY.

NILES MERIWETHER, ... In charge of Party.
A. J. MURRAY, ... In charge of Party.
H. N. PHARR, ... In charge of Party.
W. H. McCLINTOCK, ... Assistant.
W. R. POWELL, ... Assistant.
ED. FREEMAN, ... Rodman.
R. FREEMAN, ... Rodman.
L. C. GORDON, ... Rodman.

OFFICE SERVICE.

F. DE FUNIAK, ... Draftsman.
A. J. MURRAY, ... Draftsman.
J. R. STUART, ... Draftsman.
W. H. McCLINTOCK, ... Principal Calculator.
J. M. WRIGHT, ... Assistant Calculator.

CHAS. HERMANY, Chief Engineer.
E. S. CHESBROUGH, Consulting Engineer.

APPENDIX.

WATER-WORKS.

ESTIMATE OF COST FOR WOLF RIVER PLAN.

Wolf River Dam.		
15,000 c. y. excavation carried into embankment, 25c	$3,750 00	
50,000 c. y. levee embankment on Wolf River above dam, 15c	7,500 00	
		$11,250 00
840 lineal feet 12-inch piles, temporary dam, 20c	$168 00	
2,560 lineal feet 3 by 12-inch sheet-piles, temporary dam, 15c	384 00	
160 lineal feet 10 by 10-inch stringers, temporary dam, 20c	32 00	
2,500 feet stays (B. M.), temporary dam, 3c	75 00	
Labor, temporary dam	500 00	
		1,159 00
Permanent Dam.		
5,400 lineal feet 12-inch oak piles, 20c	$1,080 00	
3,600 lineal feet 12 by 12-inch oak sheet-piles, 30c	1,080 00	
10,864 lineal feet 3 by 12-inch oak sheet-piles, 15c	1,629 60	
5,048 lineal feet 12 by 12-inch oak timber, squared, 35c	1,766 80	
2,706 lineal feet 6 by 12-inch oak timber, squared, 20c	541 20	
52,000 feet (B. M.) oak lumber, 3c	1,560 00	
10,000 pounds drift and screw bolts and spikes, 15c	1,500 00	
1,300 c. y. stone masonry, $30	39,000 00	
400 c. y. concrete, $12	4,800 00	
750 c. y. stone rip-rap, $8	6,000 00	
200 c. y. rubble-stone paving, $9	1,800 00	
Carpenter's work and labor on wood-work	2,000 00	
		62,757 60
Gate-house.		
2,500 c. y. excavation, 30c	$750 00	
1,760 lineal feet 12-inch piles, 20c	352 00	
12,000 feet (B. M.) plank and stringers, 3c	360 00	
50 c. y. concrete, $12	600 00	
550 c. y. stone masonry, $30	16,500 00	
6 metal sliding gates	5,000 00	
1 set copper-wire screens	1,000 00	
144 lineal feet 12-inch cast-iron drain-pipe, $3.50	504 00	
3 twelve-inch stop-gates, $125	375 00	
Superstructure of gate-house	4,000 00	
		29,441 00
Conduit Line—Earthwork.		
154,200 c. y. conduit excavation, 25c	$38,550 00	
88,200 c. y. conduit back-filling, 20c	17,640 00	
5,000 c. y. supporting wall excavation, 25c	1,250 00	
116,600 c. y. embankment, 35c	40,810 00	
		98,250 00
Masonry, Brick, etc.		
2,500 c. y. concrete under conduit, $10	$25,000 00	
13,200 c. y. conduit supporting wall, $12	158,400 00	
32,900 c. y. conduit wall, $12	394,800 00	
Carried forward,	$578,200 00	202,857 60

Brought forward,	$578,200 00	$202,857 60
250 lineal feet 48-inch pipe to cross railroad, $24	$6,000 00	
37 c. y. ventilator or manhole walls, $12	444 00	
365 c. f. stone coping and covers, $1.50	547 50	
190 c. y. concrete for culverts, etc., $10	1,900 00	
1,750 c. y. brick-work for culverts, etc., $12	21,000 00	
1,800 c. f. stone coping for culverts, etc., $1.50	2,700 00	
		610,791 50

Gate-house and Influent Chamber at Settling Reservoir.

116 c. y. concrete, $10	$1,160 00	
329 c. y. stone masonry, $23	7,567 00	
59 c. y. brick masonry, $12	708 00	
9 metal gates, frames, gearing, and setting, $500	4,500 00	
1 gate-house superstructure	2,500 00	
		16,435 00

Sundries.

24 acres grubbing and clearing, $100	$2,400 00	
60 acres real estate, right of way, and land damages	10,000 00	
Pumping and bailing	6,000 00	
		18,400 00
		$848,484 10
Contingencies and omissions, 10 per cent		84,848 41
Total cost of dam and aqueduct		$933,332 51

Settling Reservoir—Estimate for Two Basins.

40 acres real estate, $300		$12,000 00
25,800 c. y. mucking, 20c	$5,160 00	
31,600 c. y. excavation carried into spoil bank, 20c	6,320 00	
147,100 c. y. reservoir embankment in 6-inch layers and rolled, 30c	44,130 00	
18,100 c. y. puddle-wall, 80c	14,480 00	
28,600 sq. y. soiling and seeding slopes, 10c	2,860 00	
4,800 sq. y. brick walks, 65c	3,120 00	
500 c. y. sand under same, $2.50	1,250 00	
7,200 c. y. inner slope dressing, 40c	2,880 00	
7,200 c. y. inner slope paving (brick), $11	79,200 00	
11,700 c. y. concrete bottom-lining, 0.3 feet in depth, $10	117,000 00	
5,600 lineal feet common board fencing, 50c	2,800 00	
16,300 c. y. ditching, 15c	2,445 00	
		281,645 00

Effluent Chamber Pipes and Stop-gates.

208 c. y. concrete, $10	$2,080 00	
929 c. y. stone masonry, $23	21,367 00	
423 lineal feet 40-inch effluent pipe, $23	9,729 00	
3 forty-inch stop-gates, $1,500	4,500 00	
2 twelve-inch stop-gates, $125	250 00	
32 lineal feet 12-inch drain-pipe, $3.50	112 00	
107 c. y. brick masonry, $10	1,070 00	
16 c. y. concrete, $10	160 00	
Gate-house superstructure	1,200 00	
		40,468 00

Conduit through Middle Embankment.

338 c. y. brick masonry, $12	$4,056 00	
1,300 c. y. extra puddle-wall, 80c	1,040 00	
900 c. y. excavation, 20c	180 00	
		5,276 00
		$339,389 00
Contingencies and omissions, 10 per cent		33,938 90
Total		$373,327 90

Settling Reservoir—Estimates for One Basin.

40 acres real estate, $300		$12,000 00
13,900 c. y. mucking, 20c	$2,780 00	
90,000 c. y. reservoir embankments in 6-inch layers and rolled, 30c	27,000 00	
11,200 c. y. puddle-wall in embankment, 80c	8,960 00	
19,300 sq. y. soiling and seeding outer slopes and top of embankment, 10c	1,930 00	
3,600 c. y. inner slope-dressing, 40c	1,440 00	
3,600 c. y. inner slope-lining (brick), $11	39,600 00	
5,850 c. y. concrete bottom-lining, 0.3 feet deep, $10	58,500 00	
2,600 sq. y. brick walks, 65c	1,690 00	
2,700 c. y. sand under same, $2.50	6,750 00	
3,700 lineal feet common fence, 50c	1,850 00	
14,700 c. y. ditching, 20c	2,940 00	
		153,440 00
Effluent chamber, pipe, and stop-gates, same as for reservoir, with two compartments		40,468 00
		$205,908 00
Contingencies and omissions, 10 per cent		20,590 80
Total		$226,498 80

Pumping Station—Engine-house Foundation, etc.

3,000 c. y. earth excavated and carried into embankment, 30c	$900 00	
79 c. y. concrete in pump well and engine foundations, $10	790 00	
679 c. y. pump well masonry, $23	15,617 00	
129 c. y. engine foundation, $19	2,451 00	
74 c. y. boiler-house foundation, $19	1,406 00	
160 c. y. boiler-supporting walls, $19	3,040 00	
40 c. y. concrete walls, $10	400 00	
400 c. y. brick masonry, $12	4,800 00	
908 c. f. water-table and coping, $1.50	1,362 00	
43 c. y. concrete in chimney foundation, $10	430 00	
90 c. y. stone foundation, $19	1,710 00	
344 c. y. brick masonry in shaft, $15	5,160 00	
		$38,066 00
Contingencies and omissions, 10 per cent		3,806 60
		$41,872 60
Engine-house superstructure and coal-houses		26,000 00
		$67,872 60
Two pairs Worthington's duplex steam expansive and condensing pumping engines, with boilers and all fittings complete; and capacity 3,000,000 United States gallons water, elevated by each pair in twelve hours, at $50,000 per pair		$100,000 00

Pipe System.

1,023 lineal feet 36-inch supply main from settling reservoir to pumping station, at $16 per foot	$16,368 00	
10,892 lineal feet 24-inch supply main from pumping station to the intersection of Third and Poplar Streets in the city, at $12 per foot	130,704 00	
Carried forward,	$147,072 00	

	Brought forward,	$147,072 00	
7,041	lineal feet 24-inch supply and distributing main from the intersection of Third and Poplar Streets to the intersection of Elliott Street and Hernando Road, at $12 per foot	84,492 00	
8,389	lineal feet 24-inch supply and distributing main from the intersection of Elliott Street and Hernando Road to the distributing reservoir, at $9.40	78,856 60	
			$310,420 60
1,185	lineal feet 16-inch supply main from intersection of Third and Poplar Streets to intersection of Front Row and Poplar Street, at $6.20 per foot	7,347 00	
3,760	lineal feet of 12-inch distributing pipe from intersection of Poplar Street and Front Row to intersection of Shelby and Beale Streets, at $4.10	15,416 00	
2,500	lineal feet 10-inch distributing pipe from intersection of Beale and Shelby southwardly on Shelby Street, at $3	7,500 00	
2,800	lineal feet 8-inch distributing pipe from the intersection of Front Row and Poplar Street northwardly on Front Row and Chickasaw Street, at $2.75	7,700 00	
31,680	lineal feet (six miles) 6-inch pipe for general distribution, at $1.80	57,024 00	
52,800	lineal feet (ten miles) 4-inch pipe for general distribution, at $1.25	66,000 00	
			160,987 00
8	twenty-four-inch stop-gates put to place, at $450	3,600 00	
2	sixteen-inch stop-gates put to place, at $260	520 00	
12	twelve-inch stop-gates put to place, at $125	1,500 00	
6	ten-inch stop-gates put to place, at $90	450 00	
9	eight-inch stop-gates put to place, at $75	675 00	
110	six-inch stop-gates put to place, at $50	5,500 00	
145	four-inch stop-gates put to place, at $32	4,640 00	
292	brick key vaults with cast-iron covers, at $12	3,504 00	
			20,479 00
100	four-inch fire-hydrants complete, at $100		10,000 00
50	four-inch fire-cistern supplies, at $80		4,000 00
	Total for pipe system		$505,886 60

Hernando Road Distributing Reservoir—Estimate for Two Basins.

24	acres real estate, $1,000		$24,000 00
10,800	c. y. mucking, 20c	$2,160 00	
45,600	c. y. excavation carried into embankment, 20c	9,120 00	
29,800	c. y. embankment, 40c	11,920 00	
130,300	c. y. reservoir embankment in 6-inch layers and rolled, 45c	58,635 00	
26,000	c. y. puddle-wall in embankment, 80c	20,800 00	
2,200	c. y. inner slope-dressing, 40c	880 00	
4,600	c. y. rubble-stone slope-lining, 0.85 feet deep, laid in cement, $14	64,400 00	
3,500	c. y. broken stone under slope-lining, 0.65 feet deep, $8	28,000 00	
5,900	c. y. puddle in bottom of reservoir, 0.65 feet deep, 80c	4,720 00	
3,200	c. y. concrete in bottom of reservoir, 0.35 feet deep, $10	32,000 00	
3,734	lineal feet stone-coping (0.75 by 3 inches) on top of slope-paving, $2.50	9,335 00	
3,734	lineal feet iron fence on top of embankments, $2.50	9,335 00	
	Carried forward,	$251,305 00	24,000 00

Brought forward,	$251,305 00	$24,000 00
287 c. y. concrete under walks, $10	2,870 00	
2,900 sq. y. brick paving, 65c	1,885 00	
3,360 lineal feet common fencing, 50c	1,680 00	
21,300 sq. y. slope-soiling and seeding, 10c	2,130 00	
		259,870 00

Influent and Effluent Chamber.

245 c. y. concrete, $10	2,450 00	
689 c. y. stone masonry, $23	15,847 00	
537 c. y. brick masonry, $12	6,444 00	
1,424 c. f. coping and flagging, $1.25	1,700 00	
		26,521 00
75 lineal feet 40-inch effluent and influent pipe, $23	1,725 00	
45 lineal feet 24-inch effluent and influent pipe, $11	495 00	
45 lineal feet 32-inch effluent and influent pipe, $16	720 00	
1 forty-inch stop-gate	1,500 00	
1 twenty-four-inch stop-gate	750 00	
1 thirty-two-inch stop-gate	1,200 00	
1 forty-inch check-valve	500 00	6,890 00
		$317,281 00
Contingencies and omissions, 10 per cent		31,728 10
		$349,009 10

Hernando Road Distributing Reservoir—Estimate for One Basin.

15 acres real estate, $1,000		$15,000 00
6,500 c. y. mucking, 20c	$1,300 00	
27,300 c. y. excavation carried into embankment, 20c	5,460 00	
17,900 c. y. embankment, 40c	7,160 00	
78,200 c. y. reservoir embankments in 6-inch layers and rolled, 45c	35,190 00	
15,600 c. y. puddle-wall in embankments, 80c	12,480 00	
1,100 c. y. inner slope-dressing, 40c	440 00	
2,300 c. y. rubble-stone slope-lining, 0.85 feet deep, laid in cement, $14	32,200 00	
1,750 c. y. broken stone under slope-lining, 0.65 feet deep, 80c	2,360 00	
1,600 c. y. concrete in bottom of reservoir, 0.35 feet deep, $10	16,000 00	
1,867 lineal feet stone coping (0.75 by 3 inches) on top of slope-lining, $2.50	4,667 50	
1,867 lineal feet iron fence on top of embankments, $2.50	4,667 50	
1,740 sq. y. brick paving, 65c	1,131 00	
172 c. y. concrete under same, $10	1,720 00	
12,800 sq. y. slope-soiling and seeding, 10c	1,280 00	
2,000 lineal feet common fence, 50c	1,000 00	
		152,696 00
Influent and effluent chamber, pipes, and stop-gates, same as for two compartments		33,411 00
		$201,107 00
Contingencies and omissions, 10 per cent		20,110 70
		$221,217 70

RECAPITULATION OF ESTIMATED COST.

For real estate, right of way, and land damages; grubbing, clearing, pumping and bailing for Wolf River dam and conduit line	$18,400 00	
For Wolf river dam	75,166 60	
For gate-house at dam	29,441 00	
For conduit line	709,041 50	
For gate-house at end of conduit	16,435 00	
For contingencies and omissions	84,848 41	
Carried forward,		$933,332 51

Brought forward,	$933,332 51
For settling reservoir (two basins)	373,327 90
For buildings at pumping station	67,872 60
For two pairs pumping engines	100,000 00
Pipe system	505,886 60
Distributing reservoir (two basins)	349,009 10
Total cost of Wolf River plan	2,329,428 71
$274,620.50 of which need not immediately be provided, as, in the beginning of the works, one basin in the settling and one in the distributing reservoir can be omitted	274,620 50
	$2,054,808 21

ESTIMATE OF COST FOR MISSISSIPPI RIVER PLAN.

River Work and Inlet Pipe from Mississippi.

	Real estate and right of way		$10,000 00
10,000	c. y. river slope grading, 20c	$2,000 00	
11,200	c. y. stone rip-rap, $5	56,000 00	
58,600	c. y. pipe trench excavation, $1	58,600 00	
58,600	c. y. pipe trench back-filling, 20c	11,720 00	
3,500	feet cast-iron 48-inch pipe, weighing 2,117,500 lbs., at 4c	84,700 00	
292	cast-iron sleeves, weighing 153,300 lbs., at 4c	6,132 00	
35	cast-iron bonnets for tee-pipes, with manholes, 51,625 lbs., at 6c	3,097 50	
46,880	lbs. lead for joints, 10c	4,688 00	
252,000	feet (B. M.) lumber for bedding pipe, at $25 per $1,000	6,300 00	
25,550	lbs. wrought-iron drift bolts for pipe platform, 15c	3,832 50	
1	cast-iron quarter circle bend and mouth-piece to inlet pipe, 20,000 lbs., at 6c	1,200 00	
1	movable strainer	400 00	
35	brick wells, 6 feet in diameter, 1,437 c. y., at $13	18,681 00	
974	c. f. stone coping for same, $1.20	1,168 80	
35	covers for wells, of cast-iron, 40,000 lbs., at 6c	2,400 00	
150	days' pumping and bailing, at $40 per day	6,000 00	
			266,919 80

Inlet Pipe to Wolf River.

450	lineal feet, at the same rate per foot as the inlet to the Mississippi, $76	34,200 00
		$311,119 80
	Contingencies and omissions, 10 per cent	31,111 98
		$342,231 78

Pumping Station.

10,500	c. y. earth excavation for engine-house foundation, 50c	$5,250 00	
400	c. y. concrete, $8	3,200 00	
5,600	c. y. stone masonry, $20	112,000 00	
2,050	c. f. stone coping, $1.20	2,460 00	
			$122,910 00
9,500	c. y. earth excavation for boiler-house, 20c	$1,900 00	
135	c. y. concrete, $8	1,080 00	
385	c. y. stone foundation, $18	6,930 00	
840	c. f. stone coping, $1.20	1,008 00	
			10,918 00
	Carried forward,		$133,828 00

Brought forward,		$133,828 00
140 c. y. earth excavation for chimney foundation, 20c	$28 00	
70 c. y. concrete, $8	560 00	
120 c. y. stone foundation, $18	2,160 00	
256 c. f. stone coping, $1	256 00	
		3,004 00
350 c. y. brick masonry in chimney-stack, $12		4,200 00
		$141,032 00
Contingencies and omissions, 10 per cent		14,103 20
		$155,135 20
Engine-house superstructure, and boiler and coal-houses		75,000 00
		$230,135 20
Pumping machinery, embracing two engines, four pumps, one double stand pipe, two batteries of boilers, and all needful appendages		$225,000 00

Settling Reservoir Near Cotton Factory.

31 acres real estate, $1,000		$31,000 00
10,700 c. y. mucking, 20c	$2,140 00	
3,600 c. y. surplus excavation, 20c	720 00	
84,400 c. y. excavation carried into embankment in 6-inch layers and rolled, 30c	25,320 00	
15,600 c. y. puddle-wall in embankments, 60c	9,360 00	
14,400 sq. y. slope soiling and seeding, 10c	1,440 00	
1,500 c. y. inner slope dressing, 40c	600 00	
4,600 c. y. puddle in basins, 60c	2,760 00	
2,600 c. y. concrete in basins, $8	20,800 00	
5,000 c. y. rubble-stone slope lining (0.85′), $12	60,000 00	
3,900 c. y. broken stone under same (0.65′), $6	23,400 00	
3,900 lineal feet coping, $2.50	9,750 00	
3,900 lineal feet iron fence, $2.50	9,750 00	
3,000 sq. y. brick paving, 65c	1,950 00	
300 c. y. concrete under same, $8	2,400 00	
4,000 lineal feet common fence, 50c	2,000 00	
		$172,390 00

Influent and Effluent Chamber.

2,500 c. y. excavation, 20c	500 00	
165 c. y. concrete, $8	1,320 00	
600 c. y. brick masonry, $12	7,200 00	
900 c. y. stone masonry, $20	18,000 00	
5,900 c. ft. stone coping, $1.20	7,080 00	
Superstructure	2,500 00	
		36,600 00
110 lineal feet 40-inch effluent pipe, $25	2,750 00	
3 forty-inch stop-gates, $1,500	4,500 00	
55 lineal feet 20-inch drain-pipe, $12	660 00	
3 twenty-inch stop-gates, $360	1,080 00	
1,210 lineal feet 3-feet brick drain conduit to Wolf River, $5	6,050 00	
		15,040 00
		$255,030 00
Contingencies and omissions, 10 per cent		25,503 00
		$280,533 00

Pipe System.

730	lineal feet 36-inch pump main from lower pumps to settling reservoir, $20.50	$14,965 00	
780	lineal feet 40-inch pump main from settling reservoir to upper pumps, $24	18,720 00	
100	lineal feet 40-inch pump main from upper pump main to inlet pipe, $24	2,400 00	
7,370	lineal feet 24-inch pump and supply main from pumping station to the intersection of Third Street with Poplar Street, $12	88,440 00	
	Balance of pipe system, same as by Wolf River plan	358,814 60	
			$483,339 60
	Distributing reservoir, same as by Wolf River plan (two basins)		$349,009 10

RECAPITULATION OF MISSISSIPPI RIVER PLAN.

River work and inlet pipe	$342,231 78
Buildings at pumping station	230,135 20
Pumping machinery	225,000 00
Settling reservoirs	280,533 00
Pipe system	483,339 60
Distributing reservoir	349,009 10
	$1,910,248 68

ESTIMATE OF COST FOR HATCHIE LAKE PLAN.

River Work and Inlet Pipe.

	Real estate and right of way		$6,000 00
2¼	acres clearing and grubbing, $50	$112 50	
10,000	c. y. river slope grading, 20c	2,000 00	
11,200	c. y. stone rip-rap, $5	56,000 00	
30,800	c. y. pipe trench excavation, $1	30,800 00	
30,800	c. y. pipe trench back-filling, 20c	6,160 00	
1,840	lineal feet 48-inch cast-iron pipe, weighing 1,113,200 lbs., 4c	44,528 00	
154	cast-iron sleeves, weighing 80,850 lbs., 4c	3,234 00	
18	cast-iron bonnets, with manholes for tee-pipe, 26,550 lbs., 6c	1,593 00	
24,640	lbs. lead for joints, 10c	2,464 00	
132,500	feet (B. M.) lumber for pipe platform, $25 per 1,000	3,312 50	
13,432	lbs. wrought-iron drift bolts for pipe platform, 15c	2,014 80	
1	cast-iron quarter circle bend and mouth-piece to inlet pipe, 20,000 lbs., 6c	1,200 00	
1	movable strainer	400 00	
18	brick wells, 6 feet in diameter, 739 c. y., $13	9,607 00	
504	c. ft. stone coping for same, $1.20	604 80	
18	cast-iron covers for wells, 20,500 lbs., at 6c	1,230 00	
79	days' pumping and bailing, $40 per day	3,160 00	
			168,420 60
			$174,420 60
	Contingencies and omissions, 10 per cent		17,442 06
	Total, river and inlet pipe		$191,862 66
	Building at pumping station same as for Mississippi River plan		$230,135 20
	Pumping machinery		$260,000 00

Settling Reservoir.

29 acres real estate, $50		$1,450 00
34,603 c. y. mucking, 20c	$6,920 60	
6,000 c. y. excavation carried into spoil bank, 20c	1,200 00	
184,408 c. y. excavation carried into embankment in 6-inch layers and rolled, 30c	55,332 40	
17,346 c. y. puddle-wall in embankments, 60c	10,407 60	
6,968 c. y. brick slope lining, $11	76,648 00	
9,109 c. y. concrete in basins, $8	72,872 00	
12,125 sq. y. slope soiling and seeding, 10c	1,212 50	
5,000 lineal feet board fence, 50c	2,500 00	
		227,083 10

Influent and Effluent Chamber.

Masonry same as by Mississippi River plan	36,600 00	
80 lineal feet 40-inch effluent pipe, $25	2,000 00	
2 forty-inch stop-gates, $1,500	3,000 00	
40 lineal feet 20-inch drain pipe, $12	480 00	
2 twenty-inch stop-gates, $360	720 00	
1,400 lineal feet 3-inch brick drain conduit to Bear Creek, $7.50	10,500 00	
		53,300 00
		$281,833 10
Contingencies and omissions, 10 per cent		28,183 31
Total settling reservoir		$310,016 41

Pipe System.

1,860 lineal feet 36-inch pump main from lower pumps to settling reservoir, $20.50	$38,130 00	
1,910 lineal feet 40-inch pump main from settling reservoir to upper pumps, $24	45,840 00	
100 lineal feet 40-inch main from upper pump main to inlet pipe, $24	24,000 00	
24,800 lineal feet 24-inch pump main from pumping station to the intersection of Second and Bickford Streets, $13.50	334,800 00	
700 lineal feet cast-iron inverted syphons for crossing Loosa Hatchie and Wolf Rivers, $20	14,000 00	
Balance of pipe system same as by Mississippi River plan	467,919 60	
		$903,089 60
Distributing reservoir as heretofore estimated		$349,009 10

RECAPITULATION OF ESTIMATED COST OF HATCHIE LAKE PLAN.

River work and inlet pipe	$191,862 66
Buildings at pumping station	230,135 20
Pumping machinery	260,000 00
Settling reservoir	310,016 41
Pipe system	903,089 60
Distributing reservoir	349,009 10
	$2,224,112 97

ESTIMATE OF COST FOR MAIN SEWERS.

PLAN No. 1.

Discharging Sewage Equal in Volume to Two Inches Rain per Hour.

In Bayou Gayoso, from Wolf River to a point 20 feet N. of Gayoso Street:			
37,128	c. y. excavation, at 35c	$12,994 80	
6,067	c. y. concrete, at $10	60,670 00	
51,696	c. y. supporting wall, at $10	516,960 00	
64,971	c. y. sewer wall, at $12	779,652 00	
47	manholes, at $35	1,645 00	
383,975	c. y. bayou fill, at 40c	153,590 00	
		1,525,511 80	
	Contingencies and omissions, 10 per cent	152,551 18	
			$1,678,062 98
In Bayou Gayoso, from a point 20 feet N. of Gayoso Street to South Street:			
43,326	c. y. excavation, at 35c	$15,164 10	
19,158	c. y. sewer wall, at $12	229,896 00	
25	manholes, at $35	875 00	
6,872	c. y. back fill, at 25c	1,718 00	
11,005	c. y. bayou fill, at 25c	2,751 25	
		250,404 35	
	Contingencies and omissions, 10 per cent	25,040 44	
			275,444 79
In Bayou DeSoto, from a point 20 feet N. of Gayoso St. to Wellington St.:			
21,931	c. y. excavation, at 35c	$7,675 85	
6,954	c. y. sewer wall, at $12	83,448 00	
15	manholes, at $35	525 00	
7,354	c. y. back fill, at 25c	1,838 50	
7,358	c. y. bayou fill, at 25c	1,839 50	
		95,326 85	
	Contingencies and omissions, 10 per cent	9,532 69	
			104,859 54
In Little Betty Bayou, from Bayou DeSoto at Gayoso St. to Lauderdale St.:			
5,637	c. y. excavation, at 35c	$1,972 95	
1,667	c. y. sewer wall, at $12	20,004 00	
8	manholes, at $35	280 00	
2,989	c. y. back fill, at 25c	747 25	
1,589	c. y. bayou fill, at 25c	397 25	
		23,401 45	
	Contingencies and omissions, 10 per cent	2,340 14	
			25,741 59
In Bayou Quimby, from Bayou Gayoso to Boundary Avenue:			
18,174	c. y. excavation, at 35c	$6,360 90	
12,215	c. y. sewer wall, $12	146,580 00	
17	manholes, at $35	595 00	
13,354	c. y. fill, at 25c	3,338 50	
		156,874 40	
	Contingencies and omissions, 10 per cent	15,687 44	
			172,561 84
			$2,256,670 74

Discharging Sewage Equal in Volume to One Inch Rain per Hour.

In Bayou Gayoso, from Wolf River to a point 20 feet N. of Gayoso Street:

29,606	c. y. excavation, at 35c	$10,362 10	
4,902	c. y. concrete, at $10	49,020 00	
36,917	c. y. supporting wall, at $10	369,170 00	
34,948	c. y. sewer wall, at $12	419,376 00	
47	manholes, at $35	1,645 00	
416,246	c. y. bayou fill, at 40c	166,498 40	
		1,016,071 50	
	Contingencies and omissions, 10 per cent	101,607 15	
			$1,117,678 65

In Bayou Gayoso, from a point 20 feet N. of Gayoso Street to South Street:

31,991	c. y. excavation, at 35c	$11,196 85	
11,883	c. y. sewer wall, at $12	142,596 00	
25	manholes, at $35	875 00	
8,305	c. y. back fill, at 25c	2,076 25	
19,188	c. y. bayou fill, at 25c	4,797 00	
		161,541 10	
	Contingencies and omissions, 10 per cent	16,154 11	
			177,695 21

In Bayou DeSoto, from a point 20 feet N. of Gayoso Street to Wellington Street:

18,393	c. y. excavation, at 35c	$6,437 55	
4,214	c. y. sewer wall, at $12	50,568 00	
15	manholes, at $35	525 00	
8,846	c. y. back fill, at 25c	2,211 50	
9,399	c. y. bayou fill, at 25c	2,349 75	
		62,091 80	
	Contingencies and omissions, 10 per cent	6,209 18	
			68,300 98

In Little Betty Bayou, from Bayou DeSoto at Gayoso Street to Lauderdale Street:

4,789	c. y. excavation, at 35c	$1,676 15	
861	c. y. sewer wall, at $12	10,332 00	
8	manholes, at $35	280 00	
3,082	c. y. back fill, at 25c	770 50	
1,944	c. y. bayou fill, at 25c	486 00	
		13,544 65	
	Contingencies and omissions, 10 per cent	1,354 46	
			14,899 11

In Bayou Quimby, from Bayou Gayoso to Boundary Avenue:

15,057	c. y. excavation, at 35c	$5,269 95	
7,373	c. y. sewer wall, at $12	88,476 00	
17	manholes, at $35	595 00	
8,207	c. y. fill, at 25c	2,051 75	
		96,392 70	
	Contingencies and omissions, 10 per cent	9,639 27	
			106,031 97
			$1,484,605 92

Discharging Sewage Equal in Volume to One-half Inch Rain per Hour.

In Bayou Gayoso, from Wolf River to a point 20 feet N. of Gayoso Street:

22,226	c. y. excavation, at 35c	$7,779 10	
3,995	c. y. concrete, at $10	39,950 00	
25,189	c. y. supporting wall, at $10	251,890 00	
26,628	c. y. sewer wall, at $12	319,536 00	
47	manholes, at $35	1,645 00	
448,580	c. y. bayou fill, at 40c	179,432 00	
		800,232 00	
	Contingencies and omissions, 10 per cent	80,023 20	
			$880,255 20

In Bayou Gayoso, from a point 20 feet N. of Gayoso Street to South Street:

24,291	c. y. excavation, at 35c	$8,501 85	
7,576	c. y. sewer wall, at $12	90,912 00	
25	manholes, at $35	875 00	
9,831	c. y. back fill, at 25c	2,457 75	
24,709	c. y. bayou fill, at 25c	6,177 25	
		108,923 85	
	Contingencies and omissions, 10 per cent	10,892 39	
			119,816 24

In Bayou DeSoto, from a point 20 feet N. of Gayoso Street to Wellington Street:

14,262	c. y. excavation, at 35c	$4,991 70	
3,262	c. y. sewer wall, at $12	39,144 00	
15	manholes, at $35	525 00	
8,911	c. y. back fill, at 25c	2,227 75	
11,572	c. y. bayou fill, at 25c	2,893 00	
		49,781 45	
	Contingencies and omissions, 10 per cent	4,978 15	
			54,759 60

In Little Betty Bayou, from Bayou DeSoto at Gayoso Street to Lauderdale Street:

4,045	c. y. excavation, at 35c	$1,415 75	
673	c. y. sewer wall, at $12	8,076 00	
8	manholes, at $35	280 00	
2,933	c. y. back fill, at 25c	733 50	
2,168	c. y. bayou fill, at 25c	542 00	
		11,047 25	
	Contingencies and omissions, 10 per cent	1,104 73	
			12,151

In Bayou Quimby, from Bayou Gayoso to Boundary Avenue:

10,354	c. y. excavation, at 35c	$3,623 90	
4,369	c. y. sewer wall, at $12	52,428 00	
17	manholes, at $35	595 00	
4,653	c. y. fill, at 25c	1,163 25	
		57,810 15	
	Contingencies and omissions, 10 per cent	5,781 02	
			63,591 17
			$1,130,574 19

PLAN No. 2.

Discharging Sewage Equal in Volume to Two Inches Rain per Hour.

In Concord St. and Bayou Quimby, from Miss. River to Boundary Avenue:

900 feet cast-iron pipe, at $56	$50,400 00	
86,030 c. y. excavation, at 40c	34,412 00	
25,223 c. y. sewer wall, at $14	327,899 00	
33 manholes, at $40	1,320 00	
47,178 c. y. fill, at 30c	14,153 40	
	428,184 40	
Contingencies and omissions, 10 per cent	42,818 44	
		$471,002 84

In Bayou Gayoso, from Adams Street to Concord Street:

3,322 c. y. sewer wall, at $12	$39,864 00	
16 manholes, at $40	640 00	
117,172 c. y. bayou fill, at 40c	46,868 80	
	87,372 80	
Contingencies and omissions, 10 per cent	8,737 28	
		96,110 08

In Gayoso Street, from Mississippi River to Bayou DeSoto:

800 feet cast-iron pipe, at $56	$44,800 00	
27,509 c. y. excavation, at 40c	11,003 90	
5,026 c. y. sewer wall, at $13	65,338 00	
7,050 c. y. *sewer wall, at $18	126,900 00	
691 c. y. †sewer wall, at $30	20,730 00	
15 manholes, at $40	600 00	
31,488 c. y. tunneling, at $1.75	55,104 00	
6,781 c. y. back fill, at 25c	1,695 25	
4,299 c. y. *back fill, at $1.75	7,523 25	
1,195 c. y. bayou fill, at 40c	478 00	
	334,172 10	
Contingencies and omissions, 10 per cent	33,417 21	
		367,589 31

In Bayou Gayoso, from Adams Street to Gayoso Street:

2,870 c. y. excavation, at 35c	$1,004 50	
1,509 c. y. sewer wall, at $12	18,108 00	
13 manholes, at $40	520 00	
43,325 c. y. bayou fill, at 40c	17,330 00	
	36,962 50	
Contingencies and omissions, 10 per cent	3,696 25	
		40,658 75

In Bayou Gayoso, from Gayoso Street to South Street:

32,461 c. y. excavation, at 35c	$11,361 35	
15,899 c. y. sewer wall, at $12	190,668 00	
22 manholes, at $40	880 00	
3,070 c. y. back fill, at 25c	767 50	
10,276 c. y. bayou fill, at 25c	2,569 00	
	206,245 85	
Contingencies and omissions, 10 per cent	20,624 59	
		226,870 44
Carried forward,		$1,202,231 42

* In tunnel. † Of stone.

Brought forward,		$1,202,231 42
In Bayou DeSoto, from Gayoso Street to Wellington Street:		
16,819 c. y. excavation, at 35c	$5,886 65	
6,745 c. y. sewer wall, at $12	80,940 00	
13 manholes, at $40	520 00	
4,144 c. y. back fill, at 25c	1,036 00	
7,487 c. y. bayou fill, at 25c	1,871 75	
	90,254 40	
Contingencies and omissions, 10 per cent	9,025 44	
		99,279 84
In Little Betty Bayou, from Gayoso St. at Bayou DeSoto to Lauderdale St.:		
4,402 c. y. excavation, at 35c	$1,540 70	
1,744 c. y. sewer wall, at $12	20,928 00	
8 manholes, at $40	320 00	
1,513 c. y. back fill, at 25c	378 25	
1,498 c. y. bayou fill, at 25c	374 50	
	23,541 45	
Contingencies and omissions, 10 per cent	2,354 15	
		25,895 60
		1,327,406 86
From Concord Street to Wolf River:		
409,656 c. y. bayou fill, at 44c		180,248 64
		$1,507,655 50

Discharging Sewage Equal in Volume to One Inch Rain per Hour.

In Concord St. and Bayou Quimby, from Miss. River to Boundary Avenue:		
450 feet cast-iron pipe, at $56	$25,200 00	
69,676 c. y. excavation, at 40c	27,870 40	
16,655 c. y. sewer wall, at $13	216,515 00	
33 manholes, at $40	1,320 00	
34,738 c. y. fill, at 30c	10,421 40	
	281,326 80	
Contingencies and omissions, 10 per cent	28,132 68	
		$309,459 48
In Bayou Gayoso, from Adams Street to Concord Street:		
1,704 c. y. sewer wall, at $12	$20,448 00	
16 manholes, at $40	640 00	
119,599 c. y. bayou fill, at 40c	47,839 60	
	68,927 60	
Contingencies and omissions, 10 per cent	6,892 76	
		75,820 36
In Gayoso Street, from Mississippi River to Bayou DeSoto:		
400 feet cast-iron pipe, at $56	$22,400 00	
22,476 c. y. excavation, at 40c	8,990 40	
3,913 c. y. sewer wall, at $13	50,869 00	
5,460 c. y. *sewer wall, at $18	98,280 00	
444 c. y. †sewer wall, at $30	13,320 00	
Carried forward,	$193,859 40	

* In tunnel. † Of stone.

Brought forward,	$193,859 40	
15 manholes, at $40	600 00	
19,735 c. y. tunneling, at $1.75	34,536 25	
9,463 c. y. back fill, at 25c	2,365 75	
3,121 c. y. *back fill, at $1.75	5,461 75	
1,446 c. y. bayou fill, at 40c	578 40	
	237,401 55	
Contingencies and omissions, 10 per cent	23,740 15	
		$261,141 70
In Bayou Gayoso, from Adams Street to Gayoso Street:		
1,914 c. y. excavation, at 35c	$669 90	
1,186 c. y. sewer wall, at $12	14,232 00	
13 manholes, at $40	520 00	
44,744 c. y. bayou fill, at 40c	17,897 60	
	33,319 50	
Contingencies and omissions, 10 per cent	3,331 95	
		36,651 45
In Bayou Gayoso, from Gayoso Street to South Street:		
23,431 c. y. excavation, at 35c	$8,200 85	
9,899 c. y. sewer wall, at $12	118,788 00	
22 manholes, at $40	880 00	
5,652 c. y. back fill, at 25c	1,413 00	
18,053 c. y. bayou fill, at 25c	4,513 25	
	133,795 10	
Contingencies and omissions, 10 per cent	13,379 51	
		147,174 61
In Bayou DeSoto, from Gayoso Street to Wellington Street:		
13,794 c. y. excavation, at 30c	$4,827 90	
3,994 c. y. sewer wall, at $12	47,928 00	
13 manholes, at $40	520 00	
5,161 c. y. back fill, at 25c	1,290 25	
9,657 c. y. bayou fill, at 25c	2,414 25	
	56,980 40	
Contingencies and omissions, 10 per cent	5,698 04	
		62,678 44
In Little Betty Bayou, from Gayoso St. at Bayou DeSoto to Lauderdale St.:		
3,645 c. y. excavation, at 35c	$1,275 75	
883 c. y. sewer wall, at $12	10,596 00	
8 manholes, at $40	320 00	
1,844 c. y. back fill, at 25c	461 00	
1,909 c. y. bayou fill, at 25c	477 25	
	13,130 00	
Contingencies and omissions, 10 per cent	1,313 00	
		14,443 00
		907,369 04
From Concord Street to Wolf River:		
409,656 c. y. bayou fill, at 44c		180,248 64
		$1,087,617 68

* In tunnel.

Discharging Sewage Equal in Volume to One-half Inch Rain per Hour.

In Concord Street and Bayou Quimby, from Miss. River to Boundary Avenue:

300	feet cast-iron pipe, at $47	$14,100 00	
53,363	c. y. excavation, at 40c	21,345 20	
9,928	c. y. sewer wall, at $13	129,064 00	
33	manholes, at $40	1,320 00	
28,433	c. y. fill, at 30c	11,373 20	
		177,202 40	
	Contingencies and omissions, 10 per cent	17,720 24	
			$194,922 64

In Bayou Gayoso, from Adams Street to Concord Street:

1,351	c. y. sewer wall, at $12	$16,212 00	
16	manholes, at $40	640 00	
121,099	c. y. bayou fill, at 40c	48,739 60	
		65,591 60	
	Contingencies and omissions, 10 per cent	6,559 16	
			72,150 76

In Gayoso Street, from Mississippi River to Bayou DeSoto:

200	feet cast-iron pipe, at $56	$11,200 00	
17,340	c. y. excavation, at 40c	6,936 00	
2,354	c. y. sewer wall, at $13	30,602 00	
3,334	c. y. *sewer wall, at $18	60,012 00	
282	c. y. †sewer wall, at $30	8,460 00	
15	manholes, at $40	600 00	
11,936	c. y. tunneling, at $1.75	20,888 00	
9,925	c. y. back fill, at 25c	2,481 25	
2,224	c. y. *back fill, at $1.75	3,892 00	
1,629	c. y. bayou fill, at 40c	651 60	
		145,722 85	
	Contingencies and omissions, 10 per cent	14,572 29	
			160,295 14

In Bayou Gayoso, from Adams Street to Gayoso Street:

1,382	c. y. excavation, at 35c	$483 70	
890	c. y. sewer wall, at $12	10,680 00	
13	manholes, at $40	520 00	
45,573	c. y. bayou fill, at 40c	18,229 20	
		29,912 90	
	Contingencies and omissions, 10 per cent	2,991 29	
			32,904 19

In Bayou Gayoso, from Gayoso Street to South Street:

17,627	c. y. excavation, at 35c	$6,172 45	
6,038	c. y. sewer wall, at $12	72,456 00	
22	manholes, at $40	880 00	
6,317	c. y. back fill, at 25c	1,579 25	
23,255	c. y. bayou fill, at 35c	8,139 25	
		89,226 95	
	Contingencies and omissions, 10 per cent	8,922 69	
			98,149 64
	Carried forward,		$558,422 37

* In tunnel. † Of stone.

Brought forward,	$558,422 37	
In Bayou DeSoto, from Gayoso Street to Wellington Street:		
10,696 c. y. excavation, at 35c	$3,743 60	
3,128 c. y. sewer wall at $12	37,536 00	
13 manholes, at $40	520 00	
5,864 c. y. back fill, at 25c	1,466 00	
11,349 c. y bayou fill, at 25c	2,837 25	
	46,102 85	
Contingencies and omissions, 10 per cent	4,610 28	
		50,713 13
In Little Betty Bayou, from Gayoso St. at Bayou DeSoto to Lauderdale St.:		
3,098 c. y. excavation, at 35c	$1,084 30	
700 c. y. sewer wall, at $12	8,400 00	
8 manholes, at $40	320 00	
1,908 c. y. back fill, at 25c	477 00	
2,139 c. y. bayou fill, at 25c	534 75	
	10,816 05	
Contingencies and omissions, 10 per cent	1,081 61	
		11,897 66
From Concord Street to Wolf River:		621,023 16
409,656 c. y. bayou fill, at 44c		180,248 64
		$801,281 80

BRANCH SEWERS-PLAN No. 2.

Fifteen-inch Sewers in unpaved streets:	
34,300 c. y. excavation, at 30c	$10,290 00
35,378 lineal feet 15-inch stone-ware pipe, at 90c	31,840 20
118 manholes at street crossings, $50	5,900 00
249 manholes along squares, at $35	8,715 00
238 curve junctions, at $1.50	357 00
34,300 c. y. back filling, at 30c	10,290 00
4,700 c. y. excavation, at 30c	1,410 00
8,093 lineal feet 12-inch stone-ware pipe, at 65c	5,260 45
4,700 c. y. back filling, at 30c	1,410 00
238 catch basins, at $130	30,940 00
	106,412 65
Contingencies and omissions, 10 per cent	10,641 27
Equal to $3,309 per lineal foot.	$117,053 92

Fifteen-inch Sewers in streets partly paved:	
13,500 c. y. excavation, at 30c	4,050,00
15,572 lineal feet 15-inch stone-ware pipe, at 90c	14,014 80
74 manholes at street crossings, at $50	3,700 00
92 manholes along squares, at $35	3,220 00
148 curved junctions, at $1.50	222 00
13,500 c. y. back filling, at 30c	4,050 00
3,318 c. y. excavation, at 30c	995 40
5,392 lineal feet 12-inch stone-ware pipe, at 65c	3,504 80
3,318 c. y. back filling, at 30c	995 40
148 catch basins, at $130	19,240 00
2,143 sq. y. repaving, at $1.25	2,678 75
	56,071 15
Contingencies and omissions, 10 per cent	5,667 12
Equal to $4.003 per lineal foot.	$62,338 27

Two-feet Sewers in unpaved streets:

16,491 c. y. excavation, at 30c	$4,947 30
13,055 lineal feet sewer wall, at $1.50	19,582 50
866 stone-ware slants, at 75c	649 50
41 manholes at street crossings, at $50	2,050 00
101 manholes along squares, at $35	3,535 00
75 curved junctions, at $1.50	112 50
16,491 c. y. back filling, at 30c	4,947 30
1,424 c. y. excavation, at 30c	427 20
2,400 lineal feet 12-inch stone-ware pipe, at 65c	1,560 00
1,424 c. y. back filling, at 30c	427 20
75 catch basins, at $130	9,750 00
	47,988 50
Contingencies and omissions, 10 per cent	4,798 85
Equal to $4.043 per lineal foot.	$52,787 35

Two-feet Sewers in streets partly paved:

25,367 c. y. excavation, at 30c	$7,610 10
20,265 lineal feet sewer wall, at $1.50	30,397 50
1,348 stone-ware slants, at 75c	1,011 00
75 manholes at street crossings, at $50	3,750 00
138 manholes along squares, at $35	4,830 00
149 curved junctions, at $1.50	223 50
25,367 c. y. back filling, at 30c	7,610 10
2,916 c. y. excavation, at 30c	874 80
5,364 lineal feet 12-inch stone-ware pipe, at 65c	3,486 60
2,916 c. y. back filling at 30c	874 80
149 catch basins, at $130	19,370 00
3,665 sq. y. repaving, at $125	4,581 25
	84,619 65
Contingencies and omissions, 10 per cent	8,461 97
Equal to $4.593 per lineal foot.	$93,081 62

MAIN SEWERS PLAN No. 3.

Discharging Sewage equal in volume to One Inch Rain per Twenty-four Hours.

In Beale Street, from Mississippi River to center of Causey Street:

300 feet 36-inch cast-iron pipe, at $20.50	$7,150 00	
6,329 c. y. excavation, at 40c	2,531 60	
537 sq. y. paving torn up and replaced, at $2	1,074 00	
5,470 c. y. tunneling, at $1.75	9,572 50	
623 c. y. sewer wall, at $13	8,099 00	
1,585 c. y. *sewer wall, at $19	30,115 00	
10 manholes, at $55	550 00	
4,735 c. y. back filling, at 25c	1,183 75	
1,439 c. y. *back filling, at $1.75	2,518 25	
1 waste weir or overflow	500 00	
	63,294 10	
Contingencies and omissions, 10 per cent	6,329 41	
		$69,623 51

In Beale Street, from Causey Street to DeSoto Street:

7,875 c. y. excavation, at 40c	$3,150 00	
1,029 sq. y. paving torn up and replaced, at $2	2,058 00	
Carried forward,	$5,208 00	$69,623 51

* In Tunnel.

Brought forward,	$5,208 00	$69,623 00
377 c. y. sewer wall, at $13	4,901 00	
3 manholes, at $55	165 00	
6,875 c. y. back fill, at 20c	1,371 40	
	11,645 40	
Contingencies and omissions, 10 per cent	1,164 54	
		12,809 94
In DeSoto Street, from Beale Street to Gayoso Street:		
5,451 c. y. excavation, at 40c	$2,180 40	
725 sq. y. paving torn up and replaced, at $2	1,450 00	
236 c. y. sewer wall, at $13	3,068 00	
3 manholes, at $55	165 00	
4,911 c. y. back fill, at 20c	982 20	
1 waste weir or overflow	500 00	
	8,345 60	
Contingencies and omissions, 10 per cent	834 56	
		9,180 16
In DeSoto, Madison, and Fourth Streets, from Gayoso Street to Poplar Street:		
22,825 c. y. excavation, at 40c	$9,130 00	
1,698 sq. y. paving torn up and replaced, at $2	3,396 00	
1,317 c. y. sewer wall, at $13	17,121 00	
17 manholes, at $55	935 00	
20,136 c. y. back fill, at 20c	4,027 20	
2 waste weirs or overflows, at $500	1,000 00	
	35,609 20	
Contingencies and omissions, 10 per cent	3,560 92	
		39,170 12
In Poplar Street across to Market, in Market Street, etc., from Fourth and Poplar to Concord and Alley E. of Main Street:		
18,586 c. y. excavation, at 40c	$7,434 40	
1,188 c. y. sewer wall, at $13	15,444 00	
18 manholes, at $55	990 00	
16,440 c. y. back fill, at 20c	3,288 00	
	27,156 40	
Contingencies and omissions, 10 per cent	2,715 64	
		29,872 04
In Beale Street, from DeSoto Street to 320 feet E. of same:		
3,596 c. y. excavation, at 40c	$1,438 40	
140 c. y. sewer wall, at $13	1,820 00	
2 manholes, at $55	110 00	
3,288 c. y. back fill, at 20c	657 60	
1 waste weir or overflow	500 00	
	4,526 00	
Contingencies and omissions, 10 per cent	452 60	
		4,978 60
Along Bayou DeSoto, from Beale Street to Wellington Street:		
7,076 c. y. excavation, at 40c	$2,830 40	
766 c. y. sewer wall, at $13	9,958 00	
12 manholes, at $55	660 00	
5,692 c. y. back fill, at 20	1,138 40	
1 waste weir or overflow	500 00	
	15,086 80	
Contingencies and omissions, 10 per cent	1,508 68—	16,595 48
Carried forward,		$182,229 34

Brought forward,		$182,229 34
In Causey Street, from Beale Street to South Street:		
8,675 c. y. excavation, at 40c	$3,470 00	
888 c. y. sewer wall, at $13	11,544 00	
14 manholes, at $55	770 00	
7,070 c. y. back fill, at 20c	1,414 00	
1 waste weir or overflow	500 00	
	17,698 00	
Contingencies and omissions, 10 per cent	1,769 80	
		19,467 80
Along Little Betty Bayou, from DeSoto Street to Beale Street:		
4,461 c. y. excavation, at 40c	$1,784 40	
635 c. y. sewer wall, at $13	8,255 00	
13 manholes, at $55	715 00	
3,518 c. y. back fill, at 20c	703 60	
1 waste weir or overflow	500 00	
	11,958 00	
Contingencies and omissions, 10 per cent	1,195 80	
		13,153 80
In Navy Yard Alley, N. of Auction Street, Valley of Bayou Quimby and Winter Avenue, extended from Mississippi River to Boundary Avenue:		
150 feet 24-inch cast-iron pipe, at $12	$1,800 00	
17,057 c. y. excavation, at 40c	6,822 80	
3,092 c. y. sewer wall, at $13	40,196 00	
550 c. y. supporting wall, at $10	5,500 00	
36 manholes, at $55	1,980 00	
10,188 c. y. back fill, at $25	2,547 00	
3,013 c. y. embankment, at 25c	753 25	
1 waste weir or overflow	500 00	
	60,099 05	
Contingencies and omissions, 10 per cent	6,009 91	
		66,108 96
		$280,960 41

BRANCH SEWERS—PLAN No. 3.

Thirty-six inch Sewers in paved streets:

3,112 c. y. excavation, at 30c	$933 60
1,847 lineal feet sewer wall, at $2.02	3,730 94
123 stone-ware slants, at 75c	92 25
6 manholes at street crossings, at $50	300 00
19 manholes along squares, at $35	665 00
12 curved junctions, at $1.50	18 00
3,112 c. y. back filling, at 30c	923 69
230 c. y. excavation, at 30c	69 00
432 lineal feet 12-inch stone-ware pipe, at 65c	280 80
230 c. y. back filling, at 30c	69 00
178 lineal feet cast-iron inverted syphon, at $12	2,136 00
2 waste weirs, at $400	800 00
12 catch-basins, at $130	1,560 00
821 sq. y. repaving, at $1.25	1,026 25
	12,614 44
Contingencies and omissions, 10 per cent	1,261 44
Equal to $6.852 per lineal foot.	$13,875 88

Thirty-six inch Sewers in unpaved streets:

5,384 c. y. excavation, at 30c	$1,615 20
3,195 lineal feet sewer wall, at $2.02	6,453 90
213 stone-ware slants, at 75c	159 75
11 manholes at street crossings, at $50	550 00
29 manholes along squares, at $35	1,015 00
25 curved junctions, at $1.50	37 50
5,384 c. y. back filling, at 30c	1,615 20
480 c. y. excavation, at 30c	144 00
900 lineal feet 12-inch stone-ware pipe, at 65c	585 00
480 c. y. back filling, at 30c	144 00
83 lineal feet cast-iron inverted syphon, at $12	996 00
1 waste weir	400 00
25 catch-basins, at $130	3,250 00
	16,965 55
Contingencies and omissions, 10 per cent	1,696 55
Equal to $5.693 per lineal foot.	$18,662 10

Twenty-seven inch Sewers in unpaved streets:

2,650 c. y. excavation, at 30c	$795 10
1,916 lineal feet sewer wall, at $1.63	3,123 08
128 stone-ware slants, at 75c	96 00
7 manholes at street crossings, at $50	350 00
13 manholes along squares, at $35	455 00
14 curved junctions, at $1.50	21 00
2,649 c. y. back filling, at 30c	795 00
237 c. y. excavation, at 30c	71 10
444 lineal feet 12-inch stone-ware pipe, at 65c	288 60
237 c. y. back filling, at 30c	71 10
83 lineal feet cast-iron inverted syphons, at $12	996 00
1 waste weir	400 00
14 catch-basins, at $130	1,820 00
	9,281 88
Contingencies and omissions, 10 per cent	928 19
Equal to $5.108 per lineal foot.	$10,210 07

Twenty-four inch Sewers in unpaved streets:

9,264 c. y. excavation, at 30c	$2,779 20
7,235 lineal feet sewer wall, at $1.50	10,852 50
484 stone-ware slants, at 75c	363 00
20 manholes at street crossings, at $50	1,000 00
59 manholes along squares, at $35	2,065 00
44 curved junctions, at $1.50	66 00
9,264 c. y. back filling, at 30c	2,779 20
790 c. y. excavation, at 30c	237 00
1,483 lineal feet 12-inch stone-ware pipe, at 65c	963 95
790 c. y. back filling, at 30c	237 00
287 lineal feet cast-iron inverted syphon, at $12	3,444 00
4 waste weirs, at $400	1,600 00
44 catch-basins, at $130	5,720 50
	32,106 85
Contingencies and omissions, 10 per cent	3,120 69
Equal to $4.695 per lineal foot.	$35,317 54

Eighteen-inch Sewers in paved streets:

8,885 c. y. excavation, at 30c	$2,665 50
8,270 lineal feet 18-inch stone-ware pipe, at $1.15	9,510 50
27 manholes at street crossings, at $50	1,350 00
68 manholes along squares, at $35	2,380 00
51 curved junctions, at $1.50	76 50
8,885 c. y. back filling, at 30c	2,665 50
980 c. y. excavation, at 30c	294 00
1,836 lineal feet 12-inch stone-ware pipe, at 65c	1,193 40
980 c. y. back filling, at 30c	294 00
85 lineal feet cast-iron inverted syphon, at$ 12	1,020 00
1 waste weir	400 00
51 catch-basins, at $130	6,630 00
2,297 sq. y. repaving, at $1.25	2,871 25
	31,350 65
Contingencies and omissions 10 per cent	3,135 07
Equal to $4.128 per lineal foot.	$34,485 72

Eighteen-inch Sewers in unpaved streets:

19,934 c. y. excavation, at 30c	$5,980 20
18,547 lineal feet 18-inch stone-ware pipe, at $1.15	21,329 05
65 manholes at street crossings, at $50	3,250 00
150 manholes along squares, at $35	5,250 00
121 curved junctions, at $1.50	181 50
19,934 c. y. back filling, at 30c	5,980 20
2,197 c. y. excavation, at 30c	659 10
4,122 lineal feet 12-inch stone-ware pipe, at 65c	2,679 30
2,197 c. y. back filling, at 30c	659 10
207 lineal feet cast-iron inverted syphon, at $12	2,484 00
3 waste weirs, at $400	1,200 00
121 catch-basins, at $130	15,730 00
	65,382 45
Contingencies and omissions, 10 per cent	6,538 25
Equal to $3.835 per lineal foot.	$71,920 70

Fifteen-inch Sewers in paved streets:

11,950 c. y. excavation, at 30c	$3,585 00
12,286 lineal feet 15-inch stone-ware pipe, at 90c	11,057 40
47 manholes at street crossings, at $50	2,350 00
90 manholes along squares, at $35	3,150 00
84 curved junctions, at $1.50	126 00
11,950 c. y. back filling, at 30c	3,585 00
1,520 c. y. excavation, at 30c	456 00
2,852 lineal feet 12-inch stone-ware pipe, at 65c	1,853 80
1,520 c. y. back filling, at 30c	456 00
80 lineal feet cast-iron inverted syphon, at $12	960 00
1 waste weir	400 00
84 catch-basins, at $130	10,920 00
3,072 sq. y. repaving, at $1.25	3,840 00
	42,739 20
Contingencies and omissions, 10 per cent	4,273 92
Equal to $3.802 per lineal foot.	$47,013 12

Fifteen-inch Sewers in unpaved streets:

32,422	c. y. excavation, at 30c	$9,726 60
33,332	lineal feet 15-inch stone-ware pipe, at 90c	29,998 80
115	manholes at street crossings, at $50	5,750 00
243	manholes along squares, at $35	8,505 00
233	curved junctions, at $1.50	349 50
32,422	c. y. back filling, at 30c	9,726 60
4,240	c. y. excavation, at 30c	1,272 00
7,955	lineal feet 12-inch stone-ware pipe, at 65c	5,170 75
4,240	c. y. back filling, at 30c	1,272 00
489	lineal feet cast-iron inverted syphon, at $12	5,868 00
7	waste weirs, at $400	2,800 00
233	catch-basins, at $130	30,290 00
		110,729 25
	Contingencies and omissions, 10 per cent	11,072 93
	Equal to $3.601 per lineal foot.	$121,802 18

SUMMARY OF COST FOR BRANCH SEWERS-PLAN No. 3.

2,025	lineal feet 36-inch sewers in paved streets, at $6.852	$13,875 88
3,278	lineal feet 36-inch sewers in unpaved streets, at $5,693	18,662 10
1,999	lineal feet 27-inch sewers in unpaved streets, at $5.108	10,210 07
7,522	lineal feet 24-inch sewers in unpaved streets, at $4.695	35,317 54
8,355	lineal feet 18-inch sewers in paved streets, at $4.128	34,485 72
18,754	lineal feet 18-inch sewers in unpaved streets, at $3.835	71,920 70
12,366	lineal feet 15-inch sewers in paved streets, at $3.802	47,013 12
33,821	lineal feet 15-inch sewers in unpaved streets, at $3.601	121,802 18
88,120	Totals	$353,287 31

TABLE OF ELEVATIONS OF THE PRINCIPAL POINTS

—IN—

MEMPHIS WATER-WORKS AND SEWERAGE SURVEYS.

Locality	Plane of Reference.	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Front Street and Mill Street	102.8	......	49.0	117.2
Front Street and alley south of Mill Street	102.5	......	49.3	117.5
Front Street and Sycamore Street	103.5	......	48.3	116.5
Front Street and alley south of Sycamore Street	108.7	....	43.1	109.3
Front Street and Auction Street	114.5	......	37.3	105.5
Front Street and alley south of Auction Street	118.5	......	33.3	101.5
Front Street and Concord Street	122.4	......	29.4	97.6
Front Street and alley south of Concord Street	126.9	......	24.9	93.1
Front Street and Overton Street	131.2	......	20.6	88.8
Front Street and alley south of Overton Street	134.5	......	17.3	85.5
Front Street and Jackson Street	139.1	......	12.7	80.9
Front Street and Commerce Street	140.0	......	11.8	80.0
Front Street and Winchester Street	141.0	......	10.8	79.0
Front Street and alley south of Winchester Street	140.1	......	11.7	79.9
Front Street and Market Street	138.9	......	12.9	81.1
Front Street and alley south of Market Street	143.2	......	8.6	76.8
Front Street and Exchange Street	146.3	......	5.5	73.7
Front Street and Poplar Street	145.7	......	6.1	74.3
Front Street and alley south of Poplar Street	139.6	......	12.2	80.4
Front Street and Washington Street	136.3	......	15.5	83.7
Front Street and alley south of Washington Street	143.0	......	8.8	77.0
Front Street and Adams Street	146.7	......	5.1	73.3
Front Street and alley south of Adams Street	150.0	......	1.8	70.0
Front Street and Jefferson Street	155.1	3.3	......	64.9
Front Street and alley south of Jefferson Street	152.5	0.7	......	67.5
Front Street and Court Street	151.3	.....	0.5	68.7
Front Street and alley south of Court Street	153.5	1.7	.....	66.5
Front Street and Madison Street	153.9	2.1	......	66.1
Front Street and alley south of Madison Street	150.2	......	1.6	69.8
Front Street and Monroe Street	147.2	......	4.6	72.8
Front Street and alley south of Monroe Street	149.8	......	2.0	70.2
Front Street and Union Street	152.2	0.4	......	67.8
Front Street and alley south of Union Street	154.0	2.2	......	66.0
Front Street and Gayoso Street	159.4	7.6	......	60.6
Front Street and Hotel Street	162.4	10.5	......	57.6
Front Street and McCall Street	158.6	6.8	.....	61.4
Front Street and Beale Street	142.4	......	9.4	77.6
Front Street and Linden Street	147.2	......	4.6	72.8
Front Street and Pontotoc Street	158.4	6.6	......	61.6

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Front Street and Vance Street	164.4	12.6	......	55.6
Front Street and Talbot Street	161.9	10.1	.....	58.1
Front Street and Huling Street	158.4	6.6	......	61.6
Front Street and Trezevant Street	149.5	......	2.3	70.5
Front Street and Butler Street	150.5	......	1.3	69.5
Front Street and South Street	153.5	1.7	......	66.5
Alley east of Front Street and Mill Street	97.6	......	54.2	122.4
Alley east of Front Street and alley south of Mill Street.	99.0	......	52.8	121.0
Alley east of Front Street and Sycamore Street	100.8	......	51.0	119.2
Alley east of Front Street and alley south of Sycamore St.	110.3	......	41.5	109.7
Alley east of Front Street and Auction Street	115.4	......	36.4	104.6
Alley east of Front Street and alley south of Auction St.	115.8	......	36.0	104.2
Alley east of Front Street and Concord Street	120.0	......	31.8	100.0
Alley east of Front Street and alley south of Concord St.	124.0	......	27.8	96.0
Alley east of Front Street and Overton Street	129.1	......	22.7	90.9
Alley east of Front Street and alley south of Overton St.	130.7	.. ...	21.1	89.3
Alley east of Front Street and Jackson Street	141.4	......	10.4	78.6
Alley east of Front Street and Commerce Street	144.0	......	7.8	76.0
Alley east of Front Street and Winchester Street	147.2	......	4.6	72.8
Alley east of Front St. and alley south of Winchester St.	146.4	......	5.4	73.6
Alley east of Front Street and Market Street	142.6	......	9.2	77.4
Alley east of Front Street and alley south of Market St.	147.6	......	4.2	72.4
Alley east of Front Street and Exchange Street.	150.0	......	1.8	70.0
Alley east of Front St. and alley south of Exchange St.	149.4	......	2.4	70.6
Alley east of Front Street and Poplar Street	149.0	......	2.8	71.0
Alley east of Front Street and alley south of Poplar St.	142.7	......	9.1	77.3
Alley east of Front Street and Washington Street	141.0	......	10.8	79.0
Alley east of Front St. and alley south of Washington St.	146.6	......	5.2	73.4
Alley east of Front Street and Adams Street	151.2	......	0.6	68.8
Alley east of Front Street and alley south of Adams St.	153.0	1.2	......	67.0
Alley east of Front Street and Jefferson Street	154.5	2.7	......	65.5
Alley east of Front St. and alley south of Jefferson St...	152.6	0.8	......	67.4
Alley east of Front Street and Court Street	150.6	......	1.2	69.4
Alley east of Front Street and alley south of Court St...	154.3	2.5	......	65.7
Alley east of Front Street and Madison Street	156.3	4.5	......	63.7
Alley east of Front St. and alley south of Madison St...	152.5	0.7	......	67.5
Alley east of Front Street and Monroe Street	149.2	......	2.6	70.8
Alley east of Front St. and alley south of Monroe St....	147.4	......	4.4	72.6
Alley east of Front Street and Union Street	149.7	......	2.1	70.3
Main Street and Mill Street	96.7	......	55.1	123.3
Main Street and alley south of Mill Street	100.8	......	51.0	119.2
Main Street and Sycamore Street	103.3	......	48.5	116.7
Main Street and alley south of Sycamore Street	110.0	......	41.8	110.0
Main Street and Auction Street	112.2	......	39.6	107.8
Main Street and alley south of Auction Street	115.0	......	36.8	105.0
Main Street and Concord Street	119.8	......	32.0	100.2
Main Street and alley south of Concord Street	123.2	......	28.6	96.8
Main Street and Overton Street	127.5	......	24.3	92.5
Main Street and alley south of Overton Street	132.5	......	19.3	87.5
Main Street and Jackson Street	137.1	......	14.7	82.9
Main Street and Commerce Street	141.5	......	10.3	78.5

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Main Street and Winchester Street	145.0	......	6.8	75.0
Main Street and alley south of Winchester Street	146.8	......	5.0	73.2
Main Street and Market Street	145.4	......	6.4	74.6
Main Street and alley south of Market Street	145.7	......	6.1	74.3
Main Street and Exchange Street	148.0	......	3.8	72.0
Main Street and alley south of Exchange Street	147.8	......	4.0	72.2
Main Street and Poplar Street	147.0	......	4.8	73.0
Main Street and alley south of Poplar Street	147.1	......	4.7	72.9
Main Street and Washington Street	147.7	......	4.1	72.3
Main Street and alley south of Washington Street	149.4	......	2.4	70.6
Main Street and Adams Street	152.1	0.3	......	67.9
Main Street and alley south of Adams Street	151.1	......	0.7	68.9
Main Street and Jefferson Street	150.0	......	1.8	70.0
Main Street and alley south of Jefferson Street	148.6	......	3.2	71.4
Main Street and North Court Street	148.6	......	3.2	71.4
Main Street and Court Street	149.7	......	2.1	70.3
Main Street and South Court Street	152.1	0.3	......	67.9
Main Street and alley south of Court Street	152.1	0.3	......	67.9
Main Street and Madison Street	154.4	2.6	......	65.6
Main Street and alley south of Madison Street	152.5	0.7	......	67.5
Main Street and Monroe Street	149.6	......	2.2	70.4
Main Street and alley south of Monroe Street	146.4	......	5.4	73.6
Main Street and Union Street	144.1	......	7.7	75.9
Main Street and alley south of Union Street	145.1	......	6.7	74.9
Main Street and Gayoso Street	147.0	......	4.8	73.0
Main Street and McCall Street	149.6	......	2.2	70.4
Main Street and Beale Street	148.1	......	3.7	71.9
Main Street and Linden Street	142.7	......	9.1	77.3
Main Street and Pontotoc Street	142.8	......	9.0	77.2
Main Street and Vance Street	145.0	......	6.8	75.0
Main Street and Talbot Street	145.3	......	6.5	74.7
Main Street and Huling Street	148.3	......	3.5	71.7
Main Street and Trezevant Street	154.2	2.4	......	65.8
Main Street and Butler Street	154.2	2.4	......	65.8
Main Street and Elliot Street	151.8	......	......	68.2
Main Street and South Street	139.7	......	12.1	80.3
Alley east of Main Street and Auction Street	107.9	......	43.9	112.1
Alley east of Main Street and alley south of Auction St.	109.4	......	42.4	110.6
Alley east of Main Street and Concord Street	110.9	......	40.9	109.1
Alley east of Main Street and alley south of Concord St.	116.5	......	35.3	103.5
Alley east of Main Street and Overton Street	121.5	......	30.3	98.5
Alley east of Main Street and alley south of Overton St.	124.2	......	27.6	95.8
Alley east of Main Street and Jackson Street	131.4	......	20.4	88.6
Alley east of Main Street and Commerce Street	135.2	......	16.6	84.8
Alley east of Main Street and Winchester Street	143.6	......	8.2	76.4
Alley east of Main St. and alley south of Winchester St.	144.2	......	7.6	75.8
Alley east of Main Street and Market Street	144.3	......	7.5	75.7
Alley east of Main Street and alley south of Market St.	139.6	......	12.2	80.4
Alley east of Main Street and Exchange Street	143.5	......	8.3	76.5
Alley east of Main St. and alley south of Exchange St.	148.7	......	3.1	71.3
Alley east of Main Street and Poplar Street	145.4	......	6.4	74.6

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Alley east of Main Street and alley south of Poplar St...	144.8	......	7.0	75.2
Alley east of Main Street and Washington Street.........	141.7	......	10.1	78.3
Alley east of Main St. and alley south of Washington St.	147.8	......	4.0	72.2
Alley east of Main Street and Adams Street..................	149.5	......	2.3	70.5
Alley east of Main Street and alley south of Adams St..	147.5	......	4.3	72.5
Alley east of Main Street and Jefferson Street..............	142.7	......	9.1	77.3
Alley east of Main Street and North Court Street.........	145.1	......	6.7	74.9
Alley east of Main Street and Court Square..	151.8	......	......	68.2
Alley east of Main Street and South Court Street.........	147.8	......	4.0	72.2
Alley east of Main Street and Madison Street................	148.3	....	3.5	71.7
Alley east of Main Street and alley south of Madison St.	146.2	......	5.6	73.8
Alley east of Main Street and Monroe Street................	144.3	......	7.5	75.7
Alley east of Main Street and alley south of Monroe St.	138.6	......	13.2	81.4
Alley east of Main Street and Union Street..................	136.9	......	14.9	83.1
Second Street and Auction Street	105.3	......	46.5	114.7
Second Street and alley south of Auction Street............	110.0	......	41.8	110.0
Second Street and Concord Street..................................	108.2	......	43.6	111.8
Second Street and alley south of Concord Street...........	110.4	......	41.4	109.6
Second Street and Overton Street..................................	113.9	......	37.9	106.1
Second Street and alley south of Overton Street............	118.0	......	33.8	102.0
Second Street and Jackson Street.................................	124.0	......	27.8	96.0
Second Street and Commerce Street.............................	128.6	......	23.2	91.4
Second Street and Winchester Street...........................	136.2	......	15.6	83.8
Second Street and alley south of Winchester street........	139.3	......	12.5	80.7
Second Street and Market Street...................................	142.3	......	9.5	77.7
Second Street and alley south of Market Street............	138.0	......	13.8	82.0
Second Street and Exchange Street...............................	140.2	......	11.6	79.8
Second Street and alley south of Exchange Street.........	145.1	......	6.7	74.9
Second Street and Poplar Street....................................	144.4	......	7.4	75.6
Second Street and alley south of Poplar Street..............	139.0	......	12.8	81.0
Second Street and Washington Street...........................	137.8	......	14.0	82.2
Second Street and alley south of Washington Street......	142.2	......	9.6	77.8
Second Street and Adams Street...................................	147.5	......	4.3	72.5
Second Street and alley south of Adams Street............	142.6	......	9.2	77.4
Second Street and Jefferson Street...............................	138.5	......	13.3	81.5
Second Street and alley south of Jefferson Street...........	142.4	......	9.4	77.6
Second Street and North Court Street...........................	142.4	......	9.4	77.6
Second Street and Court Street....................................	148.7	......	3.1	71.3
Second Street and South Court Street...........................	146.1	......	5.7	73.9
Second Street and alley south of Court Street	146.1	......	5.7	73.9
Second Street and Madison Street..................	143.6	......	8.2	76.4
Second Street and alley south of Madison Street...........	139.5	......	12.3	80.5
Second Street and Monroe Street.................................	137.4	......	14.4	82.6
Second Street and alley South of Monroe Street............	135.2	......	16.6	84.8
Second Street and Union Street....................................	132.1	......	19.7	87.9
Second Street and alley south of Union Street..............	135.2	......	16.6	84.8
Second Street and Gayoso Street.......................	138.7	......	13.1	81.3
Second Street and Beale Street......................................	136.6	......	15.2	83.4
Alley east of Second Street and Auction Street............	104.3	......	47.5	115.7
Alley east of Second St. and alley south of Auction St.	108.8	......	43.0	111.2
Alley east of Second Street and Concord Street	100.0	......	51.8	120.0

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Alley east of Second St. and alley south of Concord St.	105.0	......	46.8	115.0
Alley east of Second Street and Overton Street	107.8	......	44.0	112.2
Alley east of Second St. and alley south of Overton St.	110.0	......	41.8	110.0
Alley east of Second Street and Jackson Street	116.4	......	35.4	103.6
Alley east of Second Street and Commerce Street	119.3	......	32.5	100.7
Alley east of Second Street and Winchester Street	132.6	......	19.2	87.4
Alley east of Second St. and alley south of Winchester St.	137.6	......	14.2	82.4
Alley east of Second Street and Market Street	138.9	......	12.9	81.1
Alley east of Second Street and alley south of Market St.	133.5	......	18.3	86.5
Alley east of Second Street and Exchange Street	138.0	......	13.8	82.0
Alley east of Second St. and alley south of Exchange St.	142.5	......	9.3	77.5
Alley east of Second Street and Poplar Street	140.7	......	11.1	79.3
Alley east of Second Street and alley south of Poplar St.	135.5	......	16.3	84.5
Alley east of Second Street and Washington Street	134.6	......	17.2	85.4
Alley east of Second St. and alley south of Washington St.	138.9	......	12.9	81.1
Alley east of Second Street and Adams Street	141.2	......	10.6	78.8
Alley east of Second St. and alley south of Adams St	138.1	......	13.7	81.9
Alley east of Second Street and Jefferson Street	135.9	......	15.9	84.1
Alley east of Second St. and alley south of Jefferson St.	141.3	......	10.5	78.7
Alley east of Second Street and Court Street	146.4	......	5.4	73.6
Alley east of Second St. and alley south of Court St	149.0	......	2.8	71.0
Alley east of Second Street and Madison Street	141.5	......	10.3	78.5
Alley east of Second St. and alley south of Madison St.	133.5	......	18.3	86.5
Alley east of Second Street and Monroe Street	131.5	......	20.3	88.5
Alley east of Second St. and alley south of Monroe St	131.0	......	20.8	89.0
Alley east of Second Street and Union Street	128.3	......	23.5	91.7
Third Street and Auction Street	103.0	......	48.8	117.0
Third Street and alley south of Auction Street	109.2	......	42.6	110.8
Third Street and Concord Street	102.0	......	49.8	118.0
Third Street and alley south of Concord Street	102.5	......	49.3	117.5
Third Street and Overton Street	103.3	......	48.5	116.7
Third Street and alley south of Overton Street	106.0	......	45.8	114.0
Third Street and Jackson Street	109.6	......	42.2	110.4
Third Street and Commerce Street	115.6	......	35.2	104.4
Third Street and Winchester Street	127.0	......	24.8	93.0
Third Street and alley south of Winchester Street	131.8	......	20.0	88.2
Third Street and Market Street	134.0	......	17.8	86.0
Third Street and alley south of Market Street	133.4	......	18.4	86.6
Third Street and Exchange Street	134.5	......	17.3	85.5
Third Street and alley south of Exchange Street	138.1	......	13.7	81.9
Third Street and Poplar Street	137.6	......	14.2	82.4
Third Street and alley south of Poplar Street	135.2	......	16.6	84.8
Third Street and Washington Street	133.0	......	18.8	87.0
Third Street and alley south of Washington Street	134.8	......	17.0	85.2
Third Street and Adams Street	139.2	......	12.6	80.8
Third Street and alley south of Adams Street	135.6	......	16.2	84.4
Third Street and Jefferson Street	134.1	......	17.7	85.9
Third Street and alley south of Jefferson Street	137.8	......	14.0	82.2
Third Street and Court Street	142.8	......	9.0	77.2
Third Street and alley south of Court Street	145.2	......	6.6	74.8
Third Street and Madison Street	140.0	......	11.8	80.0

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Third Street and alley south of Madison	132.0	......	19.8	88.0
Third Street and Monroe Street	126.8	......	25.0	93.2
Third Street and alley south of Monroe Street	127.1	.....	24.7	92.9
Third Street and Union Street	126.0	......	25.8	94.0
Alley east of Third Street and Auction Street	101.6	......	50.2	118.4
Alley east of Third Street and alley south of Auction St.	108.2	......	43.6	111.8
Alley east of Third Street and Concord Street	96.1	......	55.7	123.9
Alley east of Third St. and alley south of Concord St.	99.4	......	52.4	120.6
Alley east of Third Street and Overton Street	100.2	......	51.6	119.8
Alley east of Third St. and alley south of Overton St.	100.7	......	51.1	119.3
Alley east of Third Street and Jackson Street	105.8	......	46.0	114.2
Alley east of Third Street and Commerce Street	108.8	......	43.0	111.2
Alley east of Third Street and Winchester Street	113.6	......	38.2	106.4
Alley east of Third St. and alley south of Winchester St.	121.2	......	30.6	98.8
Alley east of Third Street and Market Street	129.0	......	22.8	91.0
Alley east of Third Street and alley south of Market St.	128.5	......	23.3	91.5
Alley east of Third Street and Exchange Street	123.9	......	27.9	96.1
Alley east of Third St. and alley south of Exchange St.	130.5	......	21.3	89.5
Alley east of Third Street and Poplar Street	130.6	......	21.2	89.4
Alley east of Third Street and alley south of Poplar St.	133.6	......	18.2	86.4
Alley east of Third Street and Washington Street	130.7	......	21.1	89.3
Alley east of Third St. and alley south of Washington St.	132.1	......	19.7	87.9
Alley east of Third Street and Adams Street	135.1	......	16.7	84.9
Alley east of Third Street and alley south of Adams St.	132.5	......	19.3	87.5
Alley east of Third Street and Jefferson Street	130.3	......	21.5	89.7
Alley east of Third St. and alley south of Jefferson St.	133.3	......	18.5	86.7
Alley east of Third Street and Court Street	134.2	......	17.6	85.8
Alley east of Third Street and alley south of Court St.	139.2	......	12.6	80.8
Alley east of Third Street and Madison Street	134.5	.....	17.3	85.5
Alley east of Third St. and alley south of Madison St.	129.3	......	22.5	90.7
Alley east of Third Street and Monroe Street	123.4	......	28.4	96.6
Alley east of Third Street and alley south of Monroe St.	122.0	.....	29.8	98.0
Alley east of Third Street and Union Street	123.0	......	28.8	97.0
Fourth Street and Market Street	104.6	......	47.2	115.4
Fourth Street and Exchange Street	105.6	......	46.2	114.4
Fourth Street and alley south of Exchange Street	108.4	......	43.4	111.9
Fourth Street and Poplar Street	111.8	......	40.0	108.2
Fourth Street and alley south of Poplar Street	115.1	......	36.7	104.9
Fourth Street and Washington Street	118.8	......	33.0	101.2
Fourth Street and alley south of Washington Street	120.4	......	31.4	99.6
Fourth Street and Adams Street	126.6	......	25.2	93.4
Fourth Street and alley south of Adams Street	126.4	......	24.4	93.6
Fourth Street and Jefferson Street	120.7	......	31.1	99.3
Fourth Street and alley south of Jefferson Street	121.2	......	30.6	98.8
Fourth Street and Court Street	118.5	......	33.3	101.5
Chester Street and Huling Street	163.2	11.4	......	56.8
Chester Street and Trezevant Street	147.3	......	4.5	72.7
Chester Street and Butler Street	159.4	7.6	......	60.6
Tennessee Street and Linden Street	144.5	......	7.3	75.5
Tennessee Street and Pontotoc Street	154.4	2.6	......	65.6
Tennessee Street and Vance Street	160.3	8.5	......	59.7

Locallity	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Tennessee Street and Talbot Street	167.9	16.1	......	52.1
Tennessee Street and Huling Street	164.0	12.2	......	56.0
Tennessee Street and Trezevant Street	148.0	......	3.8	72.0
Tennessee Street and Butler Street	151.2	......	0.6	68.8
Tennessee Street and South Street	157.1	5.3	......	62.9
Clinton Street and Beale Street	127.4	......	24.4	92.6
Clinton Street and Linden Street	142.9	......	8.9	77.1
Clinton Street and Pontotoc Street	149.7	......	2.1	70.3
Clinton Street and Vance Street	161.3	9.5	.....	58.7
Clinton Street and Talbot Street	166.4	14.6	......	53.6
Clinton Street and Huling Street	155.2	3.4	......	64.8
Clinton Street and Trezevant Street	147.1	......	4.7	72.9
Clinton Street and Butler Street	150.9	......	0.9	69.1
Mulberry Street and Beale Street	141.0	......	10.8	79.0
Mulberry Street and Linden Street	133.0	......	18.8	87.0
Mulberry Street and Pontotoc Street	136.7	......	15.1	83.3
Mulberry Street and Vance Street	134.0	......	17.8	86.0
Mulberry Street and Talbot Street	141.5	......	10.3	78.5
Mulberry Street and Huling Street	139.3	......	12.5	80.7
St. Martin Street and Beale Street	133.7	......	18.1	86.3
St. Martin Street and Linden Street	128.4	......	23.4	91.6
St. Martin Street and Pontotoc Street	131.8	......	20.0	88.2
St. Martin Street and Vance Street	128.6	......	23.2	91.4
St. Martin Street and Talbot Street	122.6	......	28.2	97.4
St. Martin Street and Huling Street	126.2	......	24.6	93.8
St. Martin Street and Elliott Street	135.8	......	16.0	84.2
Causey Street and Beale Street	124.5	......	26.3	95.5
Causey Street and Linden Street	122.7	......	29.1	97.3
Causey Street and Pontotoc Street	122.4	......	29.4	97.6
Causey Street and Vance Street	127.1	......	24.7	92.9
Causey Street and Elliott Street	127.5	......	24.3	92.5
Causey Street and South Street	129.5	......	22.3	90.5
Hernando Street and Beale Street	123.2	......	28.6	96.8
Hernando Street and Linden Street	136.5	......	15.3	83.5
Hernando Street and Pontotoc Street	138.0	.....	13.8	82.0
Hernando Street and Vance Street	136.5	......	15.3	83.5
Hernando Street and Elliott Street	142.2	......	8.6	77.8
Hernando Street and South Street	141.5	......	10.3	78.5
DeSoto Street and Madison Street	121.9	......	29.9	98.1
DeSoto Street and alley south of Madison Street	120.2	......	31.6	99.8
DeSoto Street and Monroe Street	117.9	......	33.9	102.1
DeSoto Street and alley south of Monroe Street	115.7	......	36.1	104.3
*North DeSoto Street and Union Street	117.5	......	34.3	102.5
†South DeSoto Street and Union Street	117.6	......	34.2	102.4
DeSoto Street and Gayoso Street	120.8	......	31.0	99.2
DeSoto Street and Beale Street	128.8	.....	23.0	91.2
DeSoto Street and Linden Street	129.5	......	22.3	90.5
DeSoto Street and Pontotoc Street	135.0	......	16.8	85.0
DeSoto Street and Vance Street	133.5	......	18.3	86.5
DeSoto Street and Elliott Street	140.5	......	11.3	79.5
DeSoto Street and South Street	142.0	......	9.8	78.0

* DeSoto Street north of Union Street. † DeSoto Street south of Union Street.

Locality.	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Avery Street and Vance Street	130.4	......	21.4	89.6
Avery Street and Elliott Street.	136.0	......	15.8	84.0
Avery Street and South Street	127.5	......	24.3	92.5
Allen's Avenue and Vance Street	134.1	......	17.7	85.9
Allen's Avenue and Elliott Street	137.1	......	14.7	82.9
Ruth Street and Vance Street	136.1	......	15.7	83.9
Goslee Street and Vance Street	148.8	.....	3.0	71.2
Market Avenue and Washington Street	111.5	......	40.3	108.5
Market Avenue and Adams Street	116.1	......	35.7	103.9
Wellington Street and Old Madison Street	123.6	......	28.2	96.4
North Wellington Street and New Madison Street	125.3	......	25.5	94.7
South Wellington Street and New Madison Street	123.4	......	28.4	96.6
Wellington Street and alley south of Madison Street	130.2	......	21.6	89.8
Wellington Street and Monroe Street	138.4	......	13.4	81.6
Wellington Street and Union Street	136.8	......	15.0	83.2
Wellington Street and Beale Street	132.0	....	19.8	88.0
Wellington Street and Linden Street	131.0	......	20.8	89.0
Wellington Street and Pontotoc Street	136.1	......	15.7	83.9
Wellington Street and Vance Street	132.4	......	19.4	87.6
Wellington Street and Hernando Road	156.2	4.4	......	63.8
Turley Street and Beale Street	122.8	......	29.0	97.2
Turley Street and Linden Street	124.2	......	27.6	95.8
Echols Street and Vance Street	126.8	......	25.0	93.2
Echols Street and Elliott Street	151.5	......	0.3	68.5
Lauderdale Street and Adams Street	133.5	......	18.3	86.5
Lauderdale Street and alley south of Adams Street	131.4	......	20.4	88.6
Lauderdale Street and Jefferson Street	129.0	......	22.8	91.0
Lauderdale Street and Court Street	121.5	......	30.3	98.5
Lauderdale Street and Madison Street	149.8	......	2.0	70.2
Lauderdale Street and Union Street	131.9	......	19.9	88.1
Lauderdale Street and Beale Street	142.8	......	9.0	77.2
Lauderdale Street and Linden Street	150.6	.....	1.2	69.4
Lauderdale Street and Vance Street	140.4	......	11.4	79.6
Orleans Street and Poplar Street	148.9	......	2.9	71.1
Orleans Street and Washington Street	142.0	......	9.8	78.0
Orleans Street and Adams Street	146.8	.....	5.0	73.2
Orleans Street and Jefferson Street, extended	150.3	......	1.5	69.7
Orleans Street and Court Street, extended	132.2	......	19.6	87.8
Orleans Street and Madison Street	139.6	......	12.2	80.4
Orleans Street and Pigeon Roost Road	157.3	5.5	......	62.7
Orleans Street and Beale Street	139.4	......	12.4	80.6
Orleans Street and Linden Street	143.0	......	8.8	77.0
Orleans Street and Vance Street	148.5	......	2.3	71.5
Elliott Street and South Street	152.9	1.1	......	67.1
Alabama Street and Poplar Street	152.2	0.4	......	67.8
Alabama Street and Exchange Street, extended	138.0	......	13.8	82.0
Alabama Street and Raleigh Road	105.9	......	45.9	114.1
Charleston Avenue and Adams Street.	117.2	......	34.6	102.8
Charleston Avenue and Jefferson Street	116.8	......	35.0	103.2
Charleston Avenue and Court Street	125.2	......	26.6	94.8
Charleston Avenue and Old Madison Street	126.9	......	24.9	93.1

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Charleston Avenue and New Madison Street	140.5	... ..	11.3	79.5
High Street and Poplar Street	122.2	......	29.6	97.8
High Street and Washington Street	119.4	......	32.4	100.6
High Street and Adams Street	121.4	......	30.4	98.6
Bull Run Street and Market Street	122.3	......	29.5	97.7
Bull Run Street and Exchange St. extended	120.7	......	31.1	99.3
Bull Run Street and Poplar Street	121.8	......	30.0	98.2
Bull Run Street and Alabama Street	126.0	......	25.8	94.0
Auction Street and Raleigh Road	126.8	......	25.0	93.2
Quimby Street and Alabama Street	117.5	......	34.3	102.5
Quimby Street and Robeson Street	122.9	......	28.9	97.1
Hill Street and Alabama Street	121.4	......	30.4	98.6
Hill Street and Mosby Street	123.0	......	28.8	97.0
Hill Street and Robeson Street	115.5	......	36.3	104.5
Winchester Avenue and Alabama Street	126.2	......	25.6	93.8
Winchester Avenue and Mosby Street	129.3	......	22.5	90.7
Winchester Avenue and East Robeson Street	127.9	......	23.9	92.1
Winchester Avenue and West Robeson Street	125.8	......	26.0	94.2
Winchester Avenue and Bradford Street	126.3	......	25.5	93.7
Jones Avenue and Alabama Street	146.3	.....	5.5	73.7
Jones Avenue and Hawley Street	140.8	......	11.0	79.2
Jones Avenue and Mosby Street	144.7	......	7.1	75.3
Jones Avenue and Robeson Street	147.0	......	4.8	73.0
Jones Avenue and Bradford Street	148.1	......	3.7	71.9
Boundary Avenue and Raleigh Road	129.1	......	22.7	90.9
Boundary Avenue and Bradford Street	120.7	......	31.1	99.3
Boundary Avenue and Robeson Street	128.5	......	23.3	91.5
Boundary Avenue and Hawley Street	142.8	......	9.0	77.2
Boundary Avenue and Poplar Street	152.1	0.3	......	67.9
Boundary Avenue and Adams Street	157.2	5.4	......	62.8
Boundary Avenue and Court Street	143.1	......	8.7	76.9
Boundary Avenue and Pigeon Roost Road	160.2	8.4	......	59.8
Kerr Avenue and Hernando Road	180.7	28.9	......	39.3
Kerr Avenue and Horn Lake Road	179.5	27.7	......	40.5
Highest Point on Kerr Avenue	194.8	43.0	......	25.2
Highest point on sight of distributing reservoir	210.9	59.1	......	9.1
Flow line of settling reservoir of Wolf River plan	128.5	......	23.3	91.5
Flow line of settling reservoir of Mississippi River plan.	146.0	......	5.8	74.0
Flow line of settling reservoir of Hatchie Lake plan	138.0	......	13.8	82.0
Highest point on bluff near Hatchie Lake	195.2	43.4	......	24.8
Memphis and Charleston R. R. track at White's Station.	196.5	44.7	......	23.5
On water table N. W. cor. of Court-house in Raleigh	200.6	48.8	......	19.4
Highest point between White's Station and Wolf River.	216.5	64.7	......	3.5
Low water in Wolf River, in 1867, at Talley's Ferry	71.5	......	80.3	148.5
Low water in Wolf River at Ferry below Wynn's	77.5	......	74.3	142.5
Low water in Wolf River at New Raleigh Road	92.9	......	58.9	127.1
Low water in Wolf River at Raleigh Ferry	101.5	......	50.3	118.5
Low water in Wolf River at Macon Bridge	110.2	......	41.6	109.8
Low water in Wolf River where gaugings were made	113.5	......	38.3	106.5
Low water in Wolf River at Brooks' Mill	117.9	......	33.9	102.1
Low water in Wolf River at proposed dam	121.2	......	30.6	98.8

Locality	Plane of Reference	Court Square		Flow Line Distrib. Reservoir
	Plus	Plus	Min.	Min.
Crest of proposed dam across Wolf River at beginning of aqueduct	131.39	......	20.41	88.61
Tops of Mounds at Fort Pickering	185.5	33.7	.....	34.5
	186.8	35.0	......	33.2
Waldran Avenue and State line road	157.6	5.8	......	62.4
Summit of highest hill beyond Big Spring on State line road	177.3	25.5	......	42.7
Highest point on Survey out State line road, across to Union Avenue, and through Union Avenue to Boundary Avenue	184.2	32.4	......	35.8
Bickford Street and Randolph Road	139.1	......	12.7	80.9
Randolph Road and New Raleigh Road	142.0	......	9.8	78.0
Ridge line at crossing of Old Raleigh Road	135.2	......	16.6	84.8
Ridge line at crossing of M. & O. Railroad	138.4	......	13.4	81.6
Ridge line at crossing of Brinkley's Avenue	144.1	......	7.7	75.9
Ridge line at crossing of Bass Avenue	165.2	13.4	.....	54.8
Ridge line at crossing of Madison Street, extended	167.0	15.2	....	53.0
Ridge line at crossing of Union Avenue	174.7	22.9	......	45.3
Ridge line at crossing of Bayou Quimby line	202.9	51.1	.....	17.1
Ridge line at crossing of Pigeon Roost Road	196.8	45.0	......	23.2
Ridge line at crossing of M. & C. R. R.	198.9	47.1	......	21.1
Ridge line at crossing of Hernando Road	205.7	53.9	......	14.3
Ridge line at first crossing of Kerr Avenue	189.4	37.6	......	30.6
Ridge line at second crossing of Kerr Avenue	192.3	40.5	......	27.7
Ridge line at crossing of M. & T. R. R.	173.1	21.3	......	46.9
Ridge line on entering Horn Lake Road	171.6	19.8	.....	48.4
Ridge line at Echivan Avenue	168.7	16.9	......	51.3
Ridge line at west end of South Street	166.3	14.5	......	53.7

COST OF MEMPHIS SEWER SYSTEM, 1882.

Month	Engineering	New Flush Tanks	Repairs of Flush Tanks	House Connections	Hauling	Miscellaneous	Manholes	Obstructions	New Lines	Repairs of Paving	Pipes	Repairs of Sewers	Stationery	Trenching	Tools	Repairs Unpaved Streets	Cleaning	Total
Jan.	85.00	8.00	495.70	120.05	13.40	18.70	— —	21.15	103.86	— —	82.75	5.00	— —	44.40	6.25	120.18	25.70	1150.14
Feb.	40.45	149.80	241.34	83.50	— —	56.41	2.30	119.65	55.75	52.80	4.00	— —	1.50	— —	173.98	75.60	4.00	1061.08
March	41.25	37.75	* 250.56	154.95	— —	100.15	— —	86.00	22.75	29.50	— —	35.00	55.60	— —	4.65	35.45	— —	853.61
April	— —	71.41	255.15	115.00	8.40	147.85	57.00	60.15	397.31	37.15	191.70	9.75	2.80	— —	2.75	8.00	— —	1364.42
May	— —	32.55	95.98	220.18	8.30	256.05	51.30	40.50	36.00	84.20	307.55	— —	— —	— —	— —	34.30	51.50	1218.41
June	10.00	— —	85.66	170.00	2.70	53.25	18.80	34.35	187.55	70.75	— —	— —	— —	42.40	— —	16.60	— —	692.06
July	— —	30.96	50.00	272.35	— —	74.20	75.75	7.00	233.95	22.85	160.55	— —	3.04	— —	— —	— —	— —	930.65
Aug.	50.00	49.64	65.26	71.00	— —	63.60	19.90	6.50	219.55	2.00	586.02	— —	— —	139.25	— —	— —	— —	1272.72
Sept.	50.00	10.00	79.30	55.00	— —	132.85	— —	66.00	221.45	36.10	151.97	— —	— —	110.65	19.85	9.90	73.00	1016.07
Oct.	25.00	— —	43.00	95.00	— —	99.32	40.50	51.85	57.75	36.80	63.81	7.50	— —	115.40	— —	5.00	34.95	675.88
Nov.	30.00	97.20	40.00	39.00	— —	43.55	10.00	42.00	67.00	10.00	89.60	— —	— —	212.55	.30	— —	— —	681.20
Dec.	30.00	18.10	71.25	74.00	— —	13.50	11.50	122.00	31.00	32.00	— —	— —	— —	75.40	— —	10.10	98.60	587.45
TOTAL	361.70	505.41	1773.20	1470.03	32.80	1059.43	287.05	657.15	1633.92	414.15	1637.95	57.25	62.94	740.05	207.78	315.13	287.75	11503.69

* Includes $450 salary of Inspector and water rent.

Memphis System	$34\frac{5}{16}$ Miles.
Old Sewers (bought)	$4\frac{1}{16}$ "
Total	$38\frac{6}{16}$ Miles.

RECAPITULATION.—

New Lines	$ 5534.36
Repairs of Private Sewers	57.25
50 Obstructions	657.15—each $13.40
Cleaning	287.75
Miscellaneous	4967.18
Total	$11503.69

COST OF MEMPHIS SEWER SYSTEM, 1883.

Month	Engineering	New Flush Tanks	Repairs of Flush Tanks	House Connections	Miscellaneous	Manholes	Obstructions	New Lines	Repairs of Paved Streets	Pipes	Repairs of Sewers	Stationery	Trenching	Tools	Cleaning	Total
Jan.	20.00	111.75	58.20	68.25	32.00	69.40	60.85	102.20	36.15	88.70	— —	— —	115.50	9.25	— —	772.25
Feb.	15.00	20.00	43.75	41.00	— —	— —	50.50	160.95	40.95	93.95	Peabody	11.50	1.50	6.00	96.70	581.80
March	25.00	23.00	52.75	145.10	21.70	15.00	115.55	175.20	5.00	39.90	116.55	6.50	9.65	5.90	16.20	773.00
April	30.00	18.00	51.00	22.85	28.75	22.25	46.45	559.30	5.90	291.85	8.50	— —	— —	15.80	9.00	1109.65
May	10.00	— —	44.60	139.20	64.85	— —	26.30	528.05	— —	315.75	20.00	— —	— —	33.47	46.20	1228.42
June	70.00	— —	52.75	139.85	12.80	73.40	105.25	230.05	35.75	301.50	— —	8.85	2.00	37.75	77.35	1147.30
July	120.00	50.80	74.20	45.70	11.35	34.30	27.00	385.85	2.50	257.85	— —	— —	— —	200.85	8.00	1218.40
Aug.	85.00	12.55	40.00	100.00	— —	— —	13.50	467.10	12.00	202.30	— —	1.70	— —	— —	7.50	941.65
Sept.	105.00	50.45	57.70	96.50	24.50	8.00	45.50	346.00	6.00	248.80	72.25	— —	— —	1.00	63.50	1125.20
Oct.	100.00	11.30	49.65	111.55	— —	— —	94.50	136.80	3.00	193.30	56.60	3.60	— —	95.15	10.00	365.45
Nov.	105.00	90.70	104.60	27.45	24.10	— —	74.35	301.45	— —	104.50	27.10	9.40	— —	30.55	53.05	952.25
Dec.	110.00	77.20	62.00	65.50	18.90	109.30	123.00	350.50	— —	357.30	— —	— —	7.00	36.60	17.00	1334.30
Total	795.00	465.75	*691.20	1002.95	238.95	331.65	782.75	3743.45	147.25	2495.70	301.00	41.55	135.65	472.32	404.50	12049.67

* Includes $450.00 salary of Inspector.

Memphis System........................35 9/10 Miles.
Old Sewers............................. 4 1/10 "

Total.............................. 40 Miles.

Recapitulation.—New Lines........................$ 8039.50
Repairs of private sewers..... 301.00
73 Obstructions........ .... 782.75—each $10.72
Cleaning........................... 404.50
Miscellaneous....... .... 2521.92

Total..........................$12049.67