PLANNING *and* BUILDING *the* CITY *of* WASHINGTON

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Looking westerly from the Capitol along the Mall to Arlington Memorial Bridge

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FOREWORD

The Washington Society of Engineers, organized in 1906, has for its object the advancement of engineering knowledge and practice and the maintenance of a high professional standard among its members. There has been a widely diffused sentiment that the Society, as a whole, could carry out this object perhaps in no better way, at the present bicentennial time, than by preparing a book of relatively permanent value on the planning and building of the City of Washington, bringing out in particular the effect of George Washington's personality and foresight as a city planner and as it has reached down to the present generation. Among those most interested in putting this idea into effect was Walter I. Swanton, a member who has been especially active in civic affairs. Through years he has assembled material to serve as a nucleus or illustration of what might be done. His quiet persistence had its effect, primarily in the creation of a committee charged with the duty of formulating a plan.

This committee, a sub-committee of the Committee on Public Affairs of the Society, made a comprehensive study and consulted with various other local and national organizations so as to secure coordinated effort and to make plans for a work that would be unique and distinctive. The results of their study were finally approved by the Board of Directors of the Society and cooperation secured first with the George Washington Bicentennial, Incorporated (District of Columbia Commission) and finally with the United States George Washington Bicentennial Commission.

The Society is fortunate in securing as editor the services of its oldest living ex-president and one of its founders. Appreciation is due also to the advice and contributions not only of many members of the Society, but also to those of the American Institute of Architects, and of other outstanding people who assisted in the plans for and preparation of this work.

ALLEN B. MCDANIEL,
President.

CHAPTER VII

WATER SUPPLY SYSTEM

By Major J. D. Arthur

Wells and Springs. Apparently foreseeing more clearly than any other man of his period the needs of future generations, George Washington early appreciated the necessity of an adequate water supply system for the newly created city on the Potomac. At a time when many considered bathtubs a luxury, if not an evil, and when water consumption scarcely exceeded a few gallons per capita, he visualized the time when the supply from existing springs and wells would prove inadequate to meet the demands of a rapidly increasing population. By his direction, Major L'Enfant made several studies of the problem.

Not until 1819, however, did these studies bear fruit in a Congressional appropriation of $9,125, "for purchasing a lot of land (Franklin Square between 13th and 14th, I and K Streets, N. W.), and for constructing pipes for supplying the Executive Offices and President's house with water." Additional appropriations were made from time to time to connect existing springs and wells with the Capitol and other Government buildings. The old Capitol Spring is today visible in the center of the present McMillan Reservoir, and the pipes leading to the Capitol are still in existence, though not used. In developing these early springs and wells, some $224,000 were expended.

Great Falls Supply. With a population increase greater than predicted by the most sanguine, Congress in 1850 directed the War Department to make examinations and surveys to determine the best and most available method of

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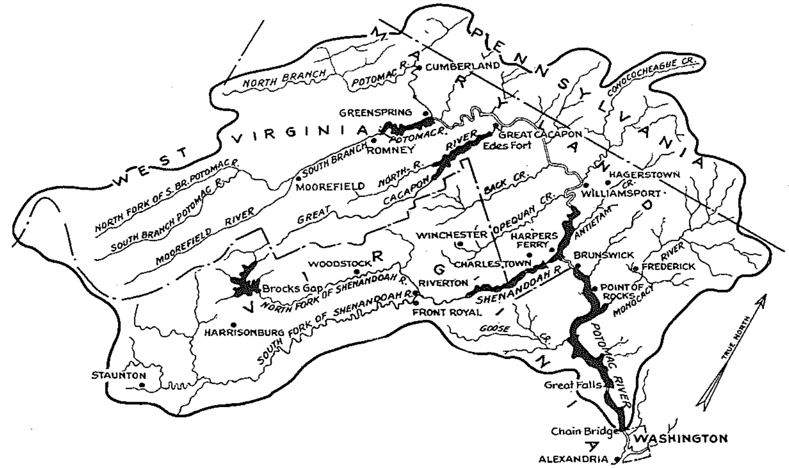
Major Joseph D. Arthur, Jr.: U. S. Military Academy, 1915; Engineering School, 1920. Mass. Inst. Tech. B. S. and M. S. in Civil Engineering, 1923; General Staff School, U. S. Army, 1930; District Engineer, Washington, D. C., in charge river and harbor improvements, the Washington aqueduct, etc.

supplying the city of Washington with pure water. Lieut. Montgomery C. Meigs, Corps of Engineers, U. S. Army, recommended that water be taken from the Potomac River at Great Falls. This river is one of the largest streams in the United States flowing into the Atlantic Ocean. Its drainage area, 11,460 square miles at Great Falls, is larger than that of the Connecticut, Hudson, Delaware, James, or Savannah Rivers. It comprises the greater part of the state of Maryland and includes portions of Virginia, West Virginia and Pennsylvania. The altitude of the basin ranges from sea level at Washington to about 4,500 feet at the divide on the south and west. The North Branch is considered the main stem of the stream even though the drainage area of the South Branch is somewhat larger.

The average annual precipitation on the basin is 38.8 inches; maximum about 46.8 inches in 1891, minimum of about 22 inches in 1930.

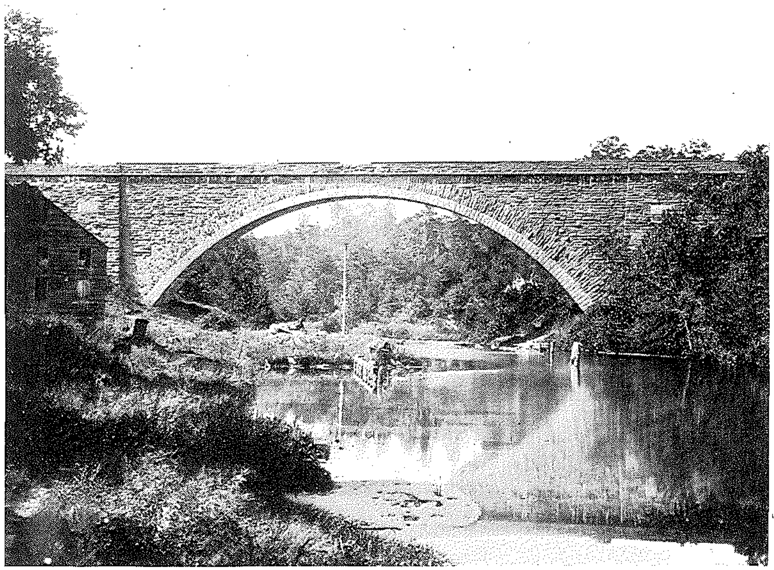
Records of the flow of the river since 1896 indicate that the maximum was about 265,000 second-feet. The median flow was about 11,600 second-feet and the minimum daily



Outline Map of Potomac River Basin

flow was about 653 second-feet in 1923. During this period of record there were five large floods ranging from 175,000 second-feet to 265,000 second-feet, the largest of these being the flood of May, 1924. The maximum known flood, however, was that of June, 1889, which was caused by a rainfall on the basin of 5.3 inches in three days. The maximum discharge of this flood was about 390,000 second-feet at Great Falls, roughly 50 per cent larger than the flood of May, 1924.

The Meigs plan was approved and work on the project commenced in November, 1853, with an original appropriation of $100,000. The project consisted of a dam across the Potomac at Great Falls; a circular brick gravity conduit 9 feet in diameter and about 11 miles long with a fall of 9½ inches per mile; a receiving reservoir (Dalecarlia)



Cabin John Arch, Carrying Original Aqueduct

formed by damming Little Falls Branch; a distribution reservoir (Georgetown); and a high service reservoir at "R" Street and Wisconsin Avenue to serve that part of the city too high to be supplied by gravity. An imposing feature of this early project was the Cabin John Aqueduct Bridge referred to on page 127.

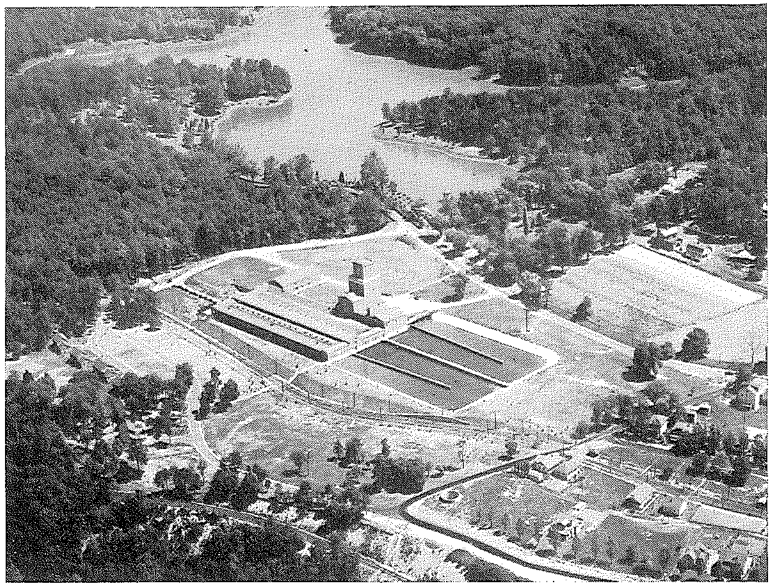
Water from the Potomac was taken into the system in 1863. As might be expected, its quality, judged by modern standards, left much to desire. Some turbidity was removed in the reservoirs, but old inhabitants probably remember its general opaqueness, and there are reports that an occasional eel found its way through the spigots.

Several minor changes in the original scheme were made, but not until 1882 were any major improvements undertaken. In that year Congress authorized the raising of the dam at Great Falls, thereby increasing the supply; the extension of the aqueduct by tunnel from Georgetown Reservoir to the site selected for a new reservoir in McMillan Park near Soldiers' Home; the construction of the new reservoir; and the new mains needed to connect this reservoir with the existing distribution system.

The tunnel from Georgetown to McMillan Reservoir included in this project is an interesting engineering structure. It is about 4 miles long entirely through rock, and is between 100 and 150 feet below the level of the city streets. Even after the completion of this project, which did not occur until 1902, the citizens of Washington were supplied with the waters of the Potomac improved only by sedimentation. In 1900, funds were provided for the construction of the present McMillan Filtration Plant.

Completed in 1905, at a cost of $3,356,000, this filtration plant is of the slow sand type. Twenty-nine filter beds, each of an effective sand area of one acre, provide a total capacity of 80,000,000 gallons per day. Three steam driven low service pumps deliver the water to the filters from McMillan Reservoir. By an ingenious and largely mechanical arrangement, the filters are periodically cleaned; the top layer of sand which is removed from them is washed and stored in concrete towers for further use without loss. At the present time, the greater portion of this plant's output is used to supply those sections of the city which can be served therefrom by gravity.

Confirming the experience of other localities, consumption soon exceeded expectations, and on June 10, 1920, Con-



Dalecarlia Reservoir and Filtration Plant, Looking Northwest

gress authorized an investigation of methods for increasing the supply. The plans of Major M. C. Tyler, Corps of Engineers, U. S. A., were approved and in 1921 construction commenced. Under these plans there were constructed by 1928 a new concrete conduit laid practically parallel to the old one; a rapid sand filtration plant located just west of Dalecarlia Reservoir on Conduit Road, shown in the accompanying view; a hydroelectric plant to utilize the water supplied by the conduit in excess of domestic consumption

for developing power to pump water to the high service areas; an electric pumping station; two new storage reservoirs; and necessary containing mains. This new concrete conduit has a water capacity of 110,000,000 gallons per day. It crosses Cabin John Creek through a steel syphon.

The Dalecarlia Filter Plant, see view on page 132, is of the rapid sand type, with a net capacity of 80,000,000 gallons per day. The essential features are mixing basins, settling basins with detention periods of 3 to 6 hours, a filtered water reservoir of 15,000,000 gallons capacity, 20 filters, and an electrically operated pumping station. Syrup of alum is used as a coagulant, and is manufactured at the plant from bauxite and sulphuric acid.

The hydroelectric plant utilizes the excess water supplied by the two conduits the old and new operating in parallel. The output of this remote control plant, containing two 1,500 kw. capacity turbines, operates the pumps serving the high service areas of the city. The high service reservoirs are constructed of concrete; each has a capacity of 15,000,000 gallons. The pipe lines from them are from 36 to 48 inches in diameter and are constructed of reinforced concrete with an incased steel cylinder as a water seal.

A study of the genesis of the present water scheme as above outlined, gives an answer to questions concerning such apparent inconsistencies as both a slow and a rapid sand filter plant in one system. It by no means follows that the ultimate result is inefficient. Each development has been a logical one, and the capabilities of the old group were in each instance utilized in the new; perhaps more important, the system as it exists today is readily adaptable to still greater expansion.

Federal Ownership. Before summarizing the existing arrangement it is necessary to here explain a condition which is unusual. As has been stated, it was the Federal Government which through the Army engineers initiated construction of a water supply system, designed primarily to meet purely Federal as distinguished from local needs. Emphasis should be placed on the fact that in 1859 Congress authorized the city of Washington to supply its citizens from the system, provided, however, that no expense in connection therewith devolved upon the United States. Under the authority of this act, the Corps of Engineers, U. S. Army, continued until July 1, 1882, to have complete supervision of the operation and maintenance of the distribution of the water as well as of the supply.

By the end of 1882 Congress provided for the creation of the Water Department under the engineer member of the District Commission, the expenses of its operation to be paid wholly out of the revenues derived from the sale of water. At the present time the United States, through the War Department, delivers filtered water to the distributing reservoirs in the city; there its activities cease.

Capacity. The combined normal capacity of the two conduits from the dam at Great Falls is about 185,000,000 gallons per day, which will shortly be increased to 217,000,000 by the construction of a booster pumping station and a lowering of the water elevation at the outlet in Dalecarlia Reservoir. The capacity of the two filter plants is 160,000,000 gallons per day, and that of the various reservoirs totals approximately 707,000,000 gallons. It appears that further expansion will be unnecessary for many years to come.

Costs. The table below shows the total construction and maintenance costs to June 30, 1931 (to nearest thousands), and the source from which derived:

Source of Funds	Construction	Maintenance
United States	$10,965,000	$1,222,000
District of Columbia	9,074,000	956,000
D. C. Water Department	15,616,000	16,925,000
Totals	35,655,000	19,103,000

Included is the cost of construction and maintenance of spring water mains, $223,600.

The approximate construction costs of some of the principal features of the system are as follows:

Item	Date finished	Approximate cost
Old Conduit	1864	$2,000,000
New Conduit	1926	3,009,000
Cabin John Arch	1864	350,000
City Water Tunnel	1902	2,500,000
McMillan Filter Plant	1905	3,356,000
Dalecarlia Filter Plant	1928	2,309,000

In the fiscal year 1930, the cost of water accounted for was $43.41 per million gallons.

Quality. In general, the raw water of the Potomac at Great Falls is satisfactory enough, though it cannot be considered fit for domestic consumption without treatment. A completely equipped chemical laboratory at the Dalecarlia plant maintains constant watch over water conditions throughout the system and its records show the following average characteristics of the raw and filtered water:

Item	Raw Water	Filtered Water
Turbidity, p. p. m.	135	0
Hardness	70	70
Bacteria per c. c.	2,500	2
Bacteria colon per c. c.	7	0.002
pH value	7.7	8.0
Color, p. p. m.	10	0

This water compares favorably with that furnished at Philadelphia and Baltimore. It is harder than that for Boston and New York, but much softer than the supply for western cities in general.*

Indicative of the purity of the water supplied by the system is the present record of typhoid death rates in Washington. The average 1930 death rate for North America and Europe per 100,000 was 4.9, while Washington with 2.4 was below the general average of the 20 largest cities in the United States. The influence of water

* Collins, W. D., The Industrial Utility of Public Water Supplies in the United States. U. S. Geological Survey, Water Supply Paper No. 496, 1923; also Relations Between Quality of Water and Industrial Developments in the U. S., Water Supply Paper No. 559, 1926.

conditions upon this figure is evident from the fact that while the average death rate when raw water was delivered to the consumers was 79, it declined to 48 when filtered water was supplied and dropped to 7 when chlorination was adopted in 1920. Each year since has shown a decline.

Many investigations have been made of all possible sources of supply for the city of Washington. The nearby Patuxent River has received perhaps the most careful investigation, but it seems to be generally agreed that the Potomac will be the logical source for many years to come. With a minimum flow of about 387,000,000 gallons per day, and a maximum daily consumption of about 115,000,000 gallons, it seems that population density in the District of Columbia much reach unprecedented figures to require an additional source.

Water Department. All phases of distribution of the filtered and chlorinated water are controlled by the Water Department of the city as previously noted. This is not directly under the Corps of Engineers of the U. S. Army nor is it in the War Department. but it is a component part of the Engineer Department of the District of Columbia and is under the direction of a colonel or major of the Corps of Engineers detailed to serve as one of the three Commissioners of the District. That is, after the Federal Government through its War Department has delivered the treated water in the city, the District officials, Army engineers acting in civilian capacity, see to its conservation and use; this being done through a superintendent who directs the city Water Department in the distribution of water for domestic, commercial, Federal and municipal uses, and for fire protection. These activities are financed wholly from funds derived from the sale of water and from water-main assessments, as described in the "Operations of the Engineer Department of the District of Columbia," 1931, p. 98.

The District is zoned according to ground elevations. All areas sufficiently low in elevation are fed by gravity flow direct from the McMillan Park Filtration Plant. This

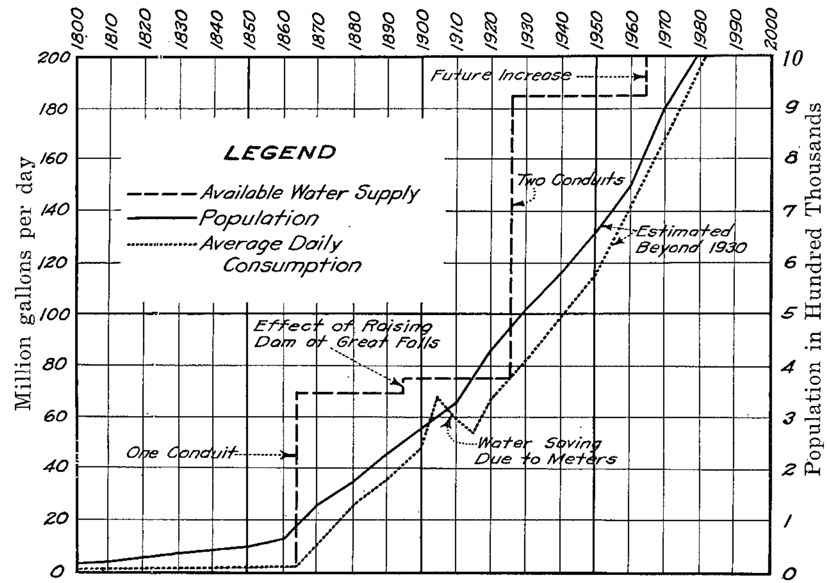


Diagram Illustrating by Solid Line the Growth of Population, 1800 to 1930, and Probable Increase to 1980; Also by Line of Dashes Available Water Supply, and by Dots the Past and Estimated Future Consumption

service requires over 40 per cent of the total water supply. Other areas known as the First, Second and Third High Services are supplied through reservoirs which receive their water by pumping from the Dalecarlia Plant. The Fourth High obtains water by pumping from the Third High Service reservoir to elevated towers in the vicinity of Tenleytown. The supply of the Anacostia section is taken from the gravity service over the Pennsylvania Avenue bridge, reaching the lower grounds of that section. The higher areas, known as the First and Second Anacostia High Services, are supplied through the pumping station at Eighteenth Street and Minnesota Avenue southeast, to steel tanks, there being two on the First High and one on the Second High. To provide for the rapidly increasing consumption of water in the First High Service in Anacostia there is now being constructed a 3,000,000-gallon capacity concrete reservoir situated on high land at the east end of W Street southeast.

The daily average quantity and percentage of water taken during the fiscal year 1930 by each district is indicated in the following table, which gives also the altitude of the reservoir for each district. The water elevation at Great Falls may be taken as being in round numbers 150 feet above mean tide, and of the Dalecarlia, Georgetown and McMillan reservoirs at 146 feet. In the clear water reservoir, which receives the outflow from the slow sand filter beds, the surface is 162 feet: this supplies the lowest or so-called gravity district which includes much of the city proper and Anacostia and aggregates over 40 per cent of the total.

Proportion of Pressure Districts

Gravity	162 ft. elevation	34.2 million gal.	41.7 per cent
First high area	250 ft. elevation	23.0 million gal.	28.0 per cent
Second high area	333 ft. elevation	15.0 million gal.	19.2 per cent
Third high area	425 ft. elevation	7.7 million gal.	9.4 per cent
Fourth high area	485 ft. elevation	1.1 million gal.	1.7 per cent
Total		81.3 million gal.	100.0 per cent

All services are fed through large trunk watermains, ranging in size from 16″ to 48″ in diameter, well gridironed or interconnected to provide ample volume of water to all areas. The Bryant Street Pumping Station which, before the installation of the Dalecarlia plant, pumped all water to the several services is now reserved as a standby station and is used to augment the supply from the Dalecarlia plant during periods of maximum water consumption. There is now being installed an electric-driven centrifugal pump of 20,000,000 gallons daily capacity to provide ample supply to the Third High Service system which has greatly increased consumption demands owing to building operations in recent years.

Consumption. The present average daily water consumption of the District of Columbia, including adjacent

Maryland, and Arlington County, Va., which buys approximately one million gallons per day from the system amounts to 85,000,000 gallons, or 170 gallons per capita. Population and water consumption curves from 1800 to 1930, and estimated future requirements up to 1980, are shown in the diagram on page 137.

Property assessments for water mains are $3.00 per front foot. Metered buildings are charged $8.75 for the first 7,500 cubic feet and $0.07 for each additional 100 cubic feet. Unmetered tenements two stories high and 16 feet or less in width are charged a flat rate of $9.85 and $0.62 for each extra foot of width. One-third of these costs is added for each story above two. Larger consumers are required to supply their meters and certain special flat rates are used for various industrial users. At the present time the city is about 90 per cent metered.