THE WASHINGTON AQUEDUCT

WATER SUPPLY

DISTRICT OF COLUMBIA

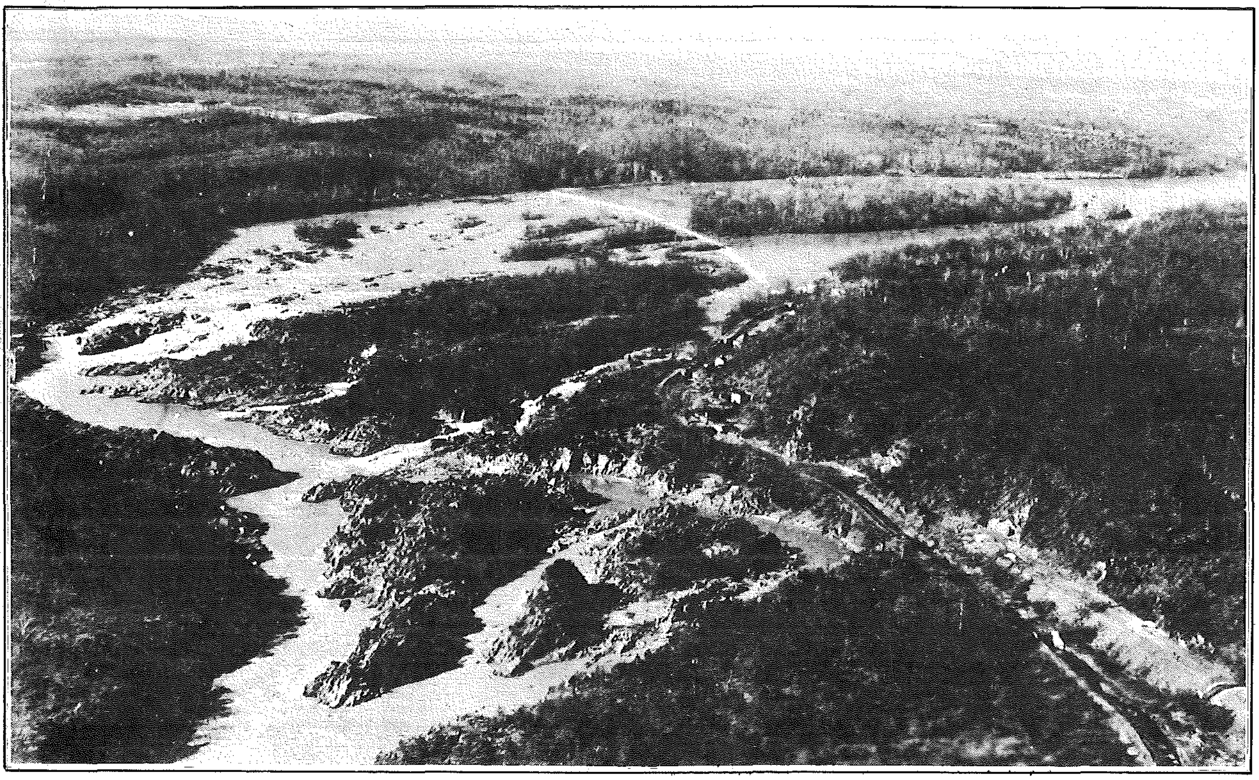
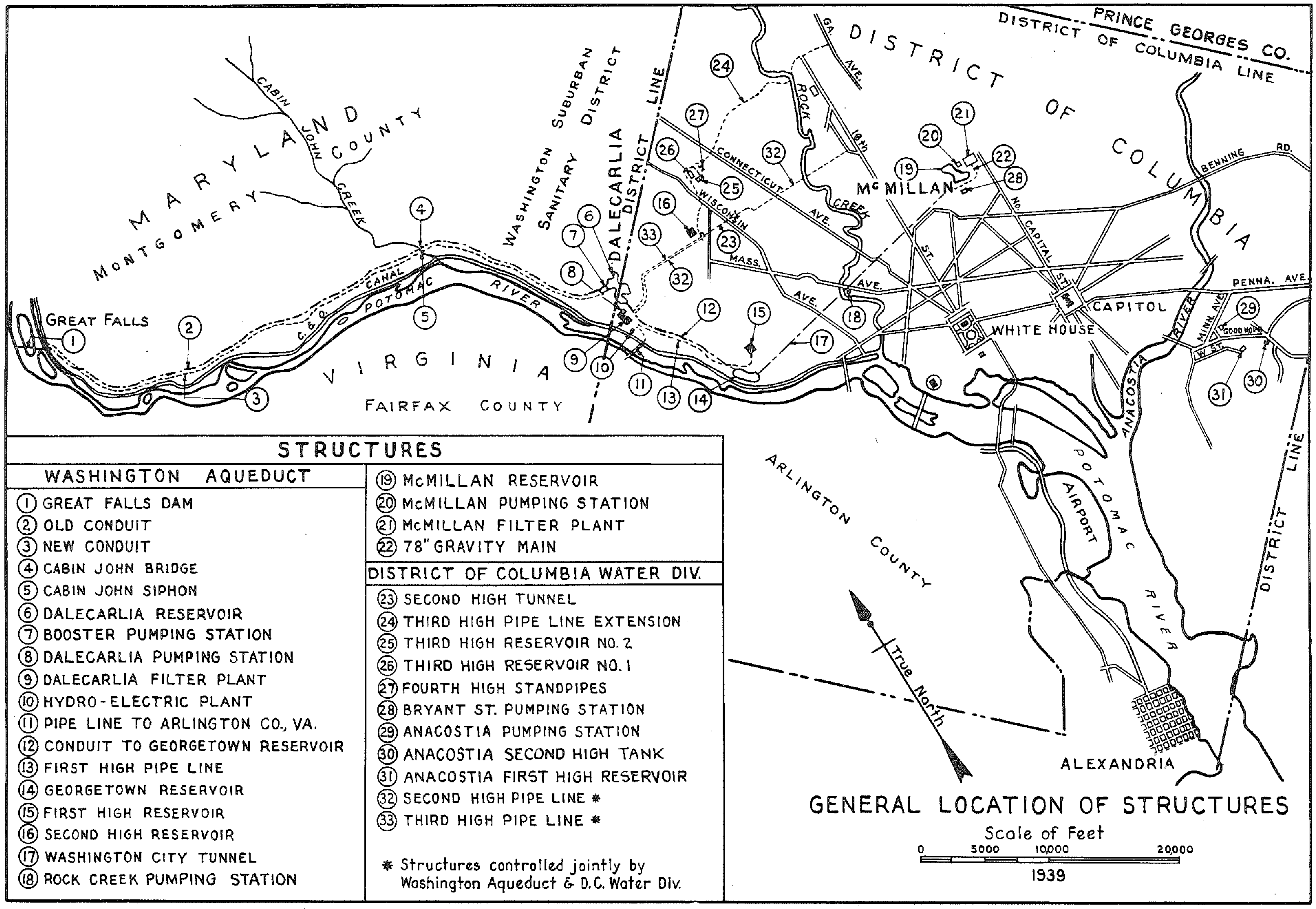


PLATE 1

POTOMAC RIVER AT GREAT FALLS, MD.
SOURCE OF WATER SUPPLY FOR WASHINGTON, D. C.

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
WASHINGTON, D. C.
JUNE, 1939



STRUCTURES

WASHINGTON AQUEDUCT

(1) GREAT FALLS DAM
(2) OLD CONDUIT
(3) NEW CONDUIT
(4) CABIN JOHN BRIDGE
(5) CABIN JOHN SIPHON
(6) DALECARLIA RESERVOIR
(7) BOOSTER PUMPING STATION
(8) DALECARLIA PUMPING STATION
(9) DALECARLIA FILTER PLANT
(10) HYDRO-ELECTRIC PLANT
(11) PIPE LINE TO ARLINGTON CO., VA.
(12) CONDUIT TO GEORGETOWN RESERVOIR
(13) FIRST HIGH PIPE LINE
(14) GEORGETOWN RESERVOIR
(15) FIRST HIGH RESERVOIR
(16) SECOND HIGH RESERVOIR
(17) WASHINGTON CITY TUNNEL
(18) ROCK CREEK PUMPING STATION
(19) McMILLAN RESERVOIR
(20) McMILLAN PUMPING STATION
(21) McMILLAN FILTER PLANT
(22) 78" GRAVITY MAIN

DISTRICT OF COLUMBIA WATER DIV.

(23) SECOND HIGH TUNNEL
(24) THIRD HIGH PIPE LINE EXTENSION
(25) THIRD HIGH RESERVOIR NO. 2
(26) THIRD HIGH RESERVOIR NO. 1
(27) FOURTH HIGH STANDPIPES
(28) BRYANT ST. PUMPING STATION
(29) ANACOSTIA PUMPING STATION
(30) ANACOSTIA SECOND HIGH TANK
(31) ANACOSTIA FIRST HIGH RESERVOIR
(32) SECOND HIGH PIPE LINE *
(33) THIRD HIGH PIPE LINE *

* Structures controlled jointly by Washington Aqueduct & D.C. Water Div.

GENERAL LOCATION OF STRUCTURES

Scale of Feet
0 5000 10,000 20,000

1939

WASHINGTON AQUEDUCT

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WASHINGTON AQUEDUCT

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WASHINGTON AQUEDUCT
INFORMATION PAMPHLET

FOREWORD

The water supply system of Washington, D.C., the National Capital is under the jurisdiction of two organizations, the War Department and the District of Columbia. The War Department, through the Chief of Engineers, U.S. Army, has control of the collection and purification divisions of the system, including dams, conduits, reservoirs, filtration plants and pumping stations. These operations are carried on by the U. S. Engineer Office, Washington, D. C. The distribution division of the water supply system, including certain high service reservoirs and standby and booster pumping stations is under the control of the District of Columbia Water Division. The term "Washington Aqueduct" is the name adopted by Congress for that portion of the water supply system which is under the jurisdiction of the War Department.

1. SOURCE OF SUPPLY. Washington, D. C., obtains its water supply from the Potomac River, which is one of the principal streams in the eastern part of the United States. Two intakes are located at the Maryland end of a low dam at the head of Great Falls, in Maryland, 10 miles northwest from the District of Columbia boundary (see frontispiece, Plate No.1). At this point the river has a watershed area of 11,460 square miles and an average discharge of 11,600 cubic feet per second, or about 7-1/2 billion gallons per day. The maximum consumption at present utilizes less than two percent of the average flow and about 25 percent of the low water flow obtaining during the drought of 1930, the lowest flow of record. The supply of water is, therefore, adequate for any present or prospective needs of Washington and vicinity.

2. LOCATION. The various structures forming the Washington Aqueduct, consisting of dams, intakes, conduits, reservoirs, filtration plants, pumping stations and transmission mains, are located partly in Montgomery County, Maryland, and partly in the District of Columbia (Location Map, Plate 2, on inside of front cover) The structures most distant from the District of Columbia are the diversion dam and the raw water intakes in the Potomac River at Great Falls, Maryland, about 16 miles from the center of the City. All parts of the Washington Aqueduct are readily accessible by the highway system of the District of Columbia and Conduit Road, built by the Federal Government

in the State of Maryland.

3. HISTORY AND AUTHORIZATION. Washington, D. C., founded in 1790, had a slow growth prior to the Civil War. During this period the water supply of the city consisted of numerous springs and wells, many of which had considerable historic interest. The Franklin Park Spring was used as the water supply for the White House and Treasury from 1816 to 1904. The Smith Spring, at the site now occupied by the McMillan Reservoir, supplied water to the United States Capitol from 1832 to 1905. Numerous municipal and private wells were used to augment the spring water supply.

With the growth of the city the question of an adequate water supply became increasingly important, and in 1850 Congress decided to install a general water supply system of ample capacity. Pursuant to acts of Congress of September 30,1850, and August 31, 1852, a report was submitted for the construction of the Washington Aqueduct (February 22,1853, S.Ex.Doc. No.48, 32nd Congress, 2d Session). Construction of the various original water supply structures under the direction of the Corps of Engineers, U. S. Army, was begun pursuant to the act approved March 3, 1853, and completed 10 years later. These structures consisted of the low masonry dam at Great Falls, a circular brick conduit 9 feet in diameter and 9 miles long, a receiving reservoir and a distribution reservoir 2 miles apart connected by a conduit, and several cast iron mains leading to Government buildings and various sections of the city. The first water was admitted to the Washington Water Supply System from the Potomac River in 1863.

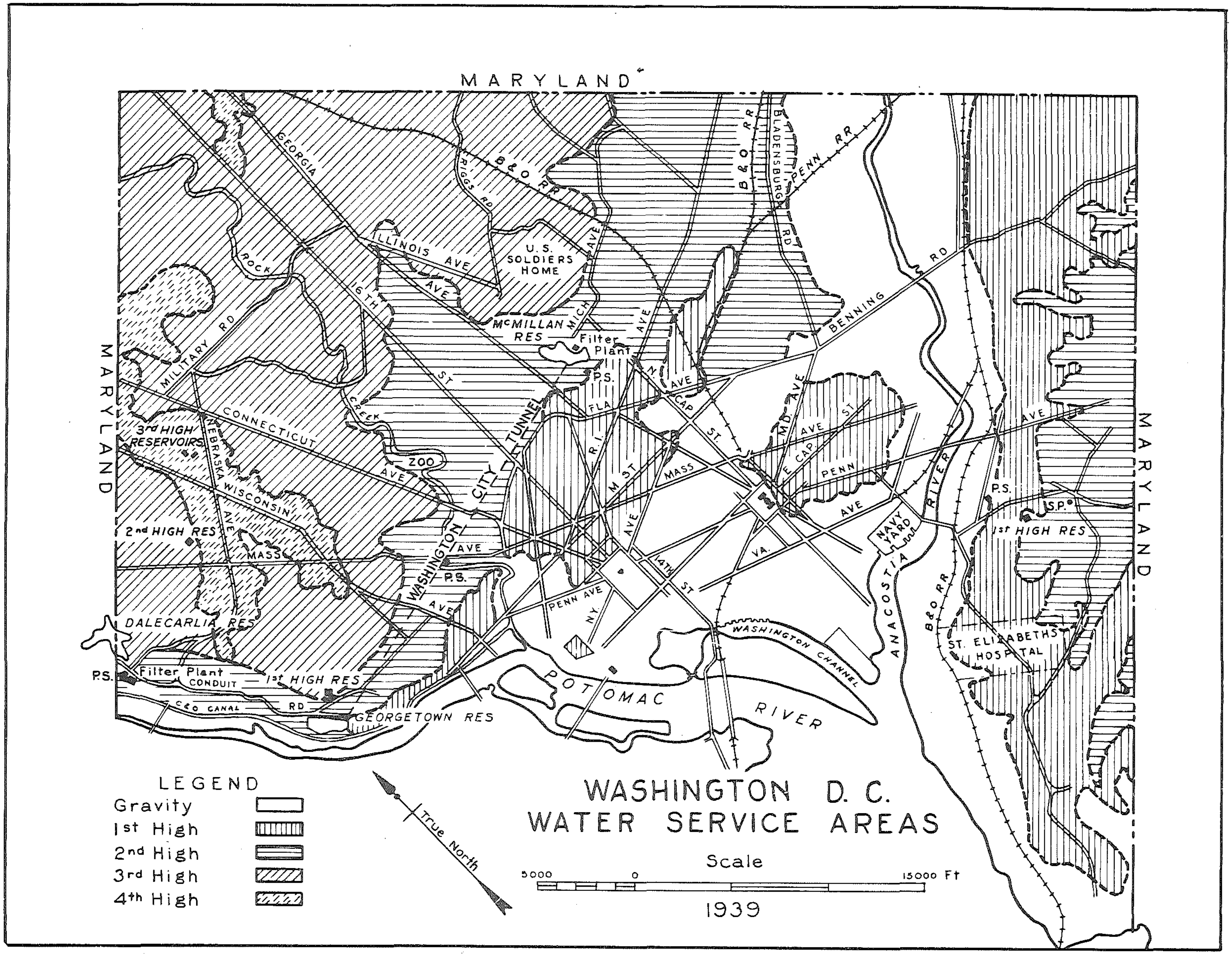
The first extensive additions to the water system were completed in 1905 when the City Water Tunnel and McMillan Reservoir and Filtration Plant were put into service. The second extensive additions to the water supply system, designated Increased Water Supply, were completed in 1928 and comprise the Dalecarlia Filtration Plant, an additional conduit from Great Falls, various pumping stations and service reservoirs. Both of these projects were also constructed under the direction of the Corps of Engineers. The total cost of the structures forming the Washington Aqueduct from 1853 to date is about twenty million dollars (for statement of capital costs see paragraph 10).

The collection, purification and transmission of the water supply for distribution to the National Capital and its environs constitutes the Washington Aqueduct system, which is under the supervision of the War Department. The United States Engineer Office, Washington, D.C., under the direction of the Chief of Engineers, U.S. Army, planned, designed and constructed the original as well the subsequent increased water supplies of the Washington Aqueduct, has operated its facilities, determined its adequacy, and for almost a century has continued to execute this trust faithfully, satisfactorily, and with economy to the water consumers.

4. SERVICE AREAS. The elevation of the land surface in the District of Columbia varies from 5 to 400 feet above mean sea level. The Potomac River at Washington is a tidal stream. By reason of the wide variation in topography five water service areas have been set up in order to provide a pressure in the mains ranging from 30 to 90 pounds with an average pressure of about 50 pounds. The five service areas are known as "Gravity", "First High", "Second High", "Third High" and "Fourth High". General limits of the areas and elevations of the various reservoirs are shown on Plates 3 and 4, respectively.

Normally all water for the gravity area and the section of the city east of the Anacostia River is obtained from the McMillan Filtration Plant. The District of Columbia Water Division pumps part of the gravity water into First and Second High areas lying east of the Anacostia River. The "First", "Second" and "Third" High Areas of the city proper are ordinarily served from the Dalecarlia Plant. The Fourth High Area is a small section located in the highest part of the city. This is served from two water towers under control of the District of Columbia Water Division. Water for these standpipes is pumped from the two Third High Reservoirs.

5. DESCRIPTION OF MAJOR STRUCTURES. (a) Diversion Dam. The diversion dam at Great Falls is a substantial, masonry structure of rectangular section, reinforced with riprap on the upstream side. The dam is 2,877 feet in length, 8 feet wide at the top, and has a height which varies in general from 10 to 15


MARYLAND
MARYLAND
MARYLAND
WASHINGTON D. C.
WATER SERVICE AREAS
Scale
5000
0
15000 Ft
1939
LEGEND
Gravity
1st High
2nd High
3rd High
4th High
True North
GEORGIA
B&O RR
RIGGS RD
B&O RR
BLADENSBURG RD
PENN RR
ILLINOIS AVE
AVE
U.S. SOLDIERS HOME
MICH AVE
McMILLAN RES
Filter Plant
P.S.
ROCK
16TH
ST
MILITARY RD
CREEK
CONNECTICUT AVE
ZOO
3rd HIGH RESERVOIRS
NEBRASKA AVE
WISCONSIN AVE
MASS AVE
2nd HIGH RES
WASHINGTON CITY TUNNEL
P.S.
AVE
FLA
R.I.
N. CAP. ST.
AVE
MD AVE
E. CAP. ST
MASS
M ST
AVE
PENN AVE
PENN AVE
VA.
14TH ST
N.Y.
NAVY YARD
BENNING RD
AVE
RIVER
ANACOSTIA
P.S.
S.P.
1st HIGH RES
B&O RR
ST. ELIZABETHS HOSPITAL
DALECARLIA RES
P.S.
Filter Plant
CONDUIT
1st HIGH RES
C&O CANAL
RD
GEORGETOWN RES
POTOMAC RIVER
WASHINGTON CHANNEL

-4-

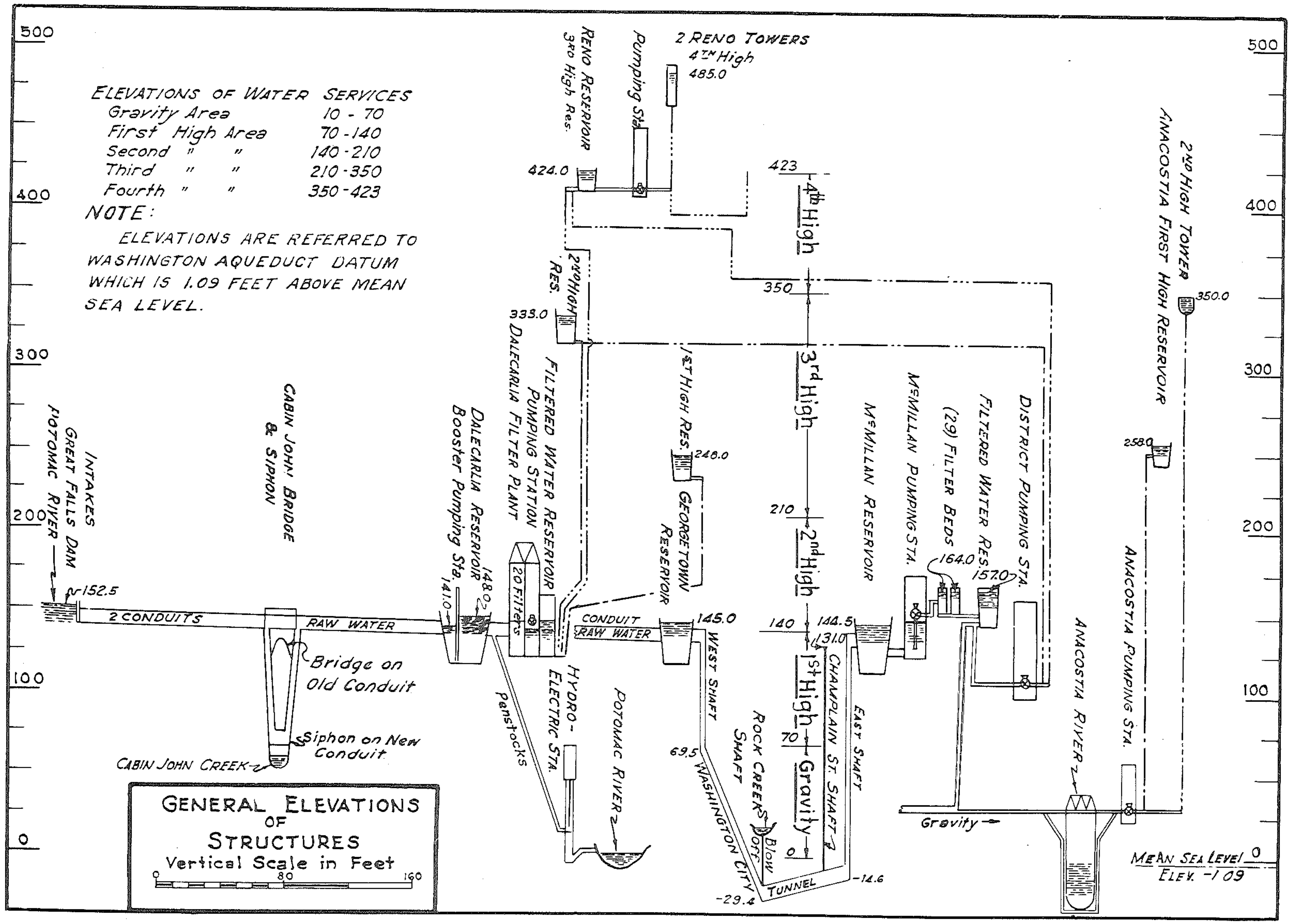
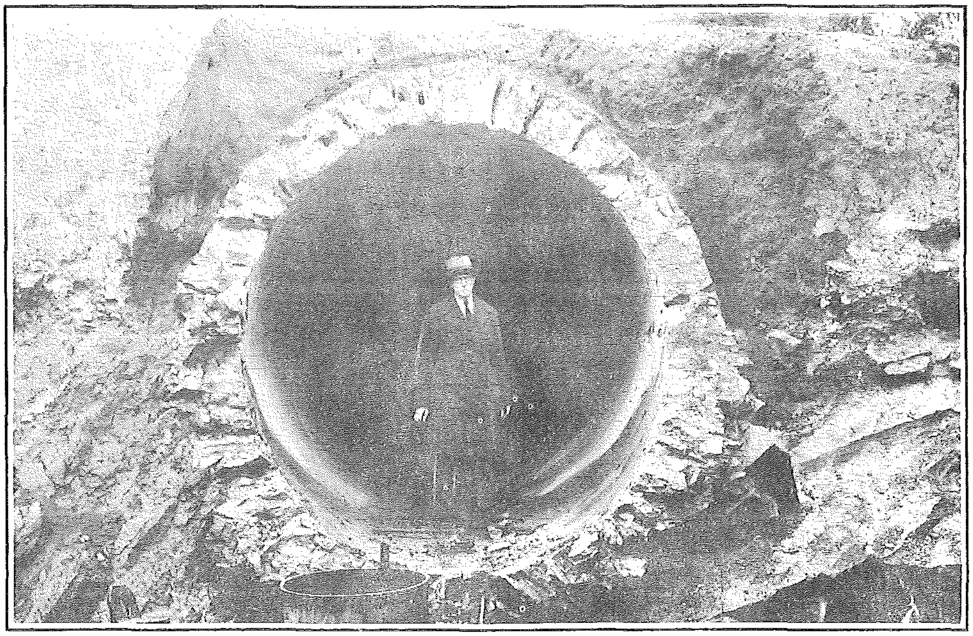

ELEVATIONS OF WATER SERVICES
Gravity Area 10 - 70
First High Area 70 - 140
Second " " 140 - 210
Third " " 210 - 350
Fourth " " 350 - 423
NOTE:
ELEVATIONS ARE REFERRED TO WASHINGTON AQUEDUCT DATUM WHICH IS 1.09 FEET ABOVE MEAN SEA LEVEL.
GENERAL ELEVATIONS OF STRUCTURES
Vertical Scale in Feet
2 RENO TOWERS 4TH High 485.0
Pumping Sta.
RENO RESERVOIR 3RD High Res.
424.0
2ND HIGH RES.
333.0
2ND HIGH TOWER 350.0
ANACOSTIA FIRST HIGH RESERVOIR
258.0
ANACOSTIA PUMPING STA.
ANACOSTIA RIVER
DISTRICT PUMPING STA.
FILTERED WATER RES. 157.0
(29) FILTER BEDS 164.0
McMILLAN PUMPING STA.
McMILLAN RESERVOIR
4th High
3rd High
2nd High
1st High
Gravity
1ST HIGH RES. 246.0
GEORGETOWN RESERVOIR
145.0
WEST SHAFT
EAST SHAFT
CHAMPLAIN ST. SHAFT
ROCK CREEK SHAFT
Blow Off
WASHINGTON CITY TUNNEL
-29.4
-14.6
69.5
144.5
131.0
CONDUIT RAW WATER
POTOMAC RIVER
HYDRO-ELECTRIC STA.
Penstocks
FILTERED WATER RESERVOIR
PUMPING STATION
DALECARLIA FILTER PLANT
20 Filters
DALECARLIA RESERVOIR 148.0
Booster Pumping Sta. 141.0
RAW WATER
CABIN JOHN BRIDGE & SIPHON
Bridge on Old Conduit
Siphon on New Conduit
CABIN JOHN CREEK
2 CONDUITS
152.5
INTAKES
GREAT FALLS DAM
POTOMAC RIVER
Gravity
MEAN SEA LEVEL 0
ELEV. -1.09

PLATE 4

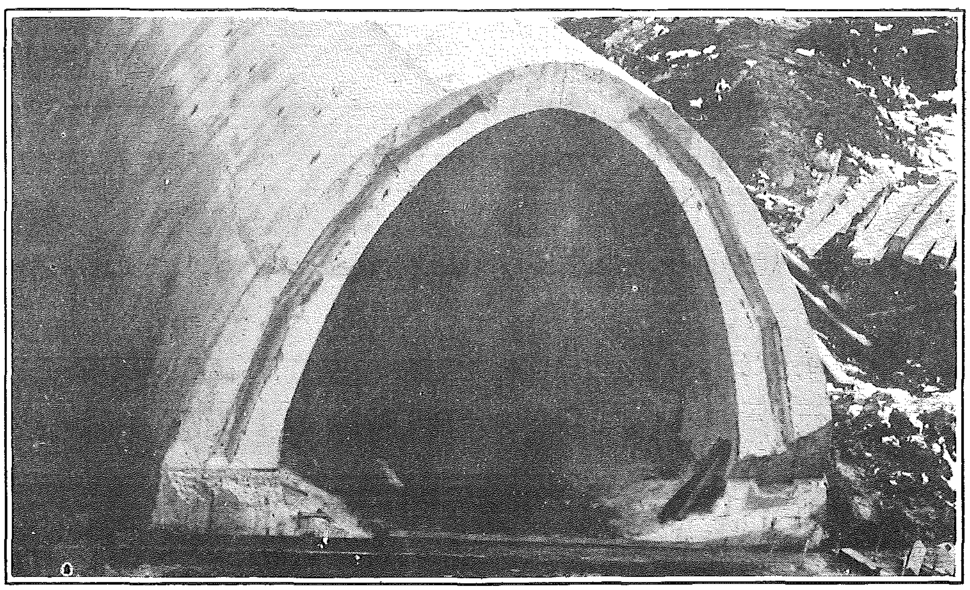
feet with a maximum height of 24 feet. The top of the entire length of the dam acts as a spillway. The first section of the present dam was constructed during the period 1864 to 1867, with a crest elevation of 147.0 This section only extended out from the Maryland shore to Conn's Island in the middle of the Potomac River. During 1883 to 1886 the dam was increased in height to 148.0 and extended to the Virginia shore. In 1896 the crest of the dam was raised to elevation 150.5 and the coping stones were anchored to the main structure of the dam with 2-inch bolts 7 feet in length. In 1928 flashboards 1-foot high were erected on top of the dam, bringing the total height to 151.5 above sea level. The average crest of water over flashboards is approximately 12 inches, so that the surface of the intake pool ranges between elevation 150.0 and 153.0.

(b) Old Conduit. The old conduit, extending 9 miles from Great Falls to the Dalecarlia Reservoir and thence 2 miles to the Georgetown Reservoir, was the largest single structure involved in the original construction of the Washington Aqueduct during the period 1853-1863. The design of this old conduit was based to a large extent on the first New York and Boston Aqueducts, completed in 1842 and 1848, respectively. The name "Washington Aqueduct" was derived in this manner. In general, the conduit is circular and 9 feet in diameter, and is constructed of either 2 or 3 rings of brick or cemented rubble masonry (Plate 5). The slope for the entire length of the conduit is about 9-1/2 inches per mile. Between Great Falls and Dalecarlia the conduit traverses 11 tunnels having an aggregate length of 5,392 feet. In the tunnel sections the rock excavation is lined entirely with concrete to an inside diameter of 9 feet. The conduit crosses a number of streams on masonry culverts or arch bridges, one of which, Cabin John Bridge (Plate 6), has a span of 220 feet and for 40 years, from 1863 to 1903, held the record of being the longest cut stone masonry arch in the world. At this bridge the conduit is strengthened by a cast iron lining with an inside diameter of 7-1/2 feet. The conduit is well provided with manholes, blow-offs, and overflows at suitable locations. The water in the conduit flows under slight pressure at the upper end, being somewhat below its hydraulic grade in the vicinity of Great Falls. Under normal conditions with the river eleva-

PLATE 5



OLD CONDUIT - 9 FEET DIAMETER



NEW CONDUIT - 10' X 10' DIAMETER

PLATE 6

CABIN JOHN BRIDGE, 220 FOOT SPAN (CARRIES OLD CONDUIT)
AND INVERTED SIPHON, AT RIGHT.

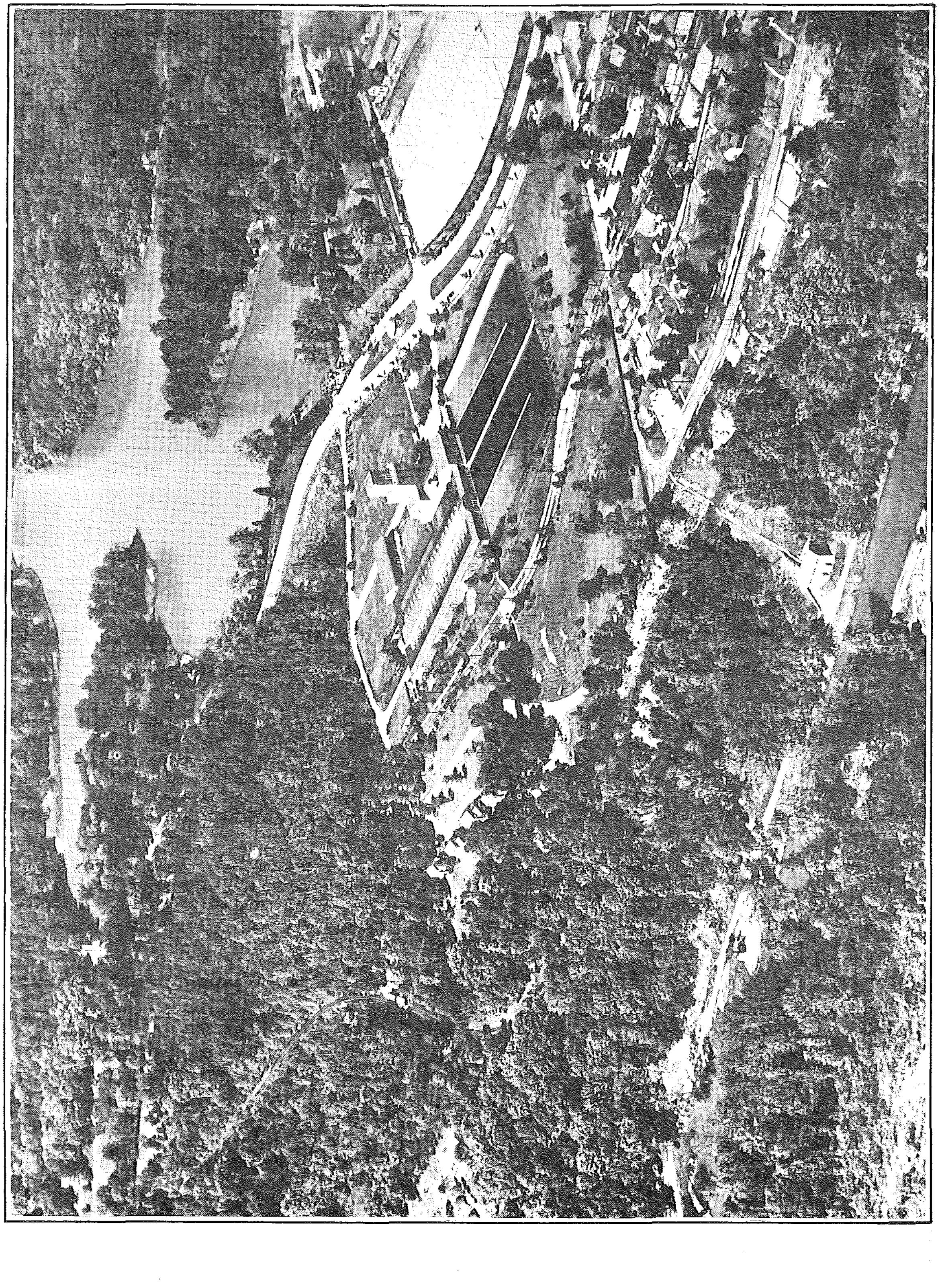
tion 152 and the water level held at elevation 141 at the outlet end in Dalecarlia Reservoir, the capacity of the old conduit is 100,000,000 gallons per day. Today, about eighty years after its construction, this conduit is in an excellent state of preservation and good for many more years of service.

(c) Conduit Road. Conduit Road extends from the District line to Great Falls, Maryland, a distance of about 10 miles, and is located for the greater part of its length over the centerline of the old conduit. The construction of this road, which was begun in 1870, was of water-bound macadam 14 feet wide. Its purpose was to give access to the various structures of the collecting system. With increasing urban development along each side of Conduit Road it is now utilized as a public highway rather than a special Federal right-of-way. The present road has a bituminous macadam surface 16 feet wide and a surface coat is applied about every third year.

(d) New Conduit. The new conduit, completed in 1926, parallels the old conduit at an average distance of 30 feet, and has practically the same slope and hydraulic gradient. The conduit is a horseshoe-shaped unreinforced concrete structure with a capacity of 120,000,000 gallons per day (Plate 5). At Cabin John Bridge an inverted siphon instead of a bridge was used for reasons of both economy and safety. The siphon is a steel pipe encased entirely in concrete (Plate 6), and provides a structure which is fully as satisfactory, although not as artistic, as the adjacent Cabin John Bridge. The new conduit is provided with numerous blow-offs and three cross connections with the old conduit so that any section of either structure may be temporarily de-watered for inspection or emergency repairs.

(e) Raw Water Reservoirs. At the time of the original construction of the Washington Aqueduct from 1853 to 1863 the purification of water by filtration or chemical treatment was not practiced in the United States. In order to partially clear the water before it was sent to the city, two large open reservoirs, known as "Dalecarlia" (Plate 7) and "Georgetown" (Plate 8) were constructed to act as sedimentation basins. These two reservoirs served as the original purification system. Dalecarlia was called the "Receiving Reservoir" and

PLATE 7



DALECARLIA RESERVOIR AND FILTRATION PLANT

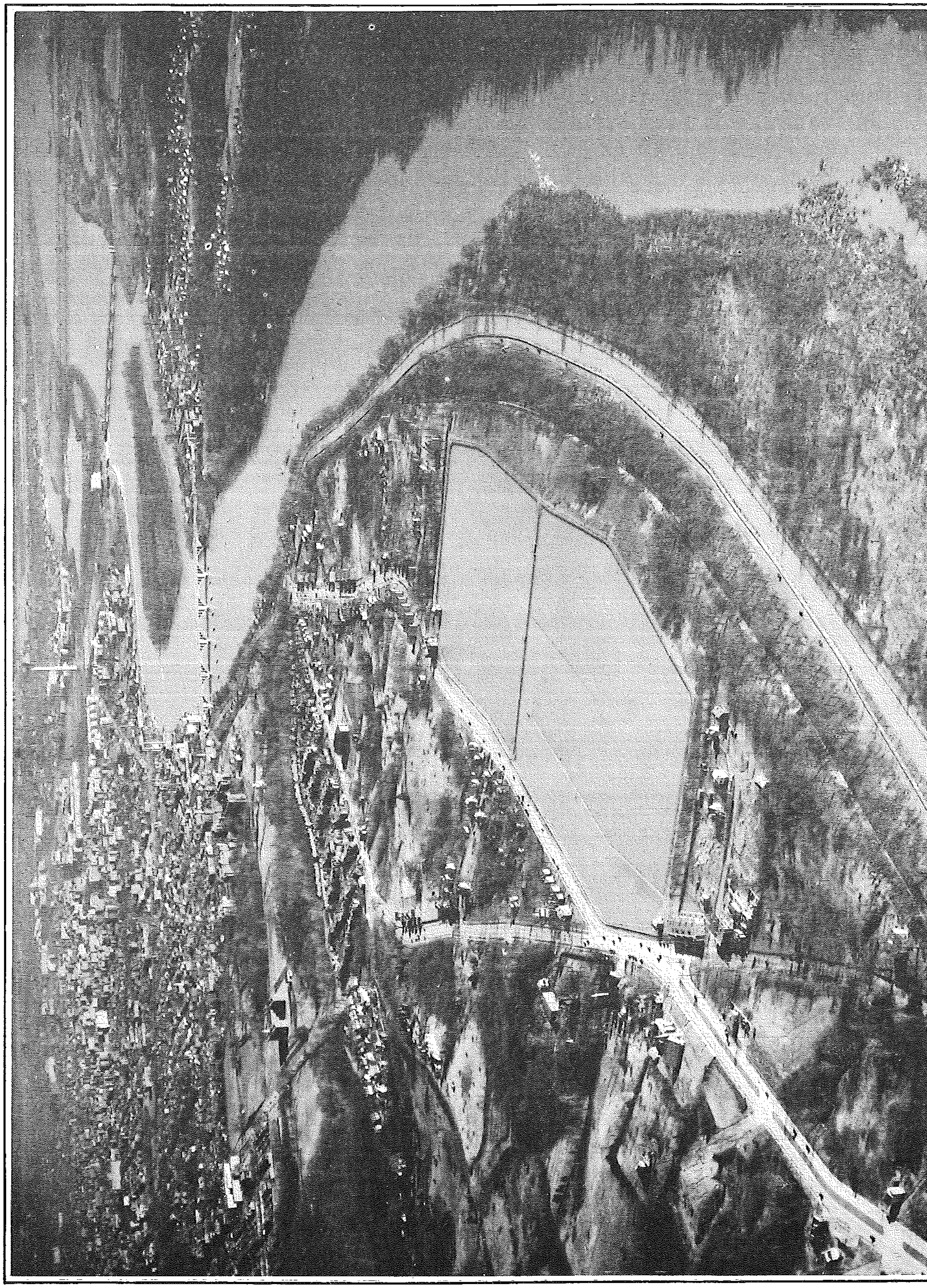


PLATE 8

GEORGETOWN RESERVOIR

Georgetown the "Distributing Reservoir". The water remained in these two reservoirs approximately six days before it went to the city. This removed the heavier river mud but did not by any means eliminate the fine material carried in suspension. The McMillan Raw Water Reservoir (Plate 9), the third in the series, was completed in 1902. These three raw water storage reservoirs still serve the important function of providing a suitable series of settling basins for the unfiltered Potomac River water, and provide sufficient storage of raw water to last the city about 48 hours.

The Dalecarlia Reservoir is located in a wooded valley at the District line in the northwest section of the city and has an area of 46 acres and a capacity of 200,000,000 gallons (Plate 7) The reservoir is equipped with spillways and drains. Dikes and channels along its borders divert adjacent streams and surface water from the reservoir, and the shores are protected with a riprap stone revetment. A conduit 9 feet in diameter,lined with rubble and brick, was built to by-pass the water around the reservoir in case of emergency.

The Georgetown Reservoir(Plate 8)is located 2 miles southeasterly of the Dalecarlia Reservoir, and has an area of 42 acres with a capacity of 173 million gallons. The shores are revetted with riprap. In 1913 certain alterations were made whereby the northerly quarter of this reservoir was prepared for use as a settling basin for the water passing to the McMillan slow-sand filters. Around-the-end baffles are provided and a 10-hour period of travel is available for the mud to settle out. The first section of the basin has a concrete floor and the mud deposits are flushed out about once a year. When the water has a high turbidity aluminum sulphate is added in the old conduit at Dalecarlia and is thoroughly mixed with the water in the 2 mile travel to the Georgetown Reservoir. A conduit 7 feet in diameter, lined with brick, was built to by-pass the water around the reservoir in case of emergency.

McMillan Reservoir(Plate 9)is located near the center of the District of Columbia, about 2 miles north of the Capitol (Plate 2) The reservoir was created by a high earth dam approximately 1300 feet in length which formed a storage basin with an area of 38 acres, having a capacity of 264,000,000 gallons. The shores of the reservoir are revetted with riprap. Since the reservoir is

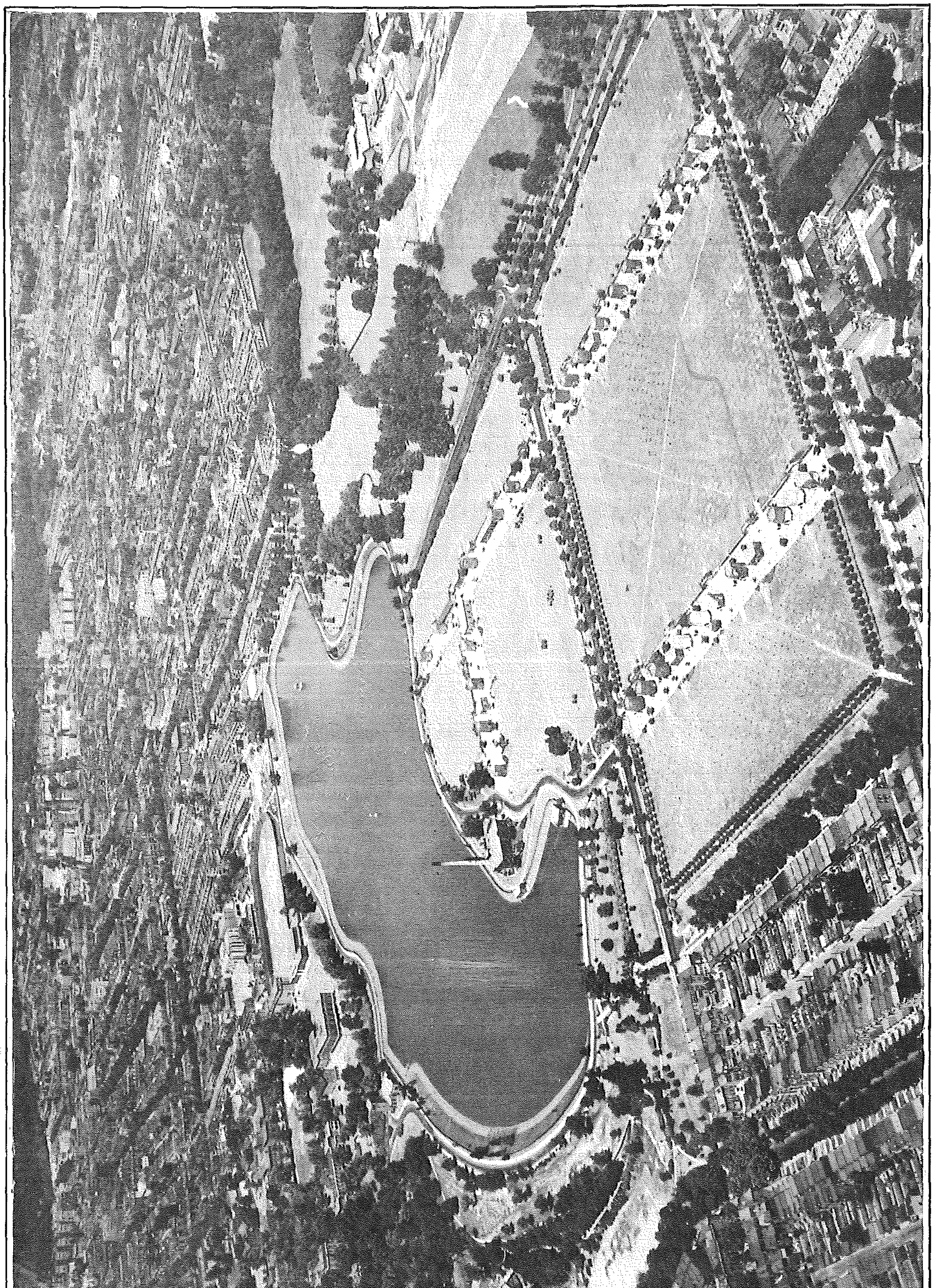


PLATE 9

McMILLAN RESERVOIR AND FILTRATION PLANT

located in a populated section of the city, storm water diversion sewers were constructed on each side of the reservoir to avoid pollution.

(f) The Washington City Tunnel. The tunnel (Item 17, Plate 2) extends for the length of 4 miles from the west shaft at Georgetown Reservoir to the east shaft at McMillan Reservoir. Under normal conditions the carrying capacity of the tunnel is 75,000,000 gallons per day. Construction of the tunnel was begun in 1882 but was discontinued three years later due to insufficient funds. The tunnel construction lay uncompleted for approximately 16 years but was finally completed in 1902. The tunnel is lined with brick, is horseshoe-shaped in cross-section, and has a height of 9 feet. At the entrance it has an elevation of plus 70 and at the discharge end an elevation of minus 14. The greater portion of the tunnel lies from 65 to 170 feet below the surface of the ground. The lowest portion of the tunnel at elevation minus 29, under Rock Creek, is lined for 400 feet with flanged cast iron plates backed with concrete.

During construction the section of the tunnel west of Rock Creek was changed and the grade of the invert lowered about 7 feet for a length of 1/2 mile. These changes were made in order that the drainage between Rock Creek and the Georgetown Reservoir could be handled by the Rock Creek Pumping Station. With the shape of the tunnel changed from a horseshoe section to an elongated ellipse, wrought iron struts were placed to reinforce the side walls. In 1927 these iron struts were replaced with concrete braces. The present condition of the tunnel is considered good.

Two shafts at the ends of the tunnel approximately 14 feet in diameter and two intermediate shafts approximately 6 feet in diameter afford access to the tunnel for inspection. The easterly three of these located at Rock Creek, Champlain Street, and the east shaft at McMillan Reservoir, are used for de-watering the tunnel. Formerly pneumatic air lifts were available for this purpose but deterioration and obsolescence led to their removal in 1937. As about 8,000,000 gallons of water must be pumped to de-water the low sections of the tunnel not drained by gravity and as the tunnel can only remain out of service for a very limited time, special pumps are to be secured at an early date so that any emergency repairs to the tunnel can be expeditiously made.

(g) Dalecarlia Filtration Plant. This plant is located in the northwest section of Washington, about 5 miles from the center of the city (Plates 2, 7, and 10). The plant, completed in 1928, is of the rapid sand filter type with a rated capacity of 80,000,000 gallons per day. Raw water for the plant is taken from the Dalecarlia Reservoir, described in paragraph 5(e).

The main structure of the plant is a brick and reinforced concrete filter building of modern design, 361 feet long and 155 feet wide. The building contains 20 rapid-sand filters, each 54 feet long and 31 feet wide, with a rated capacity of 4,000,000 gallons per filter per day, or at a rate of 125 m.g.d. per acre. These are cleaned by reversing the flow of filtered water, thus washing off the accumulated mud into gutters. Approximately 2 percent of all filtered water is used for this purpose. Chemical storage bins for lime, alum and bauxite, storage tanks for sulphuric acid, chemical feed equipment, and chemical laboratory are located in the center tower section of the structure. The pumping facilities for handling the water occupy a wing at the north end of the building.

Additional structures of the filtration plant consist of two covered concrete mixing basins, each 80 feet square and 18 feet deep, with around-the-end baffles; two open concrete-floored settling basins, each 335 feet long, 150 feet wide and 12 to 17 feet deep, which are flushed out about once a month, a covered filtered water reservoir with a capacity of 15,000,000 gallons, and various auxiliary structures, including offices, shops, garages, storerooms, and six dwellings for the principal operating personnel in charge of the plant.

The pumping and hydro-plant installations (Plates 7 and 10) and the chemical treatment at the Dalecarlia Filtration Plant are described in paragraphs 6 and 7.

(h) McMillan Filtration Plant. This plant is located at First and Douglas Streets, NW., about 2 miles north of the center of the city (Plates 2, 9 and 11). The plant, completed in 1905, is of the slow-sand type with a rated capacity of approximately 75,000,000 gallons per day. The raw water for the plant

PLATE 10

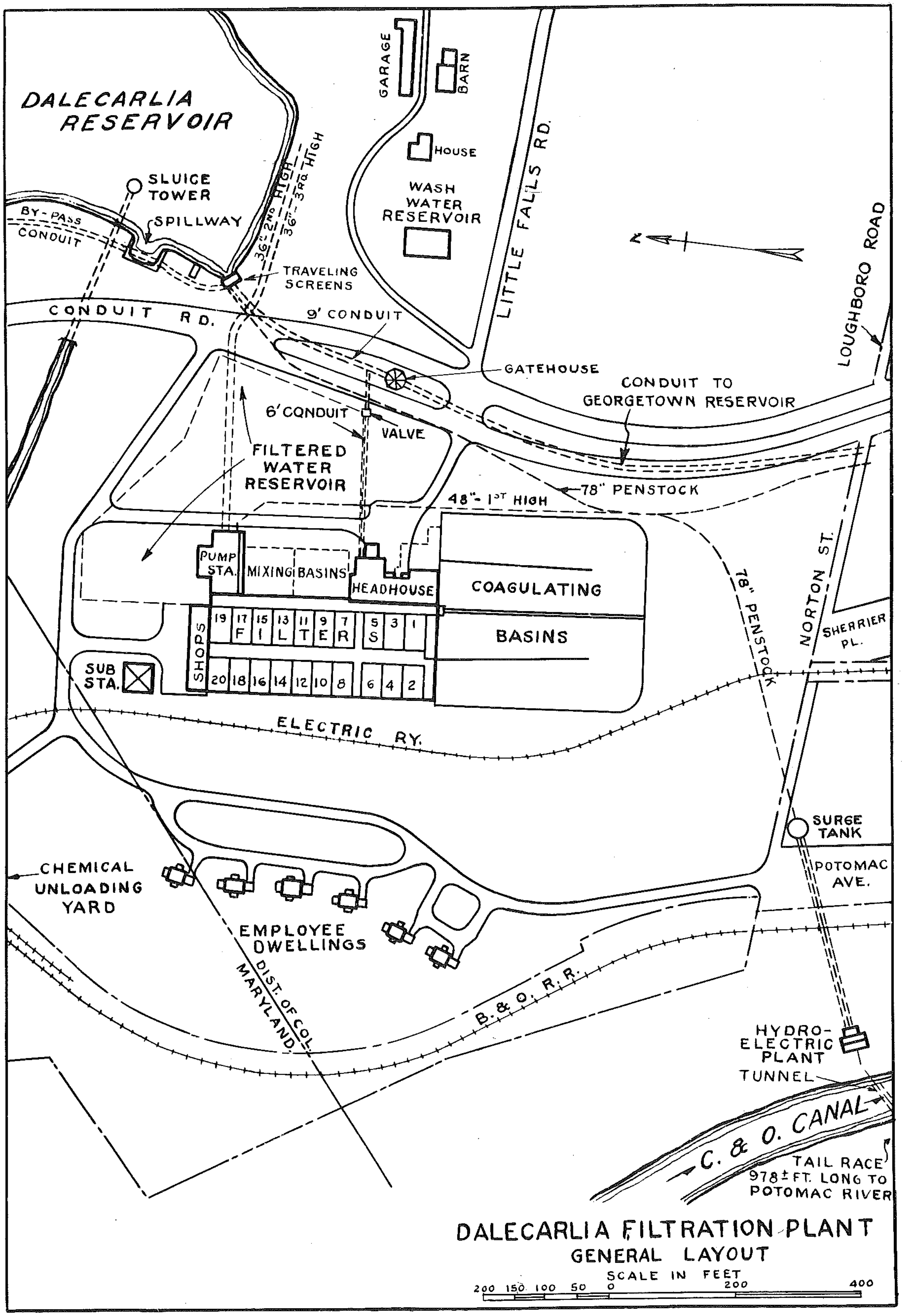
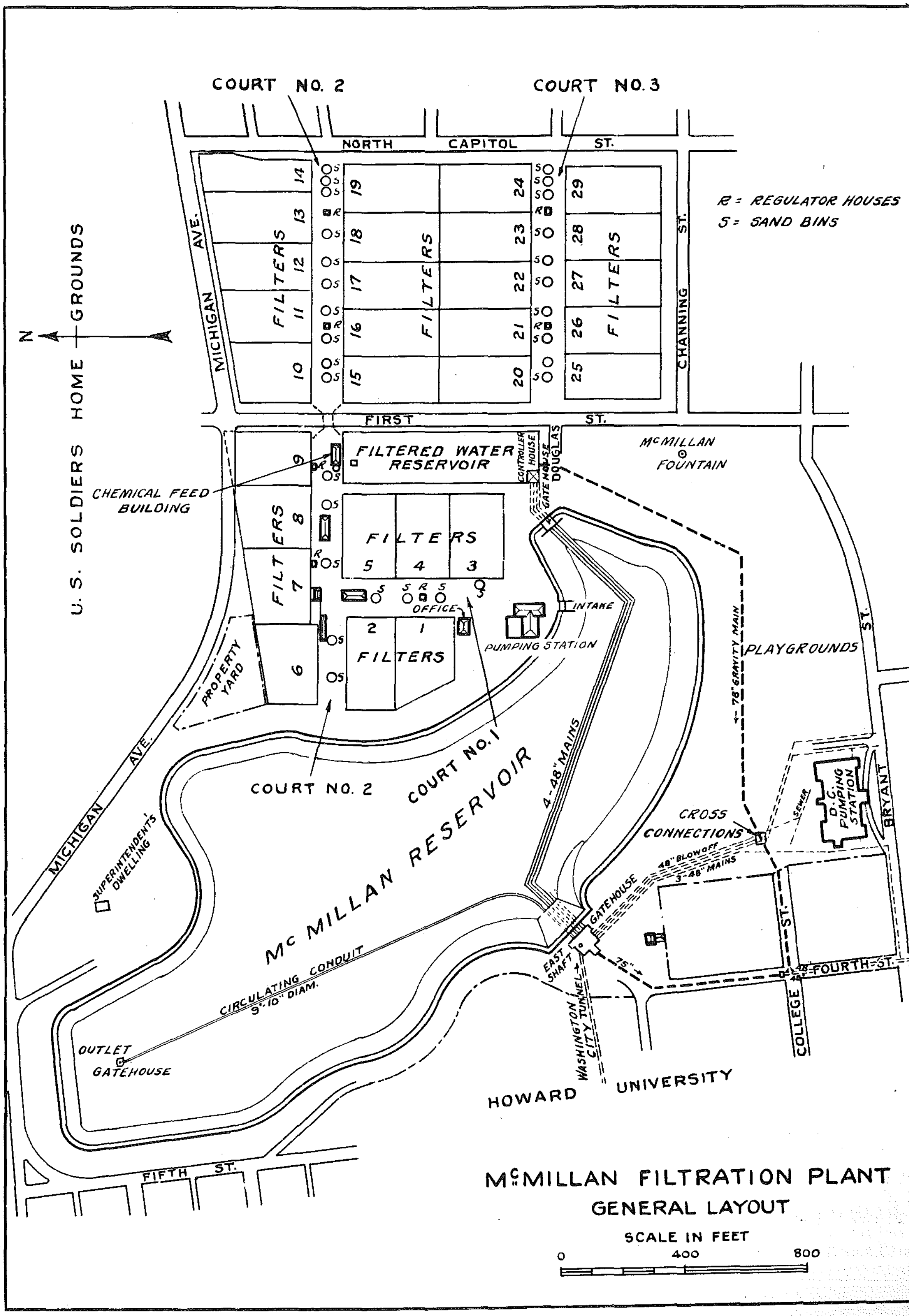

DALECARLIA RESERVOIR
SLUICE TOWER
BY-PASS CONDUIT
SPILLWAY
36" 2ND HIGH
36" 3RD HIGH
TRAVELING SCREENS
GARAGE
BARN
HOUSE
WASH WATER RESERVOIR
LITTLE FALLS RD.
LOUGHBORO ROAD
CONDUIT RD.
9' CONDUIT
GATEHOUSE
CONDUIT TO GEORGETOWN RESERVOIR
6' CONDUIT
VALVE
FILTERED WATER RESERVOIR
78" PENSTOCK
48"-1ST HIGH
PUMP STA.
MIXING BASINS
HEADHOUSE
COAGULATING
BASINS
19 17 15 13 11 9 7 5 3 1
FILTERS
SHOPS
20 18 16 14 12 10 8 6 4 2
SUB STA.
NORTON ST.
SHERRIER PL.
ELECTRIC RY.
SURGE TANK
POTOMAC AVE.
CHEMICAL UNLOADING YARD
EMPLOYEE DWELLINGS
DIST. OF COL.
MARYLAND
B. & O. R.R.
HYDRO-ELECTRIC PLANT
TUNNEL
C. & O. CANAL
TAIL RACE 978± FT. LONG TO POTOMAC RIVER
DALECARLIA FILTRATION PLANT
GENERAL LAYOUT
SCALE IN FEET
200 150 100 50 0 200 400

PLATE 11



McMILLAN FILTRATION PLANT
GENERAL LAYOUT

flows to the McMillan Reservoir by gravity from the Dalecarlia Reservoir, passing through the Georgetown Reservoir and the Washington City Tunnel (paragraphs 5(e) and 5(f)).

The principal structures of the plant consist of 29 slow sand filter beds with an area of 1 acre each; 29 concrete bins for sand storage, each 23 feet in diameter and 32 feet in height; 7 regulating houses; a 15,000,000 gallon filtered water reservoir; a pumping station for lifting the water about 18 feet from the raw water reservoirs to the filter beds; and various offices, shops, and storehouses. All major structures, which are of brick, were placed in service in 1905.

The filters consist of covered rectangular groined arch concrete structures with a net sand area of 1 acre and a designed capacity of 3,000,000 gallons per day. Ordinarily 4 filters are held out of service for cleaning. While it may be possible to filter at higher rates, the carrying capacity of the Washington City Tunnel limits the total output of the plant to approximately 75 million gallons per day. Filter sand averages 36 inches deep and rests on 1 foot of gravel. Tile under-drains collect the filtered water and carry it to regulating houses whence, in turn, it is delivered to the filtered water reservoir through cast iron mains. The filters are cleansed twice a year by scraping off about 2 inches of sand from the top of each filter. This sand is deposited in hydraulic ejector boxes, whence, through hose and pipe, it is carried to sandwashers located in the filter courts. The sandwashers operate by reverse currents of clean water which flush the mud into the city sewers, and the sand is then stored temporarily in cylindrical concrete sand bins or towers. When sufficient sand has been scraped from the filters they are hydraulically resanded from the bins. Chlorine, ammonia and lime are added as required to the filtered water. Details of the pumping installations, filtration, and the chemical treatment are described in paragraphs 6 and 7.

(i) <u>High Service Reservoirs and Transmission Mains</u>. After the water for the high service areas in the northwest section of the city is filtered and sterilized at the Dalecarlia Filter Plant it is pumped by the Dalecarlia Pumping Station to the First, Second and Third High Reservoirs (Plates 2 and 12) which serve to balance pressures in the service areas and provide limited storage. These reservoirs equalize pumping requirements, smooth out or reduce peak demands on pumping stations, and in case of power failure furnish water to the distribution system until pumping has been restored.

The First and Second High Service Reservoirs were constructed in the period 1925 to 1928 (Plate 12) and have given excellent service. Water levels in the reservoirs are remote-controlled, as described in paragraph 6.

Transmission mains, built by the Washington Aqueduct, are standard pressure type concrete pipes, varying in size from 36 inches to 70 inches. These mains were constructed between 1923 and 1928 and have a total length of 7.7 miles.

(j) Federal Meters. In addition to the primary functions of collecting, purifying, filtering and pumping the water for the City of Washington and environs, the Washington Aqueduct, through the Chief of Engineers, U.S. Army, is charged with the measurement of water consumed in all Federal buildings, parks and other Federal Government activities within the District of Columbia. As necessary, new meters are installed, old ones replaced, and all meters in service maintained in operating condition.

At present there are a total of 615 Federal meters in service, ranging from 5/8-inch disc type, for park and small building service, to a 20-inch Venturi type for larger buildings and reservations. The Federal services are 97 percent metered. These meters are inspected and read monthly and defective meters repaired immediately to insure continuous and correct recording. Meter readings are used to form a composite monthly report with those of the District of Columbia Water Division so that the complete record of water consumed within the District of Columbia may be accurately recorded, thus providing a check on losses in the distribution system.

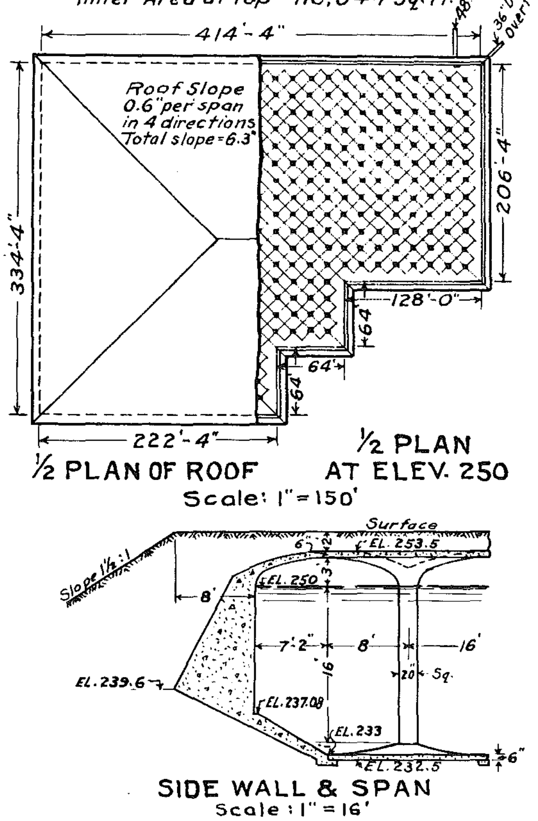
6. PUMPING PLANTS, HYDRO-ELECTRIC GENERATING STATION, AND SUB-STATION.

(a) General. There are two low-lift pumping stations in the collecting system. Even though the source of the raw water in the Potomac River at Great Falls is 125 feet above the level of the downtown area of Washington, it

PLATE 12

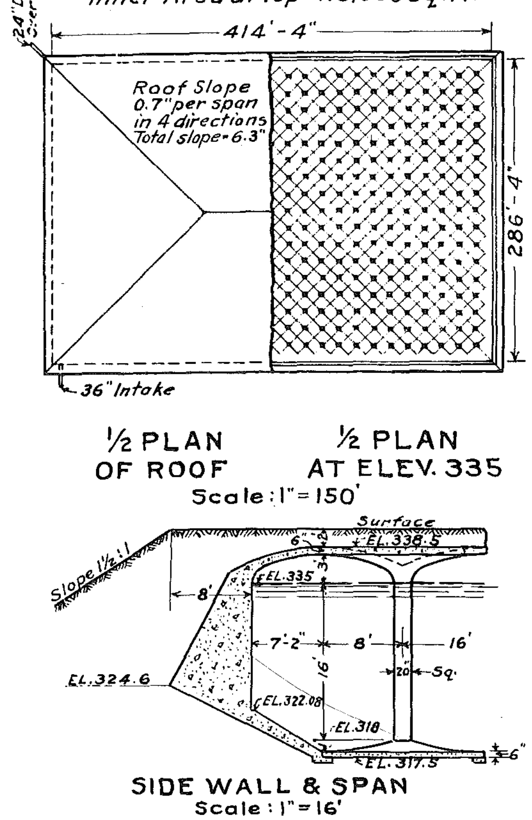
First High Reservoir

Inner Area at top = 118,044 sq. ft.



Second High Reservoir

Inner Area at top = 118,635 sq. ft.



Total Capacities of Reservoirs, at Elevations given

FIRST HIGH RESERVOIR				SECOND HIGH RESERVOIR			
Elev.	*Mil. Gals.*	*Elev.*	*Mil. Gals.*	*Elev.*	*Mil. Gals.*	*Elev.*	*Mil. Gals.*
250	14.546	241	6.657	335	14.629	326	6.700
249	13.670	240	5.780	334	13.748	325	5.819
248	12.793	239	4.904	333	12.867	324	4.939
247	11.917	238	4.027	332	11.986	323	4.058
246	11.040	237	3.151	331	11.105	322	3.178
245	10.163	236	2.289	330	10.224	321	2.311
244	9.287	235	1.146	329	9.343	320	1.460
243	8.410	234	0.620	328	8.462	319	0.627
242	7.534			327	7.581		

HIGH SERVICE RESERVOIRS

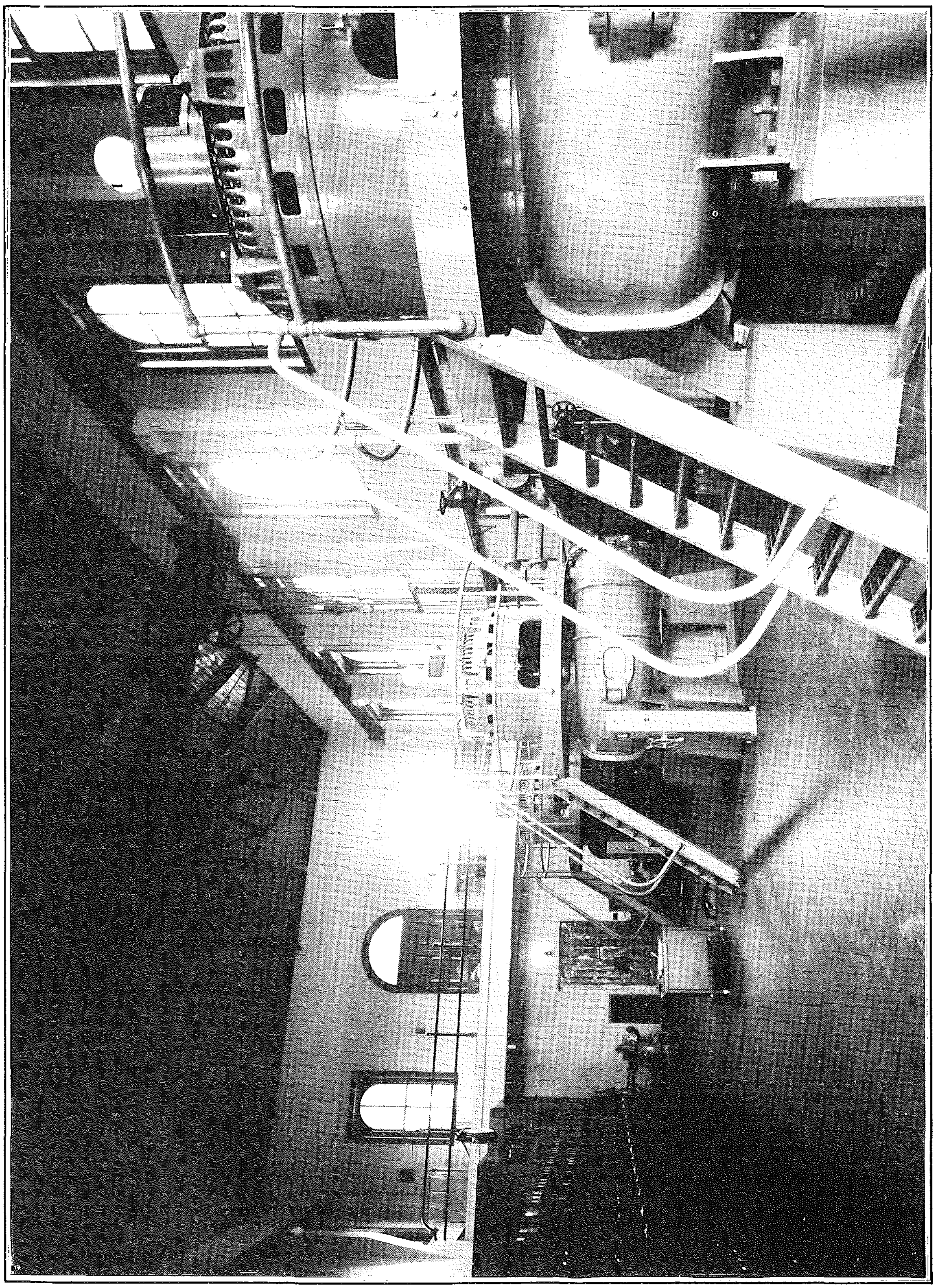
is necessary to "boost" the flow of water through the gravity conduits. The first low-lift pumping plant is located in a structure forming a dam across the northern neck of the Dalecarlia Reservoir. This station serves as a booster to increase the flow through the two gravity conduits bringing the raw water from Great Falls. By raising the water level in the Dalecarlia Reservoir the Booster Pumping Plant also increases the efficiency of the Dalecarlia filters and the chemical treatment. The second low-lift pumping station is located at the McMillan Filtration Plant and lifts the water from the storage reservoir to the filter beds. In addition to the pumping plants of the collecting system, a high-lift pumping station is located at the Dalecarlia Filtration Plant. This unit serves to pump water from the Dalecarlia Filtered Water Reservoir into each of the three high service reservoirs; i.e., First, Second and Third High areas of the northwest section of the city and to Arlington County, Va. An automatic remote-controlled hydro-electric generating station is operated in conjunction with the Dalecarlia Pumping Plant and generates approximately 60 percent of the total electric energy consumed by this station and the filtration plant. The generating plant utilizes the surplus water brought down by the two conduits from Great Falls. As the city grows the water available for generating electricity decreases and more commercial power must be purchased. At present an average of 21,000,000 kilowatt hours are consumed per annum by the Dalecarlia operations. The Dalecarlia plant is one of the largest single consumers of purchased electric energy in the District of Columbia. Due to this large power consumption a low rate structure is available so that the average cost of power is 7.2 mills per k.w.h.

All plants are arranged and laid out so that continuity of service is assured. The pumping plants are provided with duplicate auxiliary units throughout so that failure of a unit would not cripple the plant from an operating standpoint. All equipment forming an important line in the operation system is provided with full automatic protection to insure against damage in case of unexpected trouble. Automatic protective features, in keeping with modern design, have been provided in all plants in which electrical and rotating equipment were installed.

DESCRIPTION OF INDIVIDUAL PLANTS:

(b) The Dalecarlia Booster Pumping Plant is designed to lower the level of water at the outlets of the two conduits from Great Falls. This makes the hydraulic gradient of the water steeper and increases the gravity flow from Great Falls from 180 m.g.d. to 220 m.g.d. The plant is fully automatic in operation, with supervisory control carried back to the operator's desk located in the Dalecarlia Pumping Station Control Room. The pumping equipment consists of three main units of the vertical type with bottom suction and horizontal discharge. Each of the main units is designed for normal capacity of 75,000 g.p.m. or 108 m.g.d. against a total static head of 8 feet when operating at a speed of 180 r.p.m. The pumps are of the mixed flow, centrifugal type, designed with a specific speed value of 6,500. Synchronous motors of 200 horsepower rating are mounted on top of the pump casing and operate on a 2,300-volt, 3-phase, 60 cycle, alternating current. A make-up pump with a variable capacity of from 5,000 g.p.m. to 15,000 g.p.m. forms a balancing unit which automatically operates in conjunction with the main units. This unit is driven by a 40 horsepower 220-volt, 3-phase, wound rotomotor. A novel feature of this station is that the pumps are located above the water elevation of the main reservoir and the pump piping is arranged to form a siphon. The pumps are mounted in the siphon and serve to force the water over the dam. In this arrangement shut-off valves are eliminated. When a pump is shut down an air valve is automatically opened admitting air into the siphon at the high point, breaking the siphoning effect and serving as a positive shut-off, thus preventing water from flowing back from the reservoir into the forebay.

(c) The McMillan Pumping Plant (Plate 13) serves to pump water as required from the raw water storage reservoirs to the filter beds. The plant was constructed in 1905 and was originally equipped with three horizontal, steam engine driven, slow speed centrifugal pumps. In 1936 this plant was completely rehabilitated and the obsolete equipment was replaced by modern, electrically operated units. The vertical type pumps have been so successful in the Dale-



McMILLAN PUMPING STATION

PLATE 13

carlia Booster Pumping Plant that this type was adopted at McMillan. The new units are of the vertical, modified centrifugal type,designed with a specific speed value of 13,500,with bottom suction and horizontal discharge. Each unit has a 36-inch outlet and a pumping capacity of 50 m.g.d. against a total dynamic head of 21 feet. The synchronous motors are rated 250 horsepower each and operate on 2,300-volt,3-phase,60-cycle alternating current. Each pumping unit is protected against water reversal in case of power failure by an automatic cone valve (hydraulically operated plug type). The valves have a clear waterway of 36-inches in diameter and are installed immediately adjoining the pump discharge. The main pumps, with interconnected automatic pumping equipment, are arranged for automatic push-button operation. In addition to the main pumping units,the station is equipped with two high-head raw water pumping units which serve to furnish water for sand washing operations of the filtration plant. These pumps are of the horizontal,centrifugal type, arranged for automatic pressure and flow control, capable of delivering 2.0 m.g.d. and 3.0 m.g.d. against a total dynamic head of 250 feet.

(d) <u>The Dalecarlia Pumping Plant</u> (Plate 14) is the main pumping plant of the Washington Aqueduct and serves as a central or dispatching station for the entire pumping system. The supervisory control of the Booster Pumping Plant, the Dalecarlia Hydro-Electric Station and High Tension Sub-Station terminates on the supervisory board located in the control room at Dalecarlia. This plant pumps filtered water from the Dalecarlia Filtered Water Reservoir into each of the three high service reservoirs. Each service is provided with three main units, the characteristics of which are given in the following table:

Service	Capacity Each Pump, M.G.D.	Total Dynamic Head,Feet	H.P.of Pump Motor
1st High	3 @ 20	130	550
2nd High	2 @ 10	223	550
2nd High	1 @ 20	225	1250
3rd High	3 @ 10	320	770

The motors driving the pumps operate on 2300-volt,3-phase,60-cycle power drawn from the Dalecarlia Hydro-Electric Station and the system of the Potomac Electric Power Company. All pumps are of the horizontal,double-suction,centrifugal

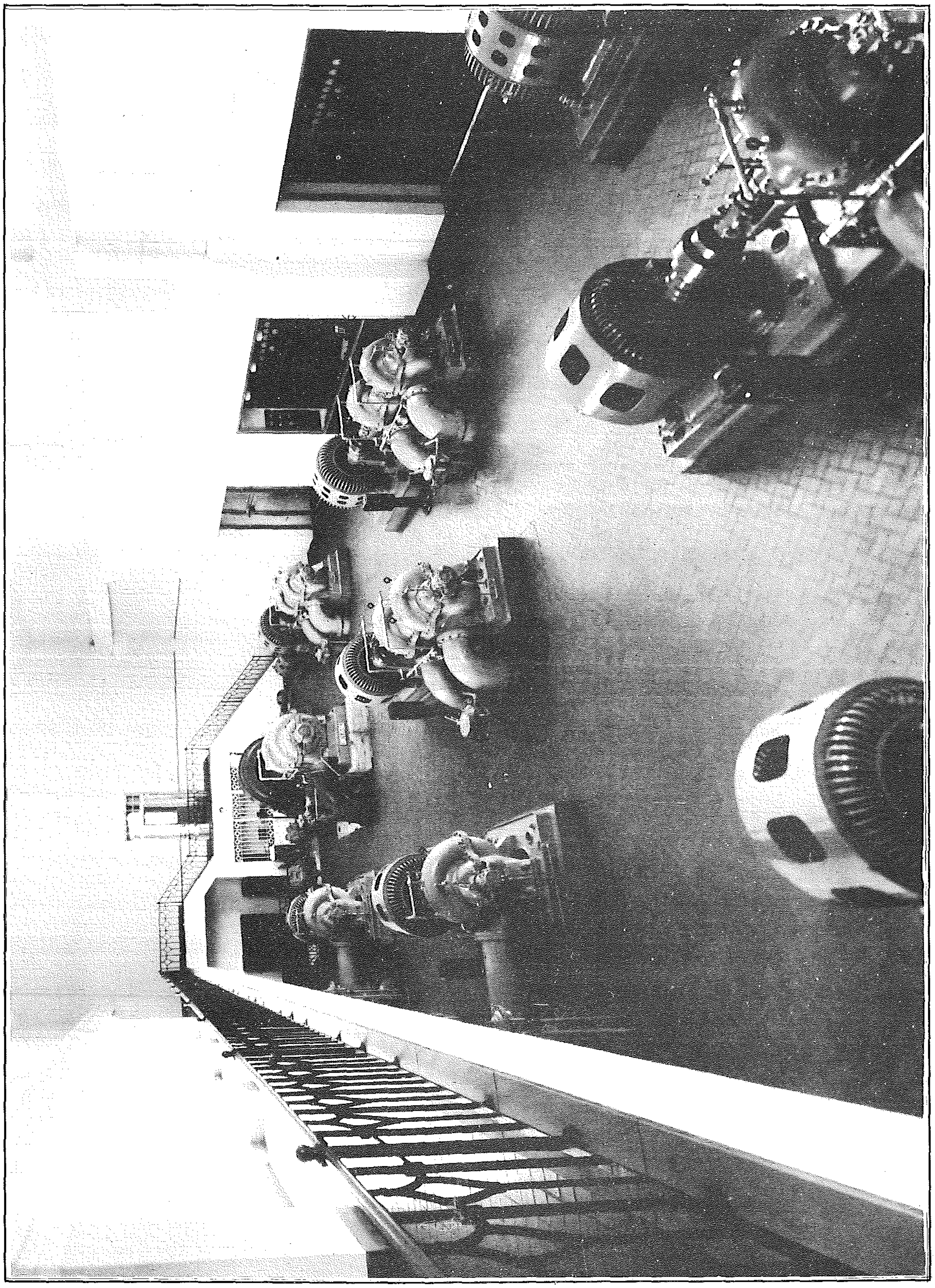


PLATE 14

DALECARLIA PUMPING STATION

type arranged with bottom suction and horizontal discharge. Each pumping unit is protected against water reversal in case of electric power failure by an automatic combination stop and check valve of the hydraulically operated rotary plug type. The First High pumps are single-stage units and the Second and Third High pumps are two stage in series, mounted on a common base with the driving motor. The pumping units are arranged for semi-automatic operation. Each unit is started from a control station located adjacent to the hydraulically operated discharge valve of the pumping unit. Full automatic protective features are provided which will shut the pumping units down in case of electrical or mechanical trouble. Due to the rapid growth of the demand on the Second High Service, one of the main units was recently replaced with a pump having a capacity of 20 m.g.d. instead of 10 m.g.d. The new unit is equipped with a 1,250 horsepower synchronous motor.

(e) The Dalecarlia Hydro-Electric Station is the full-automatic supervisory type located on the north bank of the Chesapeake and Ohio Canal, approximately 1400 feet distant from the Dalecarlia Pumping Station, and the water for its operation is drawn from the Dalecarlia Reservoir. Two mechanical traveling screens housed in a screen building are located at the south end of the Dalecarlia Reservoir and protect the turbines by removing the debris from the raw water supply to the hydro station. After leaving the screen building the water flows through a 78-inch diameter circular concrete pipe conduit to a 28-foot diameter circular concrete gravity type surge tank, having an overall depth of 35 feet. Each of the two hydraulic turbines is served by a 48-inch steel penstock direct from the surge tank. The tailrace carrying the discharge water from the plant enters the Potomac River 1200 feet distant. The hydro-electric plant is equipped with two vertical hydro-turbines with direct-connected vertical, alternating current generators. The turbines are designed for a normal output of 2,200 horsepower each with a net head of 140 feet and each generator is designed for a normal output of 1,500 k.v.a. The generating station is directly connected to the Dalecarlia High-Tension Sub-Station by two underground cables. Each cable is of sufficient size to transmit the entire output of the hydro-electric station. Control cables are also in duplicate. Both generators and all station auxiliaries are controlled by a visual supervisory system from the operator's desk located in the Dalecarlia Pumping Station Control Room. This hydro plant utilizes the surplus water not required for regular water supply purposes. The present annual production of energy averages 12,600,000 kwh and the cost of generation, including all charges, is 1.25 mills per kwh.

(f) The Dalecarlia High-Tension Sub-Station is located adjacent to the Dalecarlia Pumping Station and serves as a high-tension transforming station and 2,300-volt distribution center. Power is brought in from the system of the Potomac Electric Power Company by two 13,200-volt overhead feeders which terminate in a fenced outdoor lightning arrestor and main line oil circuit breaker structure. From the outdoor structure the two high-tension feeders are carried underground to the high-tension oil circuit breaker switch gear within the substation. Four banks of 13,200/2,300-volt transformers are connected on a high-tension bus by means of pull-out,metal-clad oil circuit breaker equipment. Each bank of transformers consists of 3 single-phase, 500 kva units,connected delta-delta. The station is provided with adequate capacity so that only three banks are required to serve the maximum summer requirements of the pumping station and filtration plant.

The low-tension layout consists of thirteen 2,300, enclosed,vertical-lift, metal-clad oil circuit breaker switch gear units. The units serve the lines as listed in the following table:

2 - Incoming lines from hydro-electric station.
2 - Outgoing feeders to booster pumping station.
4 - Outgoing feeders to Dalecarlia Pumping Station.
4 - Transformer secondary connections (P.E.P. Co's. System)
1 - Tie-breaker unit.

Both the high- and low-tension oil circuit breaker units are controlled by a supervisory system from the operator's desk located in the Dalecarlia Pumping Station Control Room. All required visual lamp indications are also carried back to the operator's board. The sub-station is an isolated fireproof building especially designed to segregate the various units of equipment so that a failure or explosion could not cause a complete failure of the entire plant. Each group of equipment is arranged so that it can be "cut out" of service without affecting the operations of the other units within the station.

7. FILTRATION AND CHEMICAL TREATMENT. The Dalecarlia and McMillan Plants differ not only in their filtration rates and types of filters, but also in the chemical treatment of the water supply prior to filtration. The filtration and sterilization processes of the two plants are described in general terms below:

(a) The Dalecarlia Rapid-Sand Filter Plant operates at the rate of 2 gallons per square foot per minute, or 125,000,000 gallons per acre per day. Continuous application of a coagulant to the influent water is required to settle out the mud carried by the raw river water. The coagulant used is aluminum sulphate, called alum, which is manufactured at the Dalecarlia plant in six large boiling tanks from bauxite, the ore of aluminum, and sulphuric acid. The amount applied varies with the turbidity of the river, and is also dependent upon certain variations in the chemical composition of the water. The average dose is 180 pounds per million gallons, or 1.2 grains per gallon, while a maximum dose of 450 pounds per million gallons and a minimum dose of 100 pounds per million gallons has been applied.

Following the application of alum the water flows rapidly through two mixing basins to the settling basins, where the chemical reaction between the alum and the basic ions of the water is completed and the aluminum floc settles, carrying down with it the coagulated mud particles. About 90 percent of the floc and mud particles are settled out in the three to four hour sedimentation period in these basins and at the same time the bacterial load is reduced.

As the settled water leaves the basins and enters the water passages leading to the filters, the first step in sterilization takes place. Anhydrous ammonia is first added to the water, fed from gas feeders in direct ratio to chlorine solution which immediately follows the ammonia. The chlorine is fed as a solution in water from two solution feeders. This combination gives a chloramine treatment to all water entering the filters, and results in an almost perfectly sterilized water prior to filtration. The chloramine compound produces a delayed sterilization action and keeps the filters in an excellent bacteriological condition. It also prevents the chlorinus tastes so often noticeable when straight chlorine alone is applied. The dosage for ammonia averages 0.8 pounds per million gallons, with a maximum of 1.5 pounds and a minimum of 0.42 pounds, while for chlorine the amounts are 3.2 pounds average, 8.0 pounds maximum, and 1.8 pounds minimum.

Immediately following filtration through the 20 filter units (Plate 15) each with a normal capacity of 4 million gallons per day, another smaller dose of chlorine, termed post chlorination, is applied to the water going to the clear well or filtered water reservoir. The amounts of chlorine applied in post chlorination averages 0.6 pound per million gallons, with maximum of 1.75 pounds and minimum of 0.3 pounds. The purpose of this application is to maintain the necessary residual free chlorine which it is desired to have remain in the water until it is carried well into the city mains. The amount of this residual varies considerably, running from 0.15 to 0.5 P.P.M. and is determined according to bacteriological and chemical tests on raw water, filter effluent samples and the temperature of the city supply. Greater residual is required during warm months, when the water leaves the plant at a maximum temperature of 85 degrees Fahrenheit, as this high temperature causes the applied chlorine to be absorbed rapidly. Winter temperatures are as low as 33 degrees Fahrenheit and absorption is relatively low.

Immediately after chlorination a carefully regulated amount of hydrated lime is added to the filtered supply entering the clear well. This is to neutralize the carbon dioxide, the by product of the action of the coagulant on the water. This ensuing carbon dioxide, if not neutralized, would result in "Red Water" in the city mains and taps, especially in hot water services. When higher turbidities require larger applications of alum, the carbon dioxide content often runs over 20 P.P.M. with a pH of 5.5. Water of this kind is decidedly acid, but it is brought to neutrality with a pH of 7.0 and zero carbon dioxide and rendered as non-aggressive to iron piping as is possible by treatment with

PLATE 15

DALECARLIA FILTER PLANT
OPERATING GALLERY

lime in amounts averaging 60 pounds per million gallons. While the addition of this lime does increase the average hardness of the Dalecarlia supply about 14 percent, this increase is less than the actual seasonal fluctuation in total hardness and is not noticeable to the consumer.

(b) The McMillan Slow-Sand Filter Plant operates at the rate of 1/20 gallon per square foot per minute, or 3,000,000 gallons per acre per day. Pre-treatment of the influent water with alum is not continuous as at Dalecarlia, being required only about 20 percent of the time. The filters form their own straining surface, or "Schmutzdecke", as it is called. This is a biological layer and is characteristic of the slow sand filters in contrast to the chemical surface layer of the rapid-sand filters. During warm months and at turbidities below 20 P.P.M. these filters yield a zero turbidity and often give perfect bacteriological results without further treatment. However this action of the "Schmutzdecke" is not to be relied upon and chlorination also is practiced continuously at this plant. Dosages are smaller in the summer when biological conditions are most active and considerably higher in winter, at which time the slow-sand filters are practically without biological effect. The dose averages 2.74 pounds per million gallons, while the maximum is 4.22 pounds and the minimun 1.38 pounds.

At periods of high river turbidity the water going to the McMillan Reservoir is treated with the same type coagulant as is used at the Dalecarlia plant. Aluminum sulphate passes to the settling basin of the Georgetown Reservoir where the floc and mud settles out, the mixing chamber in this being the 2 mile conduit between the Dalecarlia and Georgetown Reservoirs. The settled water then goes to the McMillan Reservoir, from which it is pumped to the filters at a turbidity never greater than 20 P.P.M. To date no regular corrective lime treatment has been applied to the effluent from the McMillan filters, but this is scheduled to be started during the calendar year 1939 when certain improvements for chemical treatment in the clear water reservoir have been completed.

For the past 17 years chlorine alone has been continuously applied only to the effluent of the McMillan clear water reservoir, but this, in a few months, will be changed to a chlorine and ammonia treatment added to the influent point of this clear well, so that at least six hours' detention or absorption period will be allowed before the water goes to the gravity area of the city.

(c) Special Water Treatment. To eliminate certain extraordinary tastes and odors which occasionally manifest themselves in the river water, aluminum sulphate, containing 3 percent activated carbon, is kept in readiness to be applied to the water. Activated carbon in finely divided form is also kept on hand to be used on such occasions and it has been successfully applied at Dalecarlia to combat cresol taste due to waste from a tie treatment plant being discharged into the Potomac River.

During the summer months copper sulphate is added to the water entering the settling basins at Dalecarlia to keep down algae growths in these basins. Dosages of 0.2 to 0.5 P.P.M. are applied. The Dalecarlia and other reservoirs are treated with copper sulphate as occasion demands, the principal reservoir affected being that at McMillan, where there have been recurring growths of asterionella, chro-ococcus, uroglena, and certain other micro-organisms. These growths have been eliminated by the application of copper sulphate dragged in bags through the water of the basin from a small boat. Outbreaks of synedra, a silicious diatom, have occurred in the Potomac River to quite an extent in the past five years, the counts being as high as 4000 per c.c. and persisting for a period of from one to three weeks. Copper sulphate has been of little avail on these silicious organisms, the most successful treatment being excessively high alum doses to coagulate and settle the organisms with the other suspended matter. The synedra outbreaks have all occurred during the early fall months, and generally follow a prolonged clear water period in the river.

(d) Bacteriological Examinations are made daily on water samples taken from all parts of the Washington Aqueduct system and some fifty city samples are collected each week to check up on the distribution system to determine proper dosages of sterilizing agents. Tests are run on all samples in strict accordance with United States Public Health standards. Research in bacteriological fields has been carried out for over 13 years in the Dalecarlia laboratory and has resulted in the gathering of much valuable data and the perfection of a special medium for coliform detection.

The table below gives some of the salient characteristics of the Potomac River water before and after treatment.

RESULTS OF DAILY CHEMICAL AND BACTERIOLOGICAL TESTS
Based on 6 Years' Operation Results

Supply	Turbidity P.P.M.	Total Hardness $CaCO_3$	Non-CO_3 Hardness	Alkalinity $CaCO_3$	pH	CO_2 PPM	SO_4 PPM	Bact. Count 37° 24 Hrs.
Average								
River	90	70	17	52	7.7	1.5	20	2,500
Dale Filt.	0+	70	25	42	6.7	8.0	31	4
Dale Finished	0+	83	25	55	7.8	1.5	31	2
McMillan Filt.	0+	70	17	52	7.2	4.0	20	6
McMillan Finished	0+	70	17	52	7.2	4.0	20	4
Maximum								
River	3000	130	40	120	8.8	3.0	32	50,000
Dale Filt.	2	130	54	120	7.3	26.0	45	25
Dale Finished	2	130	54	116	8.6	3.5	45	10
McMillan Filt.	3	130	45	120	8.0	12.0	36	50
McMillam Finished	3	130	45	120	8.0	12.0	36	30
Minimum								
River	6	20	6	16	6.8	0	13	50
Dale. Filt.	0	19	10	8	5.5	0	19	0
Dale Finished	0	23	10	22	7.2	0	19	0
McMillan Filt.	0	20	6	18	6.7	0	13	1
McMillan Finished	0	20	6	18	6.8	0	13	0

The chemical treatment has resulted in a water supply free from tastes and odors, clear and sparkling, non-corrosive and practically 100 percent free from all coliform organisms in all dilutions from 1 to 100 millimeters in the effluent from the two filter plants.

The water is at all times bacteriologically safe and always far superior to the limits of purity set by the American Public Health Department in their standards of potable waters.

8. <u>SAFETY</u>. Safety on the Washington Aqueduct is one of the regular activities carried on by the Washington Engineer District, and follows closely the safety requirements of the War Department in the Engineer Department at Large. Supervisors are given instructions in standard American Red Cross First Aid, safe motor vehicle operation, and various phases of safe working practices and

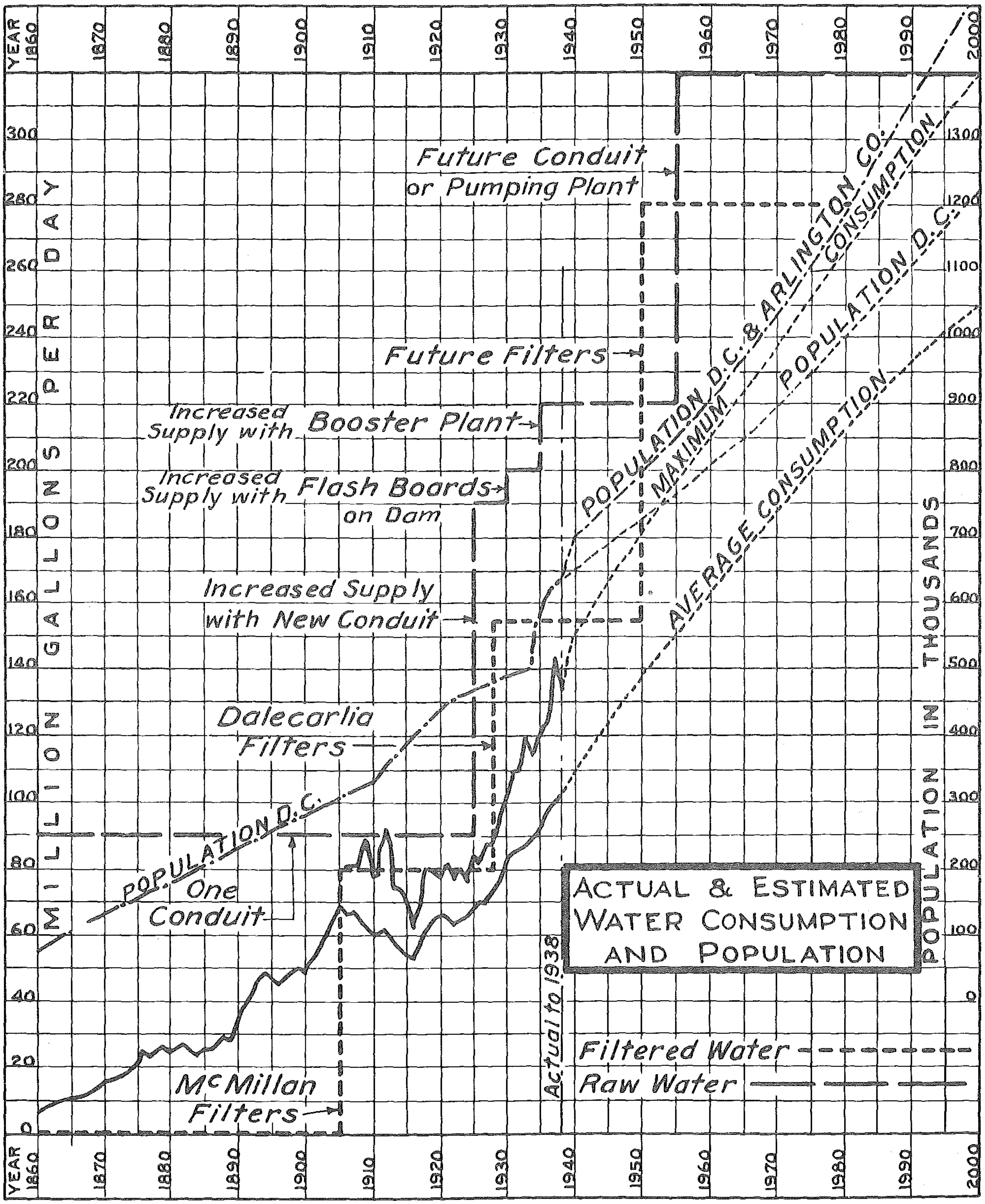
employee training. All employees are given preliminary instructions in First Aid. Regular monthly meetings are held at each unit of work during which accidents or near-accidents are discussed. Frequent inspections are made by the District Safety Council, three members of which are employees of the Washington Aqueduct, and its recommendations have resulted in the elimination of unsafe conditions and practices. In addition to the prevention of accidental injuries attention is given to sanitation, good housekeeping and adequate lighting.

A manual of safety regulations has been issued to all supervisory employees and a monthly safety bulletin describing accidents, safety precautions and standing of the various units in the safety contest is distributed among all employees. An annual safety contest is held with a bronze plaque awarded to the winner.

9. WATER CONSUMPTION. The average daily water consumption for the fiscal year 1939 was 103,260,000 gallons. During the past year the maximum daily consumption was 143,350,000 gallons, in July, 1938, while the minimum consumption was 79,730,000 gallons, in December, 1938. The rated capacity of the Washington Aqueduct water supply system, on a sustained basis, is 155,000,000 gallons per day.

Water consumption of the District of Columbia, population growth, and available raw and filtered water capacities are shown graphically on Plate 16. The curve of the average water consumption is the annual average in millions of gallons per day. The curve of the maximum consumption is the highest daily amount delivered to the city during the year. These maximum consumptions are caused primarily by periods of excessively hot weather. Air conditioning, already well established in Washington, has become a factor in increasing the use of water, and it is estimated to be responsible for a 10 percent increase in the peaks of summer water consumption. The growth of population of the District of Columbia is not regular and has varied greatly in the past, conforming generally with increased activities of the Federal Government. There are also shown two sets of lines indicating the capacities of the existing raw water supply facilities and the existing filtration facilities. The extension of these lines

PLATE 16


ACTUAL & ESTIMATED WATER CONSUMPTION AND POPULATION
MILLION GALLONS PER DAY
POPULATION IN THOUSANDS
YEAR 1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Future Conduit or Pumping Plant
Future Filters
Increased Supply with Booster Plant
Increased Supply with Flash Boards on Dam
Increased Supply with New Conduit
Dalecarlia Filters
One Conduit
McMillan Filters
POPULATION D.C.
POPULATION D.C. & ARLINGTON CO.
MAXIMUM CONSUMPTION
AVERAGE CONSUMPTION
Actual to 1938
Filtered Water
Raw Water

beyond the present date is the estimated requirement for future construction necessary to provide a water supply adequate to meet all demands.

10. CAPITAL AND OPERATING COSTS. The capital (historical) costs of the various structures forming the Washington Aqueduct as of June 30,1937,now useful and used, are as follows:

Land and Land Rights	$ 1,176,909
Dam at Great Falls	498,074
Old Conduit	2,301.152
New Conduit	2,915,923
Dalecarlia Reservoir	462,604
Georgetown Reservoir	508,046
McMillan Reservoir	813,791
City Water Tunnel	1,948,296
First High Reservoir	313,839
Second High Reservoir	299,095
Transmission Mains	979,674
Federal Meters	64,633
McMillan Filtration Plant	2,676,870
Dalecarlia Filtration Plant	2,306,418
Pumping Plants	1,097,832
Hydro Plant and Sub-Station	368,750
Conduit Road	203,697
Miscellaneous Equipment and Structures	164,406
Surveys and Investigations	100,812
Total	$19,200,812

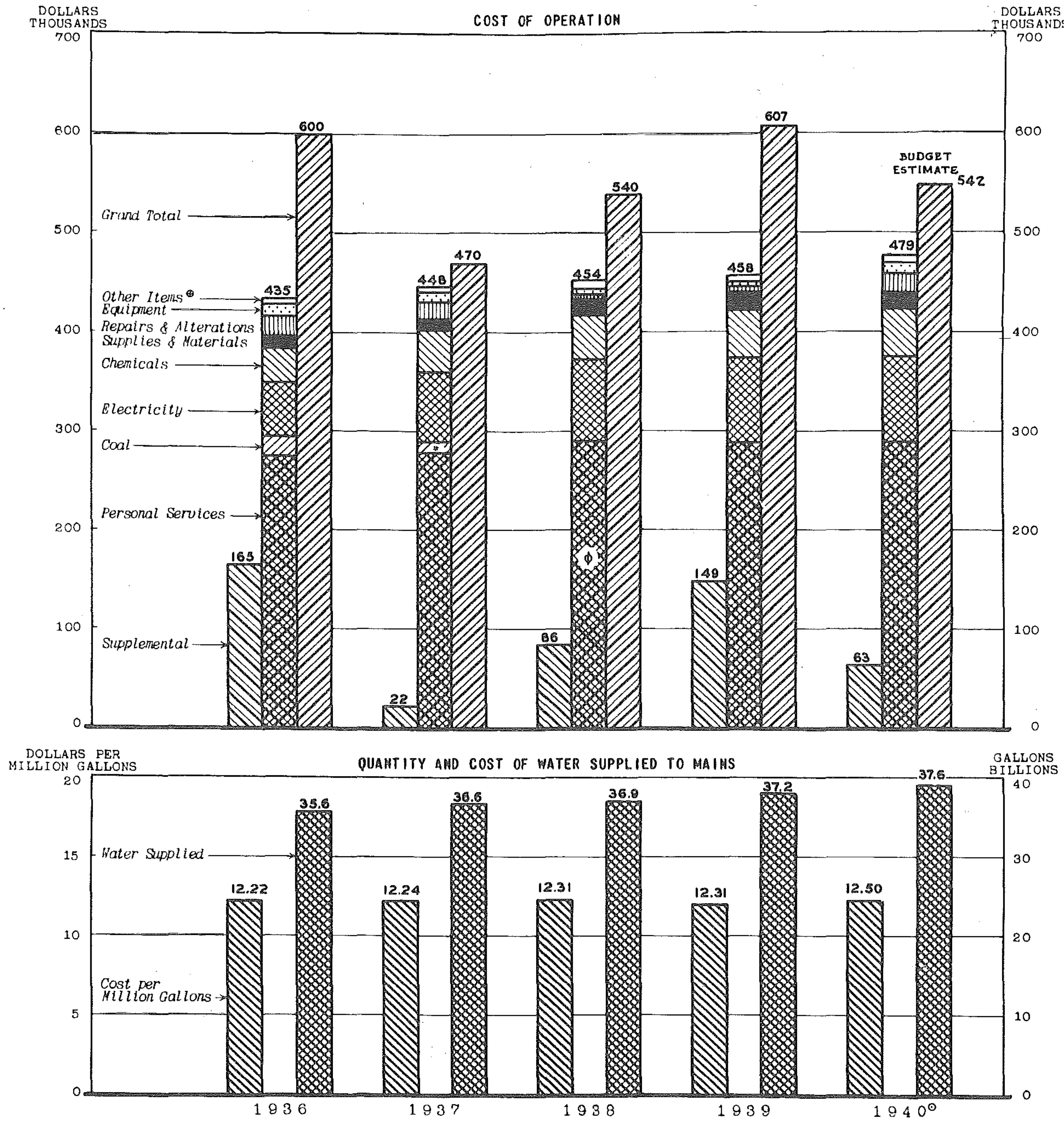
The investment of the United States in the Washington Aqueduct system which has come wholly from Federal funds is about $7,892,128, and the investment of the United States in the distribution system of the District of Columbia is about $1,027,757, or a total of $8,919,885. These amounts are for capital improvements which are now used and useful for water supply purposes.

A cost accounting system is maintained which shows in detail the cost of all operations, repairs, and betterments of each division of the Washington Aqueduct, including the collection,purification,pumping and transmission systems, and expenditures are handled under budget control. Plate No. 17 shows graphically the annual operating cost per million gallons of water,actual and estimated,for 1940,and the distribution of these costs among the various items of operation and maintenance. The column marked "Supplemental" shows the amount provided annually for renewals and replacements.

11. FUNDS. In recent years funds for Washington Aqueduct operations,

PLATE 17

WASHINGTON AQUEDUCT
ANNUAL OPERATING COSTS, QUANTITY AND COST OF WATER DELIVERED TO DISTRIBUTION SYSTEM



⊙ Estimated
* McMillan Electrification
ϕ Enforcement 44-Hour Week
⊕ Communication, Travel, Transportation, Printing, Advertising, and Rent

maintenance, and improvements have been provided annually by Congress in the District of Columbia Appropriation Act out of the amounts collected for water rentals by the Water Division of the District of Columbia. Water rates are sufficient at the present time to pay for normal upkeep of the entire system and for setting aside a limited amount for future improvements. The Washington water system differs from most cities in that it is on a "Pay as you go basis" but an increase in water rates would be necessary if this policy should be adopted for financing major improvements.

12. METROPOLITAN AREA WATER SERVICES. Sale of water by the District of Columbia to metropolitan areas in Maryland was authorized by Congress March 3, 1917. Under the terms of this act the District of Columbia sells water to the Washington Suburban Sanitary Commission of Maryland at rates varying from $56. to $75. per m.g., depending upon the location of connections. At present the Sanitary Commission obtains most of its water from its own purification plant on the Northwest Branch of the Anacostia River, and is giving consideration to an additional supply from the Patuxent River. If this extension takes place the amount of water the Commission will purchase from the District of Columbia will be reduced.

On April 14,1926,Congress authorized the Secretary of War to supply water to Arlington County, Va. Sale of this water began in 1928 and the quantity is increasing annually. The water is supplied direct from the Dalecarlia Filtration Plant,from the Third High Service transmission main through a 24-inch main which changes to two 20-inch mains where they cross Chain Bridge. Arlington County,with an area of 31 square miles, is growing rapidly and is becoming the largest outside consumer of the Washington water supply system.

Fort Myer, a cavalry post, Arlington Cemetery, and the Arlington Experimental Farm of the Department of Agriculture, all in Arlington County,Va., are supplied with water from the Second High Service of the Washington water supply system, through a 10 - inch main on the Francis Scott Key Bridge, crossing the Potomac River at Georgetown, D. C.

13. DISTRIBUTION SYSTEM. The District of Columbia Water Division has un-

der its control the distribution system. After the water has been collected, purified and pumped to the various equalizing filtered water reservoirs by the Washington Aqueduct, it is then turned over to the Water Division of the District of Columbia for distribution to the service areas of the city. The locations of the principal structures of the Water Division are shown on Plate No. 2, but detailed information regarding all of the activities of this important branch of the entire water system may be obtained directly from the Engineer Commissioner of the District of Columbia.

In general, the various structures under the jurisdiction of the Water Division include about 120 miles of transmission mains, ranging in size from 16 inches to 75 inches in diameter; 800 miles of distribution mains, ranging in size from 3 inches to 12 inches in diameter; the large Bryant Street Pumping Station which is the principal stand-by high service pumping station for the District and is equipped at present with both steam and electric pumps; the Anacostia Pumping Station, which is equipped entirely with electric pumps and which supplies all of the First and Second High areas in the section of the city east of the Anacostia River by boosting the water from the gravity mains (Plate 4); the Reno Pumping Station, which is equipped with one combined gas-electric pump and two electric pumps and which supplies the Fourth High area of the city by lifting the water from the Third High Reservoir; two covered concrete Third High equalizing filtered water reservoirs, with a combined capacity of 10,000,000 gallons; two Fourth High water towers, with a combined capacity of 245,000 gallons; one covered concrete reservoir with a capacity of 3,000,000 gallons for the First High area in Anacostia; one Second High service steel tank with a capacity of 500,000 gallons; a total of about 100,000 water meters ranging in size from 5/8-inch to 8 inches for the various residential and commercial activities of the District of Columbia, and many other miscellaneous structures including shops, property yards, storehouses, and other equipment. At the present time the city is approximately 90 percent metered and it is proposed to make the city 100 percent metered within the next year. The total historical cost of the entire distribution system property under the control of the Water Division of the District of Columbia was about $18,000,000 on June 30, 1937.

Control of the distribution of water has been under the District of Columbia since 1882, but certain of the transmission mains in the city aggregating 21 miles in length remained under the jurisdiction of the War Department until 1905. The Reno Reservoir for the Third High service was constructed in 1896 and the Bryant Street Station, together with the adjacent shops and equipment, was completed in 1904 at a cost of $1,000,000. Future plans of the Water Division include two new 15,000,000 gallon equalizing filtered water reservoirs on the First and Second High services and many large transmission mains. It is also proposed to complete the electrification of the Bryant Street Pumping Station.

14. FUTURE PLANS. The continued growth of the population of the District of Columbia and its environs, and the constant need of an unrestricted supply of water to meet the demand of the Capital City safely, makes it necessary to plan in advance for future extensions of the present water system (Plate 16).

The United States Engineer Office, which is in direct charge of the Washington Aqueduct system, proposes to make detailed studies and a report upon this situation as soon as funds are made available by Congress. The report will cover a comprehensive plan and method for increasing the raw water supply of the city, the construction of an additional filtration plant, pumping stations, necessary transmission mains and reservoirs. The proposed studies will include suitable enlargements of the present pumping plants, transmission mains and high service reservoirs. It is expected that the studies and report will cover a period of two years; that the detailed construction plans, specifications and estimates will require two years for their completion; and that construction for the water supply extensions will require five years; or a total of nine years before an increased supply of water can be furnished to the consumer.