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STATE OF NEW JERSEY

STATE WATER POLICY COMMISSION

SPECIAL REPORT 1

WATER SUPPLY PROBLEMS OF THE NORTHERN METROPOLITAN DISTRICT

ACTIVITIES OF THE COMMISSION

July 1 to December 31, 1929

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REPORT OF THE STATE WATER POLICY COMMISSION

TO THE SENATE AND GENERAL ASSEMBLY
OF THE STATE OF NEW JERSEY.

Pursuant to Chapter 267, P. L. of 1929, the State Water Policy Commission was appointed by Governor Morgan F. Larson and confirmed by the Senate June 24, 1929. The members met at the call of Governor Larson July 9, 1929, and organized as directed by law.

Among the essential duties imposed upon the Commission are the following:

"The commission shall continue and extend investigations of the water resources of the State, including the systematic gauging of rainfall and stream flow throughout the State, so as to complete a comprehensive study for the entire State, for the conservation, development, regulation and use of the waters in each of the principal watersheds of the State with reference to the accomplishment of the following public uses and purposes:

(a) The supply of pure and wholesome water from watersheds to municipalities and the inhabitants thereof and the disposal of sewage and wastes which may affect the supply.

(b) The prevention of floods.

(c) Drainage and irrigation.

(d) The conservation, development and utilization of water power.

(e) The protection of public navigation."

"The commission shall have general supervision over all sources of potable and public water supplies, including surface, subsurface and percolating waters, to the end that the same may be economically and prudently developed for public use."

Immediate arrangements were made to take over work previously carried on by the Division of Waters of the Department of

Conservation and Development and the engineers and other employees were continued in the Trenton office. An executive office was opened at 605 Broad Street, Newark, for convenience in dealing with North Jersey problems. A staff of engineers was appointed to conduct the comprehensive studies, field surveys and other investigations necessary in order to carry out the provisions of the law.

Northern Metropolitan District.

It has long been evident that the situation with respect to the water supply of the Northern Metropolitan District is the most acute in the State. This is due to the following causes:

1. Growth of population at a more rapid rate than census experts have hitherto assumed in their computations.

2. The consequent increasing use of water for both potable and industrial purposes.

3. Increasing pollution of streams now used, thus indicating ultimate abandonment and replacement with purer supplies.

4. Delays due to difficulty in securing voluntary joint action on the part of a group of communities in a major enterprise involving heavy expenditures.

We believe that the ultimate aim should be the operation of the important supplies of the Northern Metropolitan District as a unit through some co-ordinating agency and that interim developments should be in harmony with that principle.

With these and other factors in mind, the Commission instructed its engineering department to make an intensive study of the requirements of this district and the best means of meeting them economically and efficiently.

The Commission was especially interested in determining the feasibility of impounding the necessary supplies at points more remote from centers of population than heretofore suggested for the next step, provided reservoir sites at satisfactory elevations could be secured. This has been found practicable. Such a course would eliminate objections to various reservoir sites previously advocated, lessen the danger of pollution, and provide more flexibility in supplying different areas in the district.

The Report of the Engineering Department, appended hereto, shows clearly the basic principles involved and their application to

the specific problem of the Northern Metropolitan District. We direct special attention to the following:

Fundamental Principles ..... Page 3
Summary and Conclusions ..... Page 4
Recommendations ..... Page 6
Service Zones and Zone System..... Page 23
Interconnections ..... Page 24

In our judgment the interests of all important centers of population in the district can best be served by a high level development as the next step, which by the system of interconnections proposed will make available two sources of supply for each part of the district.

Southern Portion of the State.

A sub-committee of the Commission, consisting of Messrs. Grossman and Prior, is giving earnest consideration to the needs of communities in this section of the State, and detailed engineering studies have already been started.

Major Recommendations.

The major recommendations of the Commission are as follows:

1. That, in order to protect essential undeveloped sources of supply from residential or industrial exploitation, the State in the interest of all its citizens, should acquire control of such sources, potential water power sites, reservoir sites, and sufficient land adjacent thereto for their conservation and protection, and provide through the proper channels for the reforestation of such lands.

2. That, in order to make this possible, an opportunity should be given to the electorate of the State to vote by referendum at the election next November upon the desirability of an issue of bonds, to provide a revolving fund, the suggested amount being $7,000,000.

This revolving fund would be available for the purchase of the best reservoir sites for the Northern Metropolitan District, Southern Metropolitan District (Trenton, Camden and adjacent territory) and for the coast resorts. A bill to accomplish this has been introduced and its passage is recommended.

3. In connection with the above, special attention is called to the so-called Wharton Tract in the Counties of Ocean, Burlington and Atlantic, containing an area of about 156 square miles. This is

now in a single ownership and the price which it is understood the owners wish to obtain is, in the judgment of the Commission, excessive. If, however, this tract could be secured by negotiation or condemnation for a reasonable price, we believe that its purchase can be justified on four grounds:

(a) A potential supply of pure water, amounting to 240,000,000 gallons daily.
(b) Reforestation.
(c) State park and recreation area.
(d) Fish and game preserve.

During the past eleven years there has been expended from all sources upon our splendid highway system about $219,000,000. During the last few years the Department of Institutions and Agencies, in seeking to make adequate provision for the wards of the State, has expended $33,000,000. The New Jersey share of the total cost of the Holland Tunnel and the Delaware River Bridge is $40,000,000, and it is estimated that the Hudson River Bridge will cost approximately $60,000,000, of which one-half is chargeable to New Jersey. The tunnels and bridges are self sustaining and every water supply system is more than self sustaining.

The population of the State is now estimated to number four million people and a bond issue of the amount suggested, $7,000,000, would be the equivalent of $1.75 per capita.

We are convinced that the best interests of all New Jersey citizens demand prompt and adequate provision for water supplies and that the State is justified in lending its credit now, with a view to saving in the future many millions of dollars for the tax payers. We, therefore, earnestly recommend the submission of the questions involved to the electorate of the State by referendum, in order that your honorable bodies and this Commission, which is endeavoring to perform the duties you have imposed upon it, may correctly interpret the wishes of the people.

Respectfully submitted,

WILLARD I. HAMILTON, *Chairman*
CORNELIUS DOREMUS, *Vice-Chairman*
F. MORSE ARCHER
MAX GROSSMAN
THURLOW C. NELSON
HENRY G. PARKER
OWEN J. PRIOR

REPORT OF THE ENGINEERING DEPARTMENT

February 1, 1930.

WILLARD I. HAMILTON, *Chairman*
CORNELIUS DOREMUS, *Vice-Chairman*
F. MORSE ARCHER
MAX GROSSMAN
THURLOW C. NELSON
HENRY G. PARKER
OWEN J. PRIOR
State Water Policy Commission

GENTLEMEN:—

The principal duties assigned to your Engineering Department are as follows:

(a) Investigation of the water resources of the State, and preparation of plans for their economical and comprehensive development.

(b) Investigation of engineering phases of applications to the Commission for approval of plans for diversion of the waters of the State.

(c) Investigation of plans for dams and other structures encroaching on the waterways of the streams of the State.

(d) Recording and compiling data pertaining to diversion of potable waters of the State for public use.

(e) Gaging the flow of streams and the draft on ground waters of the State.

Report of the Department for the period July 1 to December 31, 1929, in respect to each of the above duties is submitted herewith.

WATER RESOURCES AND THEIR UTILIZATION

The State of New Jersey, as may be readily seen by reference to Plate 1, contains three areas which, due to the density of population, demand earnest consideration from the viewpoint of regional development of water supplies, as well as other facilities, along lines similar to those in successful use elsewhere.

These three areas are, for convenience of reference, designated as:

(1) The Northern Metropolitan District, comprising the area north of the Raritan River and east of the Passaic River, extending to the State line on the north, including the Counties of Essex, Hudson, Union and Bergen and portions of Passaic, Somerset and Middlesex Counties.

(2) The Southern Metropolitan District, comprising Trenton, Camden and the adjacent areas.

(3) The Seashore Resort District, comprising the resort areas from Sandy Hook to Cape May.

The remainder of the State, being to a very great extent sparsely settled, offers no water supply problem at present incapable of local solution.

On account of limitations of time and of appropriation available, and owing to the urgency of the water supply problem in the Northern Metropolitan District, this report and the studies and investigations on which it is based, have been for the most part restricted to that district. However, routine investigations have been and are now in progress throughout the State, together with preliminary studies of the problem at Atlantic City and adjacent resorts. A special study of the possibilities of the Wharton Tract, in South Jersey, for water supply purposes, is now in progress.

THE NORTHERN METROPOLITAN DISTRICT

The water supply problem of the Northern Metropolitan District is logically divided into four phases:

(a) The most efficient use and co-ordination of existing supplies by means of interconnections and exchange of waters.


NEW YORK
PENNSYLVANIA
DELAWARE
ATLANTIC OCEAN
NORTHERN METROPOLITAN DISTRICT
SOUTHERN METROPOLITAN DISTRICT
SEASHORE RESORT DISTRICT
PHILADELPHIA
Note
Each dot represents 1000 people or less
Census of 1920
STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION
DISTRIBUTION OF POPULATION
AND
DISTRICTS OF MAXIMUM DENSITY
AND WATER DEMAND
5 0 5 10 15
SCALE OF MILES
FEBRUARY 1930

PLATE 1

(b) The progressive development of additional supplies as the needs of the entire district increase.

(c) The gradual abandonment or the placing in reserve of such sources of supply as may in the future become unsatisfactory because of changed standards of potability or increase in pollution.

(d) The development of financial and legislative means for accomplishing these results.

FUNDAMENTAL PRINCIPLES

The importance of the water supply problem of the district is generally admitted. Its solution at any cost is essential. However, with mounting costs in all branches of public works and with the increasing demands of the public for additional facilities of every kind, the need for careful study, broad-gage vision and economical construction and operation in water supply matters is of paramount importance.

Adequate planning requires first the adoption of definite underlying principles. The following principles, many of which are not new, have been adopted after careful study and consideration of all plans heretofore suggested and of the underlying principles of plans successfully employed elsewhere. Based on these principles, the program and plan outlined herein are presented for your consideration in the belief that they offer, in general, a satisfactory solution of the water supply problem of the district. More extensive studies, now in progress, will in all probability bring out the advisability of minor changes in this plan, but such changes will not materially affect its general structure.

1. *The principal water supplies of the Northern Metropolitan District eventually will be operated as a unit, through some co-ordinating agency.*

2. *Operation will be at cost, due allowance being made for elevation and location of various consumers.*

3. *Smaller municipalities having local supplies will retain ownership and operation thereof, but extension of such supplies where located outside the municipalities will not be encouraged unless connection to a major supply is unduly expensive.*

4. *Future water supplies will be planned and constructed by such an agency when and as needed to provide adequately for the growing needs of the district as a whole.*

5. *All major existing supplies and new supplies as constructed will be interconnected by connections of adequate size, so located as to make operation flexible and economical.*

6. *The district eventually will be divided into service zones. Each zone, except the highest, which will of necessity be supplied by pumping, will be supplied from two or more gravity supplies. Each portion of the area will be served from the supply or supplies best adapted for its use, and each locality will have service available from at least two sources.*

SUMMARY AND CONCLUSIONS

The results of these studies may be briefly summarized as follows:

1. The solution of the water supply problem of the Northern Metropolitan District is urgent.

2. The potable water consumption of the district averaged 275 million gallons daily in 1928, and may be expected, in view of past records, to increase at a rate of 8 million to 10 million gallons daily (Mgd.) each year.

3. The present available supply is approximately 325 Mgd.; the completion of the Wanaque Project, in April of this year, will add 100 Mgd.; the Raritan-Millstone development of the Elizabethtown Water Company will add 10 Mgd. in 1930, and can readily be increased to at least 20 Mgd. as necessary; additions to existing developments and small new developments will be built at the average rate of from 2 Mgd. to 5 Mgd. each year.

4. In the near future, probably during 1930, the Little Falls development of the Passaic Consolidated Water Company, at present yielding about 65 Mgd., will either be abandoned, placed in reserve, or more probably adapted as an industrial supply. In any event it will be used in the future for potable water, only in an emergency.

5. Other small surface and well supplies, totaling perhaps 5 Mgd. safe yield, possibly will be abandoned within ten years, owing to pollution or other causes.

6. **A major surface supply project must be available by 1940 to meet the growing needs of the district.**

7. The larger existing supplies each serve widely separated portions of the district, to some extent at too high pressures and in some cases at inadequate pressure.

8. The larger supplies are at present generally not connected or are provided with interconnections of inadequate capacity.

9. The district is capable of separation into service zones, and existing and future supplies can readily be co-ordinated to serve appropriate zones economically and efficiently.

10. The principle of joint use and joint ownership of water supplies is established. The further steps of joint ownership by all municipalities of all the principal water supplies of the district, and of pooling the water supplies themselves, are logical and practicable; and all future water supply legislation and construction should be developed to that end.

11. **The next major water supply project should be a high level development of appropriate size and elevation to provide, in conjunction with the Pequannock supply of Newark, for the demands of the High Service Zone for many years.**

12. Such a high level project should be made available, by means of a connecting aqueduct, to the entire High Service Zone and to as much of the Intermediate Service Zone as is not adequately and more economically served by existing low level supplies.

13. Future lower level supplies should be planned and constructed to co-ordinate, by means of interconnections and interconnecting aqueducts, with the high level supply next to be built and with existing lower level supplies.

14. Three alternative high level projects for serving the High Service Zone of the district from the upper portions of the North

and South Branches of the Raritan and the Musconetcong have been investigated in sufficient detail to indicate costs comparing favorably with proposed lower level projects. Definite determination of the most advantageous project must await the completion of detailed investigation now in progress.

RECOMMENDATIONS

1. That the next major water supply project for the Northern Metropolitan District be a high level project from the upper portions of the Raritan and Musconetcong watersheds, capable of delivery to the district at approximately Elevation 400.

2. That such a project be so planned as to be available by 1940.

3. That such a project be so planned as to be available for the entire district.

4. That the studies of the three suggested high level projects be continued in order to determine definitely the most advisable solution.

5. That portions of the proposed high level interconnecting mains be constructed as parts of the project, in order to make the supply available to all parts of the district through existing transmission mains.

6. That the principle of co-ordination of all major existing and future supplies be recognized as equal in importance and urgency to the construction of a new supply.

7. That in advance of legislation facilitating or requiring such co-operation, effort be continued to carry out the recommended construction by voluntary co-operation of interested municipalities.

8. That grants for future major supplies be restricted so as to provide for recapture at cost by such State or district agency as may eventually be authorized to co-ordinate the operation of the major supplies of the district.

DETAILS OF THE REPORT

REGIONAL WATER SUPPLY CONTROL

The conclusion that the principal existing and future water supplies of the district can be practicably and economically administered by a central agency is based on the fundamental fact that systems for districts of similar area, population and diversity of interests have been successfully operated in this manner in other sections of the country. Notable among these is the Boston Metropolitan District Commission, which owns and operates the water supply systems serving Boston and some 20 adjoining municipalities, with a population in excess of 2,000,000 and having an area approximately equal to that of the suggested New Jersey Northern Metropolitan District.

The Boston Metropolitan Water Board, now merged with other boards as the Boston Metropolitan District Commission, was organized in 1895 by act of the Massachusetts Legislature, with authority to take over at an agreed price, the water supply works of the City of Boston, including pipe lines leading to the city, local storage reservoirs and works in progress of construction. All municipalities within 10 miles of the State House could be admitted to the district, which limitation has since been extended to include more distant areas.

Since 1895 the District Board and its successors have constructed the Wachusett Water Supply Project for the district, and now have under construction a second step in the progressive development of the water resources of the district, the Swift River and Ware River Projects. The purchase of the Boston supply works and all construction have been carried out under mandate of the Legislature, financed by State bonds. Interest, sinking fund charges and operating costs have been met by apportionment among the participating municipalities. This results in the sale of water to all municipalities at cost and without expense to the State, which merely has made its credit available. Certain municipalities within the district, which for the present have adequate local supplies, are assessed a small amount based

on relative valuation. This is in effect a standby or emergency charge, in consideration of which they will at any time be permitted to become full participants under equitable conditions.

The fundamental basis of the successful operation of the Boston Metropolitan Water District was the acquisition in 1895 of all the water supply works of the City of Boston. The fundamental financial principles involved were: first, making the credit of the State available to the district; and, second, the sale of water to the municipalities in the district at cost. Without these provisions, success would have been impossible.

THE NORTHERN METROPOLITAN WATER DISTRICT

The consumption of potable water in the Northern Metropolitan District in 1928, exclusive of private supplies, averaged 275 Mgd.; of this, 243 Mgd., 88 per cent., was furnished by two cities, Newark and Jersey City, and six water companies, the Passaic Consolidated, Hackensack, Elizabethtown, Commonwealth, Plainfield-Union and Middlesex. Each of these principal supplies furnishes water to several municipalities, of which the Hackensack Water Company, supplying nearly 50 communities, is the most striking example. From the above it is seen that the district principle, insofar as it relates to **joint use** of water supplies, is well established.

The completion of the Wanaque Project by the North Jersey District Water Supply Commission during the present year will bring into use the first development wherein the principles of **joint ownership** and **operation at cost** are combined with that of **joint use.**

Prior to the creation of the State Water Policy Commission it appears that the policy of the State of New Jersey in water matters was: first, that each water supply of the State should be made available for the use of all municipalities logically served therefrom, under the administration of the municipality or corporation owning said supply, and; second, that a number of municipalities might co-operate in the construction and operation at cost of a water project too great in cost and yield to be avail-

able to any one municipality. Each of these principles makes for economy, flexibility of operation and conservation of water resources.

The State Water Policy Commission Act provides that the Commission may, upon petition or upon its own initiative, require the **interconnection of public water supply systems and the furnishing of water thereby from one system to another.** This provision marks the third and perhaps the most important step yet taken in fixing the water policy of the State. By this means a gradual unification of the major systems can be brought about under existing laws, and with proper planning, these interconnections can be made a part of a greater plan whereby all these supplies are linked with each other and with future supplies to be developed as needed.

The principle of interconnection and exchange of waters being established, the next step—the application of the district principle (as exemplified in the Boston Metropolitan District) to the joint ownership and pooling of all major existing resources—is entirely reasonable. Such a plan will prove economical and advantageous to the entire district. It will enormously simplify the orderly development of the remaining water resources of the district, affording ample supply by timely construction, and, at the same time avoid the costly duplication of works necessary if each portion of the district should remain a self-contained and self-supplying unit.

Many of the water supply corporations of the district own the distribution systems in parts, or in all, of the area served and purvey water at retail to individual consumers. This is an entirely legitimate activity of any water corporation, as it is of each municipality, but if and when these corporate properties are acquired by joint action of a group of municipalities, or by some central agency to be created, the ownership of the distribution facilities within the municipalities should be divorced from joint ownership and become the property of the individual municipality. Each municipality should be supplied with water at cost from the central agency, and should resell to its own inhabitants at rates consistent with good business and municipal practice.

Constitutional limitations are such as to make impracticable for the Northern Metropolitan District the adoption in detail of

the method of financing and operation so successfully used in Massachusetts, but it is believed that some legislative means, possibly the outgrowth of the regional plan suggestion, can provide a method by which the major existing supplies of the district can ultimately be acquired and an appropriate agency charged with the duty of economically administering these supplies and supplementing such supplies by additional projects as the needs of the district increase.

THE WATER SUPPLY PROBLEM OF THE DISTRICT

Every water supply problem comprises the three phases:

(a) Quantity and pressure to be supplied.
(b) Source or sources from which such demand can be supplied.
(c) Means of delivery of water from source to point of demand.

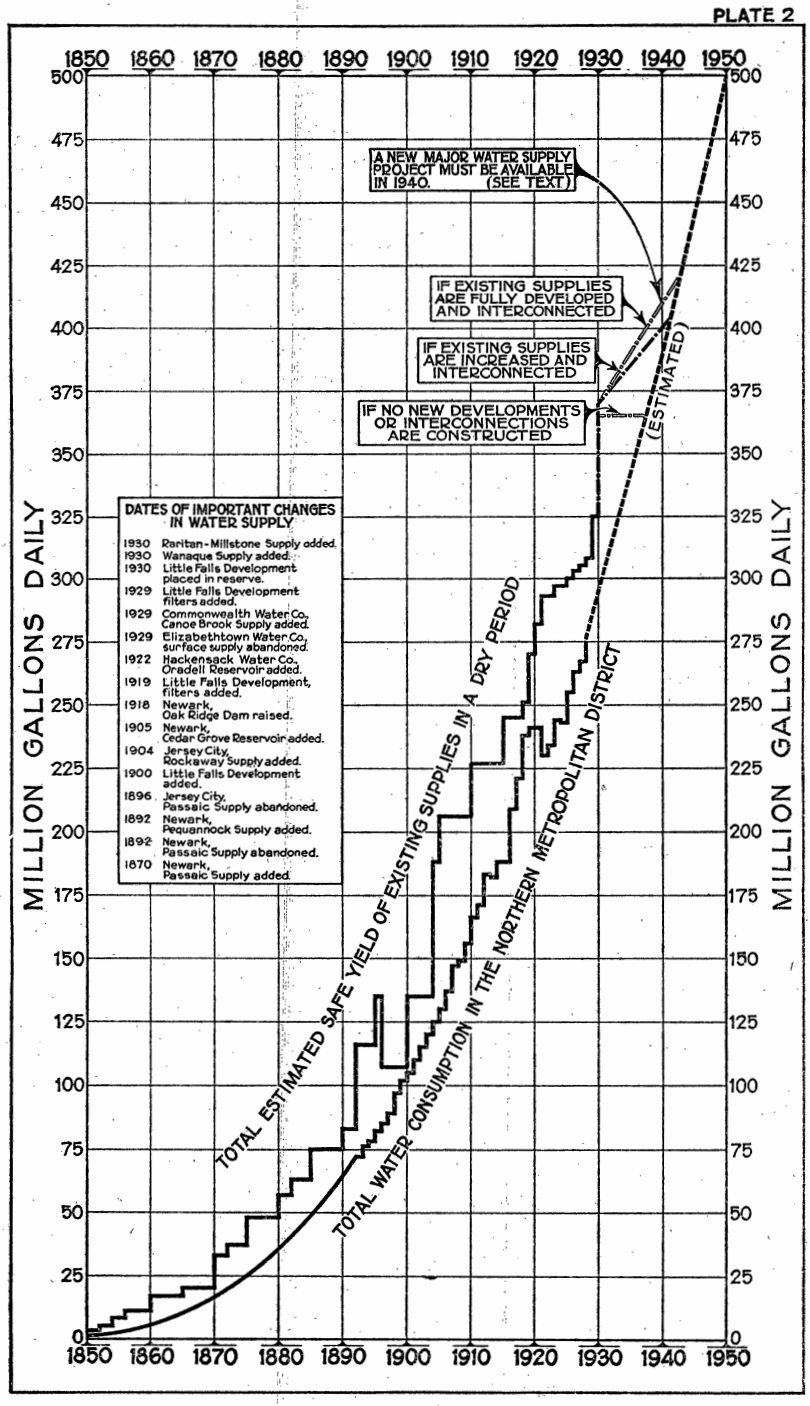
The problem of the Northern Metropolitan District varies from that of the individual municipality only in size.

Water Demands of the District

Complete and carefully compiled records of the past water consumption of the district are available and are shown herein as Tables 1, 2 and 3 and on Plate 2. Extensions of water supply systems, changes in industrial methods, water-waste control, metering, changing sanitary standards, increased prosperity — each has had and will continue to have its effect on water consumption, but actual growth in population and reliable records of past water consumption are, in the last analysis, the fundamental data for estimating future demands.

Previous reports by various authorities have been studied, notably the report of Hazen, Whipple and Fuller to the Department of Conservation and Development in 1922, the 1925 and 1926 reports of the North Jersey District Water Supply Commission, and the report of the Water Policy Commission of February, 1926. The data and conclusions contained therein, relative to consumption and estimated future increase of consumption have been found to be reasonable. The limits of the district in the various

PLATE 2



NORTHERN METROPOLITAN DISTRICT
YIELD OF SUPPLIES AND TOTAL CONSUMPTION

reports vary slightly, but not to a degree affecting the conclusions. The Dyers' Pipe Line, owned by the Passaic Consolidated Water Company and conveying non-potable water to certain industries in Paterson, is included in the quantities shown in the North Jersey District Water Supply Commission reports. This is not considered a pertinent factor and has been eliminated from this discussion.

Table 4 shows the probable water consumption of the district for each decade 1920 to 1970, as estimated by various authorities and as adopted for this report. The adopted quantities are uniformly smaller than those previously estimated, but in view of all the conditions prevailing, including the 1928 consumption records, they are believed to be liberal and somewhat in excess of those which will actually occur. However, as has been frequently pointed out, the accuracy of the estimate affects only the time when various additional supplies will be needed, and that to only a limited degree.

Table 1

NORTHERN METROPOLITAN DISTRICT WATER CONSUMPTION

Average Consumption (Million Gallons Daily)

		1920	1921	1922	1923	1924	1925	1926	1927	1928
1.	Bogota Water Co.	.16	.15	.16	.16	.16	.20	.20	.20	.20
2.	Bound Brook Water Co.	.88	.62	.74	.83	.69	.73	.74	.70	.64
3.	Commonwealth Water Co.	3.75	4.58	3.08	4.36	4.83	5.77	6.38	6.93	8.08
4.	East Orange City	3.26	3.59	3.47	3.52	3.56	3.69	3.89	3.99	4.23
5.	Elizabethtown Water Co.	7.46	9.16	8.98	11.24	11.26	12.01	11.61	10.58	10.59
6.	Essex County Institutions	.57	.57	.58	.60	.60	.60	.61	.62	.65
7.	Essex Fells Boro.	.34	.42	.48	.51	.58	.60	.63	.75	.87
8.	Fairlawn Homes Co. ...								.01	.01
9.	Garfield City	.72	.72	.88	.96	.90	.96	.92	1.58	2.04
10.	Hackensack Water Co..	31.42	30.24	31.58	28.98	26.29	27.07	27.75	28.89	30.51
11.	Haledon Boro.	.16	.16	.14	.15	.15	.15	.15	.35	.71
12.	Hawthorne Boro.	.50	.53	.43	.43	.47	.48	.55	1.07	1.13
13.	Jersey City	53.42	52.29	55.48	58.66	60.57	65.14	64.89	63.52	64.00
14.	Kearny OldSoldiers' Home	.05	.05	.05	.05	.05	.05	.05	.05	.05
15.	Lodi Boro.	.31	.39	.38	.43	.42	.40	.40	.50	.56
16.	Middlesex Water Co....	8.02	7.98	6.75	7.54	6.71	7.15	7.35	8.11	7.39
17.	Newark City	47.70	42.34	44.90	47.89	50.24	51.89	54.35	55.50	56.70
18.	New Brunswick City ...	6.76	5.93	5.64	5.59	6.36	6.40	5.54	5.31	5.36
19.	New Orange Park	.01	.01	.02	.02	.02	.03	.03	.03	.04
20.	Orange City	2.48	2.31	2.27	2.40	2.26	2.33	2.46	2.56	2.51
21.	Park Ridge Boro.							.06	.05	.06
22.	Passaic Consolidated Water Co.	51.47	47.66	46.40	46.27	44.85	47.71	52.51	56.52	58.69
23.	Perth Amboy City	9.66	7.81	8.61	8.88	7.68	8.05	7.76	6.11	6.28
24.	Plainfield - Union Water Co.	6.56	6.42	7.21	7.35	7.16	7.09	7.29	6.45	7.29
25.	Pomona Water Co., Fairlawn	.02	.02	.02	.02	.02	.02	.02	.04	.04
26.	Radio Association, Iselin	.02	.02	.02	.02	.02	.03	.03	.03	.04
27.	Rahway City	3.01	2.59	3.02	3.60	3.48	3.31	3.23	3.26	2.80
28.	Ramsey Boro.	.10	.07	.10	.10	.11	.12	.13	.14	.17
29.	Ridgewood Village		.86	.81	.89	.86	.90	.95	1.01	1.01
30.	Rochelle Park	.05	.02	.02	.03	.04	.04	.04	.04	.04
31.	Short Hills Water Co...	1.19	1.26	1.25	1.28	1.29	1.24	1.23	1.31	1.46
32.	South Orange Village..	.64	.67	.62	.67	.66	.72	.78	.82	.93
33.	Waldwick Boro.							.10	.10	.10
34.	Wallington Boro.	.23	.24	.24	.26	.25	.28	.28	.25	.25
	TOTAL	240.92	229.68	234.33	243.69	242.54	255.16	262.91	267.38	275.43

Preliminary data for more than 95 per cent. of the water consumption of the district for 1929 indicate a total consumption of about 289 Mgd.

Table 2

NORTHERN METROPOLITAN DISTRICT
1928 CONSUMPTION CLASSIFIED BY SOURCES

Surface Supplies	Million Gallons Daily		
Passaic River and tributaries:			
Pequannock, Newark City	56.7		
Rockaway, Jersey City	64.0		
Little Falls, Passaic Consolidated Water Co.	58.7		
Oldham Brook, Haledon Boro.	0.7	180.1	
Hackensack River, Hackensack Water Co.		30.5	
Rahway River, Rahway City	2.8		
West Branch, Orange City	2.5		
Robinson Branch, Middlesex Water Co.	3.0	8.3	
Raritan River			
Lawrence Brook, New Brunswick City	5.4		
Middle Brook, Bound Brook Water Co.	0.6	6.0	224.9
Well Supplies			
Bogota Water Co.		0.2	
Commonwealth Water Co.		8.1	
East Orange City		4.2	
Elizabethtown Water Co.		10.6	
Essex County Institutions		0.6	
Essex Fells Boro.		0.9	
Garfield City		2.0	
Hawthorne Boro.		1.1	
Kearny Old Soldiers Home		0.1	
Lodi Boro.		0.6	
Middlesex Water Co.		4.4	
Park Ridge Boro.		0.1	
Perth Amboy City		6.3	
Plainfield-Union Water Co.		7.3	
Ramsey Boro.		0.2	
Ridgewood Village		1.0	
Short Hills Water Co.		1.4	
South Orange Village		0.9	
Waldwick Boro.		0.1	
Wallington Boro.		0.2	
Five small systems		0.2	50.5
TOTAL			275.4

Table 3

NORTHERN METROPOLITAN DISTRICT
1928 CONSUMPTION, GRAVITY AND PUMPED SUPPLIES

	Million Gallons Daily
Gravity Surface Supplies	122.0
Pumped Surface Supplies	102.9
Pumped Well Supplies	50.5
TOTAL	275.4

Table 4

NORTHERN METROPOLITAN DISTRICT
ESTIMATED WATER REQUIREMENTS

Year	Hazen, Whipple and Fuller 1922		North Jersey District Water Supply Commission 1925		Water Policy Commission 1926		State Water Policy Commission 1930	
	Quantity Mgd.	Percentage Increase for Decade	Quantity Mgd.	Percentage Increase for Decade	Quantity Mgd.	Percentage Increase for Decade	Quantity Mgd.	Percentage Increase for Decade
1920*	244		245		245		241**	
1928*	280		280		280		275**	
1930	315	29	325	32	300	22	290	
1940	407	29	430	32	403	34	390	34
1950	520	28	540	26	525	30	500	28
1960	660	27	700	30	675	29	630	26
1970	820	24	870	24	840	24	780	24

*Actual records.
**District slightly smaller than for other reports.

That it is impracticable to estimate precisely the growth of water consumption is brought out clearly by the comparative table showing varying conditions for the various sections of the district for the period 1924 to 1928.

Table 5

NORTHERN METROPOLITAN DISTRICT
VARYING RATES OF INCREASE OF CONSUMPTION IN SECTIONS OF THE DISTRICT

District	Million Gallons Daily 1924	1928	Percent. Change
Passaic Consolidated Water Company	44.8	58.7	+ 31
Bayonne	15.1	11.5	— 24
Union and Middlesex Counties	44.0	41.3	— 6
Commonwealth Water Company	4.8	8.1	+ 69
New Brunswick	6.4	5.4	— 16
Entire District	243	275	+ 13

The disproportionate effect on water consumption of changing industrial conditions in the Paterson district should be noted:

Table 6

NORTHERN METROPOLITAN DISTRICT
RELATION BETWEEN PASSAIC CONSOLIDATED WATER COMPANY AND REMAINDER OF DISTRICT

	Passaic Consolidated Water Company	Remainder of District
1924 Consumption (Mgd.)	44.8	197.7
1928 Consumption "	58.7	216.7
Increase "	13.9	19
Increase (per cent.)	31	10

Time for Completion of Next Major Water Supply Project

Studies of growth and trend of water consumption and of the safe yield of existing supplies are important only to determine approximately when the next major water supply for the district must become available. The curves of water consumption and total safe yield of supplies for the Northern Metropolitan District, shown on Plate 2, were prepared from records to date and have been extended in accordance with the estimates made for this report, to show probable future conditions for the next twenty years. These curves indicate that **in 1940 a new large supply must be ready for service.**

The estimates are as follows:

	Yield
Total safe yield of supplies in 1929 (Table 8)	325 Mgd.
Wanaque supply to be added in 1930	100 "
Elizabethtown Water Co., Raritan-Millstone supply to be added in 1930	10 "
Total safe yield in 1930	435 Mgd.
Little Falls Development placed in reserve	65 "
Net safe yield in 1930	370 Mgd.
Estimated extension of small supplies, including Raritan-Millstone, 1930-1940	40 "
Estimated safe yield in 1940	410 Mgd.

Consumption

Total consumption in district, 1928	275	Mgd.
Increase in 12 years at the rate of 9 to 10 Mgd. per year	115	"
Total estimated consumption in 1940	390	Mgd.
Total margin in 1940 between consumption and safe yield	20	Mgd.

The indicated safety margin of 20 Mgd. in 1940 will be reduced by abandonment of small supplies due to increased pollution and also by the fact that complete interconnection of all supplies before 1940 will be impracticable.

A definite policy involving early construction of interconnections and a major project before 1940 is essential. In the absence of such construction, it will be necessary to rely on uneconomic piece-meal developments and extensions of present supplies to a greater extent than is indicated in this estimate.

Present Sources of Supply

The Northern Metropolitan District is supplied from 34 water supply systems, serving a population of approximately 2,800,000. These 34 systems, public and corporate, have been gradually developed over a period of 75 years, keeping pace, in general, with the demands of the district, but as a rule with only an inadequate surplus and without sufficient means for transfers of water to prevent recurring shortages in one section or another of the district. The larger of these supplies having been described and discussed in previous reports, a repetition at this time is not warranted. The location of each supply and the area served thereby is shown as Plate 3. Table 7 lists these supplies in order of size, bringing out the interesting fact that 50 per cent. of the supplies furnish 98 per cent. of the demand, and that the eight largest supplies alone care for nearly 90 per cent.

Table 7

NORTHERN METROPOLITAN DISTRICT
EXISTING WATER SUPPLY SYSTEMS

(Arranged in order of size)

	Water Supply	Production in 1928 Mgd.	Percentage of Total	Cumulative Percentage of Total
1.	Jersey City	64.00	23.3	23.3
2.	Passaic Consolidated Water Co.	58.69	21.3	44.6
3.	Newark City	56.70	20.6	65.2
4.	Hackensack Water Co.	30.51	11.1	76.3
5.	Elizabethtown Water Co.	10.59	3.9	80.2
6.	Commonwealth Water Co.	8.08	2.9	83.1
7.	Middlesex Water Co.	7.39	2.7	85.8
8.	Plainfield-Union Water Co.	7.29	2.6	88.4
9.	Perth Amboy City	6.28	2.3	90.7
10.	New Brunswick City	5.36	2.0	92.7
11.	East Orange City	4.23	1.5	94.2
12.	Rahway City	2.80	1.0	95.2
13.	Orange City	2.51	0.9	96.1
14.	Garfield City	2.04	0.7	96.8
15.	Short Hills Water Co.	1.46	0.5	97.3
16.	Hawthorne Boro.	1.13	0.4	97.7
17.	Ridgewood Village	1.01	0.4	98.1
18.	South Orange Village	.93		
19.	Essex Fells Boro.	.87		
20.	Haledon Boro.	.71		
21.	Essex County Institutions	.65		
22.	Bound Brook Water Co.	.64		
23.	Lodi Boro.	.56		
24.	Wallington Boro.	.25		
25.	Bogota Water Co.	.20		
26.	Ramsey Boro.	.17		
27.	Waldwick Boro.	.10		
28.	Park Ridge Boro.	.06		
29.	Kearny Old Soldiers Home	.05		
30.	Pomona Water Co., Fairlawn	.04		
31.	Rochelle Park	.04		
32.	Radio Association, Inc., Iselin	.04		
33.	New Orange Park	.04		
34.	Fairlawn Homes Co.	.01		
	TOTAL	275.43		


NEW YORK
PENNSYLVANIA
DELAWARE
ATLANTIC OCEAN
NORTHERN METROPOLITAN DISTRICT
SOUTHERN METROPOLITAN DISTRICT
SEASHORE RESORT DISTRICT
PHILADELPHIA
NOTE
Each dot represents
1000 people or less
Census of 1930
STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION
DISTRIBUTION OF POPULATION
AND
DISTRICTS OF MAXIMUM DENSITY
AND WATER DEMAND
5 0 5 10 15
SCALE OF MILES
FEBRUARY 1931

PLATE 1

NEW YORK
NEW JERSEY

Boundary of Northern Metropolitan District

RINGWOOD
HOHOKUS TWP.
WANAQUE RESERVOIR
OAKLAND
WANAQUE
BLOOMINGDALE
POMPTON LAKES
WANAQUE AQUEDUCT
BUTLER
RIVERDALE
KINNELON
PEQUANNOCK
NEWARK PIPE LINE
LINCOLN PARK
MONTVILLE
BOONTON
BOONTON RESERVOIR
CALDWELL TWP.
JERSEY CITY PIPE LINE
FRANKLIN LAKES
WYCKOFF
BERGEN CO.
PASSAIC CO.
UPPER SADDLE RIVER
SADDLE RIVER
RAMSEY
ALLENDALE
WALDWICK
MIDLAND PARK
RIDGEWOOD
GLEN ROCK
HOHOKUS
WASHINGTON
MONTVALE
PARK RIDGE
WOODCLIFF LAKE
HILLSDALE
WESTWOOD
EMERSON
PARAMUS
HAWTHORNE
NORTH HALEDON
HALEDON
FAIRLAWN
PATERSON
EAST PATERSON
SADDLE RIVER
TOTOWA
WEST PATERSON
CLIFTON
PASSAIC
LITTLE FALLS
PASSAIC CO.
ESSEX CO.
NORTH CALDWELL
CEDAR GROVE
VERONA
CALDWELL
WEST CALDWELL
ESSEX FELLS
ROSELAND
WEST ORANGE
LIVINGSTON
MORRIS ESSEX
EAST ORANGE
ORANGE
SOUTH ORANGE
MAPLEWOOD
IRVINGTON
NEWARK
MONTCLAIR
GLEN RIDGE
BLOOMFIELD
NUTLEY
BELLEVILLE
LYNDHURST
NORTH ARLINGTON
KEARNY
HARRISON
SECAUCUS
NORTH BERGEN
WEST NEW YORK
UNION CITY
WEEHAWKEN
HOBOKEN
JERSEY CITY
NEW YORK BAY
NEWARK BAY
BAYONNE
HILLSIDE
ELIZABETH
UNION
ESSEX
UNION CO.
MILLBURN
SHORT HILLS
FLORHAM PARK
MORRIS TWP.
MADISON
CHATHAM
SUMMIT
SPRINGFIELD
CHATHAM TWP.
HARDING
NEW PROVIDENCE
MOUNTAINSIDE
NEW PROVIDENCE TWP.
PASSAIC TWP.
MORRIS CO.
SOMERSET CO.
KENILWORTH
ROSELLE PARK
ROSELLE
CRANFORD
GARWOOD
LINDEN
LINDEN TWP.
WESTFIELD
SCOTCH PLAINS
FANWOOD
CLARK
RAHWAY
CARTERET
WOODBRIDGE
PERTH AMBOY
SOUTH AMBOY
RARITAN TWP.
METUCHEN
DUNELLEN
PLAINFIELD
NORTH PLAINFIELD
MIDDLESEX CO.
UNION CO.
NORTH PLAINFIELD TWP.
Boundary of Northern Metropolitan District
WARREN
BRIDGEWATER
PISCATAWAY
SOMERVILLE
RARITAN
SOUTH BOUND BROOK
NORTH BRUNSWICK
HIGHLAND PARK
NEW BRUNSWICK
NORTHVALE
ROCKLEIGH
OLD TAPPAN
NORWOOD
HARRINGTON PARK
CLOSTER
ALPINE
DEMAREST
HAWORTH
CRESSKILL
DUMONT
ORADELL
NEW MILFORD
RIVERSIDE
BERGENFIELD
TENAFLY
ENGLEWOOD
ENGLEWOOD CLIFFS
TEANECK
MAYWOOD
HACKENSACK
BOGOTA
LEONIA
RIDGEFIELD PARK
PALISADES PARK
FORT LEE
LODI
SADDLE RIVER
HASBROUCK HEIGHTS
TETERBORO
LITTLE FERRY
RIDGEFIELD
WOOD RIDGE
MOONACHIE
WALLINGTON
FAIRVIEW
CLIFFSIDE PARK
EDGEWATER
CARLSTADT
EAST RUTHERFORD
RUTHERFORD
BERGEN HUDSON CO.
PASSAIC CO.
HUDSON CO.
HUDSON
PERALE

INDEX

Water Supply Systems and areas served are indicated by numbers as follows:-

1 Bogota Water Co.
2 Bound Brook Water Co.
3 Commonwealth Water Co.
4 East Orange Water Dept.
5 Elizabethtown Water Co.
6 Essex County Institutions
7 Essex Fells Water Dept.
8 Fairlawn Homes Co.
9 Garfield Water Dept.
10 Hackensack Water Co.
11 Haledon Water Dept.
12 Hawthorne Water Dept.
13 Jersey City Water Dept.
14 Kearny Old Soldiers Home
15 Lodi Water Department
16 Middlesex Water Co.
17 New Brunswick Water Dept.
18 New Orange Park Water Co.
19 Newark Water Dept.
20 Orange Water Dept.
21 Park Ridge Water Dept.
22 Passaic Consolidated Water Co
23 Perth Amboy Water Dept.
24 Plainfield-Union Water Co.
25 Pomona Water Co. (Fairlawn)
26 Radio Ass'n. Inc. (Iselin)
27 Rahway Water Dept.
28 Ramsey Water Dept.
29 Ridgewood Water Dept.
30 Rochelle Park
31 Short Hills Water Co.
32 South Orange Water Dept.
33 Waldwick Water Dept.
34 Wallington Water Dept.

■ Indicates Pumping Station.
Pipe lines are shown in red.
Transmission mains are shown by dotted lines through areas served by other systems

STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

NORTHERN METROPOLITAN DISTRICT
EXISTING WATER SUPPLY SYSTEMS AND AREAS SERVED

1 0 1 2 3 4 5 Mi.

FEBRUARY 1930

PLATE 3

C.S.A.

Abandonment of Existing Supplies.

With increasing population on the watersheds of certain supplies, and increasing demands of the public that their water be supplied from sources of minimum actual or potential pollution, there can be no question that a number of surface supplies now serving the public eventually will be abandoned or placed in reserve. The trend in this direction is well illustrated by the abandonment of the Elizabeth River supply of the Elizabethtown Water Company in 1929, and the prospective placing in reserve of the Little Falls supply of the Passaic Consolidated Water Company for use in emergency or for industrial purposes. Similar results in the cases of the Hackensack River supply of the Hackensack Water Company and the Rahway River supply of the City of Rahway, while possibly not imminent, must eventually occur, and are even now being discussed.

Pumping

It is a natural corollary of the gradual development of individual supplies that nearly all of the small supplies and several of those of greater size are from low level sources located near the centers of population and pumped to the elevation necessary to provide adequate pressure for the municipalities served. There is no economical method available whereby pumping can be eliminated for the highest levels in the district, but with the exception of such areas, it will be shown that the entire district can be easily and economically served by gravity from existing and proposed supplies.

Capacity of Present Supplies

The estimated safe yield of each of the present supplies of the district, in comparison with 1928 consumption, is shown in Table 8, together with an estimate of the reasonable and practicable extensions thereto.

Table 8

NORTHERN METROPOLITAN DISTRICT
SAFE YIELD OF PRESENT WATER SUPPLIES

		Safe Yield in 1929—Mgd.			1928 Consumption (Mgd.)	Possible Safe Yields After Further Development of Present Sources
		Surface Supplies	Well Supplies	Total		
1.	Bogota Water Co.	....	0.2	0.2	0.20	0.3
2.	Bound Brook Water Co.	3.0	1.0	4.0	0.64	5.0
3.	Commonwealth Water Co.	5.0	10.0	15.0	8.08	17.0
4.	East Orange City	....	5.0	5.0	4.23	7.0
*5.	Elizabethtown Water Co.	....	10.0	10.0*	10.59	12.0*
6.	Essex County Institutions	....	0.8	0.8	0.65	1.0
7.	Essex Fells Boro.	....	1.7	1.7	0.87	2.5
8.	Fairlawn Homes Co.	....	0.1	0.1	0.01	0.2
9.	Garfield City	....	3.5	3.5	2.04	4.0
10.	Hackensack Water Co.	43.0	...	43.0	30.51	43.0
11.	Haledon Boro.	1.8	...	1.8	0.71	2.5
12.	Hawthorne Boro.	....	1.0	1.0	1.13	1.5
13.	Jersey City	60.0	...	60.0	64.00	90.0
14.	Kearny Old Soldiers Home	....	0.2	0.2	0.05	0.2
15.	Lodi Boro.	....	0.8	0.8	0.56	1.0
16.	Middlesex Water Co.	3.9	6.0	9.9	7.39	10.5
17.	Newark City	62.0	...	62.0	56.70	62.0
18.	New Brunswick City	10.8	...	10.8	5.36	10.8
19.	New Orange Park	....	0.2	0.2	0.04	0.2
20.	Orange City	2.5	...	2.5	2.50	4.0
21.	Park Ridge Boro.	....	0.3	0.3	0.06	0.3
22.	Passaic Cons. Water Co.	65.0	...	65.0	58.69	65.0
23.	Perth Amboy City	....	9.0	9.0	6.28	12.0
24.	Plainfield-Union Water Co.	....	8.0	8.0	7.29	10.0
25.	Pomona Water Co., Fairlawn	....	0.2	0.2	0.04	0.2
26.	Radio Association, Iselin	....	0.1	0.1	0.04	0.1
27.	Rahway City	4.0	...	4.0	2.80	4.0
28.	Ramsey Boro.	....	0.6	0.6	0.17	0.6
29.	Ridgewood Village	....	2.2	2.2	1.01	2.5
30.	Rochelle Park	....	0.1	0.1	0.04	0.1
31.	Short Hills Water Co.	....	1.5	1.5	1.46	3.0
32.	South Orange Village	....	1.4	1.4	0.93	2.0
33.	Waldwick Boro.	....	0.3	0.3	0.10	0.3
34.	Wallington Boro.	....	0.4	0.4	0.25	0.4
	TOTALS	261.0	64.6	325.6	275.43	375.2
	Wanaque (available April, 1930)			100.0		100.0
	*Elizabethtown Water Co. (Raritan - Millstone development, available 1930)			10.0		20.0
				435.6		495.2

Extensions of Present Sources

It will be noted that Table 8 indicates the general possibility of small increases in many of the supplies now in use, aggregating 60 million gallons daily. It is reasonable to anticipate that under the present system of individual management, many or all of these extensions will be made as needed. The most serious situation is that of Jersey City, which has for several years been drawing on the Boonton supply in excess of its safe yield in a dry year. This is a condition that should be remedied as soon as practicable, at least to the extent of the Split Rock development, the grant for which was obtained from the Department of Conservation and Development in 1922. Further development of existing sources or an additional supply from another source should be given immediate consideration. For the purpose of this report it is assumed that a reasonable total development for Jersey City in the Rockaway watershed would be 90 Mgd., the capacity of the existing pipe lines.

The Elizabethtown Water Company is now developing a low level supply from the Raritan and Millstone, which will be available in 1930 and can be extended to supply a total of 20 Mgd., without further grants from the State.

Bergen County has studied the possibility of extending the present supply from the Hackensack watershed and also the development of the Ramapo watershed. Both involve construction in New York and have not been included in this estimate.

Extensions of Smaller Supplies

That under the present system of individual initiative and control, those responsible for the smaller supplies have, in general, used reasonable foresight is indicated by Table 9, showing grants by the Department of Conservation and Development and the State Water Policy Commission within the district since 1921. These supplies are in the most part well supplies, which are doubtless expensive per unit of yield, although the practicability of extension in small units presents many advantages.

Table 9

NORTHERN METROPOLITAN DISTRICT DIVERSION GRANTS FOR NEW OR ADDITIONAL SUPPLIES

1922 to 1929

Year	Municipality or Corporation	Quantity per Day	New or Additional	Surface or Wells
1922	Waldwick Boro.	60,000	New	Wells
1922	Jersey City	5,000,000*	Additional	Surface
1923	Rochelle Park (5 small companies)	145,000	New	Wells
1923	Park Ridge Boro.	200,000	"	"
1924	Wallington Boro.	275,000	Additional	"
1924	Ramsey Boro.	120,000	"	"
1924	Essex Fells Boro.	700,000	"	"
1924	Lodi Boro.	2,000,000	"	"
1924	Ridgewood Village ...	1,300,000	"	"
1924	Garfield City	280,000	"	"
1925	Commonwealth Water Co.	2,500,000	"	"
1925	Garfield City	3,000,000	"	"
1926	New Brunswick City..	5,000,000	"	Surface
1926	Commonwealth Water Co.	5,000,000	"	"
1928	Essex Fells Boro.	157,000	"	Wells
1928	East Orange City	2,000,000	"	"
1928	Fairlawn Boro.	1,000,000	New	"
1929	Allendale Boro.	300,000	"	"
1929	Essex Fells Boro.	400,000	Additional	"
1929	Caldwell Boro.	200,000	New	"
	TOTAL	29,637,000 gallons		
	Average quantity granted per year ..	3,705,000 gallons per day.		

*Development of this project not yet begun.

Wanaque Project

The completion of the Wanaque Project during 1930 will bring about several important changes in the water supply situation in the district. This project is the result of the voluntary co-opera-

NEW YORK
NEW JERSEY

Boundary of Northern Metropolitan District

RINGWOOD
HOHOKUS TWP
UPPER SADDLE RIVER
MONTVALE
PARK RIDGE
OLD TAPPAN
NORTHVALE
ROCKLEIGH
RAMSEY
SADDLE RIVER
WOODCLIFF LAKE
HILLSDALE
NORWOOD
HARRINGTON PARK
ALPINE
CLOSTER
WESTWOOD
EMERSON
DEMAREST
HAWORTH
CRESSKILL
ORADELL
DUMONT
NEW MILFORD
TENAFLY
ALLENDALE
WALDWICK
HOHOKUS
WASHINGTON
WANAQUE RESERVOIR
OAKLAND
WANAQUE
MIDLAND PARK
RIDGEWOOD
WYCKOFF
FRANKLIN LAKES
GLEN ROCK
PARAMUS
BERGENFIELD
RIVERSIDE
ENGLEWOOD
ENGLEWOOD CLIFFS
BLOOMINGDALE
POMPTON LAKES
BERGEN CO.
PASSAIC CO.
HAWTHORNE
NORTH HALEDON
FAIRLAWN
TEANECK
MAYWOOD
HACKENSACK
BUTLER
RIVERDALE
HALEDON
EAST PATERSON
SADDLE RIVER
BOGOTA
LEONIA
WAYNE
PEQUANNOCK
KINNELON
PATERSON
LODI
RIDGEFIELD PARK
PALISADES PARK
FORT LEE
GARFIELD
HASBROUCK HEIGHTS
TETERBORO
LITTLE FERRY
NEWARK PIPE LINE
TOTOWA
WEST PATERSON
WOOD RIDGE
MOONACHIE
RIDGEFIELD
WALLINGTON
FAIRVIEW
CLIFFSIDE PARK
EDGEWATER
LINCOLN PARK
CLIFTON
PASSAIC
CARLSTADT
MONTVILLE
LITTLE FALLS
PASSAIC CO.
ESSEX CO.
EAST RUTHERFORD
RUTHERFORD
CALDWELL TWP.
JERSEY CITY PIPE LINE
NORTH CALDWELL
CEDAR GROVE
BERGEN CO.
HUDSON CO.
BOONTON
NUTLEY
LYNDHURST
NORTH BERGEN
WEST NEW YORK
SECAUCUS
WEEHAWKEN
UNION CITY
HOBOKEN
VERONA
WEST CALDWELL
CALDWELL
BELLEVILLE
NORTH ARLINGTON
BOONTON RESERVOIR
ESSEX FELLS
ROSELAND
MONTCLAIR
GLEN RIDGE
BLOOMFIELD
KEARNY
JERSEY CITY
WEST ORANGE
EAST ORANGE
ORANGE
HARRISON
LIVINGSTON
MORRIS CO.
ESSEX CO.
SOUTH ORANGE
NEWARK
IRVINGTON
MAPLEWOOD
NEW YORK BAY
FLORHAM PARK
MILLBURN
HILLSIDE
ESSEX CO.
UNION CO.
NEWARK BAY
BAYONNE
MORRIS TWP.
MADISON
CHATHAM
SUMMIT
SPRINGFIELD
UNION
ELIZABETH
CHATHAM TWP.
KENILWORTH
ROSELLE PARK
ROSELLE
HARDING
MORRIS CO.
UNION CO.
NEW PROVIDENCE
MOUNTAINSIDE
CRANFORD
LINDEN
LINDEN TWP.
PASSAIC TWP.
GARWOOD
NEW PROVIDENCE TWP.
WESTFIELD
SCOTCH PLAINS
CLARK
RAHWAY
CARTERET
MORRIS CO.
SOMERSET CO.
FANWOOD
PLAINFIELD
NORTH PLAINFIELD
UNION CO.
MIDDLESEX CO.
WOODBRIDGE
Boundary of Northern Metropolitan District
NORTH PLAINFIELD TWP.
WARREN
DUNELLEN
METUCHEN
PERTH AMBOY
BRIDGEWATER
PISCATAWAY
RARITAN TWP.
SOUTH AMBOY
SOUTH BOUND BROOK
SOMERVILLE
HIGHLAND PARK
NEW BRUNSWICK
NORTH BRUNSWICK

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7. Essex Fells Water Dept.
8. Fairlawn Homes Company
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11. Haledon Water Dept.
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13. Jersey City Water Dept.
14. Kearny Old Soldiers Home
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19. Newark Water Department
20. Orange Water Department
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22. Passaic Consolidated Water Co.
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32. South Orange Water Dept.
33. Waldwick Water Department
34. Wallington Water Department
35. Wanaque System

Pipe lines are shown in red.
Transmission mains are shown by dotted lines through areas served by other systems.
■ Indicates Pumping Station.

STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

NORTHERN METROPOLITAN DISTRICT
EXISTING WATER SUPPLY SYSTEMS AND AREAS SERVED AFTER COMPLETION OF WANAQUE SYSTEM

1 0 1 2 3 4 5 Mi.

FEBRUARY 1930

C.S.A.

PLATE 4

tion of eight municipalities in a plan to make available to each a supply unavailable to any one municipality alone.

That it results in a radical rearrangement of the service areas of the district is evident by comparison of Plate 3, showing existing service areas, and Plate 4, showing the service areas for each supply system after completion of the Wanaque Project. The principle of voluntary co-operation in the development of supplies and the provision whereby each participant is permitted to sell the surplus of its allotment at cost, or at a profit, leads to a widespread and possibly uneconomic distribution of the supply. The participation in the project of certain municipalities requiring high level supplies has resulted in the planning of the project so that by means of auxiliary pumping equipment the delivery is at a higher elevation than necessary for much of the area served, without eliminating the necessity of a second pumping for the higher level communities. The fact that three of the Wanaque participants, Montclair, Bloomfield and Glen Ridge, are now served by the high level Pequannock supply and are contemplating continuing that service after the completion of the Wanaque Project to avoid the inconvenience and cost of pumping, is noteworthy.

The very great advantages of the method of development of water supplies by voluntary co-operation, as exemplified by the Wanaque Project planned and executed by the North Jersey District Water Supply Commission, must not be minimized or overlooked. Existing legislation provides no other means whereby the larger developments can be made available at cost to each of a group of interested municipalities. The fact that no single project can be developed which meets exactly the needs of each participant as to elevation and location is a handicap which is relatively unimportant.

Service Zones

The elevation of the various municipalities of the district and the elevation at which water is delivered to consumers from the various supplies vary widely. Plate 5 indicates approximately the relation of areas served and water delivery elevations. This curve shows clearly that there is no definite demarcation between what may be termed the Intermediate, High and Special High Service

Zones, but that practically all delivery elevations between Elevation 90 and Elevation 750 are represented by one or more supplies. The multiplicity of supplies, large and small, many of which serve a number of municipalities having a wide range of elevation, manifestly is an uneconomic plan.

A Logical Zone System

The problem of economical service zoning of the district is entirely capable of at least approximate solution. As a result of preliminary investigations, zones are tentatively established as indicated on Plate 5, having characteristics as shown below:

Table 10

SERVICE ZONES

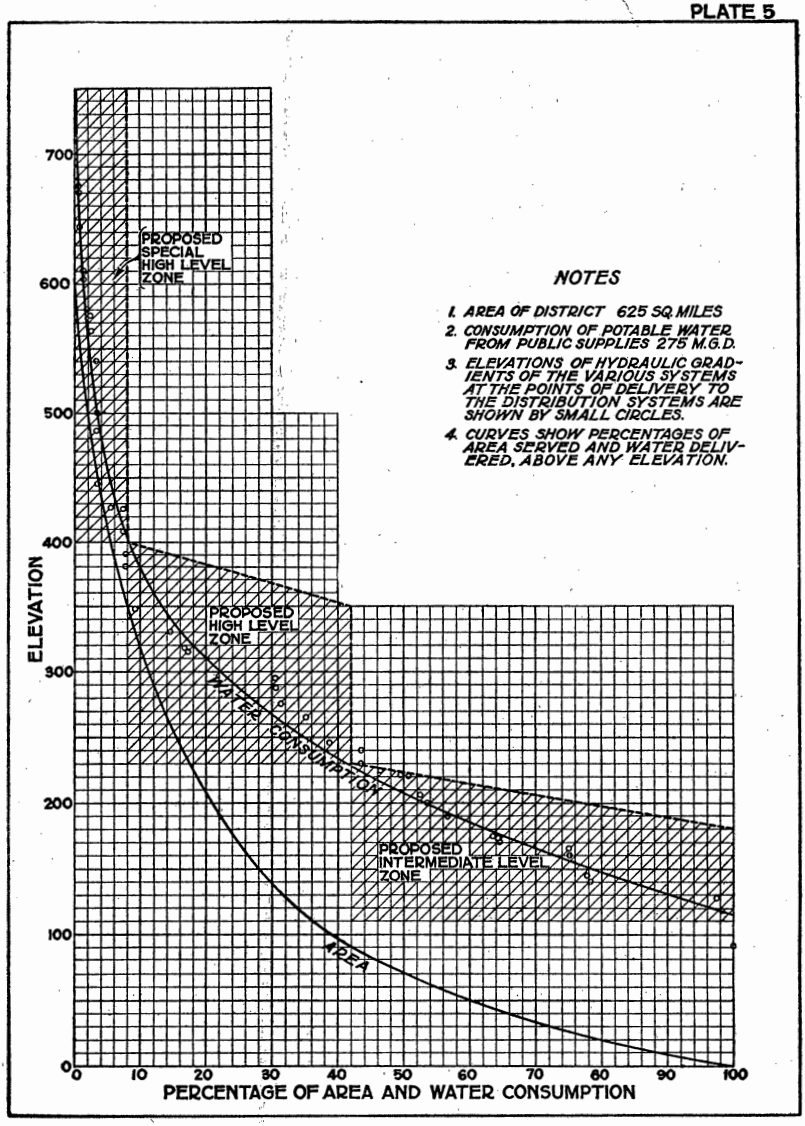
Service Zones	Present Delivery Elevation	Proposed Delivery Elevation	Approximate Percentage of Consumption
Intermediate	110 - 230	230	58
High	230 - 400	400	34
Special High (pumped)....	above 400	as required	8

The selection of the delivery elevations of the various zones is such that the principal gravity supplies of the district, the Wanaque, the Rockaway and the Pequannock, comprising 62 per cent. of the present available supplies, exclusive of the Little Falls development, can be readily adapted without material change. It will be shown that additional projects for the district as a whole can be economically developed as the need occurs to supply each of these zones. Plate 6 shows, in general, the portions of the district now falling within the zone limits as above outlined; Plate 7 shows a tentative and approximate division of the district into the proposed pressure zones, together with an indication of the principal interconnecting transmission mains serving each zone.

Interconnections

If a single agency were delegated to supply water to the district, the division of the district into appropriate service zones would naturally follow and interconnecting mains would be con-

PLATE 5



NORTHERN METROPOLITAN DISTRICT
VARIATION IN ELEVATION OF WATER DEMAND AND AREA

These curves show that the district varies from sea level to Elevation 600 and that existing water supplies are delivered at various elevations, averaging about 130 feet (55 pounds) above the surface.

The curves represent the percentage of the area and water consumption, respectively, above the indicated elevation.

The proposed service zones indicate that, for a unified system for the whole district, delivery would be at only a few different elevations, each serving its proportion of the whole demand. The Special High Service would be delivered from existing supplies and from several small pumping stations supplied by the High Service.

structed to serve properly the various zones. It is not to be assumed that these mains would be single large aqueducts, but that they would be of such size and in such locations as economically to serve the demands of the zones. However, for this preliminary presentation, single lines will best serve the present purpose. Each zone would be served by its own separate main extending throughout the zone. Each main would be connected to the main in the next lower zone for standby service and each main would be supplied from all available systems having sufficient elevation for gravity delivery. Such a system is outlined on Plate 8 and consists of a High Level Main along the eastern side of the Watchung Mountain, extended to the high level areas in the north and northeast portions of the district. This main would be supplied from the proposed High Level Project and the existing Pequannock system. An Intermediate Level Main extends the entire length of the district and would be supplied from the existing Wanaque and Jersey City systems and from future developments located southeast and north of the district. When the project for the next development is adopted, involving as it will a decision on the general scheme of water supply for the whole district, it will be necessary to make a complete study of the existing distribution systems. This study would determine points to be interconnected, location, size and type of interconnecting mains, and time and order of construction to meet the demands of the district. In the absence of such detailed study, any preliminary estimate of these features and of their cost might be misleading.

Supplies Available for the District

A repetition of the description of areas available for the development of water supplies for the Northern Metropolitan District can well be avoided, since this subject has been fully covered in other reports, notably in those of the Geological Survey of New Jersey, 1894; Hazen, Whipple and Fuller to the Department of Conservation and Development, 1922; the North Jersey District Water Supply Commission, 1925, and the Water Policy Commission, 1926. The entire northern half of the State is available for the development of surface supplies for the district, except the area of the district itself and the Pequannock and Wanaque watersheds, which are fully developed. See Plate 9.

NEW YORK
NEW JERSEY

Boundary of Northern Metropolitan District

RINGWOOD
HOHOKUS TWP.
UPPER SADDLE RIVER
MONTVALE
PARK RIDGE
RIVERVALE
OLD TAPPAN
NORTHVALE
ROCKLEIGH
NORWOOD
RAMSEY
SADDLE RIVER
WOODCLIFF LAKE
HARRINGTON PARK
ALPINE
WANAQUE RESERVOIR
ALLENDALE
HILLSDALE
CLOSTER
WESTWOOD
WALDWICK
HOHOKUS
WASHINGTON
EMERSON
HAWORTH
DEMAREST
OAKLAND
CRESSKILL
WYCKOFF
MIDLAND PARK
RIDGEWOOD
ORADELL
DUMONT
WANAQUE
FRANKLIN LAKES
NEW MILFORD
RIVERSIDE
TENAFLY
GLEN ROCK
PARAMUS
BERGENFIELD
BLOOMINGDALE
POMPTON LAKES
BERGEN CO.
PASSAIC CO.
HAWTHORNE
NORTH HALEDON
FAIRLAWN
ENGLEWOOD
ENGLEWOOD CLIFFS
BUTLER
RIVERDALE
HALEDON
TEANECK
MAYWOOD
HACKENSACK
EAST PATERSON
SADDLE RIVER
BOGOTA
LEONIA
WAYNE
KINNELON
PEQUANNOCK
PATERSON
BERGEN
PASSAIC CO.
LODI
GARFIELD
RIDGE-FIELD PARK
PALISADES PARK
FORT LEE
HASBROUCK HEIGHTS
TETERBORO
LITTLE FERRY
TOTOWA
WEST PATERSON
LINCOLN PARK
WOOD RIDGE
MOONACHIE
RIDGEFIELD
WALLINGTON
FAIRVIEW
CLIFFSIDE PARK
EDGEWATER
MONTVILLE
LITTLE FALLS
CLIFTON
PASSAIC
CARLSTADT
PASSAIC CO.
ESSEX CO.
EAST RUTHERFORD
RUTHERFORD
CALDWELL TWP.
NORTH CALDWELL
CEDAR GROVE
BERGEN
HUDSON
WEST NEW YORK
BOONTON
NUTLEY
LYNDHURST
CO.
CO.
NORTH BERGEN
WEST CALDWELL
VERONA
MONTCLAIR
BLOOMFIELD
BELLEVILLE
NORTH ARLINGTON
SECAUCUS
UNION CITY
WEEHAWKEN
CALDWELL
BOONTON RESERVOIR
ESSEX FELLS
GLEN RIDGE
HOBOKEN
ROSELAND
KEARNY
WEST ORANGE
ORANGE
EAST ORANGE
JERSEY CITY
HARRISON
MORRIS CO.
ESSEX CO.
LIVINGSTON
NEWARK
SOUTH ORANGE
NEW YORK BAY
FLORHAM PARK
MAPLEWOOD
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GAR-WOOD
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NEW PROVIDENCE TWP.
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RAHWAY
CARTERET
FANWOOD
MORRIS CO.
SOMERSET CO.
UNION CO.
MIDDLESEX CO.
Boundary of Northern Metropolitan District
NORTH PLAINFIELD TWP.
NORTH PLAINFIELD
PLAINFIELD
WOODBRIDGE
WARREN
DUNELLEN
METUCHEN
PERTH AMBOY
PISCATAWAY
RARITAN TWP.
SOUTH AMBOY
BRIDGEWATER
BOUND BROOK
SOMERVILLE
HIGHLAND PARK
NEW BRUNSWICK
NORTH BRUNSWICK

LEGEND

SPECIAL HIGH LEVEL
Areas where present hydraulic gradients are above Elev. 400.

HIGH LEVEL
Areas where present hydraulic gradients are between Elev. 400 and Elev. 230.

INTERMEDIATE LEVEL
Areas where present hydraulic gradients are below Elev. 230.

Uncolored areas within the Metropolitan District are not served by public water supplies.

STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

NORTHERN METROPOLITAN DISTRICT
EXISTING SERVICE ZONES

1 0 1 2 3 4 5 Mi.

FEBRUARY 1930

PLATE 6

C.S.A.

NEW YORK
NEW JERSEY

Boundary of Northern Metropolitan District

INTERMEDIATE LEVEL SUPPLY

HIGH LEVEL SUPPLY

HIGH LEVEL SUPPLY

ALTERNATIVE LOCATIONS

INTERMEDIATE LEVEL SUPPLY

Boundary of Northern Metropolitan District

LEGEND

SPECIAL HIGH LEVEL
Areas to be served by pumping from the High Level supplies

HIGH LEVEL
Areas to be served by gravity from the High Level supplies

INTERMEDIATE LEVEL
Areas to be served by gravity from the Intermediate Level supplies.

High Level interconnecting mains

Intermediate Level interconnecting mains

STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

NORTHERN METROPOLITAN DISTRICT
PROPOSED SERVICE ZONES

1 0 1 2 3 4 5 Mi.

FEBRUARY 1930

PLATE 7

C.S.A.

NEW YORK
NEW JERSEY

Boundary of Northern Metropolitan District

RINGWOOD
WANAQUE RESERVOIR
HOHOKUS TWP.
UPPER SADDLE RIVER
MONTVALE
PARK RIDGE
OLD TAPPAN
NORTHVALE
ROCKLEIGH
RAMSEY
SADDLE RIVER
WOODCLIFF LAKE
PIERMONT
NORWOOD
HARRINGTON PARK
ALPINE
ALLENDALE
HILLSDALE
CLOSTER
WESTWOOD
WALDWICK
HOHOKUS
WASHINGTON
EMERSON
DEMAREST
HAWORTH
OAKLAND
WYCKOFF
MIDLAND PARK
RIDGEWOOD
ORADELL
CRESSKILL
DUMONT
WANAQUE
FRANKLIN LAKES
GLEN ROCK
PARAMUS
NEW MILFORD
RIVERSIDE
TENAFLY
BERGENFIELD
BLOOMINGDALE
POMPTON LAKES
BERGEN CO.
PASSAIC CO.
HAWTHORNE
NORTH HALEDON
FAIRLAWN
ENGLEWOOD
ENGLEWOOD CLIFFS
WANAQUE AQUEDUCT
BUTLER
RIVERDALE
HALEDON
MAYWOOD
TEANECK
HACKENSACK
WAYNE
EAST PATERSON
SADDLE RIVER
BOGOTA
LEONIA
KINNELON
PEQUANNOCK
PATERSON
LODI
RIDGEFIELD PARK
PALISADES PARK
FORT LEE
HASBROUCK HEIGHTS
TETERBORO
LITTLE FERRY
NEWARK PIPE LINE
GARFIELD
TOTOWA
WEST PATERSON
WOOD RIDGE
MOONACHIE
RIDGEFIELD
LINCOLN PARK
WALLINGTON
CLIFFSIDE PARK
EDGEWATER
FAIRVIEW
MONTVILLE
CLIFTON
PASSAIC
CARLSTADT
LITTLE FALLS
PASSAIC CO.
ESSEX CO.
EAST RUTHERFORD
CALDWELL TWP.
JERSEY CITY PIPE LINE
NORTH CALDWELL
CEDAR GROVE
RUTHERFORD
BERGEN CO.
HUDSON CO.
WEST NEW YORK
BOONTON
NUTLEY
LYNDHURST
NORTH BERGEN
SECAUCUS
WEST CALDWELL
VERONA
CALDWELL
MONTCLAIR
BLOOMFIELD
BELLEVILLE
NORTH ARLINGTON
UNION CITY
WEEHAWKEN
HOBOKEN
BOONTON RESERVOIR
ESSEX FELLS
GLEN RIDGE
ROSELAND
KEARNY
WEST ORANGE
EAST ORANGE
ORANGE
HARRISON
JERSEY CITY
MORRIS ESSEX
LIVINGSTON
SOUTH ORANGE
NEWARK
IRVINGTON
MAPLEWOOD
NEW YORK BAY
FLORHAM PARK
MILLBURN
HILLSIDE
ESSEX UNION
BAYONNE
MORRIS TWP.
CHATHAM
SUMMIT
SPRINGFIELD
UNION
ELIZABETH
NEWARK BAY
KENILWORTH
ROSELLE PARK
ROSELLE
CHATHAM TWP.
HARDING
MORRIS UNION
NEW PROVIDENCE
MOUNTAINSIDE
CRANFORD
OAKWOOD
LINDEN
LINDEN TWP.
PASSAIC TWP.
NEW PROVIDENCE TWP.
SCOTCH PLAINS
WESTFIELD
CLARK
RAHWAY
CARTERET
FANWOOD
MORRIS SOMERSET CO.
UNION CO.
NORTH PLAINFIELD
PLAINFIELD
UNION MIDDLESEX
WOODBRIDGE
WARREN
DUNELLEN
METUCHEN
PERTH AMBOY
NORTH PLAINFIELD TWP.
RARITAN TWP.
SOMERVILLE
BOUND BROOK
HIGHLAND PARK
NEW BRUNSWICK
NORTH BRUNSWICK

HIGH LEVEL SUPPLY

INTERMEDIATE LEVEL SUPPLY

HIGH LEVEL SUPPLY

INTERMEDIATE LEVEL SUPPLY

ALTERNATIVE LOCATIONS

Boundary of Northern Metropolitan District

HUDSON RIVER

LEGEND

High Level interconnecting mains

Intermediate Level interconnecting mains

STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

NORTHERN METROPOLITAN DISTRICT

PROPOSED INTERCONNECTING TRANSMISSION MAINS

1 0 1 2 3 4 5 Mi.

FEBRUARY 1930

C.S.A.

PLATE 8

A visualization of available water supply areas alone is only a part of the picture, another important factor being the elevation of these supply areas. Perhaps too little attention has been given to the availability of water supply areas from this standpoint. Not only is it true that water supplies for the district can be brought in from almost any direction, but it is also true that they can be delivered by gravity at any reasonable elevation. Plate 5, showing the relation of area and ground elevation in the district, indicates that the elevation of the district varies from 0 to 600 feet. A curve drawn for the available water supply area would be found to be similar in shape, the elevations varying from about 40 along the Raritan River to above 930 in the vicinity of Lake Hopatcong, and above 1,100 near the New York State line. The variation in elevation and, consequently, in demand in the district, would be troublesome from the water supply standpoint were it not for the compensating factor of similar variation in elevation of supply areas. A third important factor, in the consideration of available supplies, is the location of suitable storage reservoir sites, preferably in or near the watersheds to be developed. Plate 10 shows the location and approximate elevation of the reservoir sites throughout the northern part of the State that have been studied in considerable detail for this and previous reports. Further search will result in increasing the number of known available reservoir sites, but it is evident on Plate 10 that there is no lack of reservoir sites at various elevations. For that future time when watersheds largely outside the State must be developed, appropriate reservoir sites are also available.

Available surface supplies of an aggregate capacity several times that of all existing supplies, various elevations of these supplies to almost exactly meet the demands of the district by gravity, and an abundance of good reservoir sites strategically located, serve as a challenge to all who are influential in the development of a co-ordinated water supply for the district to grasp this unique opportunity to work out a well balanced district water supply system, operated largely by gravity, and to secure the possible economic advantages inherent in such a system.

It is not necessary at this time to discuss the potentialities of the more distant watersheds, but only those nearby which might be included in the next development. In other words, only the

Ramapo and Hackensack to the north; the Rockaway, North and South Branches of the Raritan and the Musconetcong to the west; and the low level Raritan and Millstone to the south, would naturally be considered for the next development. Only sufficient consideration will be given to the more distant watersheds to show that their development will not be made more difficult by the construction of the next supply.

The most advantageous developments of the Ramapo watershed require construction in New York State, and involve legal difficulties incident to the interstate character of the projects. Developments of the Ramapo wholly within New Jersey, and all developments of the Hackensack are at low elevation, necessitating pumping even for low service use. Use of these watersheds should be deferred pending more pressing demand for a supply from the north, at which time some solution of the interstate problems will be found.

The development of the Millstone and Lower Raritan is now in progress. This supply can be extended far in excess of the present grant of 20 Mgd., but due to the low elevation, making pumping necessary, and due to increasing pollution near the point of diversion, further development should not be considered in view of the availability of high level supplies of much higher quality.

Choice of the next development is thus narrowed down to the nearby watersheds to the west, including the Musconetcong, the North and South Branches of the Raritan, and portions of the Rockaway watershed if deemed advisable, which are capable of development to the extent of from 140 Mgd. to 200 Mgd. by any one of several methods. Such a development will meet the increase in demand in the district for a period of at least 15 years after completion. Later developments of the branches of the Delaware located farther to the west and north, and of the Delaware itself, will furnish very large supplies for future generations.

THE NEXT PROJECT FOR THE DISTRICT

An ideal gravity system for the whole district includes supplies developed at several different elevations, each serving its appropriate Service Zone in the district, thus taking full advantage of the unusually favorable existing physical conditions and

PLATE 9

J.I., C.S.A.

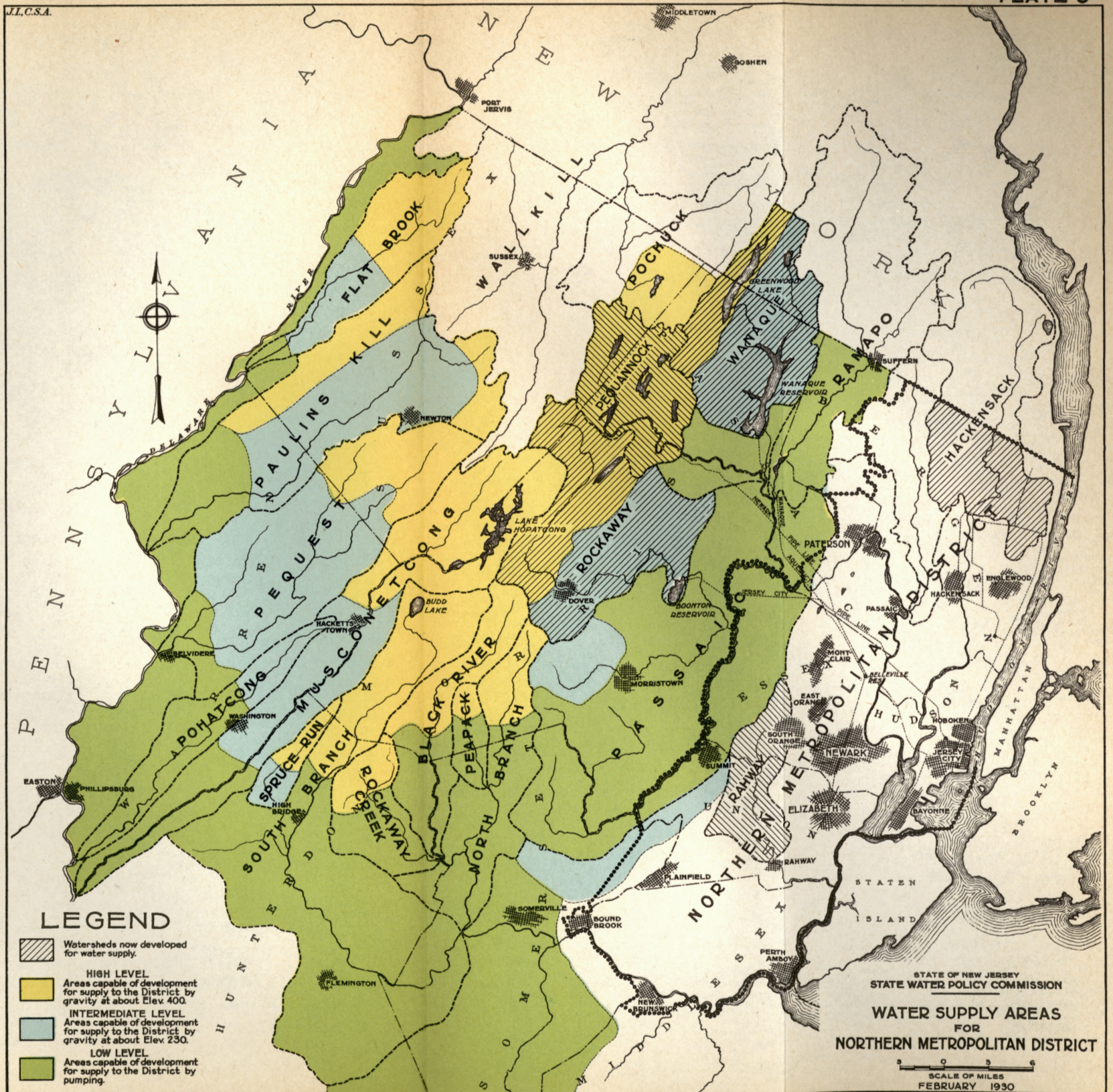
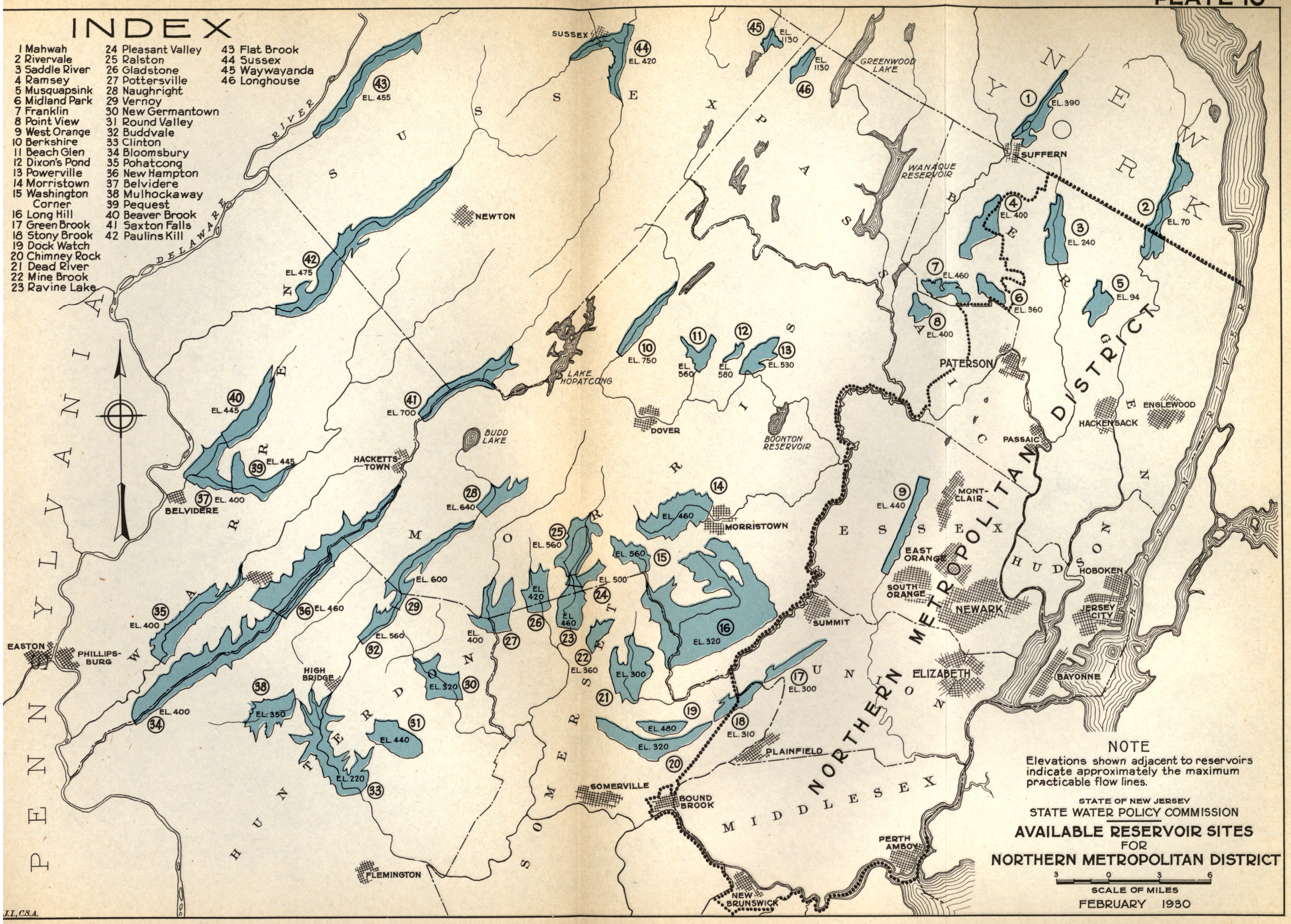


PLATE 10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HUNTERDON
ESSEX
UNION
MIDDLESEX
HUDSON
BERGEN
PASSAIC
DELAWARE RIVER
HUDSON RIVER
GREENWOOD LAKE
WANAQUE RESERVOIR
LAKE HOPATCONG
BUDD LAKE
BOONTON RESERVOIR
SUFFERN
NEWTON
PATERSON
ENGLEWOOD
HACKENSACK
PASSAIC
DOVER
HACKETTSTOWN
BELVIDERE
MORRISTOWN
MONTCLAIR
EAST ORANGE
SOUTH ORANGE
NEWARK
HOBOKEN
JERSEY CITY
SUMMIT
ELIZABETH
BAYONNE
EASTON
PHILLIPSBURG
HIGH BRIDGE
PLAINFIELD
SOMERVILLE
BOUND BROOK
PERTH AMBOY
NEW BRUNSWICK
FLEMINGTON
NOTE
Elevations shown adjacent to reservoirs indicate approximately the maximum practicable flow lines.
STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION
AVAILABLE RESERVOIR SITES
FOR
NORTHERN METROPOLITAN DISTRICT
3 0 3 6
SCALE OF MILES
FEBRUARY 1930
J.L.,C.S.A.

serving every portion of the district by gravity. This system can be supplemented, if necessary, at some future time, by pumping from the low level supply areas to supply the lowest zone in the district. Practical considerations will, of course, vary this ideal system to some extent, but only in detail. Plate 5 shows that so small a percentage of the total demand requires service at elevations above 400 that it would be uneconomical to provide gravity service at this time for the highest zone; whether or not a gravity supply for this zone will ever be necessary or economically advisable, only the future can tell. Existing pumped surface and well supplies are at present a considerable factor and would be utilized in the general system, but in the future these supplies would become of increasingly less importance in the system as a whole.

There is a considerable range of choice in the number and limits of the proposed service zones; based on studies that have so far been made, a preliminary assignment of limits has been made as follows:

Special High Level with delivery above Elevation 400, by pumping from the High Level.

High Level with delivery between Elevation 230 and 400.

Intermediate Level with delivery below Elevation 230.

Low Level, a future zone, with delivery below that of the Intermediate Level, to be determined by future conditions.

Preliminary Studies

The general principle of the development of gravity supplies to serve the various service zones being established, it is clear that a project so located as to serve the High Level Zone, if such were available at a cost not appreciably greater than a project adapted only to the Intermediate Level, offers incontestable advantages over the latter. This is particularly true at the present time in that the Rockaway and Wanaque supplies can be readily adapted to serve the Intermediate Level without pumping, while the High Level, with the exception of areas served from the Pequannock, is now wholly served by pumping. It is evident that the Intermediate Level can be served temporarily, and in future as an emergency supply, from a High Level development by means

of interconnections. Plate 5 shows that about 40 per cent., about 110 Mgd. out of the present total demand of 275 Mgd. is now delivered to the various distribution systems of the district at above Elevation 230, or within the proposed High and Special High Level Zones. Even with increased consumption this ratio will probably remain fairly constant.

More water will soon be required in all zones, but only a High Level supply can serve all of this increased demand by gravity.

The development of the next project as a High Level Project of sufficient size for the long-time need of the High Service Zone indicates, naturally, that the next subsequent project will be developed to serve the Intermediate Level in conjunction with the existing Rockaway and Wanaque supplies. Plate 9, showing water supply areas available for the Northern Metropolitan District, indicates clearly that the logical catchment area for developing a High Level Supply is located, in general, in the higher portions of the Raritan and Musconetcong watersheds. **The use of this area for an Intermediate Level supply would seriously reduce the amount of available High Level water and would be not only an economic waste, but would interfere greatly with any plan for eventually supplying water by gravity to the entire district.**

The topographic maps of the State were carefully searched to find all possible reservoir sites for the development of the North and South Branches of the Raritan and the Musconetcong, and field investigations were made throughout the region to determine the location of dam and reservoir sites and to note any existing physical conditions that would affect the estimates of cost of the projects. Estimates of cost of fifteen different reservoirs were made in order to determine the best storage sites to use as bases for comprehensive projects to develop this supply area. Eleven different projects were outlined, including necessary aqueducts for delivery to the district, and estimates of cost were prepared on a strictly comparative basis, using the same unit prices and points of delivery for all projects. This study has resulted in the elimination of several reservoirs from further consideration, since, for one reason or another, their use in connection with the development of the Branches of the Raritan and the Musconetcong would be unduly expensive. Some excellent reservoir sites have been thus eliminated, such as Long Hill, which is unnecessarily large and expensive; Dock

Watch, which is too small for the proposed development; and Round Valley, which is located too far off line between the supply area and the district, thus requiring additional aqueduct construction.

Preliminary studies indicated that New Hampton, Pleasant Valley, Ravine Lake and Chimney Rock reservoirs for the Intermediate Level; and Buddvale, Vernoy and Ralston reservoirs for the High Level Supply, were worthy of more detailed consideration and that it would be entirely feasible to develop either a High Level or Intermediate Level supply from this area, utilizing some of these reservoir sites, and that there was little difference in the cost of the various projects.

Preliminary studies and estimates indicated that there are several alternative projects available for the development of the Upper Raritan and Musconetcong watersheds which are substantially equal in cost per unit of yield. Of these, the Buddvale, Ralston and Vernoy projects will furnish a high level supply, while the Chimney Rock, Pleasant Valley and New Hampton Projects would be adapted to furnishing a supply for some intermediate level.

Due to the urgency of the problem it was deemed advisable, within the limits of time and appropriation available, to undertake more detailed and extensive studies of the comparative cost of these projects, with particular attention to the high level projects, preliminary estimates of which compare favorably, on the basis of cost, with the intermediate level projects, and which in other characteristics are markedly superior.

Field Investigations

The features of the various projects requiring more detailed study were:

(a) Real estate values.

(b) Location and profile of dams.

(c) Location of ledge rock at dam sites.

(d) Character of underlying ledge rock.

(e) Water powers and water rights affected by diversion.

The land and buildings for the various reservoir sites are being appraised by a competent real estate expert, the values used in the preliminary estimates having been prepared by members of the engineering staff necessarily not conversant with actual values in the localities studied. These appraisals are to a large extent completed and indicate, in general, lower values than previously estimated.

Field reconnaissances were made to determine the most desirable sites for dams and dikes, followed by surveys of the profile of the various dam sites selected. These surveys proved valuable in that they showed large variations from the available contour maps of the region, resulting in the abandonment of one site which from map data appeared favorable, and showing much decreased length at another nearby site.

Dr. Charles P. Berkey, of Palisades, New Jersey, Professor of Geology at Columbia University, was retained to advise as to the probable geological conditions to be encountered, including an estimate of the depth below the surface at which ledge rock might be anticipated. Following preliminary field investigation and on recommendation of Dr. Berkey, the Schlumberger Electrical Prospecting Methods, Inc., was engaged to apply to the problem in hand a newly perfected method for electrical determination of the location of the rock floor. The results obtained by this method are stated by Dr. Berkey to be entirely reasonable, and have been, as far as practicable, checked by soundings and other independent methods. The results vary widely from the assumptions made in preliminary estimates, showing substantial savings in some instances.

Office Studies

Based on field investigations as outlined above, and on more detailed analyses of unit costs, the approximate costs of several of the projects are being re-estimated and have already reached a status which indicates that the High Level Projects can with certainty be stated to be no more costly per unit of yield than any available Intermediate or Low Level Project developing the same or similar catchment areas. Further studies and more careful analyses of all elements involved are essential before definite recom-

mendation can be made as to the actual project most advisable from all viewpoints.

High Level Projects

General Features: The three High Level Projects: Ralston, Buddvale and Vernoy, shown on Plates 11, 12 and 13, are similar in all important features. Each consists of a single reservoir which serves to store water from its own watershed, together with water diverted thereto from adjoining streams. The total supply area includes the higher portions of the branches of the Raritan and the Musconetcong and is substantially the same for all projects.

Diversions include small intake reservoirs constructed on the various streams at elevations slightly above the flow lines of the main storage reservoirs. Diversion aqueducts are, in nearly every case, tunnels through the rocky ridges that separate the watersheds in this region. The sizes of diversion aqueducts and intake reservoirs have been planned to provide the most economical combined diversion capacity computed in terms of cost per unit of safe yield. The diversion aqueducts will deliver to elevations near the draft line in the storage reservoirs, thus providing maximum diversion capacity at the times when it is most needed due to depleted storage. The overflow from Lake Hopatcong will be diverted by means of an open cut through the low ridge at the south end of the lake into either the South Branch or the Black River, this method being cheaper than the alternative method of handling the water from this area by way of the channel of the Musconetcong and thence through a diversion tunnel.

All points of diversion will be provided with suitable gates to bypass an amount in excess of the dry-weather flow of the streams at all times and account has been taken of this factor in computing the net safe yields of diversions.

The safe yields of the diversions and also of the entire projects have been computed, using the runoff records of the streams in conjunction with the long-term runoff records of the Pequannock, which is near enough in location and general character to the rivers involved to serve as a reliable guide.

Delivery aqueducts for each project are estimated to have a carrying capacity of 125 per cent. of the safe yield of the project

and to extend to an available site, near the city of Summit, for filtration works and an equalizing reservoir. Several alternative lines for the delivery aqueduct for each project were studied and estimated. The delivery aqueduct for each project consists of a tunnel through the ridge lying east of the storage reservoir, thence across the intervening country by grade aqueduct and pressure pipe to the filter site.

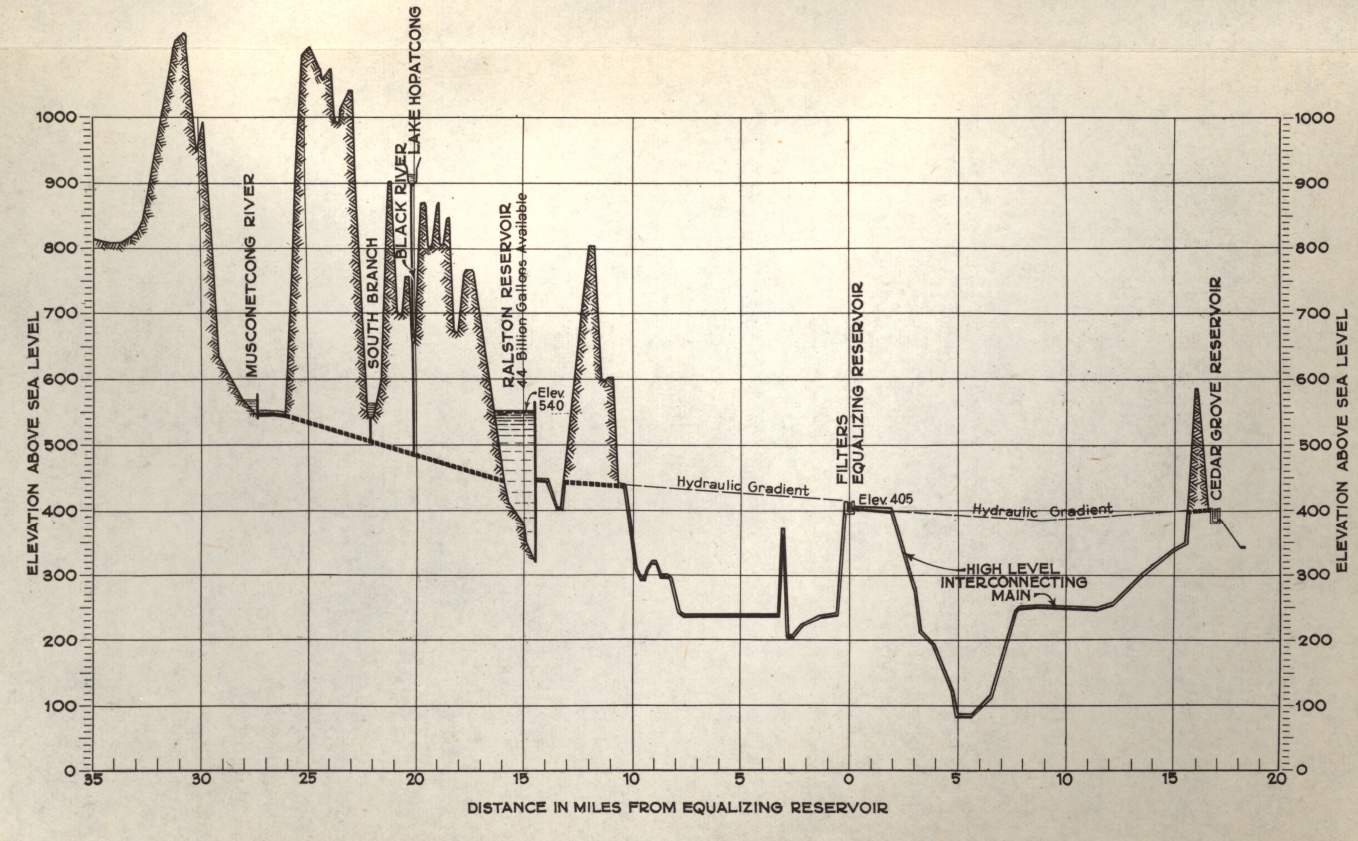
The equalizing reservoir for each project will be of sufficient size to equalize the peak demands above 125 per cent. of the average and will also serve, in conjunction with Cedar Grove reservoir, as a storage reservoir located as near as possible to the Metropolitan District. Filtration is included in all the estimates and no successive construction steps for the projects have been indicated although actual design of any of these projects would probably include as a first step streams producing the highest quality of water, thereby possibly making it practicable to omit filtration during the early years of use of the project.

Any of these projects can be supplemented in the future, as required, by additional high level diversions from the areas shown on Plate 9 lying to the north and northwest and none of them serves to bar such additional high level development.

The Ralston Project (see Plate 11) consists of a storage reservoir located on the North Branch of the Raritan formed by the construction of a masonry dam about one and one-half miles below the village of Ralston, and an earth dike closing a gap in the hills west of the main dam. Intake reservoirs and a diversion aqueduct will pick up and deliver the water of the Musconetcong, South Branch and Black Rivers to this storage reservoir.

The real estate required for the construction of Ralston reservoir will include the farm lands and estates located in North Branch valley in the townships of Chester and Mendham and the Borough of Mendham, Morris County. Included in this area are the entire village of Ralston and outlying portions of Mendham. The main highway now passing through Ralston will be relocated around the north side of the reservoir. No railroad reconstruction will be required.





STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

RALSTON PROJECT
PLAN AND PROFILE

FEBRUARY 1930

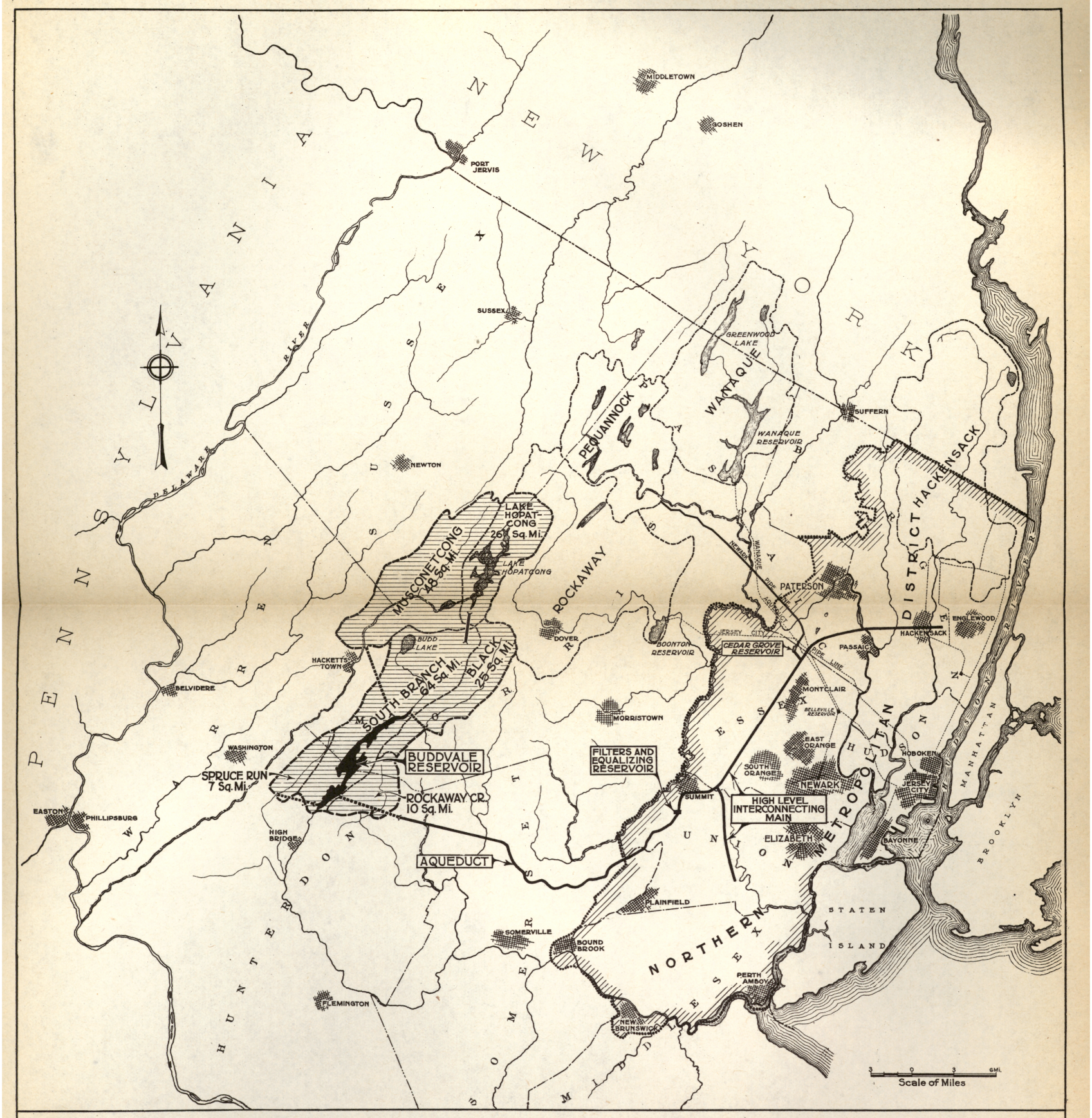
PLATE 11

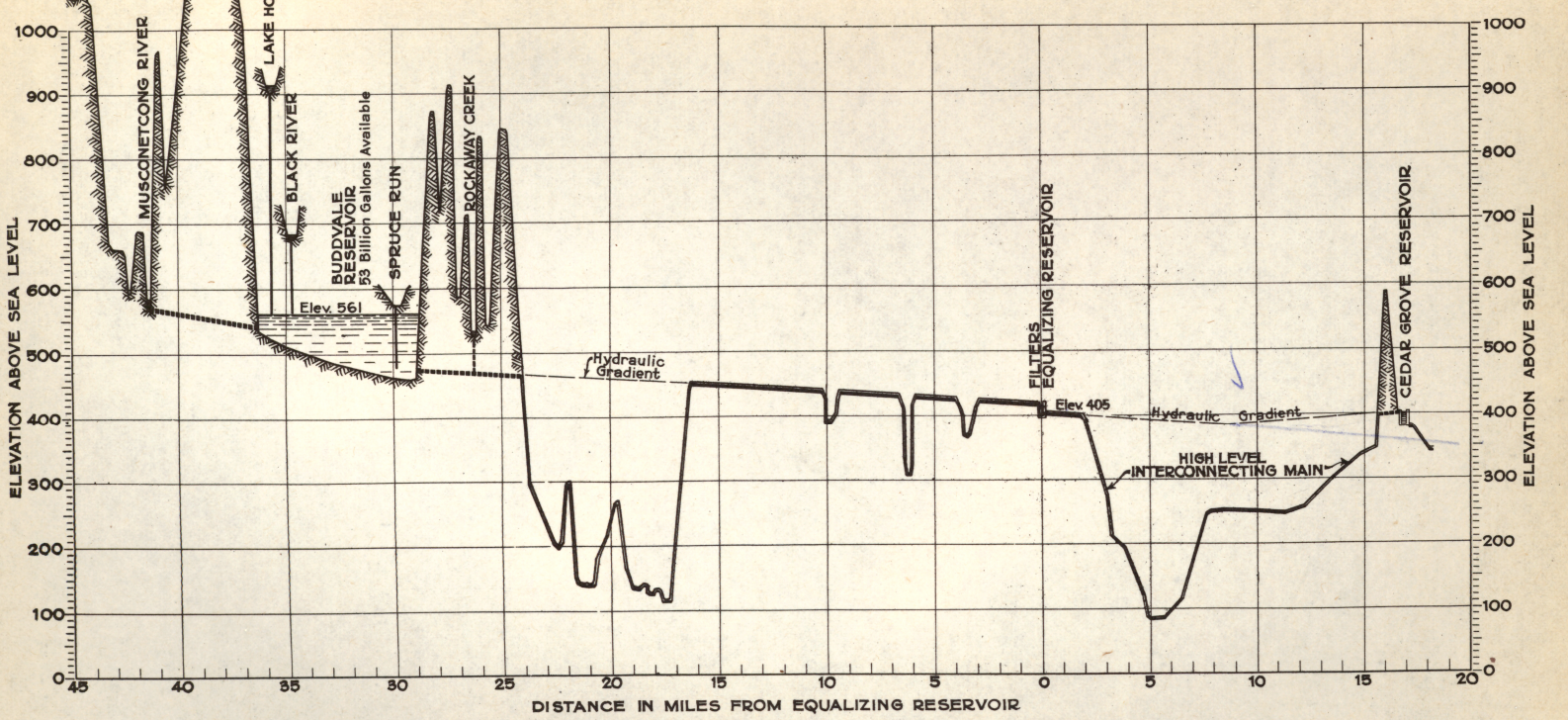
The main dam site is at the upper end of a gorge with a favorable location for an overflow weir and channel at the east end. The geological conditions at the dam site are favorable, the valley being very narrow with exposed ledges of granite and granitic gneiss on both sides of the stream, separated by a flat-bottomed valley about 200 feet wide. There is no doubt that this rock formation underlies the whole site. The flat valley bottom has a bouldery glacial drift cover of mixed type about 30 feet deep. The east side is covered quite uniformly by heavy bouldery glacial drift about 20 feet deep and similar overlying material on the west side appears to be of a depth varying from about 20 feet near the bottom to perhaps 40 feet near the west end of the dam.

The valley in which the dike is located is broad and open with a considerable depth of glacial drift fill at the eastern end. Kittatinny limestone is exposed near the center of the valley and is not heavily covered to the west where there is probably a change to gneiss near the end of the dike. The limestone formation is siliceous and shaly with strong bedding structure standing nearly on edge, dipping to the north. The composition varies widely in different parts of the formation. In addition to the limestone there is Hardyston quartzite lying beneath and granites and granitic gneisses at the east end of the structure covered with glacial drift of a mixed character, increasing toward the east end, where it is over 40 feet deep. There is at least one and possibly more than one fault in this valley. These faults, termed "dead faults" geologically, are probably not subject to future movement and need give no concern as to the stability of the structure.

Ralston Reservoir would be at a reasonable elevation for delivery to the High Level Zone without being so high as to unduly reduce the watershed area tributary thereto. The principal unfavorable factor of the Ralston project is the damage to the attractive old village of Mendham; however, the center of the town would not be affected, but only those portions lying to the west and northwest.

The Buddvale Project (see Plate 12) is based on a storage reservoir on the South Branch of the Raritan with a dam at Buddvale, about two miles below the village of Califon. Diversions from the Musconetcong, Black, Spruce Run and North Branch of Rock-





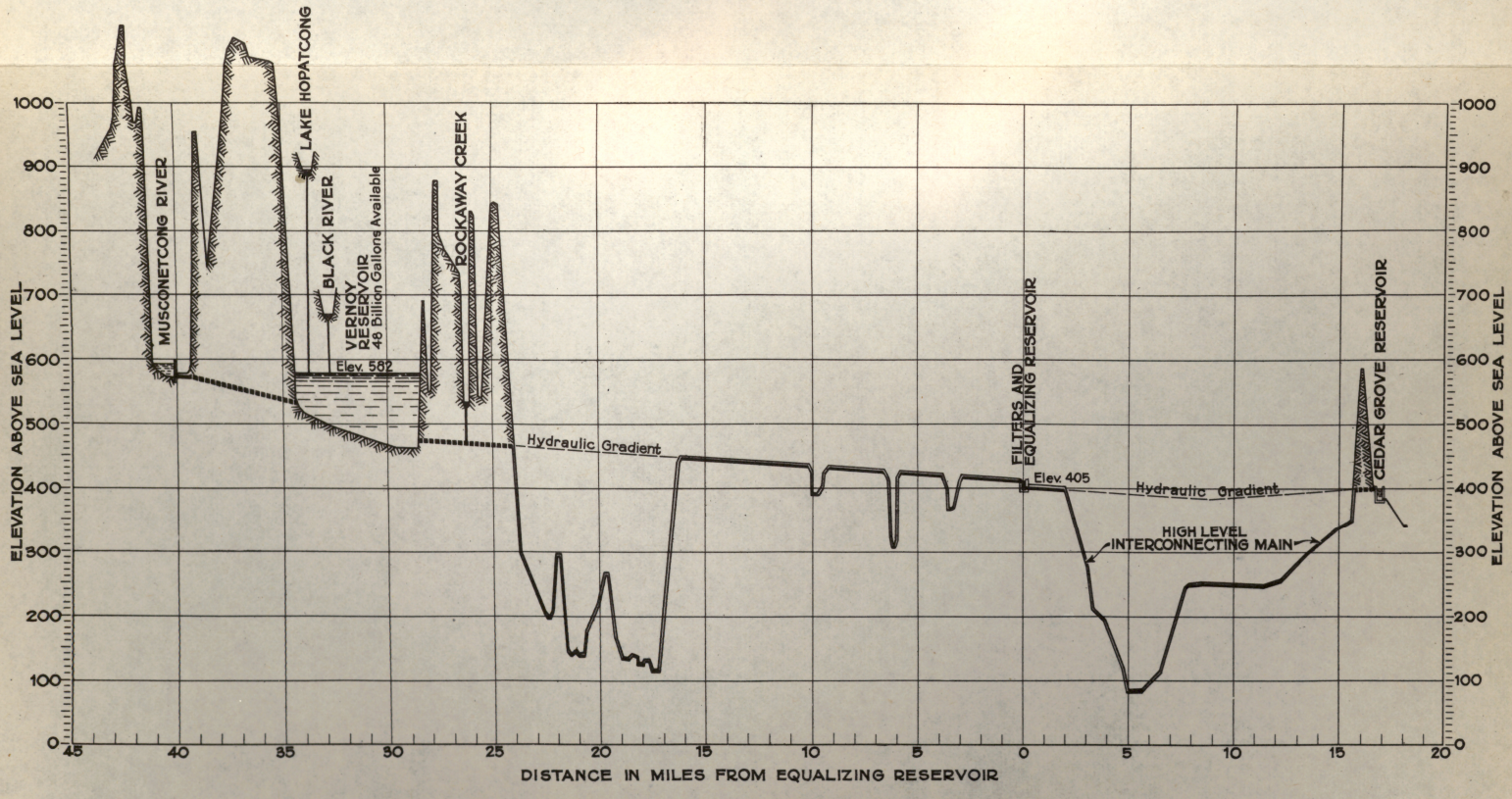
STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

BUDDVALE PROJECT
PLAN AND PROFILE

FEBRUARY 1930

PLATE 12





STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

VERNOY PROJECT
PLAN AND PROFILE

FEBRUARY 1930

PLATE 13

away Creek, together with the 64 square miles of the South Branch itself, furnish the water for this project. The Buddvale reservoir is located in the townships of Lebanon and Tewksbury and the Borough of Califon, Hunterdon County and Washington Township, Morris County, and will obliterate the villages of Califon, Middle Valley and Long Valley. Aside from these villages the area of the reservoir is now devoted largely to farming and includes a few quarry sites that have been worked in the past but are not in use at present. The High Bridge Branch of the Central Railroad of New Jersey traverses the entire length of the reservoir and 14 miles of expensive relocation will be required. Two highways across the reservoir will be required and considerable highway relocation will be necessary to duplicate present facilities for north and south traffic. An oil pipe line of the Tidewater Oil Company's system crosses the reservoir and will need to be relocated below the dam.

The Buddvale dam site is the most advantageous of any considered in this report, being at the upper end of a very narrow rock gorge with practically no overburden. Ledges of gneiss are exposed at many points on or near the line of the dam for its entire length, forming an ideal foundation for a heavy masonry structure. No dikes are required for this project.

The principal disadvantageous features of the Buddvale project are the taking of three settled communities of considerable size, with the consequent disruption of the life of that region, and the fact that this project will not utilize the water from the upper portions of the North Branch. Favorable factors are the excellent dam site, high elevation of draft line in the reservoir and central location of reservoir with respect to the tributary watersheds and hence shorter and smaller diversion tunnels.

The Vernoy Project (see Plate 13) is similar to the Buddvale project, having a storage reservoir on the South Branch, with its main dam at Vernoy, about one-half mile above Califon. Diverted streams will be the Musconetcong, Black and North Branch of Rockaway Creek. The Vernoy reservoir will be in Lebanon and Tewksbury Townships, Hunterdon County and Washington Township, Morris County, and will cover the present village sites of Middle Valley and Long Valley. Railroad and highway relocation

will be similar to that required for Buddvale, but less in extent. No important dikes will be required for this project.

The Vernoy dam site is at the lower end of a narrow portion of the valley, having no well defined site apparent from casual inspection. A study of the valley, made by Dr. Berkey from a geological point of view, disclosed the fact that the east side of the valley consists of a ridge of ancient granitic gneiss for its entire length, but that the west side has great beds of Kittatinny limestone exposed at the upper end of the valley, changing to gneiss at some point near the lower end. It was therefore determined to locate the proposed dam at a point where the more satisfactory rock foundation is available. The underlying gneiss appears, from the few exposed ledges, to be of a uniform character throughout the length of the structure, but may have a fault zone near the center of the valley which need not, however, cause uncertainty as to the safety of the structure. The overlying material is heavy, bouldery, watercharged glacial drift over the valley floor with a deposit of heavy mixed till on the west side. An earth dam with concrete core-wall extending to rock is estimated for this location, with overflow weir and channel in the rock at the east end.

Other Projects

A number of other reservoir sites, including Pleasant Valley, Ravine Lake, New Hampton and Chimney Rock, were studied in some detail as to the possibility of use in the development of the watershed areas included in the three High Level Projects described above. None of these sites will provide a reservoir at sufficient elevation to furnish water to the proposed High Level Zone. They would be worthy of further study only in the event that no High Level development of the Raritan or Musconetcong is undertaken.

The Pleasant Valley Project consists of a main storage reservoir formed by a dam at Pleasant Valley on the North Branch of the Raritan, with diversions from practically the same areas as for the Ralston project. This project is very similar to the Ralston in every respect except the elevation of delivery to the Metropolitan District, which is at about Elevation 325, at the equalizing reservoir near Summit.

The main dam site at Pleasant Valley and a dike site to the east have been surveyed and rock surface has been located by the electrical method. Rock ledges, chiefly granitic gneisses, somewhat similar to those at the Ralston site are exposed on the west side of the stream on the proposed dam line. The bottom of the valley, about 400 feet wide, is nearly level and filled with glacial drift to a depth of over 30 feet. Both sides of the valley are covered with glacial drift of a bouldery character to a maximum depth of about 40 feet at each end of the dam. Precambrian granitic gneisses underlie the whole site, furnishing satisfactory foundation conditions.

If the upper zone limit in the district were reduced from Elevation 405 to about Elevation 325, this project would warrant further consideration, although it is at a disadvantage in any case when compared with Ralston, due to the relatively unfavorable and expensive dam site at Pleasant Valley.

The Ravine Lake Project would include a reservoir located about two miles below Pleasant Valley on the same stream. Owing to the high cost of the reservoir, as determined by preliminary studies, no project utilizing it has been estimated.

The New Hampton Project is based on the development of a very large reservoir on the Musconetcong, for the storage of water from its own watershed, together with water to be diverted from the Black River and the South Branch of the Raritan. Preliminary studies indicated a cost for this project approximately equal, per unit of yield, to the High Level projects. For this reason geological investigations of the main dam site were undertaken. It is apparent from the results obtained that a structure of the type and magnitude necessary for the large reservoir could not be safely constructed, due to the impracticability of preventing excessive seepage through the underlying limestone formation.

Investigations are in progress as to the possibility of constructing a lower dam and reservoir appropriate for an Intermediate Zone development.

The Chimney Rock Project, described in the report of the North Jersey District Water Supply Commission for 1925, included as a so-called first development the diversion of the higher portions of

the branches of the Raritan to a storage basin located between the first and second ridges of the Watchung Mountains, north of Bound Brook.

The first development of Chimney Rock project has been estimated on a price basis uniform with the other projects and with a delivery aqueduct to a point opposite Summit on the east side of Watchung Mountain, thus obtaining an estimated cost that may be compared with the costs of the High Level and other projects.

The Chimney Rock project will deliver water by gravity only to the lower portions of the district. Its delivery elevation is about the same as that of Belleville reservoir, which now serves the lowest of the three existing pressure zones in the city of Newark. None of the larger systems now serving the district is at this low level.

Comparative data for the proposed High Level projects, together with such other projects as have been estimated, for the development of the higher portions of the branches of the Raritan and the Musconetcong are presented in Table 11. All estimates have been made on the same assumptions as to yield, unit costs, common delivery points, storage required and size of aqueducts and other structures, so that comparison can be made.

Table 11

NORTHERN METROPOLITAN DISTRICT ALTERNATIVE PROJECTS FOR THE DEVELOPMENT OF THE UPPER RARITAN AND MUSCONETCONG WATERSHEDS

Comparative Data

Feature	High Level Projects			Other Projects	
	Buddvale	Vernoy	Ralston	Pleasant Valley	Chimney Rock
Total watershed area, square miles	180	164	158	175	165
Total reservoir capacity, million gallons	55,000	50,000	53,000	50,000	**58,000**
Available reservoir capacity, million gallons	**53,000**	48,000	44,000	48,000	47,000
Safe Yield, Mgd.	**178**	162	147	164	158
Flow line elevation	561	**582**	540	500	304
Draft line elevation	480	**500**	442	375	241
Water surface, acres	**4,300**	3,400	1,900	2,250	3,650
Land required, acres	7,400	6,200	**3,500**	4,000	5,800
Buildings to be removed	531	315	140	**129**	268
Railroads relocated, miles.	14	10	**0**	**0**	**0**
Distance from center of district, miles	43	43	29	31	**28**
Delivery elevation	**405**	**405**	**405**	326	200

Comparative Costs

Project	Total Cost	Cost per Mgd. of Safe Yield
High Level Projects		
Buddvale	$46,280,000	**$260,000**
Vernoy	**42,120,000**	**260,000**
Ralston	45,570,000	310,000
Other Projects		
Pleasant Valley	50,840,000	310,000
Chimney Rock	48,980,000	310,000

The costs shown in Table 11 (approximate only) represent construction, real estate and overhead expenses for the projects to and including the equalizing reservoir and filtration works. The cost of the High Level Interconnecting Main through the district is indeterminate, but probably will not exceed $10,000,000.

Figures shown in bold face are the most favorable for each feature.

Discussion of these alternative projects for the next development should not be closed without pointing out the fact that none of the proposed projects, if constructed, would interfere with the progressive development of the Intermediate Level areas shown on Plate 9.

It is true that the construction of any of the High Level projects would seriously interfere with the development of Chimney Rock reservoir as a base for an Intermediate Level supply, since these projects take most of the water that was to be diverted for storage in Chimney Rock reservoir, as outlined in the 1925 report of the North Jersey District Water Supply Commission. A more desirable base reservoir for the Intermediate Level supply, which will eventually follow the next development, would be located in or near the lower Musconetcong watershed (see Plate 14) and would serve as a storage reservoir for the lower Musconetcong and for diversion from streams further to the north, with a delivery aqueduct to the southwestern part of the district, delivering to an Intermediate Level Interconnecting Main. Later developments would include storage in the Pequest and Beaver Brooks, and the construction of additional diversion from the more distant Paulins Kill and Flat Brook, to be followed in turn by the construction of storage on those streams, thus completing the developments to provide approximately the same yield as indicated by Hazen, Whipple and Fuller's report of 1922 and by the North Jersey District Water Supply Commission report of 1925.

The Intermediate Level Project indicated on Plate 14 is presented only for the purpose of showing its feasibility. Plans for such a project must await the adoption of one of the alternative projects for the first development and the determination of the future requirements of the Metropolitan District. If Elevation 230 is finally established as the correct elevation for delivery to the Intermediate Zone, it will probably be possible to utilize a lower reservoir site in the neighborhood of Bloomsbury as a base reservoir in place of the New Hampton site shown on Plate 14.

The More Distant Future

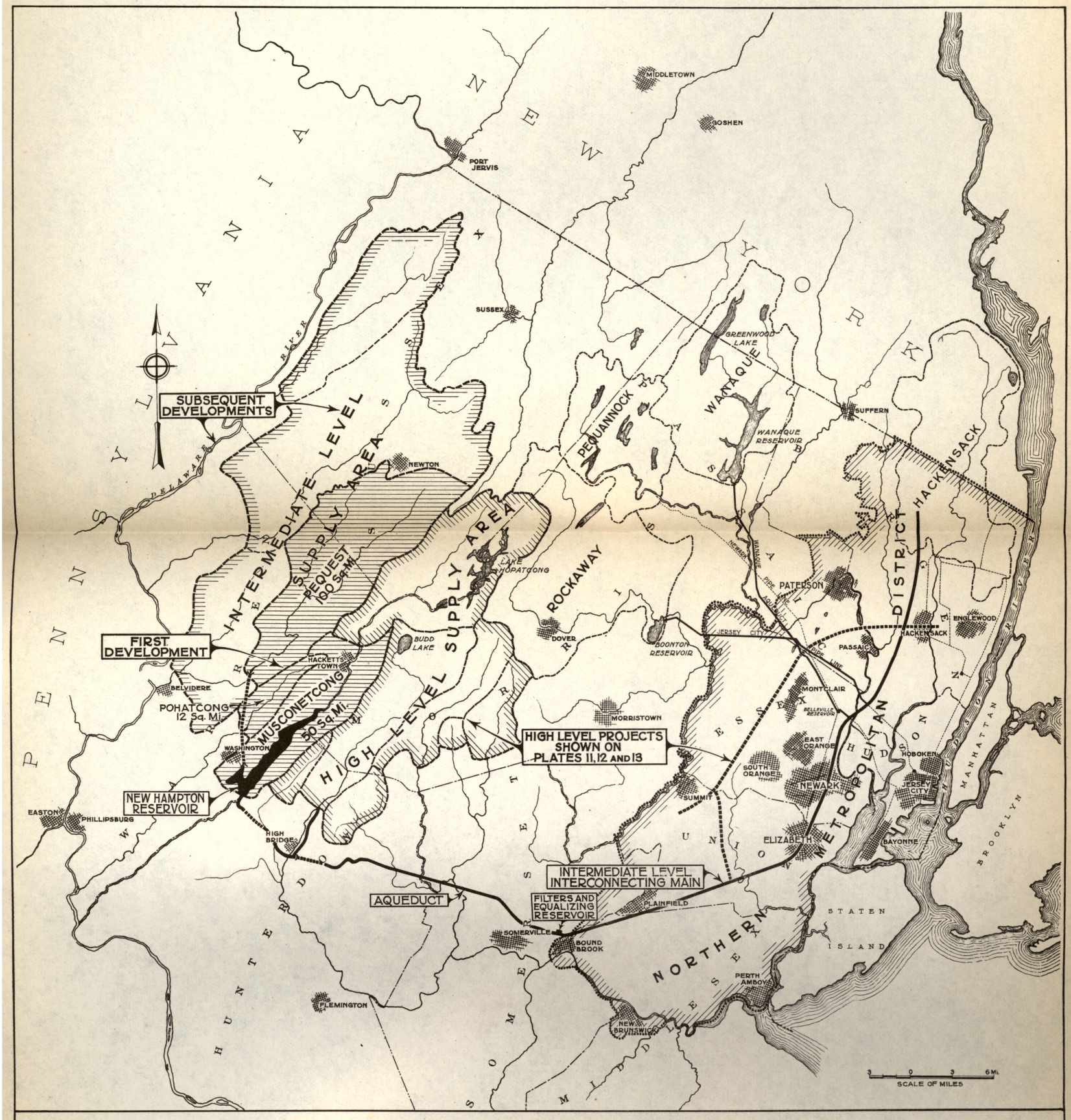
The foregoing indicates that an additional supply for the district must be available by 1940; that it should be a high level sup-

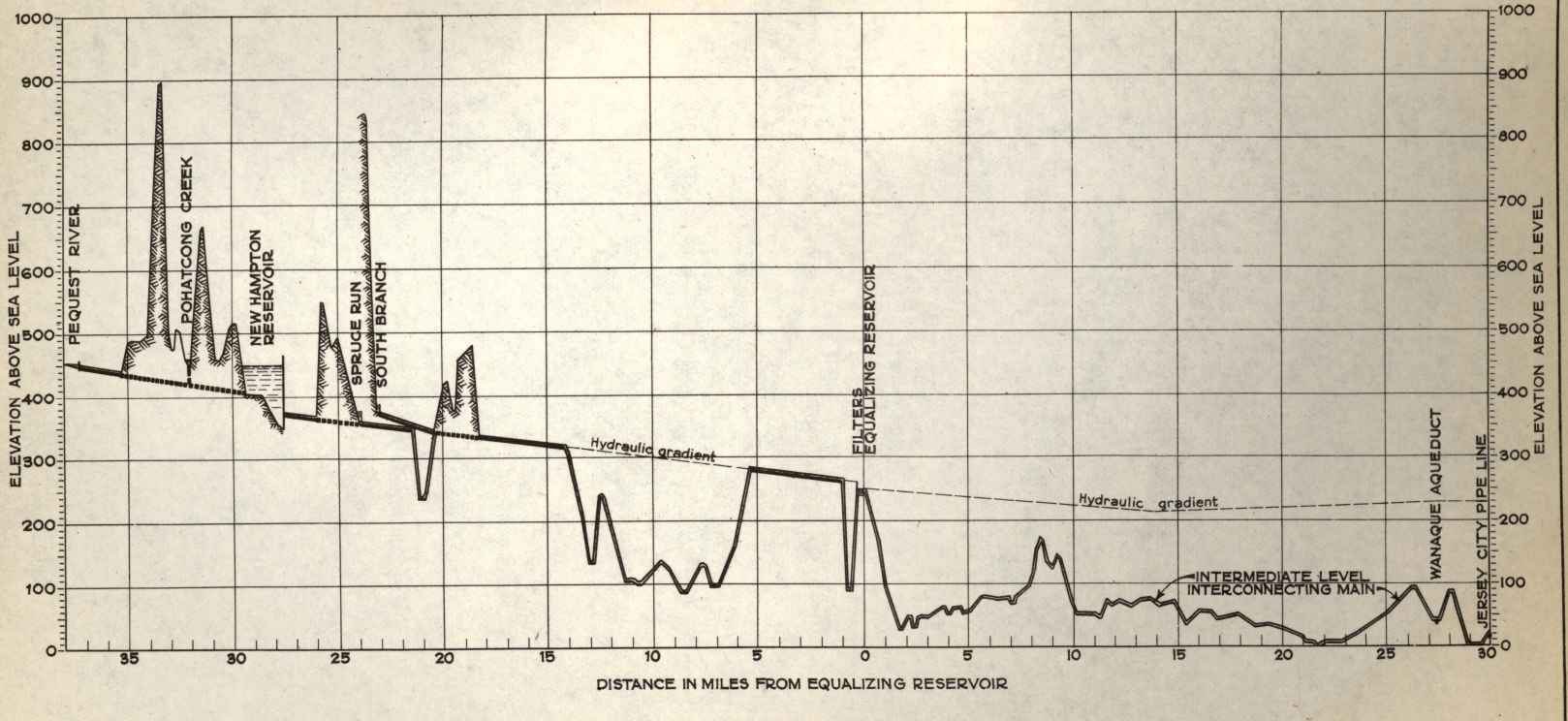
ply, and that later a lower level supply must be developed. It is probable that these two next projects will yield 250 to 300 million gallons daily, and will be adequate for the district until perhaps 1960. The demands of the district will continue to increase and additional development will of course eventually be required, but studies and estimates relating thereto have not yet been undertaken. That there are ample water resources available when needed is admitted by all students of the subject; wise planning and forethought are required to make the best and most economical use of these resources. At this time the establishing of sound principles on which to found a future program is more important than the selection of the actual program for the remote future.

SOUTHERN METROPOLITAN DISTRICT
SEASHORE RESORT DISTRICT

Owing to the urgency of the water supply problem in the Northern Metropolitan District, only sufficient consideration has been given the remainder of the State to make it evident that for the immediate future there exists no situation of so serious a nature that it cannot be solved locally.

The water supply problem of the Atlantic City region was studied to some extent during the summer of 1929, and it is believed that there is no immediate need for anxiety in that locality, although eventually the demand will exceed the practicable development of the well and surface supplies now in use.





STATE OF NEW JERSEY
STATE WATER POLICY COMMISSION

INTERMEDIATE LEVEL PROJECT
PLAN AND PROFILE

FEBRUARY 1930

PLATE 14

DIVISION OF APPLICATIONS

The Division of Applications has continued the work formerly done by the Division of Waters of the Department of Conservation and Development. This included investigation and report on applications for diversion of water for public use, examination of plans and sites for the construction and repair of dams and reservoirs and also inspection of construction work, determination of the character and extent of the water resources of the State through the establishment and operation of stream flow stations and ground water observation stations. In addition to continuing this work, this Division has also handled the applications for permits to construct encroachments on streams, other than dams, such as culverts, bridges and other structures in or along streams of the State.

During the six-month period ending December 31, 1929, 17 applications for diversion rights for public water supply have been received and acted upon by the Commission. All applications but one were approved with certain conditions, three approvals having been contracts between municipalities. The total diversion of water authorized was 7.25 million gallons daily, 0.4 million gallons daily from surface water and 6.85 million gallons daily from wells.

The examination of plans and sites for new dams, their inspection while under construction and the supervision of existing dams has been continued, as well as similar work on applications for building other encroachments on streams. The Commission has approved drawings and issued permits for the construction of ten new dams and has approved the size of waterway of one bridge.

The intensive study of ground water conditions in important areas within the State and the stream gaging work carried on in co-operation with the United States Geological Survey were continued.

The supervisory work on public water supply development and the construction of dams and other encroachments on streams as required by law must be carried on as necessity requires. The investigational work on our water resources must be continued uninterruptedly to produce the greatest benefit and to make avail-

able records that will cover critical periods. The demand for accurate information on these subjects is ever increasing on account of the work the Commission must do under the law, and also because of the need for information by engineers and officials in charge of the development of our water resources.

APPLICATIONS FOR DIVERSION OF POTABLE WATERS

Chapter 252, Laws of 1907, and Chapter 304, Laws of 1910, relate to the diversion of water for potable and public use. Chapter 152, Laws of 1917 (Article XXXII, Sections 1 and 15), confers certain jurisdiction regarding contracts between municipalities for water supplies. The activities of the Commission under the provisions of these laws are summarized as follows:

Period July-December, 1929

Applications for right to divert:

Approved	12
Disapproved	1
Approval of contracts	3
Consolidation and extension in territory	1
Total number of diversions	17

Quantity of water approved for diversion — Million Gallons Daily.

Surface	0.40
Underground	6.85
Total	7.25

The name of each applicant, the source of supply, the quantity of water authorized to be diverted, the action of the Commission and date are shown in the following table:

Table 12

APPLICATIONS FOR PERMITS FOR DIVERSION OF POTABLE WATER

Application No.	Applicant	Source	Amount, Gallons Daily	Action	Date
328	Ocean County Water Co...	Wells	Consolidation and extension in territory.*	Approved	August 14, 1929
329	Town of Boonton	"	1,500,000 (A) **	"	" " "
330	Borough of Lavallette	"	200,000 (A)	"	July 24, 1929
331	Morris & Sussex Water Service, Inc. (Bear Pond)	"	50,000 (N)	"	" " "
332	Borough of Point Pleasant	"		Denied	November 13, 1929
333	City of Bridgeton	"	2,000,000 (A)	Approved	August 14, 1929
334	Borough of Allendale	"	300,000 (N)	"	September 11, 1929
335	Merchantville-Pensauken Water Commission	"	1,000,000 (A)	"	" " "
336	Pottersville Water Co.	Cold Brook	400,000 (A) †	"	" " "
337	Borough of Essex Fells	Wells	400,000 (A)	"	December 11, 1929
338	Princeton Water Co.	"	1,000,000 (A)	"	October 9, 1929
339	Morris & Sussex Water Service, Inc. (Lake Rogerene)	"	50,000 (N)	"	" " "
340	Borough of Caldwell	"	200,000 (N)	"	December 11, 1929
341	Bellmawr-Brooklawn		Contract	"	November 13, 1929
342	Blackwood Water Co.	"	150,000 (A)	"	December 11, 1929
343	Newark-Elizabeth		Contract	"	November 13, 1929
344	North Jersey District Water Supply Commission-Bayonne-Kearny		Contract	"	" " "

*Application 328. Approval confirmed previous rights amounting to 750,000 gallons daily.

†Application 336. Approved for 500,000 gallons daily, including 100,000 gallons daily previously granted.

**(A) Additional Supply; (N) New Supply.

EXCESS DIVERSION CHARGES

Chapter 252, Laws of 1907, and Chapter 304, Laws of 1910, provide that a charge for the diversion of surface water in excess of a certain free allowance be made for each calendar year and certified to the State Comptroller for collection. The Commission fixed for 1929 a rate of $1.00 per million gallons, the minimum required by law.

INSPECTION OF DAMS AND ENCROACHMENTS

Chapter 243, Laws of 1912, and Chapter 267, Laws of 1929, confer jurisdiction over the construction and repair of dams and other structures in and along streams of the State, to the end that such structures may not unduly obstruct the natural channel of the streams or otherwise become a menace to life and property by reason of the water impounded or retarded and by improper construction. During the period covered by this report the Commission has approved plans and issued permits for ten new dams. In each case the plans and specifications submitted have been examined, the site of the proposed work inspected and a report made prior to such action. The following table gives the applicant, stream, location and purpose in each case.

Table 13

APPLICATIONS FOR APPROVAL OF PLANS FOR DAMS AND RESERVOIRS

Application No.	Name of Applicant	Stream	Location	Purpose
146	Ricker Realty Corporation	Post Brook	At Haskell	Real estate development
147	Oak Ridge Lake Park Realty Co.	Rockaway River	Near Oak Ridge	Real estate development
148	D. H. Applegate, Jr., Agent	Quigley's Creek	Near Red Bank	Real estate development
149	Hohokus Bleachery	Hohokus Creek	Near Waldwick	Water supply
150	Commonwealth Realty and Improvement Company	Ridgeway Branch	Near Lakehurst	Real estate development
151	Town of Morristown*	Harmony Brook	Near Brookside	Water supply
152	County of Salem	Cool Run	Near Alloway	Recreation
153	Passaic Consolidated Water Company†	Branch of Passaic River	Near Great Notch	Water supply
154	A. G. Preen	(None)	Near Oldwick	Water storage
155	William C. Casperson, Pres.	Branch of New Milford Stream	Near New Milford	Real estate development
156	State Highway Commission	Mullica River	At Atsion	Recreation
157	William E. Butler	Musconetcong River	Near Changewater	Recreation

*Plans for this dam are under revision and application has not been formally approved.
†Application dismissed.

In addition to the above applications for approval and permit, plans for seven small dams have been examined. In these cases the Commission ruled that no formal application need be made because of the low height of the dam and small quantity of water impounded.

Table 14

APPLICATIONS FOR APPROVAL OF PLANS FOR DAMS AND RESERVOIRS

(Formal Application Not Required)

Name of Owner	Stream	Location	Purpose
Houvenkopf Country Club	Small brook	Near Suffern, N. Y.	Water supply
Hackensack Golf Club	Small brook	Near Oradell	Golf hazard
Hopatcong Country Club	Small brook	Near Landing	Golf hazard
Hendon Chubb	Branch of Black River	Near Chester	Recreation
F. H. Raub	Trout brook	Near Blairstown	Recreation
J. E. Turner	Small brook	Near Quarryville	Ice pond
Lawrenceville School Camp, Inc.	Small brook	Near Asbury	Recreation

One complaint against a dam, one case of an unauthorized use of flashboards and one case of the unauthorized beginning of the construction of a dam have also been investigated.

Inspections of dams have been made as follows:

In connection with the applications above listed	15
Dams under construction under the above and earlier applications	35
Existing dams	33
Sites for which application has not been made	2
Total inspections	85

STREAM ENCROACHMENTS

The approval of plans for structures other than dams, encroaching on the waterways of the streams of the State, was not required prior to the enactment of the laws creating the State Water Policy Commission, although similar legislation has been in existence in other states for many years. The importance and necessity of this work is recognized and the problem of the preparation of regulations pertaining to such structures, including bridges, culverts, retaining walls and buildings is receiving thorough study. A preliminary booklet of instructions to aid applicants for approval of drawings for such structures has been prepared and is available for distribution to interested parties. The jurisdiction and responsibility of the Commission extend only to insuring that the stream channel be not unreasonably restricted and do not include questions of structural sufficiency.

In accordance with the provisions of this portion of the act, the following permit has been issued:

Table 15

APPLICATIONS FOR APPROVAL OF PLANS FOR STREAM ENCROACHMENTS

No. of Application	Name of Applicant	Stream	Location	Structure
1	Mercer County	Assanpink Creek	Trenton	Bridge

GROUND WATER

Ground water investigations have been continued throughout the period at certain typical localities and intensive studies have been made in seven regions, as follows: Atlantic City, Camden, Asbury Park, Runyon, Princeton, Canoe Brook and East Paterson.

The observations made are for the purpose of studying the occurrence of ground waters and the determination of the ultimate capacity or safe yield of the various water-bearing horizons. The equipment and observations were originally established in 1923, in co-operation with the United States Geological Survey. The equipment consists of 14 well gages, two evaporation stations, six soil evaporation tanks, 47 periodic water level measurement points and five water sampling points for chloride content analysis. The following table shows the equipment installed and the observations made in each of the seven regions, viz:—

Region	Equipment and Observations
Atlantic City	4 well gages.
	1 evaporation station.
	3 soil evaporation tanks.
	Water samples for chloride content at five points.
	Periodic water level measurements at seven points.
Camden	2 well gages.
Asbury Park	1 well gage.
	Periodic water level measurements at ten points.
East Paterson	2 well gages.
	Periodic water level measurements at one point.

Runyon	2 well gages.
	1 evaporation station.
	3 soil evaporation tanks.
	Periodic water level measurements at fifteen points.
Princeton	Periodic water level measurements at six points.
Canoe Brook	3 well gages.
	Periodic water level measurements at eight points.

Records of pumpage have been obtained from twenty-six co-operating parties in the regions named above (ten public water supplies and sixteen private water supplies).

STREAM GAGING

The work of measuring flow of streams has been conducted in co-operation with the United States Geological Survey and has been continuous since 1921. There are now 42 stream gaging stations, of which 37 are equipped with automatic water stage recorders, and 6 are equipped with artificial controls. One new station with automatic gage has been established on Canoe Brook near Summit, and a new float well and shelter for automatic gage was built on Lawrence Brook at Farrington Dam to replace an old one. Artificial controls were erected at two gaging stations on Flat Brook, near Flatbrookville, and Pequest River, at Pequest. In connection with the work, 137 current meter measurements of discharge were made.

The use of automatic gages to record the continuous stage of streams overcomes trouble from daily fluctuation in the streams caused by artificial regulation of the flow by mill operators, etc., and also eliminates difficulty in getting competent gage observers at some remotely located stations. The construction of artificial controls stabilizes the relation between the stage (or gage height) and discharge of the streams, reduces the amount of field and office work necessary to obtain daily flow past the stations and also increases the accuracy. The interest in this work throughout the State is reflected in the fact that one-third of the gaging stations have been constructed largely at the expense of the co-operating parties, the Commission maintaining and operating most of them. The following table gives a complete list of stations being operated, type of gage and name of co-operating party:

Table 16

STREAM FLOW GAGING STATIONS

Station	Location	Gage	Co-operating Party
Absecon Creek	Absecon	Automatic	Atlantic City Water Department
Assanpink Creek	Trenton	"	
Batsto River	Batsto	"	
Beaver Brook	Belvidere	"	
Beaver Brook	Split Rock Pond	"	Jersey City Water Department
Black River	Pottersville	"	
Canoe Brook	Summit	"	Commonwealth Water Company
Delaware River	Belvidere	"	United States Army Engineers
Delaware River	Riegelsville	"	
Delaware River	Trenton	"	United States Weather Bureau, City of Trenton
Elizabeth River	Elizabeth	"	
Flat Brook	Flatbrookville	"	
Great Egg Harbor River	Folsom	"	
Green Brook	Bound Brook	Staff	
Hackensack River	New Milford	Automatic	Hackensack Water Company
Lawrence Brook	Farrington Dam	"	City of New Brunswick
Millstone River	Blackwells Mills	"	
Musconetcong River	Bloomsbury	"	Warren Manufacturing Company
Musconetcong River	Hackettstown	"	Morris Canal and Banking Company
Musconetcong River	Lake Hopatcong	"	Morris Canal and Banking Company
Passaic River	Millington	"	
Passaic River	Paterson	*	*
Paulins Kill	Blairstown	Automatic	
Pequannock River	Macopin	"	Newark Water Department
Pequest River	Pequest	"	
Rahway River	Rahway	Staff	
Ramapo River	Mahwah	Automatic	
Ramapo River	Pompton Lakes	"	Jersey Central Power and Light Company
Rancocas Creek, North Branch	Pemberton	"	
Raritan River	Manville	"	
Raritan River, North Branch	Far Hills	"	Somerset Lake and Game Club
Raritan River, North Branch	Milltown	Staff	
Raritan River, South Branch	High Bridge	Automatic	Taylor-Wharton Iron and Steel Company
Raritan River, South Branch	Stanton	"	
Rockaway River	Boonton	"	Jersey City Water Department
Saddle River	Lodi	"	
Swimming River	Red Bank	"	Monmouth Consolidated Water Company
Wanaque River	Greenwood Lake	"	North Jersey District Water Supply Commission
Wanaque River	Wanaque	"	North Jersey District Water Supply Commission
Whippany River	Morristown	Staff	Department of Public Works, Town of Morristown

*The flow of the Passaic River at Paterson has been determined by compilation of records furnished by the Society for Establishing Useful Manufactures, Newark Water Department, Jersey City Water Department, East Orange Water Department and Commonwealth Water Company.

Nature of Work

Stream gaging work consists primarily in keeping continuous record of the actual flow of the streams. Only a portion of the rainfall and snowfall finds its way into the surface stream. The relation between the precipitation and surface runoff in the stream varies so widely with different conditions of topography, character of soil and underlying strata, forest cover, vegetation, temperature, wind movement, distribution of rainfall, etc., that direct measurement of the runoff is the only satisfactory way of determining its amount.

Records of the flow of New Jersey streams are necessary in determining the amount of water that they may be depended upon to yield for water supply and other purposes. Stream flow varies so much from day to day, from month to month, and from year to year, that a single measurement or a single season's record cannot give the true measure of a stream.

Continuous Records

It is important that these records extend over a period of years. Records of ten years are of considerable value, but in such a short period the maximum and minimum conditions of the flow may not occur. These extremes, as well as reliable averages, are needed before accurate studies of our water resources can be made.

Available Data

The stream gaging information collected by the United States Geological Survey is published in the Water-Supply Papers by runoff years, ending September 30. These papers give the following information for each gaging station: description of station, list of discharge measurements, tables of daily and monthly discharge. There is necessarily some delay in getting this information into print. Therefore, the Geological Survey and this Commission are prepared to furnish unpublished data for later periods in blue print form upon request from interested parties. In requesting this

information, give name of stream, location, and character of information desired. Bulletin 33 of New Jersey Department of Conservation and Development presents all available data to September 30, 1928, relative to the stream gaging operation and stream flow records of the State.

Respectfully submitted,

MORRIS R. SHERRERD,

Chief Engineer.

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*Engineers of the United States Geological Survey engaged in stream flow measurements and ground water studies in co-operation with the State Water Policy Commission.