FIRST REPORT of the

NEW JERSEY WATER RESOURCES ADVISORY COMMITTEE

APRIL 25, 1957

April 25, 1957

Hon. Joseph E. McLean, Commissioner

Department of Conservation and Economic Development

State House Annex

Trenton 7, New Jersey

Dear Commissioner McLean:

The Water Resources Advisory Committee, appointed by you in September, 1956, is glad to submit this report. It represents the completion of the Committee's first project which will provide 80 million gallons daily of additional water supply; more than double the minimum flow in the Raritan River, and a simultaneous increase of the minimum flow in the South Branch and Millstone Rivers.

The Report includes an account of the work of the Committee, engineering studies and recommendations, and the Committee's detailed consideration of these recommendations and its concurrence. Additionally, the Report presents for consideration of the Administration and the Legislature certain alternative methods of financing and managing the recommended projects.

The Committee appreciates the assistance and cooperation of Administration officials, members of the Legislature, and many public-spirited persons who have made it possible to provide a practical solution to a significant part of the State's water supply problem.

The Committee intends now to focus its attention on future reservoir sites and on plans to protect and increase the availability of the vast underground water supplies throughout the State, and especially in the southern part of New Jersey. A practical plan for further development of these resources is our next goal.

FOR THE WATER RESOURCES ADVISORY COMMITTEE

George F. Smith, Chairman

NEW JERSEY WATER RESOURCES ADVISORY COMMITTEE

FIRST REPORT

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NEW JERSEY WATER RESOURCES ADVISORY COMMITTEE

Committee Membership and Basis of Its Work

Since establishment of the Water Resources Advisory Committee in September, 1956, and selection of its membership from industry, labor, agriculture and recreation sources, meetings have been held regularly. A membership list is at EXHIBIT A.

To avoid scattering its efforts, the Committee early adopted the policy of being generally alert to all opportunities for increased water supplies, but concentrating its major attention on one significant project at a time. The successful and relatively quick completion of the first project seems to confirm the wisdom of the policy adopted.

In the Committee's first meetings it developed a statement of guiding principles for the use of the engineering consultants and as a basis for the work of the Committee itself. The statement at EXHIBIT B contains 14 items. All of them have proved provocative and helpful in the deliberations over the past months.

When studies indicated that on-river reservoirs on upper Raritan tributaries could provide raw water delivered to a central point at a cost significantly below that of high-level, off-river reservoirs, the Committee decided on the on-river water supply method in the first project even though it meant a break with past engineering recommendations. Other benefits of this novel approach to additional supplies of water included the provision of downstream water supply for many miles of the river basin for agricultural, municipal and industrial use and the availability of the reservoirs for fishing, swimming and boating. The attractiveness of land adjacent to the reservoir sites makes widespread development inevitable. Municipalities should consider appropriate zoning provisions to realize fully the potential advantages that are inherent in that situation.

The reservoir sites would result in a relatively moderate displacement of families since most of the land is in fairly large tracts.

Bipartisan Approach

The Committee has been bipartisan in its work. It has benefited from the advice of Administration officials, Legislators of both parties and many others whose help was of real value.

Financial Support of the Committee

The Committee's work, restricted to engineering, financial, administrative, legislative, legal and public information matters pertinent to the State's water needs, has been privately financed. We are pleased to report that 34 industrial and commer-

cial firms and the State CIO Council have contributed $48,825 to the Committee's efforts. The average contribution was $1,395 and the largest contribution in any instance was $5,000. A list of contributors to date is at EXHIBIT C.

Engineering Report on the Reservoir Projects

Numerous and, in some cases, very comprehensive engineering studies on water supply have been made in the past. In view of this the Committee decided to employ a highly qualified engineering firm to review all earlier works and to undertake only those re-studies or new studies which were obviously needed.

In keeping with this plan the Committee engaged the services of the engineering firm of Whitman, Requardt & Associates, Baltimore, Maryland. The results of their engineering review and additional studies, and their recommendations are contained in this Report at EXHIBIT D. Detailed data supporting the conclusions and recommendations will be filed with the Division of Water Policy and Supply, New Jersey Department of Conservation and Economic Development.

The Committee has consulted with the Engineers continuously since they were retained and has reviewed the Engineer's recommendations. After careful consideration of each one it concurs in all the recommendations.

The Committee in consultation with the Engineers, set as one of its long-range goals the maximum development of the water potential of the Raritan River Basin. The recommendation below is the first stage in a step-by-step program under continuous consideration.

The Committee recommends the purchase of two reservoir sites, Spruce Run and Stony Brook, and the construction of these two reservoirs. The Spruce Run Reservoir should be developed immediately. It can be reasonably anticipated that the additional water made available by this reservoir will be purchased rather promptly. The Stony Brook Reservoir should be constructed when about half of its water supply is actually committed for sale under contracts.

These two reservoirs will provide 80 million gallons daily (mgd) of additional water supply apparently sufficient to meet the demands for seven to ten years ahead. In addition, the Spruce Run and Stony Brook Reservoirs will significantly increase the low flow in the South Branch and Millstone Rivers and assure twice the recorded low flow at the confluence of the Millstone and Raritan Rivers.

Recent rechecks of real estate values in the Stony Brook and Spruce Run areas indicate that the Engineer has made ample provision for cost increases occurring since the estimates of 1955. Moreover, the allowance for construction cost increases and the substantial contingency reserve are adequate if reservoir construction is not delayed unduly.

The Committee has also been giving active consideration to an additional reservoir, in the North Branch area, for future development. This reservoir was

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Present Allocation

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of Raritan water ... Company
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of new water supplies from the Raritan Basin.

Financing the Reservoir Projects

The Committee recommends that projects to develop additional water supply in the State be self-sustaining and self-liquidating. New water supplies should be paid for by the users of the water. Citizens who do not use the new water should not be required to pay for the cost of its development.

On the basis of present cost estimates the proposed on-river reservoirs will be self-supporting and self-liquidating if a charge of $25 per million gallon is made for the water committed or sold. This is a reasonable charge for raw water and the Committee recommends that a uniform price apply to all contracts for water.

The Committee recommends that $14 million be authorized for the purchase of two reservoir sites at Spruce Run and Stony Brook. The Spruce Run Reservoir should be developed immediately. It can be reasonably anticipated that the additional water made available by this reservoir will be purchased rather promptly. The Stony Brook Reservoir should be constructed when about half of its water supply is actually committed for sale under contracts. The sale of bonds required

Errata

First Report of the New Jersey Water Resources Advisory Committee

On page 3, the first sentence of the last paragraph is incomplete. The sentence reads; "The Committee recommends that $14 million be authorized for the purchase of two reservoir sites at Spruce Run and Stony Brook." This sentence should be amended to add: "and the construction of these two reservoirs."

The full statement on cost, sites and dams is on page 23:

"Recommendation No. 7

"Authorization for an expenditure of $14 million should be obtained as soon as possible. On the basis of present estimates, this will permit (1) the purchase of all the land for the two reservoirs and the construction of Spruce Run Reservoir immediately, all at a cost of about $9 million and (2) the construction of Stony Brook reservoir at a cost of about $5 million when needed."

for the construction of the Stony Brook Reservoir should be delayed until the funds are needed.

The Committee's financial plan recognizes that the income from water charges in the early years probably will not cover all interest and operating costs. Therefore the proposed bond issue will include a sizeable contingency reserve to cover any deficits in the early years of the project. After 3 years it is anticipated that all annual costs will be met and that amortization of the bonds will begin.

How should the initial $14,000,000 be provided? It is obvious that this sum cannot be supplied from current state funds and that a special bond issue will be necessary.

If the on-river reservoirs are to be built and operated by the Division of Water Policy and Supply, a General Obligation Bond issue is indicated. If it is decided to create a new and separate water agency, and if its bonds require pledging the faith and credit of the State, such agency should be subject to Executive and Legislative budgetary control.

The objective is to build and finance the projects stage by stage; to anticipate and provide for early year deficits; and gradually to amortize the bonded indebtedness. It appears entirely safe to assume that each bond issue will be retired within 35 years even though the charge for water will be at an attractive rate. After all the bonds are retired the State will enjoy a clear profit of about $700,000 a year. These funds could be used to underwrite additional water supply projects probably needed then, or the State could reduce its charges for water originating in the Raritan Valley reservoirs.

Management of Reservoir Projects

For several years the Division of Water Policy and Supply, New Jersey Department of Conservation and Economic Development has allocated water from the Delaware & Raritan Canal as approved by the Water Policy Council, collected charges for water and recommended operational and construction procedures. This Division could manage the on-river reservoir projects in the same way.

A second method for reservoir management could be the creation of a separate Water Agency. The authorization for such an Agency could, if desired, be an integral part of the legislation for the reservoir projects.

Wharton Tract and Round Valley

While initial study was concentrated on the Raritan Basin because it is the last undeveloped and large-scale potential water resource in northern New Jersey, and closest to the area of greatest need, the Committee considered water problems in other parts of the State. It was noted with satisfaction that the State of New Jersey had purchased the Wharton Tract in southern New Jersey and the Round Valley reservoir site in the western central area.

The Committee gave first consideration to the Delaware River as a future water source for the filling of the proposed Round Valley Reservoir. However, because the Delaware River source must await completion of a three-year survey now being conducted by the United States Army Corps of Engineers, United States Supreme Court action and other steps, a plan for limited water supply from the Raritan Basin has been evolved and suggested in the Engineer's Report. The On-River Reservoir project recommended above does not interfere with the eventual development of the Round Valley Reservoir.

Underground Water Report

Vast opportunities for additional water supplies in many parts of the state can be realized by appropriate development of underground water resources. The Committee therefore employed the firm of Leggette, Brashears & Graham, consulting ground-water geologists to study this question. Their preliminary report is at EXHIBIT E.

The Committee has considered the Engineer's recommendations and fully concurs in them.

Public Information

Realizing that every public water supply program requires public support, the Committee embarked on a public information program. The services of Williams & London, Newark, were retained.

Legislators are well aware of the need for new water supplies. The average citizen, however, must be informed to prepare him for intelligent action when he is presented with a program to solve the immediate water problem.

Future Program

The Committee intends to continue its studies and report progress from time to time on each of the following projects:

1. Continuation of underground water surveys and engineering studies so that data and recommended programs on underground water resources will be available for the entire State.

2. The next stage of development of the surface water supply potential of the Raritan River Basin.

In addition the Committee will remain alert to the desirability of additional supplies from the Delaware River. Any definite program, however, must await completion of the studies now being conducted by the United States Army Corps of Engineers.

EXHIBIT A

NEW JERSEY WATER RESOURCES ADVISORY COMMITTEE

Mr. George F. Smith, President (Chairman)
Johnson & Johnson
New Brunswick, New Jersey

Mr. James Kerney, Jr., Editor, (Vice-Chairman)
The Trenton Times
Trenton, New Jersey

Mr. Bernard Hellring (Secretary)
1180 Raymond Boulevard
Newark, New Jersey

Mr. V. E. Atkins, General Manager (Treasurer)
Organic Chemicals Division
American Cyanamid Company
Bound Brook, New Jersey

Mr. John T. Connor, President
Merck & Co.
Rahway, New Jersey

Mr. Oliver G. Willits
Chairman of the Board
Campbell Soup Company
Camden, New Jersey

Mr. Frank J. Valgenti, Former Chairman
New Jersey State Fish & Game Council
1 Waverly Place
Madison, New Jersey

Mr. Louis P. Marciante, President
N. J. Federation of Labor
790 Broad Street
Newark 2, New Jersey

Mr. Paul Krebs, President
New Jersey State CIO Council
772 High Street
Newark, New Jersey

Mr. W. Grant Parry, General Sales Manager
Jersey Central Power & Light Company
New Jersey Power & Light Company
9 West Blackwell Street
Dover, New Jersey

Mr. Clarence Alles, Overseer
New Jersey State Grange
R. D. #1
Flemington, New Jersey

Mr. Edward A. Curtis, Vice-President
New Jersey Bell Telephone Company
540 Broad Street
Newark 2, New Jersey

Mr. Bayard L. England, President
Atlantic City Electric Company
1600 Pacific Avenue
Atlantic City, New Jersey

Mr. Ernest Lass, Publisher
The Asbury Park Press
Asbury Park, New Jersey

Miss Jane Stretch, Editor
The Camden Courier Post
Camden, New Jersey

Mr. John C. Williams
Williams & London Advertising Agency
58 Park Place
Newark, New Jersey

EXHIBIT B

October 31, 1956

NEW JERSEY WATER RESOURCES ADVISORY COMMITTEE
STATEMENT OF GUIDING PRINCIPLES

1. The State Water Resources Advisory Committee is statewide in scope. It will be necessary to plan for water needs years ahead with a program of development by stages. The first step might be to provide for the next ten years, and each of the subsequent stages to provide for equally long periods. Cost estimates will be needed for each stage. Recommended projects should fit into existing and planned water supply programs.

2. We would want to point to the immediate acquisition of the sites necessary to the complete program to avoid higher costs later and to minimize inconvenience to the public. Cost estimates of such acquisitions will be needed.

3. We regard it important to provide complete, satisfactory assurance to upriver counties that there would be no lowering of their optimum lake and stream levels and that such counties would always have sufficient water for their own needs and growth.

4. Raritan water supplies are to be developed for use in the Basin, for Northeast New Jersey, and other parts of the State. The water may be used for potable needs, industrial purposes, irrigation, recreation and stream regulation.

5. The Legislature has stipulated that the water for the Round Valley Reservoir must come from the Delaware River. However, we should be prepared to recommend Raritan Valley water sources to the Legislature if it should later find that Delaware River supplies are not available, not available soon enough, or not available in sufficient quantity to make optimum use of the Round Valley Reservoir.

6. We would give consideration to the relative merits of supplying raw water or filtered water to meet the differing needs of potential customers. Similarly, we would give consideration to the question of whether water should be delivered or provided on a come-and-get-it-basis. Accordingly, any plan should be designed to enhance rather than jeopardize the activities and programs of existing water companies and commissions.

7. Use of the Raritan watershed rivers and streams to carry the water supply to the points of use or nearby is a desirable goal. The anti-pollution programs now underway in the Raritan River Valley materially increase the feasibility of such a plan.

8. We should strive to have a minimum daily flow of 130 million gallons in the Raritan at Bound Brook below the Elizabethtown Water Company intake. Consideration should be given whether this minimum daily flow might be reached in stages. The plan should provide an initial basic minimum flow of at least 100 million gallons per day.

9. In addition to that initial basic minimum river flow of 100 million gallons per day, we would strive for an additional 100 million gallons per day which would be available for sale to water supply companies, industries and municipalities; an initial minimum flow of 200 million gallons per day in the Raritan at Bound Brook below the Elizabethtown Water Company intake.

10. We must give consideration to the use of both gravity flow and pumping wherever each is most feasible. The questions of supply, dislocation of people and other conditions are all-important in this connection.

11. We want to achieve the maximum of protection against soil erosion. In these and in other respects we want to give consideration to the Federal aid which may be available for such purposes.

12. While primary consideration must be given to the foregoing factors, we want to take advantage of practical opportunities for considered land improvements and recreation facilities.

*13. Water supplies to meet the anticipated needs may be made available from either on-river or off-river reservoirs, or from any combination of reservoirs.

*14. Any water supply project will be self-liquidating.

*Approved at February 14, 1957 meeting of the Water Resources Advisory Committee.

EXHIBIT C

FINANCIAL CONTRIBUTORS

to the

New Jersey Water Resources Advisory Committee

(AS OF APRIL 18, 1957)

American Cyanamid Company

Anheuser-Busch, Inc.

Bakelite Company

Baker & Company, Inc.

Ballantine, P. & Sons

Belleville Manufacturers Assn.

Benzol Products Company

Blanchard Bro. & Lane, Inc.

Cities Service Oil Co.

Continental Can Company

Daystrom, Inc.

Driver, Wilbur B. Co.

Duhernal Water System

Edison, Thomas A., Inc.

Elizabeth Daily Journal

Helme, George W. Co.

Johnson & Johnson

Johns-Manville Corporation

Kieckhefer Container Co.

Mengel Company, The

Merck & Company

National State Bank of Newark

New Jersey Bell Telephone Co.

Jersey Central Power & Light Co.

New Jersey State C.I.O. Council

North Jersey Quarry Co.

Okonite Company, The

Public Service Electric & Gas Co.

Prudential Insurance Co. of America

Revlon Company

Roebling's Sons, John A. Corporation

Ruberoid Company

Singer Manufacturing Company

Standard Oil Company (N. J.)

Triangle Conduit & Cable Co.

TOTAL CONTRIBUTIONS (Through April 18, 1957)	$48,825
AVERAGE CONTRIBUTION	$ 1,395
LARGEST INDIVIDUAL CONTRIBUTIONS	$ 5,000

EXHIBIT D

WHITMAN, REQUARDT and ASSOCIATES

EZRA B. WHITMAN, Cosultant
GUSTAV J. REQUARDT
A. RUSSELL VOLLMER
ROY H. RITTER
WILLIAM F. NEALE
RAYMOND C. REGNIER
HENRY A. NAYLOR, JR.

Engineers

1304 ST. PAUL STREET
BALTIMORE 2, MARYLAND

TELEPHONE
SAratoga 7-3450

ERNEST C. NORTH
KENNETH A. McCORD
ROLAND A. CLARK
CHARLES F. MILLARD
ROGER T. POWERS
NEVIN S. WEISS

April 3, 1957

New Jersey Water Resources Advisory Committee
Attention: Mr. George F. Smith, Chairman

Gentlemen:

In accordance with your authorization of October 2, 1956, we submit herewith a program of providing additional surface water resources immediately in the Raritan River Basin to serve North Jersey as well as the Raritan Valley and it is recommended that the current tests and investigations of underground water resources in South Jersey and other parts of the State be continued. In developing this program, we have been guided by the list of fourteen principles established by the Committee.

The conclusions and recommendations discussed hereinafter are the results of our findings and the exchange of ideas and suggestions during the many meetings held with the Water Resources Advisory Committee.

In selecting the reservoir sites to carry out the program, we have used the information in the comprehensive survey and report authorized by the New Jersey Legislature and prepared by Tippetts-Abbett-McCarthy-Stratton in 1955. This report, information from the Department of Conservation and Economic Development and other data being available, it was unnecessary to make any further investigations of new reservoir sites. Cost data in the Tippetts-Abbett-McCarthy-Stratton report have been spot checked and appear reasonable for 1955. Allowances have been made for the increase in interest rates, land costs and constructions costs which have occurred since that time.

It is the opinion of the Committee and ourselves that the State should now purchase the land for two on-river reservoir sites in the Raritan River Basin and should immediately construct one dam and reservoir, Spruce Run, all at a total cost of about $9 million, which will provide 40 millions gallons per day (mgd) of additional water supply and raise the present natural minimum flow at the confluence of the Millstone and Raritan Rivers from 45 mgd to a sustained minimum flow of 90 mgd. The second dam and reservoir, Stony Brook, can be constructed when needed

at a cost of about $5 million (if construction was not unduly delayed) and will provide another 40 mgd and raise the sustained minimum flow in the Raritan from 90 mgd to 100 mgd. Future reservoir capacity can be constructed when needed and will provide up to 100 mgd of additional water and raise the sustained minimum flow in the Raritan from 100 mgd to 120 mgd.

The presently predicted increase in the consumption of water in the northeastern region of the State is at the rate of 8 to 11 mgd each year. On that basis Spruce Run and Stony Brook reservoirs providing 80 mgd of water could take care of the increased consumption over the next 7 to 10 years depending upon the demand. Other reservoir capacity providing 100 mgd should take care of the demand for water for a further 9 to 12 years. The three or more reservoirs providing a total of 180 mgd should take care of the needs for the next 16 to 22 years depending upon the demand for raw water. Accelerated water requirements resulting from increased population and industrialization could shorten these time spans considerably.

The three or more reservoirs will make it possible to have a total sustained flow of not less than 320 mgd at the confluence of the Raritan and Millstone Rivers in the event the greatest drought on record (1930) should happen again. The 320 mgd would provide the 20 mgd previously allocated to the Elizabethtown Water Company, the guaranteed 120 mgd sustained minimum flow in the river, and make available for use 180 mgd of new raw water supply to be taken from the Raritan and Millstone Rivers in a manner similar to the present methods of using water from the Delaware & Raritan Canal. The charge for water should be set so as to make the project self-sustaining and self-liquidating.

The Round Valley Reservoir can be constructed whenever needed in the future on the excellent site whose acquisition was recently authorized by Legislative Act. The legislation carries the stipulation that the water for the Round Valley Reservoir must come from the Delaware River, but as directed by the Committee, we have shown how Raritan River water could be used to a limited extent for that purpose.

Very truly yours,

WHITMAN, REQUARDT AND ASSOCIATES

By ROY H. RITTER

Roy H. Ritter/cr

CONCLUSIONS

Conclusion No. 1

It is generally agreed that there is an immediate need for a new major supply of water to meet the present acute water requirements in the Northeastern Metropolitan Counties and in the Raritan Valley. A program of stage-by-stage development to provide water for future requirements as needed represents the most practical approach to the problem.

Conclusion No. 2

The Raritan River Basin is the only area where large quantities of additional water can be obtained immediately and economically to serve the Northeastern Metropolitan Counties as well as the counties in the Raritan Valley. This basin is about equal in size to the Passaic River Basin, is wholly within the State, is reasonably close to the counties needing water and is virtually undeveloped for water supply.

The existing water sources in the Hackensack, Passaic, Rockaway, Wanaque and Pequannock Rivers have been and are now being developed to the reasonable limit of the capacity of these rivers by municipalities and water companies in the Northeastern Region of New Jersey. Well supplies in this region have also approached their limit of practicable development.

The Chimney Rock project to provide additional water from the Raritan River at Bound Brook, including a pumping station, Chimney Rock Reservoir, filtration plant and filtered water transmission main, was defeated in the 1955 referendum. It does not appear that this project could be redesigned so as to make it acceptable.

Delaware Valley water supplies can be made available for New Jersey's long-range needs. Such supplies are dependent on a comprehensive survey now being conducted by the U. S. Army Corps of Engineers; on U. S. Supreme Court decision to establish the rights of the several States involved and on joint legislation of and cooperation between New Jersey and neighboring States.

Conclusion No. 3

Because there are many municipalities and water companies in need of water, we believe a new major water supply from the Raritan River Basin should be developed. We believe further that the project should be managed by the State of New Jersey in a manner similar to its handling of the allocation of raw water from the Delaware and Raritan Canal. Such a project can be financially self-sustaining and self-liquidating by making appropriate charges for the water allocated.

Interviews with potential users of raw water indicate that requests for allocation will be made as soon as the reservoirs are authorized for construction and that such potential users are willing to pay reasonable charges for water.

The Raritan Valley supplies to be developed would be for use in the entire Raritan Basin, for Northeast New Jersey, and other parts of the State. The water could be used for potable needs, industrial purposes, irrigation, recreation and stream regulation.

Conclusion No. 4

The State should only build reservoirs to provide a supply of raw water. The State should not build pipe lines to deliver water nor construct filtration plants and related distribution systems. Existing and new filtration plants and pipe lines operated by municipalities, water commissions and water companies can readily distribute filtered water to the ultimate user.

By limiting the State's participation to the provision of raw water supplies, the project is financially practicable. Moreover, there would be no needless duplication of municipally owned or privately owned facilities.

Conclusion No. 5

Any program furnishing additional water supply from the Raritan River Basin should also provide for increasing the natural flows of the Raritan and Millstone Rivers during droughts and other low flow periods. This can be accomplished as the reservoirs are built in stages. During drought periods the flow of the Raritan River has been below 45 mgd. The first reservoir recommended, Spruce Run, will provide a sustained minimum flow of 90 mgd in the Raritan River at its confluence with the Millstone River. After the second reservoir at Stony Brook is constructed, this flow will be increased to 100 mgd and after future reservoirs are completed, this will be increased to 120 mgd.

The increased and sustained minimum flows would improve the quality of the water in the river and would reduce the salinity in the tidal reaches. These increased flows will improve the upper river and its tributaries for recreational purposes.

The two on-river reservoirs at Spruce Run and Stony Brook would improve stream levels on the South Branch and the Millstone below the dams. Water for filling the reservoirs would come from the streams and in no case from upstream lakes.

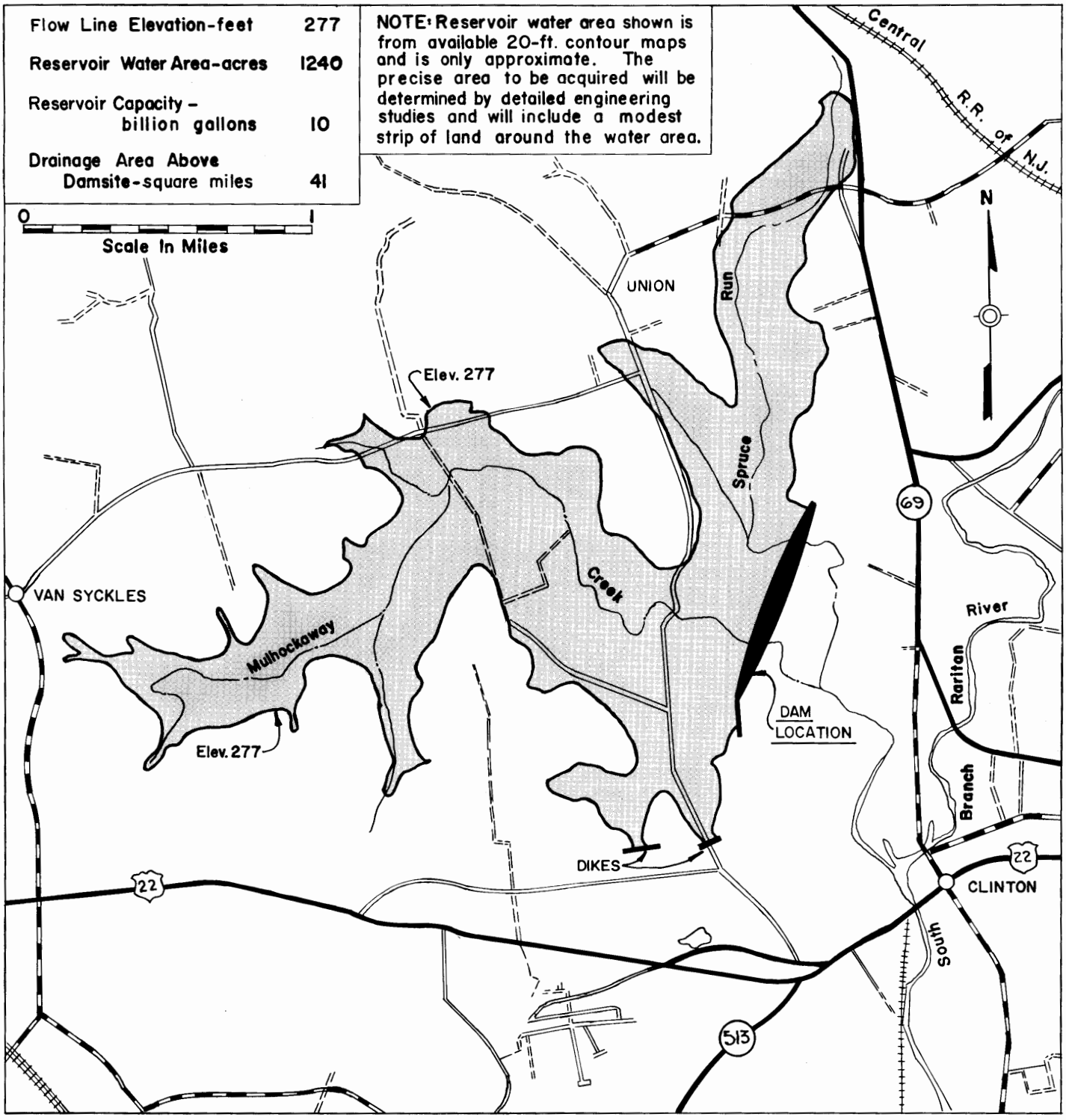
Conclusion No. 6

Future reservoir sites to provide for about 30 billion gallons of additional water storage should be decided on within the next year or two so that the water supply potential of the Raritan River can be realized as needed.

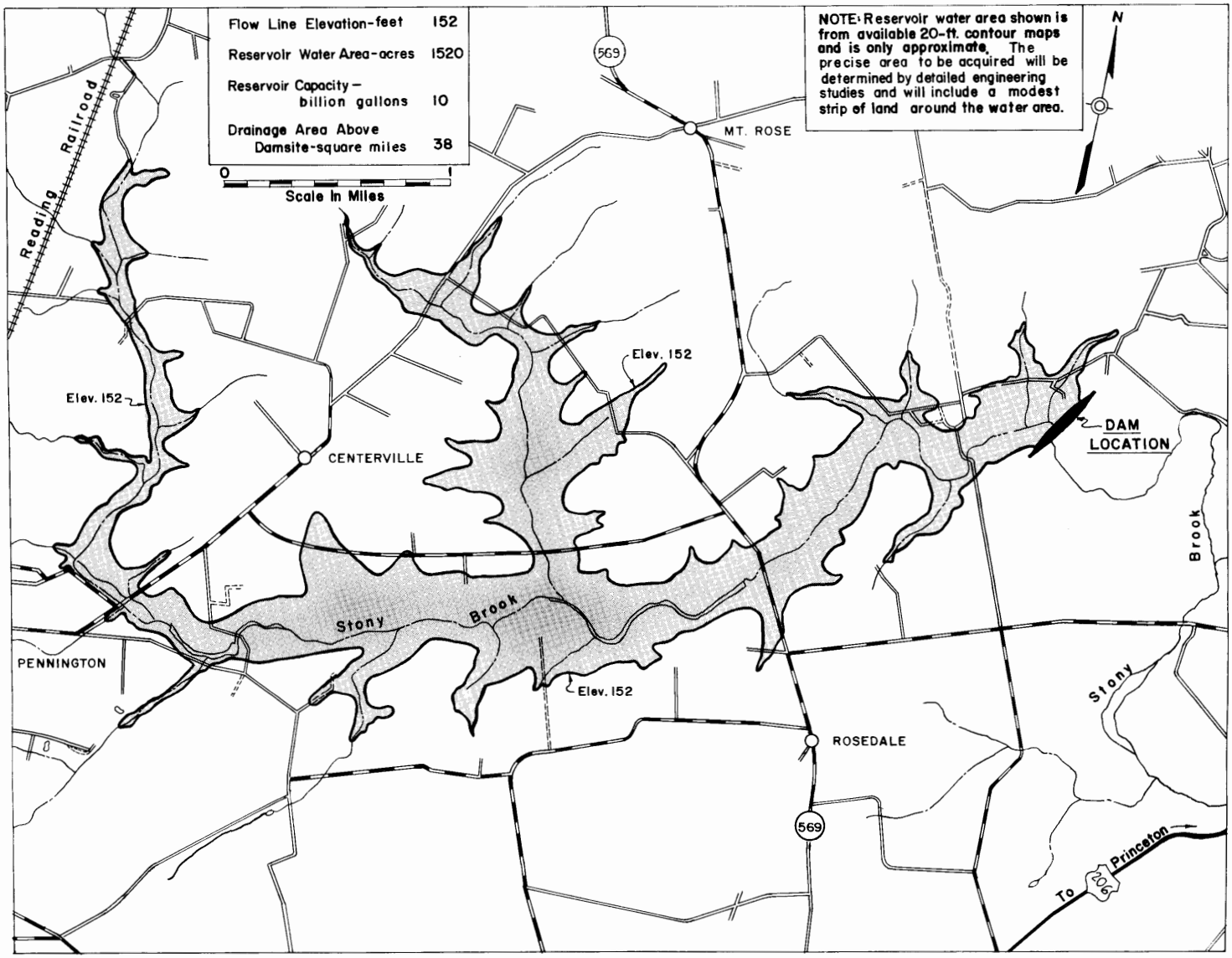
The on-river storage capacity of 30 billion gallons, in conjunction with two previously named reservoirs—Spruce Run and Stony Brook, each of 10 billion-gallon capacity, would increase stream flows to assure 120 mgd of sustained minimum flow

(Continued on page 20)


THE
RARITAN RIVER BASIN
(Unshaded Area)
Direction of flow of surface water. (Limit of watershed)
SCALE OF MILES
5 0 5
General Drafting Co., Inc.
SUSSEX
Netcong
Wharton
Rockaway
Dover
Mountain Lakes
Boonton
Hackettstown
MORRIS
Morristown
Paterson
Fair Lawn
East Paterson
PASSAIC
Hackensack
Teaneck
Englewood
Clifton
Garfield
BERGEN
Fort Lee
Passaic
Montclair
Verona
Nutley
West Orange
Bloomfield
Belleville
North Arlington
North Bergen
West New York
HUDSON
ESSEX
Orange
Kearny
Union City
East Orange
Newark
Madison
Millburn
Maplewood
Irvington
Union
Summit
Hillside
Jersey City
Roselle Park
Elizabeth
Bayonne
UNION
Cranford
Roselle
Westfield
North Plainfield
Plainfield
Linden
Rahway
Carteret
Dunellen
Washington
WARREN
Bernardsville
Spruce Run Reservoir
High Bridge
Lebanon
Clinton
P.S.
Round Valley Reservoir
North Branch
N. Branch
Raritan
Somerset
Bound Brook
Woodbridge
HUNTERDON
Frenchtown
South Branch
Manville
Metuchen
Perth Amboy
SOMERSET
Flemington
Highland Park
New Brunswick
Raritan R.
South Amboy
Millstone R.
Sayreville
South River
Keyport
MIDDLESEX
Lambertville
Stony Brook Reservoir
Princeton
Jamesburg
Rumson
Red Bank
Pennington
Oceanport
MONMOUTH
Long Branch
MERCER
Hightstown
Freehold
Trenton
Asbury Park
Ocean Grove
N
457



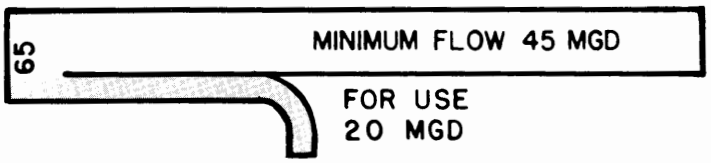
SPRUCE RUN RESERVOIR



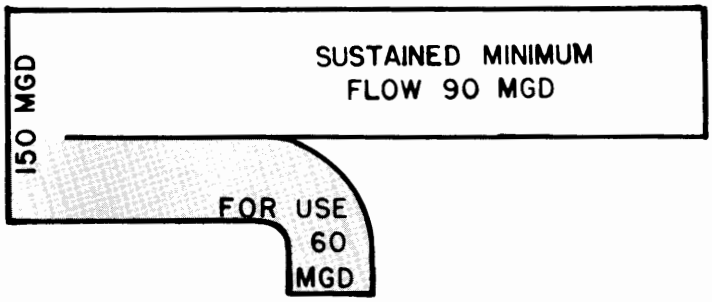
STONY BROOK RESERVOIR

EFFECT OF ON-RIVER RESERVOIRS AT CONFLUENCE OF RARITAN AND MILLSTONE RIVERS

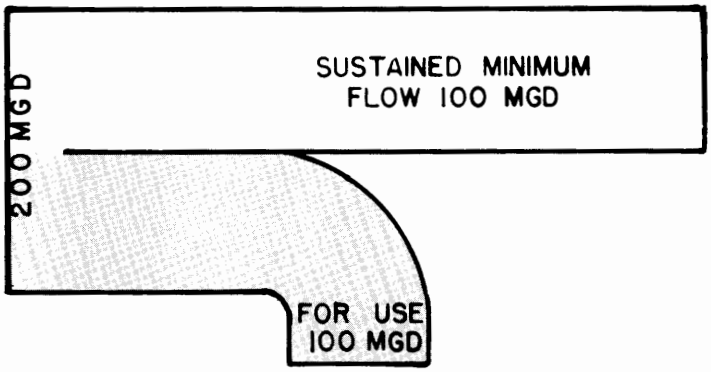
NOW - NO RESERVOIR



WITH SPRUCE RUN RESERVOIR - 10 BG

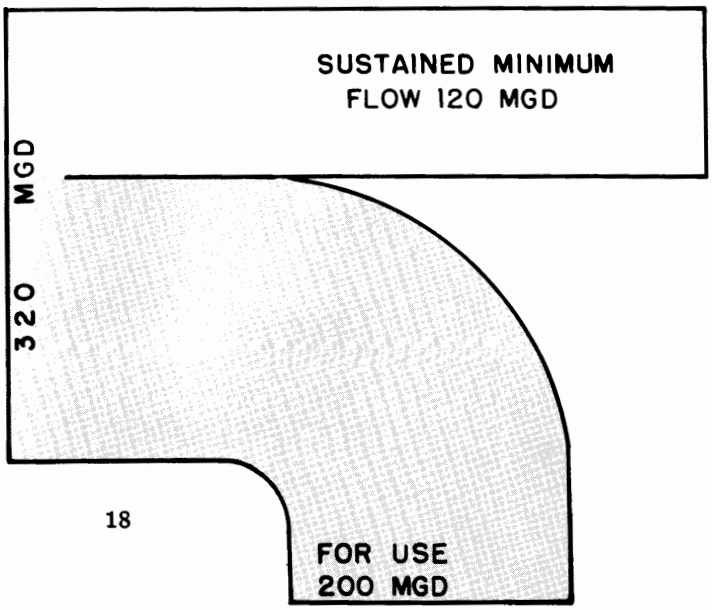


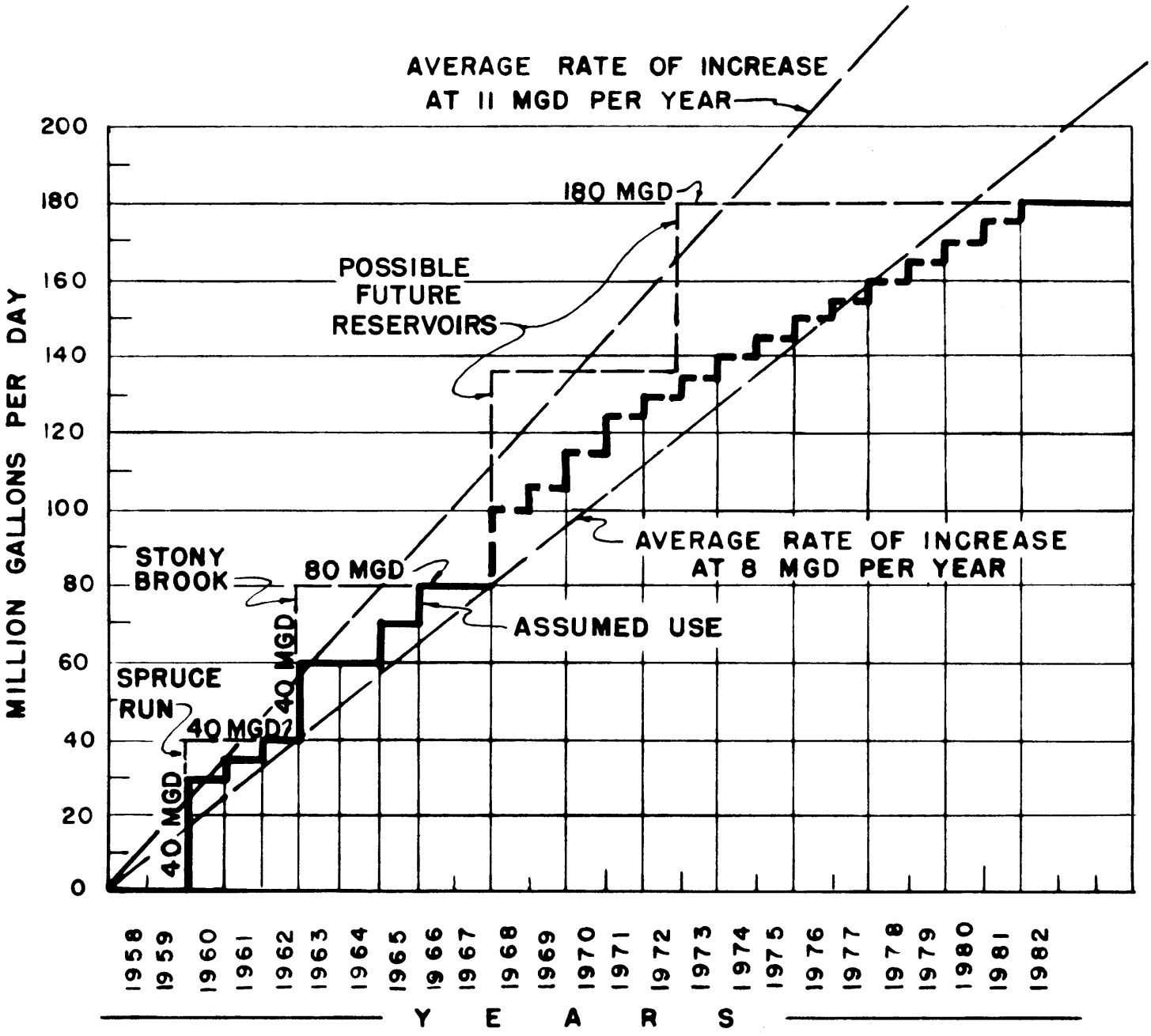
WITH SPRUCE RUN AND STONY BROOK RESERVOIRS - 20 BG



WITH POSSIBLE FUTURE RESERVOIRS

WITH SPRUCE RUN, STONY BROOK AND POSSIBLE FUTURE RESERVOIRS - 50 BG





PROJECTED WATER DEMAND

at the confluence of the Raritan and Millstone Rivers, and 180 mgd of new water supply in addition to the 20 mgd already allocated; a total of 320 mgd at the juncture of the rivers even if the worst drought on record (1930) should happen again.

A North Branch Reservoir appears, from a water supply point of view, to be the most desirable on-river reservoir to provide the full 30 billion-gallon capacity at one site. This reservoir area, located four miles northwest of Somerville, is backed up by a large drainage area of 174 square miles. It would provide a lake of 5,400 acres, 55 feet in depth near the dam at a water level 120 feet above sea level.

The practicability of the North Branch Reservoir came into question when recent real estate appraisals indicated that the cost of the property had appreciably increased over the 1955 estimates. This added cost for land would increase the interest charges during the next 7-10 years without any compensating revenue. This would result in an undesirable increase in the price of water.

As an alternative to construction of one large reservoir of 30 B.G. capacity, such as North Branch, it is possible to build three on-river reservoirs each of about 10 B.G. capacity in order to provide the additional 30 B.G. for realizing the potential of the Raritan. There are four such reservoir sites, in addition to Spruce Run and Stony Brook.

Recommendations concerning future reservoirs will be made after more complete engineering, financial and real estate data are developed.

Conclusion No. 7

The Round Valley project using water solely from the Delaware River can readily be built in stages. A logical first stage would be the construction of a 30 billion gallon (B.G.) reservoir, 13.4 miles of 96-inch pipe line and a 240 mgd pumping station on the Delaware River at a cost, at today's prices, of approximately $33 million. Such a project would develop a safe yield of 120 mgd. In addition, the State would have to pay its share of the cost of a reservoir on the Delaware River to provide compensating water.

A second stage in development could be the raising of the capacity of the Round Valley Reservoir from 30 B.G. to 50 B.G. and increasing the pumping station capacity from 240 mgd to 300 mgd without laying another pipe line between Round Valley and the Delaware River. This second stage would develop another 50 mgd for a total of 170 mgd.

The third and final stage would involve raising the Found Valley Reservoir from 50 B.G. capacity to its maximum capacity of 70 B.G., laying a second pipe line between Round Valley and the Delaware River and increasing the capacity of the pumping station on the Delaware River above Frenchtown to about 600 mgd. This development would provide another 130 mgd for a total of 300 mgd.

Conclusion No. 8

If Delaware River water were not available soon enough to meet the need, and if it were determined to be necessary or desirable to use Raritan Valley water for the Round Valley Reservoir, this could be accomplished as follows:

The first stage in filling the Round Valley Reservoir could logically be divided into two parts—A and B. Stage A would include constructing the reservoir to 30 B.G. capacity, 3.4 miles of transmission mains to Hamden, and a 200 mgd pumping station on the South Branch of the Raritan River at Hamden. This stage A could be constructed at a cost of $21 million. The pumping station at Hamden would pump only the flood waters from the South Branch of the Raritan River during the wet season into Round Valley Reservoir. The safe yield of this project would be 50 mgd per day under maximum drought conditions like that of the period 1930-1934. This capacity of 50 mgd would be in addition to the capacity of Spruce Run Reservoir which would be reserved for the purpose previously stated. No pumping of flood waters at Hamden is contemplated if water is needed at the confluence of the Raritan and Millstone Rivers. Spruce Run Reservoir would be built in advance of any Round Valley project in order to have a sustained minimum flow in the South Branch of the Raritan River during droughts and other low flow periods. By following this procedure no water would have to be released from the Round Valley Reservoir to provide for a sustained minimum flow in the stream. (Stage B) Later, if indicated and when Delaware River water is available, the program outlined in Conclusion No. 7 could be followed by extending the pipe line from Hamden to Frenchtown.

RECOMMENDATIONS

Recommendation No. 1

All the land for two on-river reservoirs, Spruce Run and Stony Brook, should be purchased immediately and the 10 Billion-Gallon Spruce Run Reservoir located about one mile northwest of Clinton should be completed as soon as possible. The stored water in this reservoir would be released during low flow periods so that at all times 40 mgd of additional new raw water supply would be available at the confluence of the Millstone and Raritan Rivers. In addition, this one reservoir will make it possible to maintain a sustained minimum flow of 90 mgd at that point.

Thus the Spruce Run Reservoir will increase minimum stream flows to make available 90 mgd of sustained minimum flow and 40 mgd of new water supply, in addition to the 20 mgd presently allocated to the Elizabethtown Water Company; a total of 150 mgd at the confluence of the Raritan and Millstone Rivers, even if the worst drought on record (1930) should happen again.

The release of water from Spruce Run Reservoir will also substantially increase the low flow in the 32 miles of the South Branch of the Raritan River and of the Raritan River above its confluence with the Millstone River and further increase the flow of the Raritan below that point.

Spruce Run Reservoir has a drainage area of 41 square miles, will provide a lake of 1240 acres, will be 80 feet in depth near the dam, and will have a water level of 277 feet above sea level.

Recommendation No. 2

The 10 Billion Gallon Stony Brook Reservoir, located about two miles west of Princeton, should be constructed two to five years after Spruce Run is completed unless the demand for water indicates that an earlier construction of this reservoir is required.

The Stony Brook Reservoir would have the same capacity as Spruce Run Reservoir and therefore would provide at all times (including drought periods) a minimum of 40 mgd of additional new raw water supply. In addition, the Stony Brook Reservoir will make it possible to raise the sustained minimum flow of 90 mgd to 100 mgd at the confluence of the Millstone and Raritan Rivers.

The two reservoirs, Spruce Run and Stony Brook thus will increase minimum stream flows to make available 100 mgd of sustained minimum flow and 80 mgd of new water supply, in addition to the 20 mgd presently allocated to the Elizabethtown Water Company; a total of 200 mgd at the confluence of the Raritan and Millstone Rivers even if the worst drought on record (1930) should happen again.

The release of water from Stony Brook Reservoir will also substantially increase the low flow in the 27 miles of Stony Brook and the Millstone River between the reservoir and the confluence of the Raritan and Millstone Rivers and further increase the flow of the Raritan below that point.

Stony Brook has a drainage area of 38 square miles, will provide a lake of 1520 acres, will be 70 feet in depth near the dam, and will have a water level of 152 feet above sea level.

Recommendation No. 3

In order to develop an additional 100 mgd in the Raritan River Basin, future reservoir capacity of about 30 billion gallons should be constructed, possibly in stages. At least part of this additional capacity will be needed four to five years after the Stony Brook Reservoir is built, or even earlier if water demands exceed the present projection.

Determination of where the future reservoirs, other than Spruce Run and Stony Brook, should be constructed can be made when detailed data are available. The 30 B.G. capacity can be developed in one large reservoir such as North Branch or by a combination of three on-river reservoirs, each of 10 B.G. capacity. An early decision on future reservoirs should be made so that land can be acquired before its cost becomes excessive.

Recommendation No. 4

These on-river reservoirs, Spruce Run, Stony Brook and others, could be used for recreational purposes, such as fishing, boating, swimming, camping and picnicking. This is practicable because the water from the on-river reservoirs will travel many miles in the stream before it is taken from the stream and then filtered, purified and distributed to the ultimate users of potable water.

The value of the privately owned land on the hills surrounding these reservoirs will be greatly enhanced. Houses could be constructed near the reservoir and have a magnificent view overlooking a large body of water.

Recommendation No. 5

The riparian owners on each side of the 32 miles of the South Branch of the Raritan River and the Raritan River, along 27 miles of Stony Brook and the Millstone River, a total of 118 miles of river banks above the confluence of the Raritan and Millstone Rivers, will, of course, have the right to use the water and return it to the stream undiminished in quantity and quality. This is also true of the eight miles of river bank on each side of the four miles of the Raritan River between the confluence and Five-Mile Dam.

Recommendation No. 6

About 20 mgd of the new water supply to be available at the confluence of the Raritan and Millstone Rivers might be substituted in the future for existing water allocations from the Delaware and Raritan Canal thereby making more canal water available. When all of the water from the canal (approximately 75 mgd) has been allocated, it would be quite economical to lift water from the Raritan and Millstone Rivers, at their confluence near Bound Brook, into the canal to further increase the canal water available to the area downstream.

Recommendation No. 7

Authorization for an expenditure of $14 million should be obtained as soon as possible. On the basis of present estimates, this will permit (1) the purchase of all the land for the two reservoirs and the construction of Spruce Run Reservoir immediately all at a cost of about $9 million and (2) the construction of Stony Brook Reservoir at a cost of about $5 million when needed. Bonds to finance this program should only be sold as funds are required. Since future reservoirs will probably not be needed until sometime after the construction of Spruce Run and Stony Brook, authorization for their construction can be postponed. If all the land for future reservoirs is not purchased within the next few years, the sites may not be available or the cost of acquiring the land might be prohibitive because of inevitable development. The present estimated cost of acquiring land for the two recommended reservoirs is already considerably greater than the 1955 estimate of land acquisition.

Early acquisition of reservoir sites is also desirable to avoid unreasonable hardships to those who might otherwise build homes or improve properties in the areas affected.

Recommendation No. 8

During the hurricane season, August to November, the reservoirs could in emergency be lowered several feet in order to capture as much as possible of the runoff behind the dams and thereby reduce some of the damage from hurricane floods, particularly in the areas immediately downstream from the dams.

Spruce Run and Stony Brook together could have captured about 8% of the volume of the maximum 24-hour flood recorded in August, 1955 at Bound Brook just below the confluence of the Raritan and Millstone Rivers. Water could be released rapidly but at a controlled rate from the reservoirs after the first storm is over so that within a few days the reservoirs might be again lowered to receive the runoff from a second storm.

EXHIBIT E

SUMMARY REPORT ON THE GROUND-WATER RESOURCES OF NEW JERSEY

Beneath the land surface of New Jersey there is a great quantity of water contained in crevices and pore spaces in the bedrock and sand and gravel formations. This volume of water is vastly greater than all the water contained at any particular time in the rivers, lakes and storage reservoirs on the land surface. Water is slowly moving through these natural underground reservoirs from areas where infiltration from rainfall is occurring, to natural outlets such as springs and seeps in the beds of surface streams, to the ocean from aquifers underlying the continental shelf and to points of artificial diversion at wells and filter galleries. Essentially all ground water in New Jersey has its source in precipitation that falls within the State.

There is a pronounced difference between geologic formations as to the amount of water they contain and the rate at which this water can move through these formations and into wells. Although New Jersey contains a great variety of rock types, broad areas of the State are of sufficient similarity in kind of rock and land topography to be characterized as geologic provinces. There are four such regional geologic provinces in the State. These are the Highlands, the Appalachian Valley, the Piedmont Plain and the Atlantic Coastal Plain. The Highlands and the Appalachian Valley are somewhat alike with respect to the occurrence of ground water, and for the purpose of this report they are considered to form a single ground-water province. Therefore, New Jersey's underground water resources can be classified into three major ground-water provinces, the Highlands and Appalachian Valley Province, the Piedmont Plain Province and the Atlantic Coastal Plain Province.

The ground-water province formed by the Highlands and Appalachian Valley contains consolidated rocks that are generally unfavorable for the production of large supplies of ground water, but there is a good possibility that coarse sands and gravels deposited in some of the major valleys by glacial streams would permit local developments of moderate to large size.

The Piedmont Plain Province is underlain chiefly by sandstones and shales and to a minor extent by trap rock. In the northern portion of the province, glacial deposits mantle the surface. Glacial outwash sediments occur in many of the major stream valleys.

The sandstones and shales are moderately productive of ground water. Many of the smaller communities have obtained satisfactory quantities of water by drilling a number of wells in these formations. However, in the Piedmont Plain, the deposits of glacial sand and gravel have the most favorable potential for large new ground-water developments. These deposits have not been carefully mapped, nor have their water-bearing properties been widely studied. It is probable that by geophysical sur-

veys, test drilling and additional geological studies, the courses of the streams that deposited highly permeable sands and gravels can be ascertained and additional well fields developed. It is estimated that an increase in withdrawal of perhaps 25 to 50 million gallons per day may be possible from new wells drilled in the outwash gravels where river infiltration from nearby surface streams can be utilized.

For the purpose of this report the Atlantic Coastal Plain Province has been divided into three ground-water sub-provinces. The eastern portion, designated as the Coastal Area, forms a band in a north-south direction along the ocean from the mouth of the Raritan River to Cape May. The sub-province designated as the Lower Delaware Valley Area forms a narrow belt along the Delaware River below Trenton. The broad area between these two sub-provinces has been designated the Interior Plain.

All of the Atlantic Coastal Plain Province is underlain by layers of sands, gravels, and clays which dip gently to the southeast. The coarser beds in these deposits are very favorable for the storage and movement of ground water. A large percentage of the regional precipitation enters the soil in this province and a considerable part of it is transmitted through the permeable formations to the banks and beds of nearby streams. Not only is there a very large amount of water moving through the formations, but the total quantity stored in the sediments of the Coastal Plain is vast, aggregating many hundreds of billions of gallons.

The Lower Delaware River Valley Area of the Atlantic Coastal Plain Province is a narrow belt one to three miles wide bordering the Delaware River and Delaware Bay, from Trenton to Cape May. Throughout most of this area, the sand and gravel deposits are in direct hydraulic contact with water in the Delaware River. Under the natural conditions that existed before the development of any ground-water supplies, the water table was higher than the river and ground water augmented the flow of the river. Under present-day conditions of pumping, the ground-water gradient has been reversed in a number of places by the drawdown due to pumping, so that induced infiltration of river water now augments the ground-water supply in these areas.

Although river infiltration can take place anywhere in the Lower Delaware Valley where shallow sands and gravels are connected with the river, the development of additional supplies of fresh water along the river will have to be restricted very largely to the area extending upstream from Palmyra. Present development and prior use of river frontage for docks and buildings may prevent further major ground-water development along a segment of several miles in the Camden area. Below Paulsboro the water in the Delaware River is brackish during periods of low flow. Thus, the potential from river infiltration in the valley south of the Camden area is counteracted by the presence of salt water in the river.

Assuming that no more than one-half of the distance from Trenton to Palmyra may be geologically and physically suited for ground-water developments constructed so as to depend in considerable part on infiltration from the Delaware River, it is probable that more than 100 million gallons per day of additional ground water might be developed from the strip of aquifer within a mile of the river.

Excluding the strip near the river where river infiltration can take place, there remains a band only a mile or so in average width in which the Raritan-Magothy formations crop out at the surface in which precipitation is the principal source of recharge. This narrow band constitutes the chief natural intake area for the aquifer. To the southeast of this outcrop zone the aquifer dips beneath shallow clays but can be reached by wells for a number of miles in the down-dip direction. Some additional recharge may be provided by vertical leakage from overlying beds in down-dip areas of the aquifer, and to some extent by infiltration from streams crossing the narrow outcrop area.

Other studies in New Jersey indicate that recharge from precipitation averages about one million gallons per day per square mile in the Atlantic Coastal Plain. This would indicate that there is a total of about 50 mgd that can be withdrawn continuously from that part of the outcrop area of the Raritan-Magothy aquifer lying a mile or more back from the river. One-quarter to one-third of this quantity is probably being withdrawn by existing wells. The remainder, perhaps 25 to 35 mgd, is available for additional development.

Thus, it is believed that from 100 to 150 mgd of additional ground water can be developed in the Lower Delaware Valley Area of the Atlantic Coastal Plain, principally from shallow aquifers bordering the Delaware River between Trenton and Palmyra.

The Coastal Area sub-division of the Atlantic Coastal Plain does not differ geologically from the rest of the Atlantic Coastal Plain. The Coastal Area bears about the same hydrologic relation to the Atlantic Ocean that the Lower Delaware Valley Area bears to the Delaware River. Prior to the withdrawal of ground water from wells along the coast, the level of fresh water in the underground reservoirs was higher than mean sea level, so that the ground-water gradient was toward the ocean and bays. As resort areas and permanent communities developed, groups of wells in many areas caused cones of depression to extend below sea level in places where sea water or brackish water in bays and inlets could replace the fresh water withdrawn. Such conditions have occurred chiefly in the shallow sand and gravel deposits that are not overlain by impermeable material.

Wells in the southern part of the Coastal Area obtain water from relatively shallow depths in the Cohansey formation or from sands of the Kirkwood formation at depths of several hundred feet. In the area from Asbury Park to Perth Amboy, ground water is obtained from geologically older beds.

Because the shallow Cohansey aquifer along the coast of southern New Jersey is quite susceptible to salt-water contamination, additional development of this aquifer near the coast should be undertaken only on a limited scale and withdrawals should be widely spaced and as far from bodies of saline water as possible. Generally, the quantity of water withdrawn should not exceed about one mgd for each square mile of area in which recharge by precipitation can occur.

For the most part, the deeper aquifers form artesian systems with upper confining layers of clay that effectively retard or prevent the direct downward infiltration of sea water into the producing sands. The creation of large cones of depression in these artesian systems beneath bodies of salt water will not ordinarily produce appreciable changes in quality due to infiltration from local surface water. However, highly mineralized water, which already occurs in the down-dip portions of most of the Coastal Plain aquifers, may be near enough to centers of withdrawal along the coast to invade the well fields. Therefore, in most areas of present withdrawal from the deeper aquifers along the coast, very little additional development can be made without ultimately causing salt water to move into the well fields. However, new developments of moderate size can probably be made in the deeper aquifers if the wells are properly located with respect to existing developments. As in the shallower aquifers, new wells should be spaced over a broad area and as far from the shore as practicable.

The Interior Plain Area of the Atlantic Coastal Plain, New Jersey's largest and best ground-water region, lies essentially undeveloped and unchanged from its original natural condition. It comprises an area of roughly 2,000 square miles. Nearly all of the Interior Plain is underlain by sand, principally the Cohansey formation.

Essentially all of the more than 2,000 square miles of outcrop of this one formation alone is an area of very high infiltration capacity. For the magnitude of water in storage, the availability and directness of recharge and for the ease and economy with which large quantities of water may be withdrawn, this formation has no equal in northeastern United States. Properly constructed large diameter wells, perhaps 100 to 200 feet deep, may be expected to have yields averaging 500 to 1,000 gallons per minute or more.

If completely utilized, the Cohansey aquifer would probably sustain a development of perhaps two billion gallons per day—the equivalent of a million gallons of infiltration per day for each square mile of outcrop.

All of the Coastal Plain aquifers that crop out in the western part of the Atlantic Coastal Plain underlie the Cohansey sand in the Interior Plain. The Kirkwood occurs just beneath the Cohansey and in places may be economically important for water supply even where the Cohansey would receive first choice in development. Generally, none of the aquifers that underlie the Cohansey sand in the Interior Plain

will receive much development as long as the more favorable potential of the Cohansey remains available. The water-bearing characteristics of the deeper aquifers are not well known, although there is evidence that they thicken to the southeast in the down-dip direction.

Probably the most feasible method of developing the vast quantity of available water in the Interior Plain is to construct ground-water installations along major streams so that river water is caused to infiltrate into nearby wells, horizontal collectors or infiltration galleries.

The records show that the dry-weather flow of the Mullica River in the State-owned Wharton Tract is not less than about 90 mgd. If it can be shown by pumping tests, as is now believed to be the case, that the aquifer adjacent to the stream is in direct hydraulic connection with the stream, a closely-spaced line of wells installed along the lower reaches of the Mullica River in the Wharton Tract could produce a dependable supply of up to 90 mgd. Such a development would obtain essentially the same water that would be pumped from individual wells spaced one to each square mile throughout 90 square miles of drainage area of this stream.

By inducing river infiltration from the Wading River in the eastern part of Wharton Tract in the same manner as just described for the Mullica watershed, an additional supply of ground water of approximately 40 mgd would appear to be feasible for development to supply the southern New Jersey coastal area.

The development of additional ground water within the Atlantic Coastal Plain Province need not be restricted to large, centralized projects, such as considered in the Wharton Tract. Many smaller developments suitable for industrial and community needs can be generally be obtained throughout South Jersey, except in some border areas where salt-water encroachment is a problem, as previously noted.

It is thus apparent that from the standpoint of the quantity of ground water available in South Jersey, there is no present shortage of the overall resource nor will there be for many years in the future. The major water problems in this region of the State are those that relate to quality of water, chiefly contamination by salt water along the Lower Delaware River Valley and along the Atlantic Coast.

Much more serious is the problem of obtaining large additional supplies of water in north-central and north-eastern New Jersey, principally in the New Jersey portions of the New York Metropolitan area. This area, a part of the Piedmont Plain Province, is not favorable for the development of additional large ground-water supplies except where outwash sands and gravels occur in some of the stream valleys. The bedrock formations will yield additional supplies of moderate size but such developments will have to be dispersed, and some parts of the area have probably already attained maximum development. Additional ground-water supplies in

northern New Jersey, in the Highland and Appalachian Valley Provinces, are quite limited, with the possible exception of some sand and gravel deposits in a few of the major stream valleys.

The most urgent ground-water problems in New Jersey occur in the Piedmont Plain in the counties near New York City where there is need for additional water, and in the Camden and Atlantic City areas of the Atlantic Coastal Plain, where the quality of water rather than quantity is the chief concern. These areas should receive first priority for the necessary geologic and ground-water studies that are required to permit maximum development of the local supplies, consistent with long-term dependability. A highly important but less urgent need is to undertake ground-water studies in those parts of the State where there will be an increase in demand in the near future and where the potential for additional ground-water supplies appears favorable. It should be recognized that a sound evaluation of the ground-water resources of any area must be based on an understanding of natural long-term variations in the sources of recharge, changes in natural storage, and other factors involving seasonal or annual conditions. In general, the longer the record of hydrologic data, the more significant a study of the resource will be. It should be noted that funds available for hydrologic studies are of greater value if spread over a period of years than if the same total amount is applied to a short-term investigation. Foresight must be exercised in the early recognition of future problems so that studies may be initiated well in advance of the development stage.

The following recommendations are made for a program of ground-water studies in New Jersey.

1. Provide for detailed county-wide investigations and reports on the ground-water resources of the eastern half of the Piedmont Plain Province, starting with those counties near New York City. Special attention should be given to the mapping and testing of glacial-outwash sands and gravels if such deposits are present in the major stream valleys.

2. Enlarge the network of ground-water observation wells in the Lower Delaware River Valley Area, particularly from Palmyra to Deepwater Point, and make periodic inventories of the water withdrawn from all public water-supply, industrial and irrigation wells. Particular emphasis should be given to determining any changes in the quality of water in observation wells bordering the Delaware River.

3. Enlarge the program of sampling water from wells for salinity determination in the Atlantic City area and other Coastal Areas with similar problems.

4. Undertake detailed ground-water studies in the Interior Plain of South Jersey for the purpose of determining the ground-water supply potential of the several sand and gravel aquifers. Although the Wharton Tract is of great interest

as a future source of water for large South Jersey municipalities, attention should also be given to other parts of the Interior Plain where moderate to large supplies can be developed near to areas of demand.

5. Provide for ultimate state-wide coverage of New Jersey by reconnaissance-type county investigations and reports that should include an inventory of existing wells, the identification of the principal aquifers, the establishment of permanent observation wells and inventories of ground-water use.

LEGGETTE, BRASHEARS & GRAHAM

/s/ R. M. Leggette

R. M. Leggette

April 9, 1957