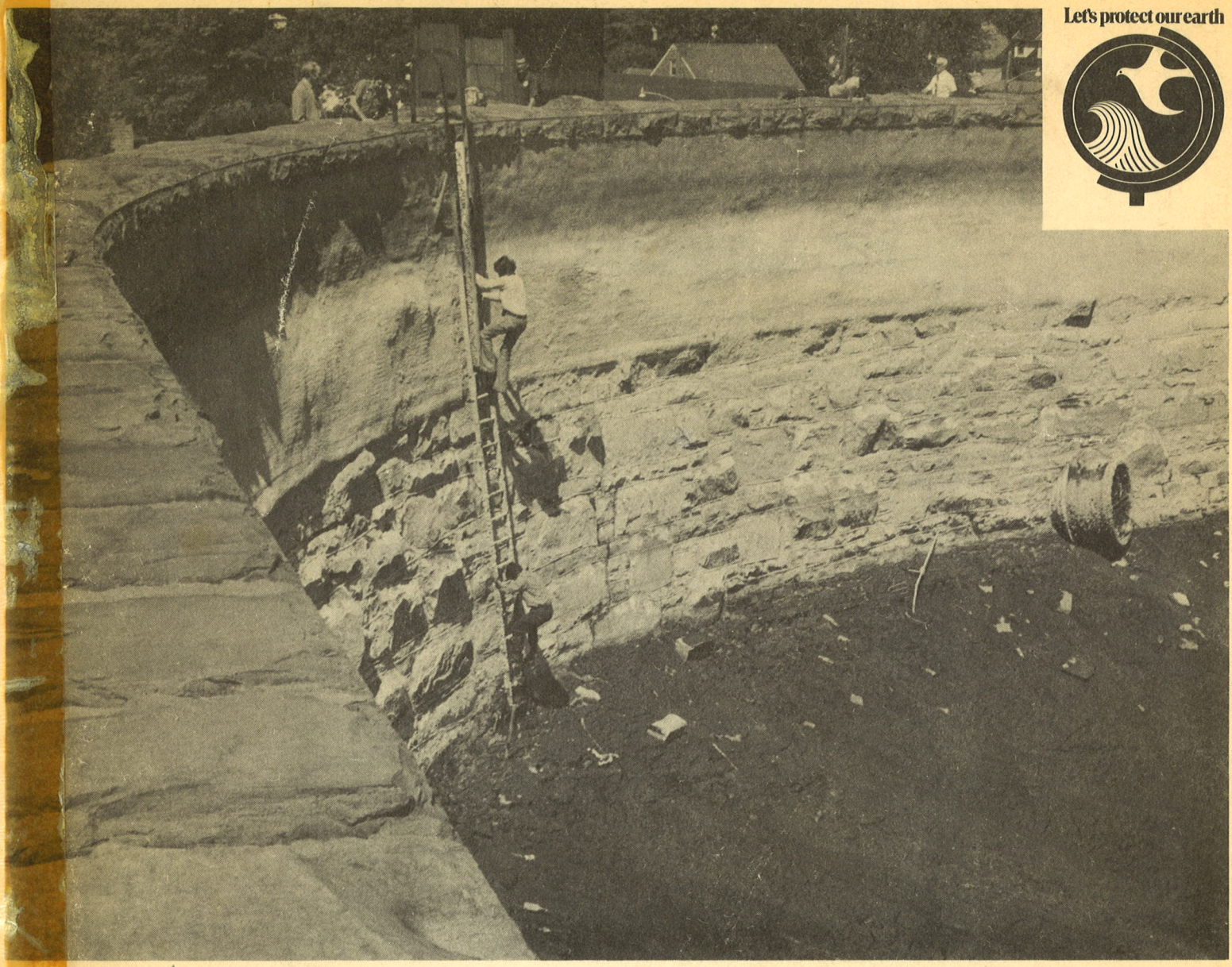


Let's protect our earth

REPORT ON THE

ENTON WATER CRISIS

RSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

MAY 1976

TC
224
.N5
N48
1976

BRENDAN BYRNE
GOVERNOR

DAVID J. BARDIN
COMMISSIONER

2) REPORT ON THE

TRENTON WATER CRISIS

1) NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Brendan Byrne
Governor

David J. Bardin
Commissioner

Board of Experts:

Samuel S. Baxter
(Chairman)
Charles P. Cella
John G. Copley
David F. Hansen

Advisory Panel:

Henry Fagin
Dr. Owen P. Hall, Jr.
William K. Jones
Robert V. Phillips
Herman G. Roseman
Harry C. Ways

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DAVID J. BARDIN, COMMISSIONER
P. O. BOX 1390
TRENTON, N. J. 08625
609-292-2885

To the Honorable Brendan T. Byrne,
Governor of the State of New Jersey

Between Sunday, August 31 and Monday, September 8, 1975, the City of Trenton and adjacent portions of Ewing, Hamilton and Lawrence Townships suffered an unparalleled failure of water utility service. Cascading events, involving human error, equipment failure and design vulnerability knocked out Trenton's water filtration plant on the Delaware River, the sole source of supply for the water utility system owned by the City of Trenton. Over two hundred thousand residents of the City and the adjacent Townships depend on that water utility.

The Trenton water utility had no interconnections with neighboring water systems. Members of volunteer and city fire companies valiantly laid down canvas hose interconnections with nearby purveyors. Responding immediately to the Mayor of Trenton's request on September 2, you activated the full Civil Defense network. State, county and local governments joined with the purveyors to augment the flow, replacing the hoses with emergency, above-ground steel pipelines stockpiled by the federal government for civilian defense purposes. Emergency municipal proclamations drastically curtailed industrial and non-essential personal consumption.

These efforts all helped stretch out the available water supplies, yet the Trenton reservoir ran dry. Pressure fell throughout most of the distribution pipeline network; the flow of water to most faucets ceased. The drought lasted several days for many customers at the higher elevations of the service area.

Restored pumping began Friday, September 5 and all customers had water again by September 8. Until September 10, however, my Department continued to direct residents to boil or chemically treat water for personal use because of fear of contamination.

Structural damage incapacitated half the filtration capacity until completion of repairs on March 8, 1976. In the meantime, Trenton laid permanent, underground interconnections which could in the aggregate supply almost a quarter of Trenton's average daily needs in case of another failure. Trenton also made other investments to improve plant reliability and to perform needed maintenance.

Once service had been restored, you directed me to investigate the circumstances of and draw lessons from the Trenton water emergency. This emergency had unusual technical ramifications. I appointed a four-member Board of Experts which carried the burden of the investigative efforts, and a six-member Advisory Panel which helped me review the Board's findings. The Board of Experts' collective experience covers

Gift

135974
ROBERT W. VAN HOUTEN LIBRARY
NEW JERSEY INSTITUTE OF TECHNOLOGY

water and other utility operations, water engineering, publicly-owned and investor-owned utility management, municipal administration, and emergency operations. The Advisory Panel provided perspectives in water utility engineering and management, automatic controls, law and public utility regulation, utility economics, and political science.

The Board of Experts undertook to determine the causes and consequences of the water utility failure and offer their advice for improving the system and its operations so as to reduce the likelihood of another failure. Specifically, my charge to the Board was:

(1) determine the actual events, the causes and consequences of the emergency, and the actions taken in response to it;

(2) review the design of the plant, the condition of the equipment, and the recruitment, training and experience of plant personnel at all levels;

(3) review the operating and financial records pertinent to the Trenton water utility, including future capital projects, operating expenses, pay scales, rates charged to customers, and budget policies;

(4) review the operating procedures of the Trenton water utility, including maintenance and replacement schedules, and planning for emergencies;

(5) review the organization of the Trenton water utility as a municipal department in comparison to other possible forms of public utility organization;

(6) draw conclusions and make recommendations with respect to all of the above items, bearing in mind that I would particularly value views as to the appropriate roles and responsibilities of state government, the utility ownership, the system operator and the local governments throughout the service area.

The Board filed a unanimous report, which I hereby transmit together with the comments of the Advisory Panel members and my own conclusions and recommendations.

Faithfully,

David J. Bardin

David J. Bardin
Commissioner

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The following reports and appendices reflect the individual and collective efforts of many people. The officials of the City of Trenton, its waterworks and other affected jurisdictions, and Trenton's present consulting engineer cooperated fully in the investigation. Members of the Board of Experts and Advisory Panel have all contributed generously and candidly to these analyses.

Recognition is due particularly to Mr. Samuel S. Baxter, the Chairman of the Board of Experts, whose readiness to carry out that demanding assignment exemplifies the spirit of public service which dominates his distinguished careers. Acknowledgement is also due to Deputy Commissioner Rocco Ricci, Assistant Commissioner Betty Wilson, Dennis Helms, George Hampton, John Wilford, Michael Galley, Kemble Widmer, John Kremper, John Olschewski, Frank Daly and Victoria Posluszny, without whose help the following materials could not have been completed.

All views expressed, of course, are the responsibility of their indicated authors.

COMMISSIONER'S
REPORT

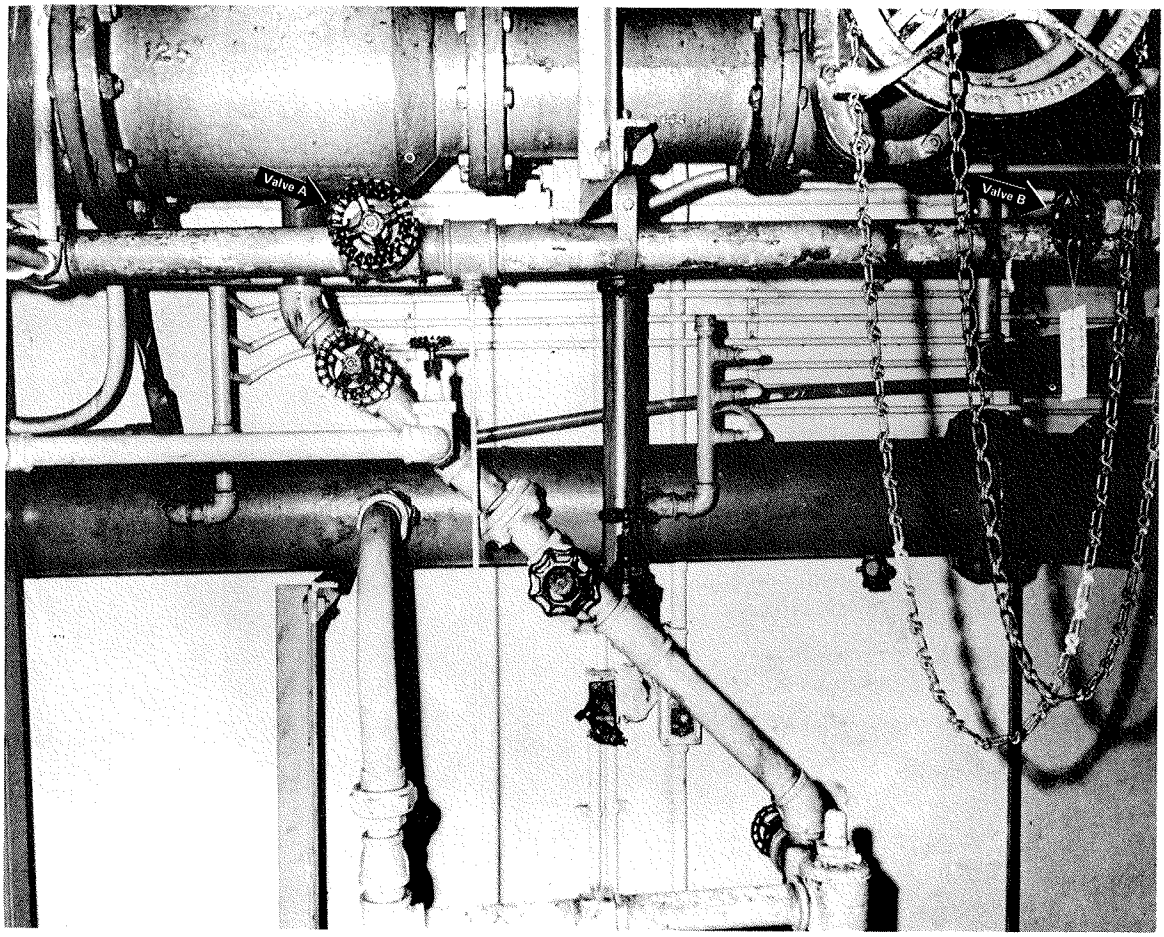
Introduction

Urbanized and suburbanized life depends upon water utility service. Competent water utility management delivers adequate and reliable service, making reasonable provisions for emergencies. The Trenton water utility let its customers down. Trenton's water emergency endangered public health, disrupted the area economy and burdened the taxpayers. It need not have occurred. More important, decisive responses can reduce the risk of similar emergencies in Trenton and elsewhere.

What happened?

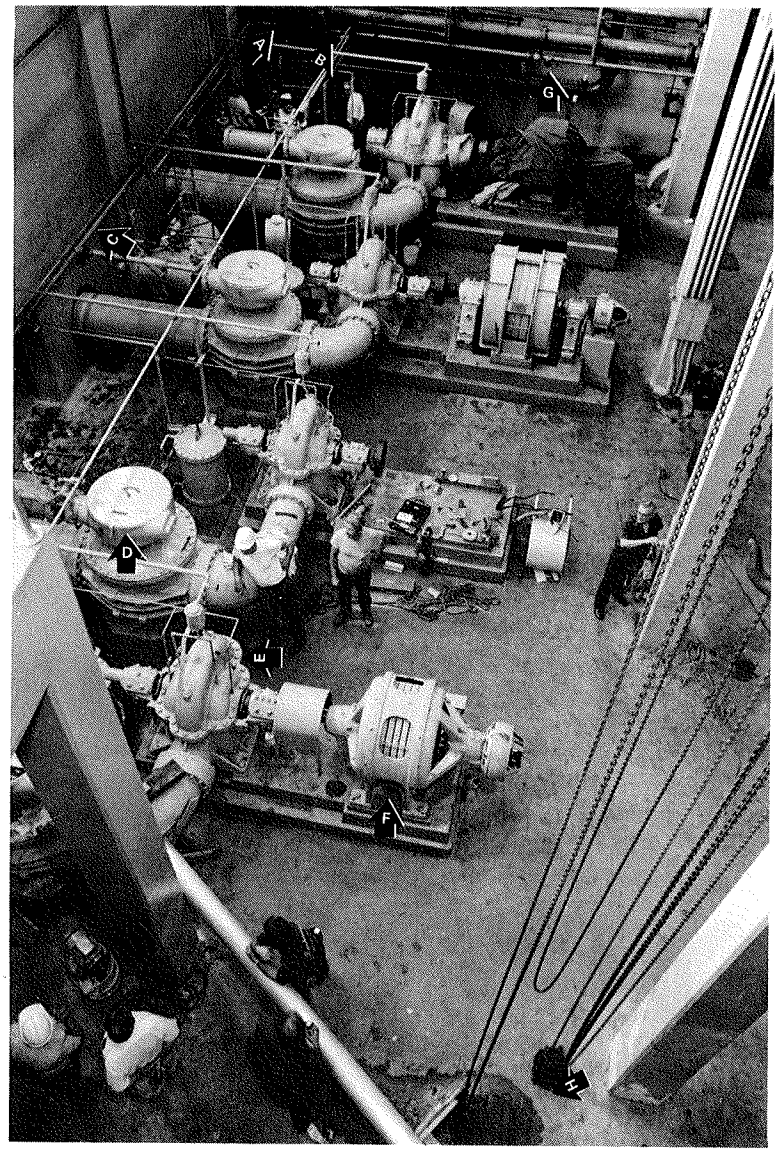
A cascade of events triggered the failure of the Trenton water system on Labor Day Weekend, 1975. Inadequacies of personnel, system design and maintenance led to the failure of utility service and to problems in emergency response and in restoration of service. Trenton was slow to recognize the magnitude of the emergency and unprepared to marshall the technical and construction efforts needed to overcome it.

The Trenton water system (like most surface water systems) depends on a single source, the filtration plant. The utility had planned no emergency interconnections. The location, design and maintenance of pump control systems made the entire water supply needlessly vulnerable to operating personnel errors. It was a case of an accident just waiting to happen.



The Beginning of the Trenton Water Crisis

On Sunday, August 31, 1975, the mistaken turning of the general supply valve (marked A) instead of the supply valve for pump number 4 (marked B) probably triggered cascading equipment failures which caused the Trenton Water Crisis.



The Pump Room

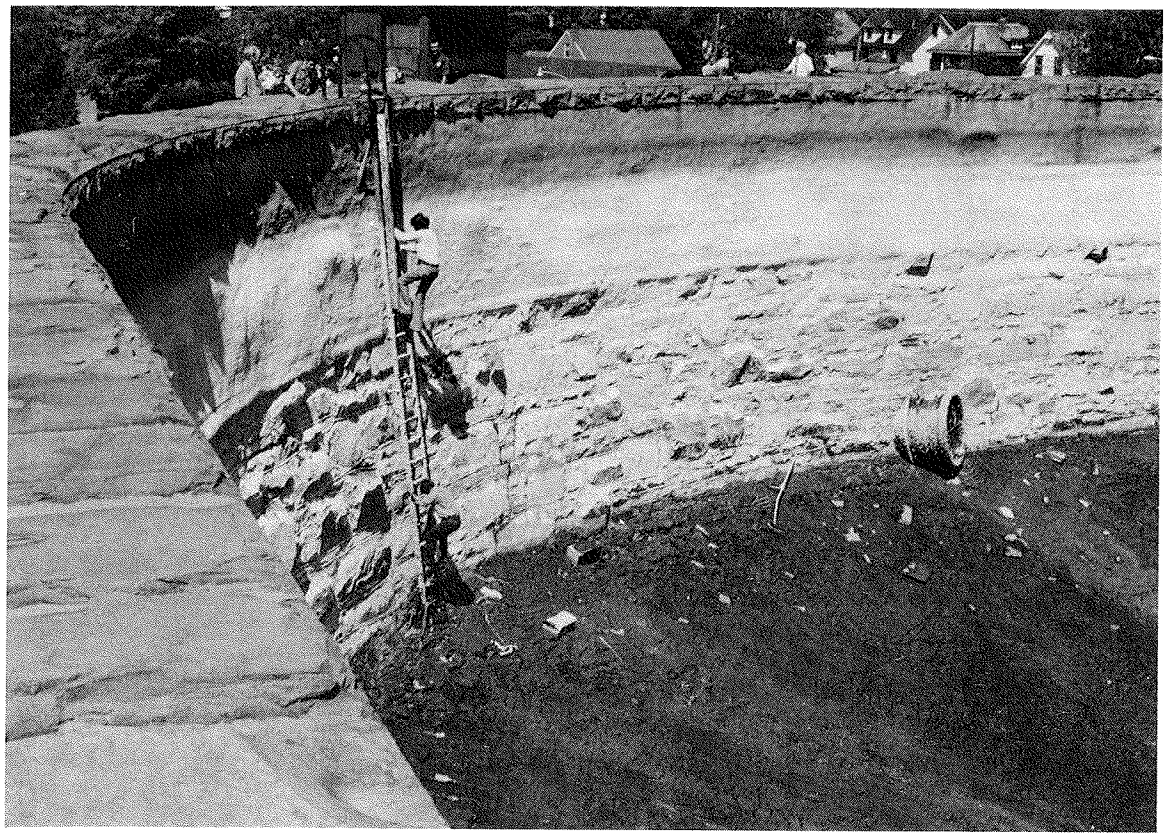
The below-ground pump room encloses four high lift pumps, their cone valves and their motors. In descending order are high lift pumps #4, #3, #2, #1.

The arrows indicate:

(A) General supply valve for pumps #1, #2, and #3
(B) Supply valve for pump #4 only
(C) 2 1/2 inch supply line for pumps #1, #2, #3
(D) Typical cone valve
(E) Typical high lift pump
(F) Typical high lift pump motor
(G) Master supply valve for pumps #1, #2, #3 and #4
(H) Ruptured floor

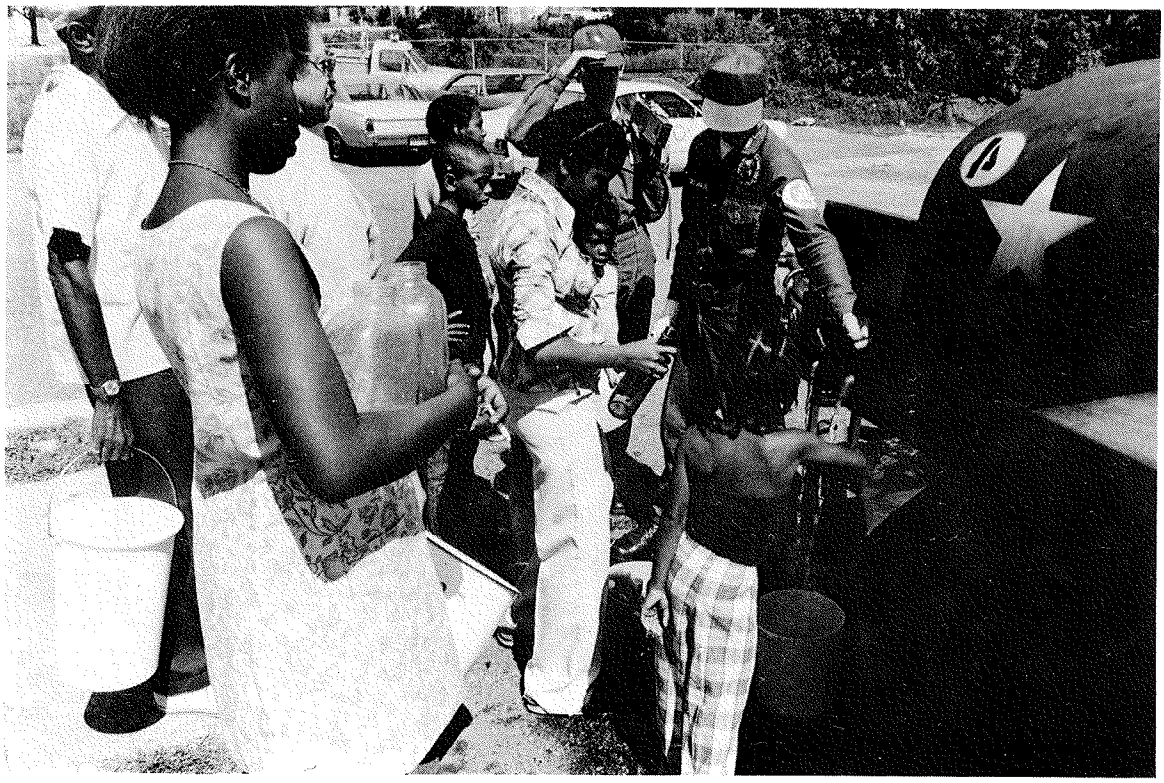
With the cone valves only partially closed, water rushed back from the reservoir through the cone valves and pumps, turned motors in reverse, filled the clear wells under the concrete floor, ruptured the floor and flooded the pump room to a height of 12 feet.

The picture was taken after flood waters were pumped out and three of the four motors were baked dry and replaced.



Nearly Dry Reservoir, Wednesday, September 3, 1975

While the high lift pumps were out of operation, the water level in the reservoir fell rapidly. Normally the reservoir would contain about 90 million gallons of water, which is approximately a three day supply. At the time of the failure, daily consumption was about 30 million gallons a day.



Water Delivery by Truck

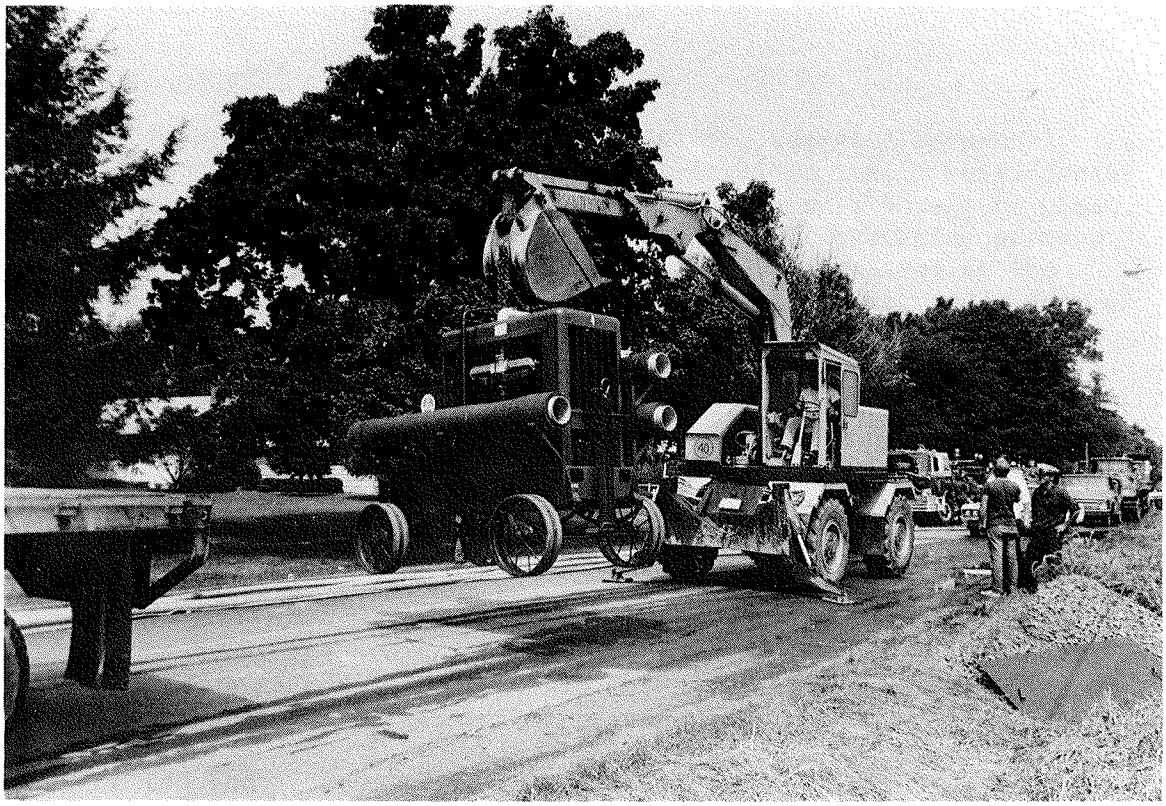
Almost all customers lost service at some point during the crisis; residents at the highest elevations of the water delivery system did not receive tap water for several days. Water had to be carted by truck throughout the service area, an operation coordinated by Civil Defense. During the crisis the mayors issued emergency orders restricting water to essential purposes. Still the water supply dwindled.

Fire Truck "Lifeline" Brigade

Four water emergency "lifelines" were established by more than 150 volunteer and municipal fire companies, with fire trucks spaced 700 feet apart and pumping water at the rate of 1,000 gallons per minute. A 2.5 mile long series of trucks and hoses organized by Rudy Fuessel of the Slackwood Volunteer Fire Company connected the hydrants of Lawrence Township and Princeton via the Princeton Pike. However, the "lifeline operations" only provided a small fraction of the demand of the Trenton System users.

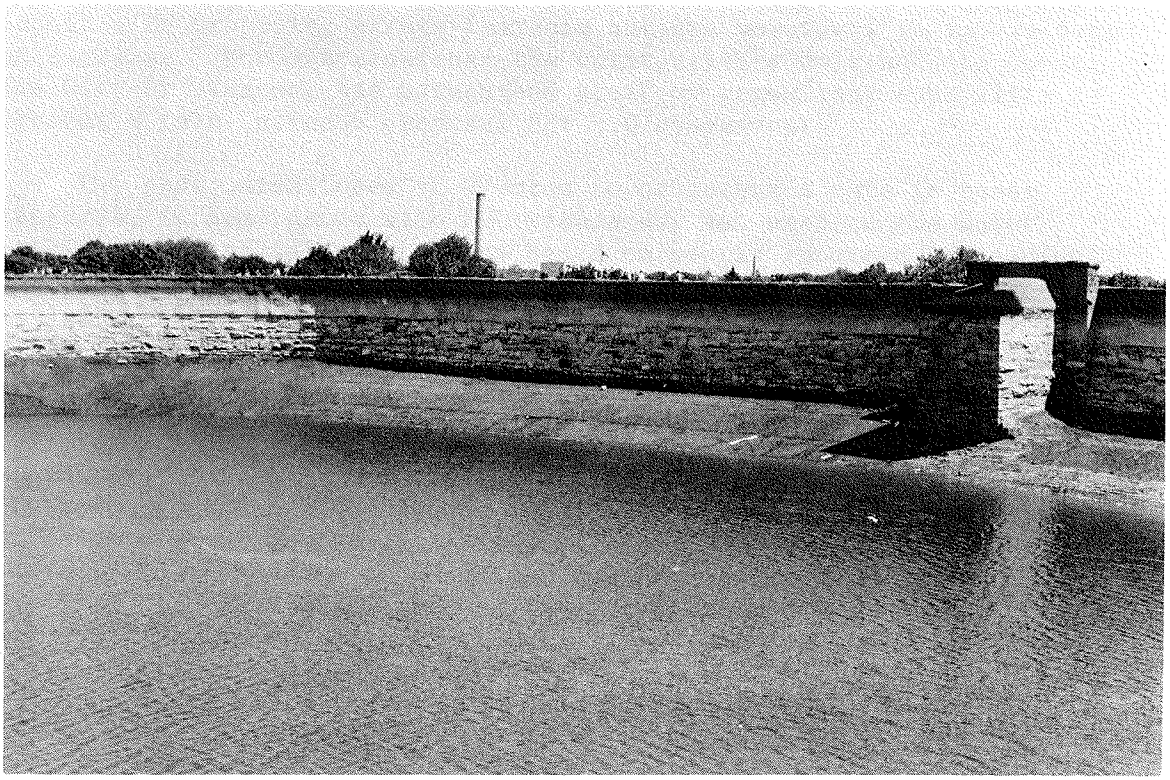
Governor Byrne Inspects Emergency Pipeline

Immediately upon request of Trenton's Mayor, Governor Byrne ordered a State of Emergency on September 2, 1975. On Wednesday, September 3, he placed Commissioner Bardin in charge of emergency water supply efforts. The Department of Environmental Protection ordered all tap water to be boiled or chemically treated and spearheaded the laying of emergency pipeline interconnections to replace the fire hoses and augment the water supply.



Installation of the "Twin Pipeline" along Princeton Pike

Around-the-clock, non-stop efforts from Thursday, September 4 through Saturday, September 6, connected Trenton's system by several above-ground pipelines to the systems of Elizabethtown Water Company (Princeton), Garden State Water Company (Hamilton Square), the City of Bordentown and the City of Morrisville (Pennsylvania). These interconnections resulted from the coordinated efforts of the various units of Civil Defense and Disaster Control, the State Departments of Transportation and Environmental Protection, the affected municipalities, other water purveyors, and in cooperation with volunteers from all parts of New Jersey and Pennsylvania.



Return of Water to the System

After nine days (August 31 - September 8) filtration plant pumps were back in operation and water was being delivered throughout the system. All structural damage was not repaired until March 8, 1976; full filtration plant capacity (essential for peak use in summer) was restored in April, 1976.

Why did it happen?

The Trenton water utility has not employed adequate personnel, its governing body (mayor and council) has not involved itself sufficiently in water utility matters, and the revenue requirements have gone unmet. The Board of Experts found insufficient training of operating personnel, an absence of emergency plans, a lack of proper maintenance at the plant, insufficient funding for maintenance and training, and a lack of understanding of the factors which are essential to the efficient and reliable operation of a water utility. These factors include:

(1) A governing body dedicated to the provision of high quality water service which uses sufficient oversight to achieve such service.

(2) Personnel at all levels who are experienced, properly trained, adequately paid, and selected for ability and knowledge.

(3) A financial program and rate structure which provide the funds needed to operate and maintain the system properly and to provide for extensions and renewals.

The Trenton water utility is a distinct organizational unit within one of the City departments. It has no separate corporate structure with revenue raising powers of its own (either through taxation or through rate change). It does not even have direct access in practice to the nominal governing body, the City Council and the Mayor. On the other hand, rate increases to out of town customers are subject to utility type regulation by the State Public Utilities Commission under the N.J.S.A. 40:62-85.1. The municipal political processes are indispensible to proposing a rate increase but are powerless to impose such an increase. Moreover, neither the water utility unit nor its owner, the City of Trenton, has maintained staff or consultant capability to present a rate increase proposal for PUC assessment.

The past unreadiness of Trenton to prosecute a rate increase proposal, in accordance with PUC standards, has exposed the water utility to financial constraints based on poorly informed bargaining between the owner, City of Trenton, whose residents consume about one-half the water, and the three other municipalities served by the system.

Conclusions

The Trenton experience demonstrates that at least one water utility in the State did not have an adequate program for assessing the reliability of its design, operations and maintenance nor did it recognize the risks of doing without emergency interconnections. Moreover, neither the State's Division of Water Resources in DEP nor the State PUC has been assigned clear cut statutory, not to mention budgetary, responsibility for auditing the reliability of water supply systems in the State.

The State has not conducted an effective program to persuade the utilities to interconnect to individual sources of supply of a utility or among several utilities, much less to compel them to do so. The

State does not have a current program to plan emergency interconnections. The new State Water Supply Master Plan proposal will include such planning to reduce risks in limited source service areas. It will also provide a basis for emergency, contingency and conservation programs.

Above all, the experience raises the question: How much reliability should the public -- residential and industrial water users -- reasonably demand and be prepared to pay for? The public need not accept the risk of recurring threats of loss of its water supply. It is a State responsiblity to recommend changes and oversee implementation of the recommendations and plans for the future.

RECOMMENDATIONS

1. Trenton Water System

(a) Governing Body

The Trenton water utility should be governed so as to carry out the utility obligation to provide safe, adequate and reliable water service. The governing body should include persons skilled in exercising financial and management responsiblity. The utility governing body should be separate from the elected officials who serve the general needs of the community.

The governing body should set policy. It should acquaint itself with the problems of water supply operations including a careful review of the annual budget, operating results and system reliability. It should demand from the chief water utility executive an accounting for the adequacy of the facilities, their maintenance and operation. It should authorize and review the recommendations of outside consultants to the water utility and should have the right to special consultant reports.

(b) Personnel Resources

The Trenton water utility should have a full time chief executive accountable directly to the appropriate governing body. The chief executive may be employed either by the water utility or by an outside firm retained to manage the water utility.

The water utility should revise personnel practices for selection, training and supervision of technical and management personnel at all levels. A thorough management audit should guide the specific reforms.

In addition, the Trenton water utility should retain outside consulting services on a regular basis. Such consultants should periodically assess operating and maintenance practices, personnel training, condition of facilities and plant design in light of progress in water supply technology. In addition, consultants should be available to solve special problems beyond the capability of permanent personnel.

(c) Facilities

The Trenton water utility should comprehensively reassess the design of its facilities, including the adequacy of its present emergency interconnections and the wisdom of a much larger permanent interconnection with Elizabethtown Water Company.

Other recommendations of the Advisory Panel have been considered by the Trenton water utility and its consultants. With the exception of the suggestion to provide an overflow from the clear well which is considered impractical, work has been completed or is in progress to improve reliability of the system.

(d) Water Utility Finance

The Trenton water utility should prepare and publish annual and multi-year operating and capital budgets which reflect the full maintenance and replacement needs of the system and allow for strengthening the system over a reasonable period of time. The water utility should develop a rate structure that will meet the foreseeable revenue requirements. The full estimate of revenue requirements should be presented to the public and to any required regulatory body. The water utility should distribute determinations of the regulatory body, after adjudication or informal procedures, together with explanations understandable to the general public.

(e) Water Utility Organization

The City of Trenton should immediately evaluate the organization and ownership of the water utility and would do well to consult the views of neighboring municipalities in the region. The final form selected may involve an investor owned utility, a municipal authority, a county-regional authority or a multi-municipal authority. Since Trenton owns the facilities and bears present responsibility for their maintenance and operation, the choice belongs legally to the City of Trenton unless the Legislature should withdraw the choice from it.

The Trenton water utility should be organized as a distinct corporate body with utility responsibility for water supply and the wherewithal to meet its revenue requirements. The utility should have accounting integrity and effective managerial responsibility.

If the City wishes to retain ownership of the facilities, they will remain subject to PUC jurisdiction. In that case, Trenton should assign utility responsibility to a municipal authority with the right to seek rate increases from the PUC on its own motion. The City may well wish to reserve the right to be consulted in the interest of its resident-customers and to offer similar consultation rights to the other municipalities in the service area. The City will similarly want to protect its ownership interests through control over appointments and tenure to the municipal authority's governing board.

If the City elects to sell the water facilities to an investor-owned utility, PUC rate regulation over all rates (in Trenton as well as out of town) would follow to strike the reasonable balance between an

interest in low rates and the assurance of necessary funds to provide adequate and reliable service.

If Trenton and its neighbors wish to avoid the costs and delays of Public Utilities Commission regulation, they may join to assign responsibility for the water system to a regional authority. Such an authority might be an existing or new county agency, or a special agency of the municipalities in the service area.

Whether Trenton ultimately chooses an investor owned utility, a county-regional authority or a multi-municipal authority, the City should take the interim step of immediately creating a separate Water Department within City government. A separate department could improve management during the period of time it takes to establish the final choice.

2. Water Utilities -- Generally

(a) Water utilities should review the adequacy and structural design of their systems, maintenance programs, financial structures, management procedures and personnel practices on a regular basis. They should either maintain a specialized review-audit staff or employ outside consultants for that purpose. Audits should include:

1. An assessment of the design features of the facilities in terms of effectiveness, reliability, and obsolescence determined by age or availability of improved technology.

2. An evaluation of operations and maintenance practices including the training and supervision of operating personnel.

3. A review of the adequacy of the facilities replacement and rehabilitation programs, in relation to the supporting financial program.

Top management should review and act upon such periodic analyses.

(b) Water utilities should develop and periodically review emergency response plans to deal with water supply crises. They should evaluate the adequacy of interconnections and emergency storage. In case of breakdown of water supply, the utility should retain whatever outside technical and construction services are necessary to restore service and maintain emergency levels of supply. Water utilities should explore a pooling of resources amongst themselves or through a contracting agency to be prepared to handle emergency demands. There should be formal agreements to assure the availability of such pooling.

3. State and Federal Regulatory Agencies

Primary responsibility for reliability of water supply should continue to rest with the water utilities rather than any regulatory agency. Legislation and adequate budgets should provide for the following:

(a) Regulation of water supply reliability should require regular assessment reporting by each utility on operating practices and facilities design, maintenance, rehabilitation and replacement.

(b) A state regulatory agency should periodically review actual conditions at each utility and should report publicly its conclusions and recommendations.

(c) State or federal regulatory agencies should attempt to develop design criteria and guidelines for facilities, maintenance and operation, which incorporate the current state of technology.

(d) A state regulatory agency should require each water utility to prepare a five year program for rehabilitation and replacement. A state agency should periodically spell out a full assessment of the financial, budgetary and rate structure position of each water utility.

(e) A state regulatory agency should be assigned responsibility to require needed interconnections and to prescribe fair terms and conditions in the absence of a needed agreement among systems.

David J. Bardin
Commissioner

BOARD OF EXPERTS' REPORT

Members of Board of Experts

Samuel S. Baxter (Chairman)

Present - Consultant
Philadelphia, Pa.

Formerly - Commissioner and Chief Engineer, Water Department of the City of Philadelphia
- President, American Society of Civil Engineers
- President, American Water Works Association
- President, American Public Works Association

Charles P. Cella

Present - President, Government Studies and Systems, Inc.
(a subsidiary of Mathematica, Inc., Princeton, N.J.)
Philadelphia, Pa.

Formerly - Director, Research and Consulting Center
Fels Institute of Local and State Government
The Wharton School, University of Pennsylvania

John G. Copley

Present - Chairman, Chemung River Basin Comprehensive Water Resources Planning Board
Elmira, New York

Formerly - General Manager, Elmira Water Board
Elmira, New York
President, American Water Works Association

David F. Hansen

Present - President and Chief Executive Officer
Pennsylvania Gas and Water Company
Wilkes Barre, Pa.

Formerly - Vice President, Minnesota Gas Company

SAMUEL S. BAXTER
CONSULTING ENGINEER
(215) 722-3300
7048 CASTOR AVENUE
PHILADELPHIA, PA. 19149

March 29, 1976

Hon. David J. Bardin
Commissioner - Dept. of Environmental Protection
Labor & Industry Building
John Fitch Plaza
Trenton, New Jersey 08625

Dear Commissioner Bardin:

I am transmitting herewith the report of the Board of Experts for the Investigation of the Trenton Water Crisis which you appointed to review matters related to the incident at the Trenton Water Filtration Plant on August 31, 1975, such a review having been initially requested by a resolution of the New Jersey Assembly.

The Board held hearings on five days at which testimony was taken from a number of persons. It has met at other times for discussion and review of the problem, and has considered the matter through correspondence and telephone calls. It has met once with the Advisory Panel which you appointed, and has considered the written comments from members of this panel, who reviewed the first draft of our report.

When you asked me to chair this Board, I accepted with the direct understanding that the work would not become a "witch hunt". It was agreed that the work would encompass not only the events of August 31 and the days immediately following, but that there would be a review of the board and long range problems of water supply in the Trenton area. We hoped that there might emerge some valuable lessons for other water utilities in New Jersey, and even throughout the country.

While we believe that we have accomplished most of the items included in your charge to us, we did not delve deeply into the overall design of the original plant, except as it directly involved those facilities which were related to the trouble on August 31. We felt that a complete study of the design of the plant, and the listing of shortcomings, would be considered by the consulting engineer who is supervising the expenditure of $800,000 to correct problems in the plant. We subscribe to the thought that excellence in original design is the first step to avoid trouble, and we have noted as one example of poor design, the discharge of overflow from the wet well area to the pump room floor instead of to an area outside the plant.

We have expressed our opinion on the probable specific conditions and events which existed and occurred during a few minutes at approximately 9:50 a.m. on August 31, 1975, and which led to a chain of events which affected all phases of community life in the Trenton area for a week or more. But having reviewed these conditions and events and expressed our opinion about them, we have used our time and experience to delve into the indirect but vital factors which were present, and the causes thereof. In doing this, we have pointed some fingers, expressed our opinion on the operation and management of the Trenton water utility, and made some recommendations for its future.

You have supported us throughout this project, and we express our thanks and appreciation for this support, and especially for your willingness to permit us to have a free hand in our work. We note also, with appreciation, the assistance given to us by Messrs. Ricci and Galley of your department.

We make special note of the contribution to this project of Dennis J. Helms, Esq. who was assigned to us as Counsel by agreement between you and the Attorney General. He has worked long and assiduously in obtaining documents and other information, in examining witnesses who appeared before us, and in preparing the several drafts of this report.

The Board as a group, or through its Chairman, will be glad to present the report publicly in any manner you suggest and to answer questions about our work.

Respectfully submitted,

BOARD OF EXPERTS FOR THE INVESTIGATION
OF THE TRENTON WATER CRISIS

Samuel S. Baxter — John G. Copley
Charles P. Cella, Jr. — David S. Hansen

By: Samuel S. Baxter
Samuel S. Baxter, Chairman

SSB:lea
Encs.

SUMMARY REPORT OF THE BOARD OF EXPERTS ON THE TRENTON WATER CRISIS

The immediate cause of the incident at the Trenton Water Filtration Plant on August 31, 1975 was the failure of the cone valves to operate on certain of the high lift pumps, after power to the pumps had been turned off. The pumps are used to lift water to a reservoir, and the failure of the cone valves to close, after the motors had stopped, resulted in a back flow from the reservoir, through the valves and pumps, which resulted in the flooding of the pumping station. The incident occurred during a routine operation to shut down two pumps which were in operation, and substitute another pump.

The probable cause of the failure of the cone valves to operate (close) was the inadvertent shutting off of flow and pressure in the two and one-half inch hydraulic line which operates the cone valves. The poor arrangement of the interlocking system involving the hydraulic line, the valves on this line, the cone valves, the motors, and the controls, was an important contributing factor.

Indirect factors which were involved were insufficient training of operators, absence of emergency plans, lack of proper maintenance at the plant, insufficient funds for maintenance and training, and the lack of understanding at all levels of supervision and management in the City of Trenton of the factors essential to the efficient operation of a water utility.

Although there have been some recriminations about the way in which the overall emergency was handled, it appears that there was satisfactory response, once the severity of the problem was recognized, by officials of the State, the City of Trenton, and the surrounding townships. There was commendable response also by many private and semi-public groups. The delay of more than 48 hours in declaring a state of emergency was an important shortcoming in this work.

Three factors which should be present in a well-run water utility are: (1) Personnel at all levels who are experienced, properly trained, adequately paid, and selected for ability and knowledge; (2) A governing body or group which is dedicated to the provision of high quality water service and uses sufficient oversight to guarantee such service; and (3) A financial program and rate structure which provide funds needed to properly operate and maintain the system, and provide for extensions and renewals. None of these factors was present at a satisfactory level.

Since more than half of the customers of the Trenton Water Division are in the Townships of Lawrence, Ewing and Hamilton, more efficient mechanisms are needed for intercommunication on all matters pertaining to the Water Division, and especially in the matter of rates. There is evidence that the amount of the last rate increase in 1972 was arrived at by a negotiated reduction of the actual amount needed, and as a result of political expediency. Officials and citizens are both responsible for the present lack of understanding in the matter of rates and

the relations of an adequate rate structure to the proper management and operation of a water utility.

The provision of $800,000 by the City of Trenton, shortly after the incident, will finance the repair of damaged facilities and provide some items of deferred maintenance. This should minimize the possibility of a similar occurrence in the near future, but it is not enough for the long pull.

The Board recommends that the Water Division be immediately given full status as a City Department, with special recognition of the fact that it is the one department of the City which must operate with funds (rates) derived from its own services.

The Board recommends that further study be given to the possibility of an organizational structure which would use one of the following plans: (1) A Commission or Board within the Trenton City government. (2) An independent municipal corporation or authority. (3) A joint municipal authority for the City and the townships. (4) Sale to, or operation by, an investor-owned water utility.

The citizens of Trenton and the townships in the service area must make some hard choices. These are: (1) Trenton and the townships can choose to keep rates as low as possible, defer maintenance and renewals to future generations, and accept service inadequacy, and potential interruptions to service. (2) If Trenton decides to improve the system now and pay for it, and the townships decide otherwise, or if the opposite occurs, there is bound to be legal and political confrontation which will delay action for a long time. (3) If both Trenton and the townships agree to provide adequate service and pay for it now, recognizing that this is needed to improve the economic base of the area, some method of joint control and/or ownership will be necessary.

March 29, 1976

REPORT OF
THE COMMISSIONER'S BOARD OF EXPERTS TO INVESTIGATE
THE TRENTON WATER CRISIS

THE INCIDENT

The Trenton Water Crisis began with an incident which occurred on the morning of August 31, 1975 in the City's filtration plant, located in Trenton immediately up river from the Calhoun Street Bridge between Route 29 and the Delaware River. This plant is part of the Water Division of the City of Trenton's Public Works Department. It has three low lift pumps drawing raw water from the river which, after filtration and treatment, flows into clear wells which are connected by a conduit beneath the pump room floor. Water from the clear wells passes through this conduit and is pumped by four high lift pumps into lines which lead to a reservoir and to the distribution system. The normal flow line on the reservoir is 136 feet above the pump room floor. All seven pumps are on the same pump room floor - the three low lift pumps on the river side of the building, and the four high lift pumps on the street side of the building. The pump room floor is lower than ground level on the street side of the building. Each high lift pump has a cone valve and a suction valve. These valves are hydraulically pressurized by water from a 2 1/2 inch line. On the street side of the high lift pumps, each has a 36 inch gate valve. In addition, there are two 48 inch gate valves outside the plant which, when closed, isolate the plant from the reservoir. Water from the clear wells passes in sequence through the suction valve, the pump, the cone valve, the 36 inch valve, the 48 inch outside valve and thence to the reservoir and distribution system. Each suction valve is operated by a six inch wrench which allows water from the 2 1/2 inch line to activate the mechanism. Each cone valve is operated either by start-stop buttons on the valve or coincidentally by start-stop buttons for the pump on the wall. If the cone valve button is pushed, it will activate the valve only, without affecting the pump motor.

The high lift pumps are numbered 1, 2, 3 and 4 and have rated capacities respectively of 12 million gallons per day ("M.G.D."), 17 M.G.D., 23 M.G.D. and 23 M.G.D. There is evidence that the pumps did not produce their full rated capacities.

Under operating conditions at the time of the incident, only two pumps were required to maintain appropriate operating levels in the reservoir, and under some conditions only one high lift pump was required. The operators on each shift made the decision as to which pumps were required to be working in order to meet operating conditions. Changes were made frequently, and it was in the midst of one of these changes on August 31, at 9:50 a.m. that the incident occurred which precipitated the Trenton water crisis.

Events of August 31, 1975

The following individuals and their respective functions should be noted:

Joseph T. Tuccillo, Jr. — Director of the Department of Public Works of which the Water Division is a part.

Lewis W. Klockner, Jr.	Superintendent and Chief Engineer of the Water Division of the Department of Public Works.
E. C. Bushnell	Superintendent of Filtration and Treatment at the Filtration Plant.
Ralph Coppola	Assistant Chief Pump Station Operator
Richard Irven	Senior Pump Operator
John Gilsdorf	Pump Operator

1. At 0700 the midnight to eight shift changed from using No. 1 and No. 4 high lift pumps to using No. 1 and No. 2 high lift pumps.

2. At 0715 Irven and Gilsdorf arrived early for the eight to four shift, and were told by the shift operator on duty that the reservoir was higher than it needed to be, considering the reduced demand of a holiday weekend.

3. At 0930 Irven and Gilsdorf decided to switch from No. 1 and No. 2 to No. 4 alone. The purpose was to reduce pumpage from a rated 29 M.G.D. to 23 M.G.D.

4. At 0945 Gilsdorf opened the supply valve on 2 1/2 inch line to No. 4.

5. At 0955 Gilsdorf signaled to Irven that the change could be made. Gilsdorf was on the pump room floor while Irven was on the balcony overlooking the pump room floor. This was normal operating procedure since the main pump indicator and pump motor control are located on this balcony. The cone valves, however, cannot be operated from this balcony.

(Hereafter time lapses are unclear.)

6. Gilsdorf pushed the wall stop button on No. 2 and watched the cone valve. (Apparently No. 4 was started at this time but there is conflicting testimony as to who started it.)

7. No. 2 cone valve moved sluggishly to a one-half closed position.

8. Gilsdorf signaled to Irven who directed Gilsdorf to push the cone valve stop button on No. 2.

9. Gilsdorf pushed this button and nothing happened. The cone valve remained stuck at one-half closed position.

10. The timing mechanism shut off No. 2 pump motor.

11. Irven then directed Gilsdorf to close the suction valve.

12. Gilsdorf tried and failed.

13. Water began to flow back through No. 2 pump into clear well.

14. Irven telephoned for assistance and reached Coppola.

15. Irven pushed the stop button on No. 1 cone valve in an effort to close this valve without shutting off the motor. He was also unsuccessful.

16. Irven, now on the pump room floor, then tried to close the suction valve on No. 1. He was also unsuccessful.

17. Ralph Coppola arrived. He noticed the high clear well.

18. No. 1 motor stopped and water began running back through No. 1 pump.

19. No. 4 motor stopped.

20. Irven attempted to restart No. 4. He was unsuccessful. He found that cone valve would not open. (No explanation was discovered as to how it became closed.)

21. Irven attempted to start No. 3. He was unsuccessful.

22. Water began flooding the pump room from the clear well overflow relief vent that, unfortunately, discharged into the pump room by design. Considerable noise accompanied this overflow discharge.

23. Other plant personnel arrived in answer to various calls. Plant electricity was disconnected both inside by Bushnell and outside by Public Service Electric and Gas.

24. Bushnell attempted to close the 36 inch gate valves on the pump discharge header. He was unsuccessful, as too much time was required and the water was getting high.

25. Klockner, after receiving notification at home, ordered crews out to close the two outside 48 inch valves, and he then proceeded to the plant.

26. Sometime after 1300 hours one outside valve had been closed and the other had been partly closed.

27. At some point the ceiling of the clear well conduit, which was also part of the floor of the pump room, ruptured. (This rupture was not discovered until morning of September 1, when firepumpers had reduced the water on the pump room floor from a maximum level of 12 feet down to about 1 1/2 ft.)

28. Sometime in late afternoon the supply valve on the 2 1/2 inch line controlling the hydraulic pressure to the cone and suction valves on No. 1, No. 2 and No. 3 was found closed.

All of the occurrences listed above were obtained from testimony of persons appearing before the Board. Much of this testimony was not clear and some was contradictory. As a result the Board could not accurately determine when many of the actions took place.

The Board further notes that none of the persons appearing before the Board was testifying under oath, and that all had previously testified at a hearing conducted by the City's Director of Public Works.

Causes

It is possible that the faulty operation of the cone valves resulted from a lack of proper maintenance, although there was testimony to the effect that the valves, while in poor condition, should have operated upon the application of adequate pressure.

It is possible that insufficient hydraulic pressure was exerted on the cone valves from the 2 1/2 inch line since one of the general supply valves to the 2 1/2 inch line was later discovered to have been closed. Testimony also exists that this line may have been clogged and that all of the valves on this 2 1/2 inch line leaked excessively. Unfortunately, the accumulator, which was the emergency backup pressure system for this line, had been out of service for several years.

It is possible that one of the pump operators mistakenly closed the general supply valve governing the 2 1/2 inch line to high lift pumps No. 1, No. 2 and No. 3. (No. 4 had a separate supply valve). It is also possible that a third valve controlling water to the entire supply line was closed. The general supply valve for No. 1, No. 2 and No. 3, and the separate valve to No. 4 and the master supply valve to all four are relatively close together. The operators on duty did not check any of these three supply valves. The operators testified that they had been instructed never to touch these valves.

It is not possible for the Board to draw a firm conclusion as to the precise cause of the indicent. We nevertheless feel that it was more likely that the closure of the general supply valve to the 2 1/2 inch supply line governing hydraulic pressure to the valves to high lift pumps No. 1, No. 2 and No. 3 was a more likely cause than the poor maintenance of the cone valves or the debris found in the screens of the 2 1/2 inch line. This closure, when combined with excessive leakage of the cone valve cylinders and the fact that all the cone valves appear to have been partially open at one time, along this 2 1/2 inch line, so reduced the pressure that the valves would not operate.

The Board's preference for the closure theory is supported by the fact that a pump change was made at 7 a.m. that same day without incident. That change required an open supply valve. In addition, there is testimony to the effect that the stature of the operator opening the supply valve for No. 4 high lift was such that he had to stand on the pump to accomplish it and that in such a position it would have been easier for him to reach the general supply valve rather than the supply valve to No. 4 high lift. None of these valves was equipped with name plates indicating their function, or giving any operating instructions.

A more indirect but important cause was the design flaws in the cone valves. Each of these valves had a timing mechanism on the wall control (as opposed to the control located on the valve itself which had no such device). Thus, when the wall control was pushed to stop the motor, the mechanism would activate the cone valve to close and then, 45 to 80 seconds later, shut off the motor regardless of whether the cone valve had actually closed. There was some testimony that once the motor stopped the water flowed back too quickly to restart the motor. There was also other testimony that it takes 2 minutes for flow back to occur. But it is not clear that this procedure was even attempted since, when it occurred to the operators on duty to restart the motor, it was already running in reverse and, therefore, impossible to restart.

Another indirect but essential factor in causing this incident was the fact that the operators were so unqualified in either experience or training that they were unable to cope with an emergency of this kind. This is apparent because they did not make an immediate effort to restart the motor of No. 2 pump. They did not check the supply valves to the 2 1/2 inch line to see if they were open. They did not realize that trying to start No. 3 high lift pump while the others were running backward would make the situation worse and not act to lower the high clear wells. They did not attempt to close the manual 36 inch safety valves on the pump discharge header when the cone and suction valves would not function.

For all of these reasons the Board concludes that so many factors contributed to causing this incident that the selection of one as paramount would be more misleading than helpful. Moreover, the Board concludes that no testimony received by it revealed activities of a criminal nature.

Effects

When the water from the reservoir flowed back into the plant, it ran back through the pumps, spinning the motors in reverse, and then emptied into the conduit connecting the clear wells under the pump room floor. The clear wells filled rapidly and when they were full the water shot out of the clear well overflow relief vent above the conduit from the clear well and began to flood the pump room floor. Thereafter, at an undetermined time, but presumably prior to the closure of the two 48" mains outside the plant, the pressure from the head of the reservoir became too great and the escape through the clear well relief vent inadequate. At this point, the fourteen inch, steel reinforced concrete slab on the pump room floor ruptured. Water from each of the four 750,000 gallon clear wells also escaped into the pump room floor through this rupture.

Needless to say, the flooding of the pump room, to a height at the worst part of the incident of some twelve feet, caused the motors to be soaked beyond on-site repair. This meant that while the water was being pumped out by fire pumpers, riggers had to be brought in. When the water was down low enough, about daylight on Monday, September 1, the rigger began unbolting the motors, lifting them off the pump room floor, out to flat bed trucks for transportation to where they were baked in industrial ovens. One actually had to be rewound.

In the meantime, the City hired a consulting engineer from the firm of Buck, Seifert & Jost to assist in restoring the plant to operation. Under his direction, using fast drying, early strength concrete, the plant personnel with the aid of outside contractors succeeded in isolating the half of the plant containing the ruptured section by Thursday, September 4.

While these repairs were under way the City and surrounding townships had to survive on the water in the reservoir, and the five water towers. On the morning of the 31st, testimony indicates that the reservoir was "27 inches high". That meant it contained approximately ninety million gallons of water. Also, there were 5 million additional gallons of water in the elevated tanks which are part of the reserve supply system. During the average day the system's consumers will draw off somewhere between 30 M.G.D. and 35 M.G.D. Therefore, at the time of the incident the reserve supply system contained approximately 95 million gallons or roughly three days' supply of water. All of this was not available to all parts of the service area.

In addition, some water was being supplied to the system through interconnections, beginning with the one, via firehoses, over the Calhoun Street bridge from Morrisville, Pennsylvania. This commenced on September 2. All in all, nine interconnections were made and their maximum combined contribution was between 12-15 M.G.D., or less than one half of what was required per day. It should be noted, however, that this new water could not be pumped to all parts of the system. Of these interconnections, four were with private water companies and the other five were relatively low yield wells in public or private hands. Only one of the four water company sources went off the line on September 5. The other three were used until about 1730 hours on September 15, when the reservoir had been built up to approximately 78 million gallons.

Simple mathematics dictate that a severe shortage resulted. While some areas of the central city which were low lying retained a trickle of water throughout the crisis, other areas, particularly in the townships were bone dry for as long as 72 to 96 hours. The Central Pumping System, located at the reservoir, which lifts water to higher service areas, shut down at about 1100 hours on September 3 and did not commence pumping again until 0200 hours September 7. Consumers in the highest elevations did not receive water until the early morning of September 8. In addition, businesses had to close as a result of the emergency proclamations issued on Tuesday, September 2. Many of them did not reopen until the following Monday.

State government activities were also severely restrained during this period at an additional cost to the State. All in all, the monetary losses, across the board, have been variously estimated at between five and ten million dollars.

Along with these bad effects, the crisis provided some important, though costly, benefits to the system. It focused attention on the poor physical condition of the equipment in the filtration plant and the central pumping station and set in motion action to rehabilitate it. For example, it was discovered that the seals and rings on the pumps

were in bad condition since none of the pumps appears to have been reconditioned for sixteen years. Similar problems were found to exist with valve cylinders. It is anticipated that all of these repairs will have been made by April 1, 1976.

As a direct result of this crisis the City of Trenton has passed two appropriation ordinances. The first on September 18, 1975 authorized the use of $300,000 financed by an Emergency Note due December 31, 1976, and the second, on October 2, 1975, authorized the issuance of bonds or notes in the amount of $500,000. In addition, some monies were still available from the November 21, 1974 bond issue.

The Board believes that the expenditures of these funds, with the advice of the consulting engineers who have been involved in the emergency repairs from the onset of the crisis, will make a genuine improvement in the overall condition of the plant and reduce the likelihood of a plant and system failure in the immediate future.

The Management of the Crisis

Numerous forces were brought to bear on this crisis. There were the plant personnel who, led by Superintendent Klockner, rushed in about noon or shortly before on Sunday, the 31st, and worked tirelessly thereafter. There were the volunteer firemen who also arrived in late morning of the same day and continued pumping until the plant was clear of water and who were the first to begin pumping fresh water back into the system in the small hours of Tuesday morning, September 2, and continued until they were no longer needed. There were the City officials led by the Mayor and the Director of Public Works who were increasingly active on Monday, September 1, declared a State of Emergency during the morning of September 2, and were on duty throughout the crisis. City and County Civil Defense and Disaster Control personnel plus countless volunteers did everything possible to provide assistance in making more water available and in supporting those who did. State officials entered the crisis officially on Tuesday at midday when the Governor, at the request of the City, declared a State of Emergency, thus making available State personnel from governmental departments and from the State's Civil Defense and Disaster Control apparatus. Overall leadership was supplied by Commissioner Bardin of the State's Department of Environmental Protection who was given operational command of the crisis by the Governor on Wednesday evening, September 3. The Officials of the water systems in Princeton, Hamilton and Bordentown provided support and water. Finally, but not least importantly, there were the mayors of the townships of Ewing, Lawrence, and Hamilton who worked diligently to assist their townships.

During the course of this crisis nine separate interconnections were made, three of which have become permanent. This involved a tremendous amount of work and coordination. While the Board had some testimony that the rigid Civil Defense and Disaster Control chain of command was frequently side-stepped, the Board believes that, on balance, the crisis was handled well under the circumstances. Some of those circumstances, however, might well have been avoided and deserve to be discussed.

The condition of the equipment and the training of the plant personnel are circumstances which, when combined with an overall underfinancing of the system, were destined to cause difficulties. These circumstances are analyzed elsewhere in this report.

Other circumstances of probable avoidability were the 48-hour delay between the incident at the filtration plant and the declaration of emergency on Tuesday morning, and the lack of an emergency plan at the state or city level to deal with a water emergency.

With respect to the delay, the Board notes that City officials placed a great deal of reliance on Klockner as to technical matters. There was a genuine though mistaken belief on Klockner's part that the plant personnel could contain the crisis. These factors seem to have created circumstances in which no one carefully examined the situation until Monday evening when, at a meeting of firemen to discuss the crisis, Klockner and others began to concede that they were fighting a losing battle. The Board believes that a local disaster emergency should have been declared the moment pumping at the plant was discontinued or, at the latest, the following morning when the ruptured floor was discovered. In this manner the tremendous drain on the reservoir would have been mitigated a full day or two earlier and would have materially lessened the damage caused by the crisis.

As to the nonexistence of an emergency plan, again no one appears to have noted that when 211,000 people are served by a system that has only one treatment plant drawing from a single source of water the potential for danger exists. This is all the more true when the system serves the seat of State government. Among the important consequences of not having such a plan were that no system of priorities had been developed to determine who were the first and who the last to obtain rationed water. No inventory existed which listed the location of pipe, trucks, tankers, pumps and motors used to cope with a water crisis. No chains of command existed which contained water-experienced personnel. No system of hypothetical interconnections had been mapped with approximations of their respective yields so that time factors could be calculated.

The Board believes that it is essential to the well-being of this State and others similarly situated that such a plan be drawn up and that State and local officials should not be influenced by the fact that there has not been a comparable crisis in the past.

New organizational structures should be considered in determining the optimum form for governing and managing a municipally-owned water utility. These forms include:

(1) The elevation of the Water Division to a full department of the City government.

(2) The formation of a municipal commission or board within the city government.

(3) The creation of an independent municipal corporation or authority.

(4) The establishment of a joint municipal authority for the City of Trenton and the townships of Ewing, Hamilton and Lawrence.

(5) The sale to or operation by an investor owned company.

Pending consideration of these options we recommend that the Water Division be elevated immediately to a full department of City government. This would not prejudice the later adoption of other alternatives.

In addition, and unless a structure is created which inherently deals with this problem, there must be a satisfactory resolution of the issue of how neighboring municipalities served in whole or in part by this system participate in the governance, management, and financing of the system.

In the event the water system remains as an integral part of the city government, decisions will have to be reached as to which official or body should have final authority with respect to capital requirements and budget, operating requirements and budget, rate structure, maintenance program and budget, internal administrative structure, personnel policies of hiring and training, job classifications and salary plans, and the preparation of emergency and disaster plans including interconnection capabilities.

Another issue needing resolution is whether permanent connections should be made with other systems in the state or whether other permanent means should be undertaken, such as another plant, or reservoir to insure a water supply under emergency conditions.

There should be a firm definition of the State's role and responsibilities (regulation, monitoring, technical assistance, financing) with respect to plant and equipment, operating policies and procedures, personnel, emergency plans including interconnection capabilities, and finances.

An analysis will have to be made of the Safe Drinking Water Act as it will have important implications for water suppliers. Higher quality water will require more and better trained employees, and improved equipment.

We recommend that all of these issues be explicitly considered in the formulation of the State's Water Supply Master Plan.

BACKGROUND AND ANALYSIS

Fiscal Matters

It is clear that, with respect to fiscal matters, there was little communication between Superintendent Klockner and the City Council, the members of which are denominated "directors" in the Annual Report of the Water Division to the Board of Public Utility Commissioners (the "P.U.C."). The annual budget for the Water Division was worked out by Superintendent Klockner and the Comptroller of Trenton who was also the chief

accountant for the water utility. There was a ritual of making a budget request based on need, but the fact was that by statute the Water Division was required to subsist upon the funds generated by the sale of water at rates controlled by the P.U.C. Thus, this budget had a fixed ceiling from the beginning. The Board approves the requirement that a water utility should subsist on its own revenues, but this requires a practical approach to rate determination. Once internally prepared, the budget does not appear to have been subjected to any thorough departmental review and was given to the City Administrator and the Council at about the same time so that the City Administrator had little or no time to review it. To the extent that any review did take place at this point, it was accomplished under the belief that the authorities in charge of financial review and budget approval were fully capable of determining which maintenance projects were necessary and which could be deferred or rejected despite their lack of technical expertise. This relationship between operating management and financial controllers was not conducive to mutual problem solving with respect to Water Division budgets.

Nor does there appear to have been an overwhelming desire by the City Council to rehash the budget. Nevertheless, there was testimony which indicated that it was the belief of the City Administration that any emergent needs arising in the Water Division would be coped with by the City Council.

In fact, numerous problems of an emergent nature did exist, even though they may not have been apparent to the untrained observer.

Thus, the Board must conclude that somewhere in this information exchange process a great deal of essential information about the physical condition of the plant, to say nothing of the condition of management and personnel relations, was not being apprehended by the City Council.

The reasons for this communication failure are not clear. What is clear, however, is that this inability to explore in depth the inner workings of the water division resulted in an uninformed executive, an uninformed "legislature", and uninformed consumers. There was no excuse, including the fact that there was a rigid budget ceiling directly tied to revenues produced by water sales, for the administration or the council not to engage in an active and ongoing discussion of priorities for the maintenance and improvement of the system. Moreover, had such discussions taken place there might well have been greater pressure applied to the production of the working papers necessary to sustain a new application to the P.U.C. for a badly needed increase. As it was, these papers, according to the testimony, were delayed over a year beyond the time when they might have been ready.

For these reasons the Board concludes that an essential ingredient to the operation of a good water utility - a concerned governing body interested in high quality performance - was missing.

Another missing ingredient was an adequate rate structure, and its absence is central to an understanding of the problems confronting the Trenton water system.

During the past three or four years, the Water Division has received approximately 25% of the additional funds it requested for operation and maintenance of the filtration plant and the water storage and delivery system. During the year roughly preceding the incident it received only 12% of its request but this was attributed to the issuance of $500,000 worth of bonds in the fall of 1974. What is important to note is that there was systematic underfinancing of the Water Division.

As alluded to above, the financing of the Water Division is essentially contingent upon revenues from the sale of water to commercial and residential customers in the City of Trenton and the townships of Ewing, Hamilton and Lawrence. These sales are on the basis of rates approved by the P.U.C. The last rate increase was 24% in the year 1972, well below the 42% felt necessary by the executives of the Water Division.

The process by which these rates are established begins in the Water Division. Traditionally, after a review of current and projected needs, the Water Division made a recommendation as to the amount of increase necessary to operate properly. But, this recommendation did not go directly to the P.U.C. It went to a group of representatives from the townships of Ewing, Hamilton and Lawrence, whose residents pay at a rate of 50% higher than City residents for their water. These township representatives, on behalf of the users of one half of the entire system, then bargained with the City. This bargaining, however, was not based upon an intimate understanding of the needs of the system, for there was testimony conceding a lack of acquaintance with this technical information. In fact, the township representatives bargained on the basis of purely political considerations relating to the unpopularity of rate increases and to the advantages of showing tangible benefits (e.g. the Extension of the Distribution System) rather than essential but intangible benefits (e.g. Preventive Maintenance). On such a basis, then, the rates in 1972 were negotiated from 42% to 24% for presentation to the P.U.C., who apparently accepted them at face value.

Here an unwillingness to learn about the system and a reluctance to face up to the political consequences of adequately financing it combined to create an unsatisfactory situation.

While the City has apparently made efforts to explain the need for rate increases to the townships, its efforts have been unavailing. To date no mechanism has been designed to include representatives from the townships in the management of the Water Division on an ongoing basis. But if these townships, who are even now, after the crisis, decrying a new rate increase, are not brought into substantially closer touch with the workings of the Water Division then the largest share of the responsibility for this poor communication must fall on the City of Trenton and the attainment of an adequate rate structure will continue to be extremely difficult.

A basic understanding of the rationale for a rate increase is essential now because the City plans to request a 60% increase which includes a provision for two million dollars to cover the reservoir in compliance with State directives. It should be noted, however, that the

60% increase was designed to meet the needs of the system prior to the crisis. Since the crisis, at least $800,000 has had to be expended. For this reason, there may now be a question as to whether the 60% increase, if granted, will be large enough, particularly if the covering of the reservoir cannot be postponed. In saying this, however, the Board wishes to note that it has insufficient evidence to pass on the merits of the 60% increase and is simply pointing out the need to include in whatever increase is agreed upon an amount needed to cover all appropriate repairs and improvements.

Accordingly, the Board concludes that the Townships must be brought into close and continuous contact with the affairs of the Water Division so that all the citizens using the system can be made to understand its needs. With regard to the rate differential issue, certain residents of the townships feel that their rates are inequitably calculated when compared to those enjoyed by City residents. The Board recognizes that a rate differential is proper, but believes that an analysis should be made to accurately determine the amount of the differential, and the number of exceptions to it, e.g. hospitals. Finally the Board concludes that an inadequate rate structure was a prime contributing factor to the occurrence of the incident itself because of the pervasive effects it had on the deterioration of so much of the system for water delivery. It is unfortunate that present procedures do not require the P.U.C. to assure adequate rates to properly finance the system.

Internal Management and Personnel Policies

Although the Board did not become deeply enmeshed in the personnel management policies of the Water Division some facts became almost immediately apparent. The first was that among management and supervisory level personnel there was far too wide a discrepancy in ability to perform as required from a technical standpoint. Furthermore, there appeared to be a fairly consistent lack of managerial competence throughout the same level. An important example of this was the lack of a well developed and adhered to chain of command from the Superintendent to his subordinates. Indeed, there was some testimony suggesting that the Superintendent frequently by-passed both his supervisory personnel and union officials so as to generate unnecessary problems with an otherwise allegedly cooperative union.

In addition to these deficiencies in personnel management the Board found that many workers below the supervisory level were well below the level of competence needed to perform the tasks assigned them, other than menial labor. Most particularly, many of those employees charged with the maintenance and operation of motors and pumps had neither the training nor the experience to deal adequately with emergencies or with situations beyond starting and stopping, oiling and packing. Their entire training was accomplished on the job by middle level supervisors who were themselves without technical knowledge of the plant's operation, at least with respect to the pumping operation. In fairness the Board did not inquire deeply into the treatment operation of the plant. This is not to say that everyone on the pump room floor must be an engineer, far from it. But, when machinery, as essential to the operation of a vital utility as this, is to be left in the hands of unsupervised

operators on nights, weekends, and holidays, those operators must possess a basic understanding of the hydraulic system operating the crucial cone and suction valves and must have received adequate training in emergency procedures.

In line with these observations, the Board notes that there exists no operating manual for either the pumping or treating phases of filtration plant operation. Such a manual would provide obvious advantages in training men.

Having pointed to the need to upgrade training and employee competence, the Board must also note that the employee salary structure is substantially below that needed to attract highly skilled employees in the first instance. As these are civil service employees, however, a change in the rate structures governing Water Division revenues would not, in itself, cure this deficiency. A separate study of civil service examination procedures and salary structures should be made to solve this problem.

Thus, with respect to personnel policies in the Water Division, the Board concludes that they are currently inadequate in recruitment, training and day-to-day supervisory management. The Board, therefore, believes that the Water Division would be well served by a management audit performed by outside consultants, so that a realistic plan for change could be developed and implementd within the parameters of existing or obtainable resources. In this regard, the Board wishes to point out that State certification of employees is an issue which will arise in the course of such an examination. Only five supervisory personnel hold State certificates and it would be desirable for Trenton to require certification at some level for those in charge of shift operations.

As a further means of assuring that plant operations are keeping pace with modern standards, it might be advisable to enter into some type of consultant relationship with private well-run utilities who could provide technical advice and training.

Technical Matters

There is no schedule of preventive maintenance for the plant, and it is not performed for the most part on any basis, systematic or otherwise.

The physical condition of the filtration plant on August 31 was poor with some equipment nonfunctioning or malfunctioning. An accumulator tank, which could have supplied extra pressure to the 2 1/2 inch line, for example, has not been operating for several years. The pumps had not been overhauled in 16 years.

The entire hydraulic control system should be reviewed. Specifically, it is clear that there was an inadequate review of the modifications to the cone valves made by an outside contractor in the recent past. The inclusion of an automatic 80-second pump shut-off on the wall-mounted cone valve actuator, which operated regardless of whether the cone valve in fact closed, was not good practice, in the opinion of

the Board, and undoubtedly contributed directly to the incident.* The Board also found that the wiring diagrams for the valves in use on August 31 are so poor that the wiring configuration of the controls could not be determined. No adequate checks had been made of the operating condition of the suction valves. No quick acting valves existed to isolate the plant from the back flow from the reservoir.

It should be noted that many of these recommendations are being implemented currently. They are set forth here, however, to record the state of affairs in which the Board found the system at the time of the crisis.

Service Delivery

The present distribution system appears adequate. A program for cleaning and lining existing mains is in progress.

The pumping station has poorly functioning equipment but appears otherwise adequate to supply the existing system.

The reserve supply of water for the system appears adequate since the reservoir normally contains at least 85 million gallons of useable water and the four water towers and the standpipe each contain one million gallons. All told this means that the reserve supply is at least 90 million gallons or roughly three days supply. It should also be mentioned that the existing reservoir has been ordered by the State to be covered for quality reasons. In addition, any discussion of alternative means of expanding Trenton's water supply in an emergency, should include a consideration of the advantages and disadvantages of constructing another reservoir. While the Board thinks this issue worthy of discussion, it has not passed upon its merits.

External Management

While aspects of the problems in external management of the Water Division have been alluded to elsewhere in this report, they are sufficiently important to reiterate in more detail here.

By external management the Board means those individuals above the Superintendent in the management chain. Principally these include the Director of Public Works, the Mayor and the Business Administrator, and the City Council.

The Director of the Department of Public Works has many responsibilities, only one of which is the Water Division. The Superintendent appears to have been solely responsible for the management of that

---

* The Board wishes to add that it was not able to explore this area in the depth it might have wished because George Townsend, President of Municipal Maintenance Corporation, the outside contractor for this work, did not appear before the Board as he was requested to do. During the entire course of the Board's inquiry, Mr. Townsend was the only individual public or private, to refuse the Board's request to appear.

division. Not until the incident does it appear that the Director really took an active interest in its affairs. For example, he testified that he had never seen a copy of the utility's Annual Report to the P.U.C. What this points up is that the system never required of him that he adequately supervise the Water Division and that he did not take it upon himself to do it. What is more, there is nothing which has come to the Board's attention to indicate that the Director and the Superintendent did not enjoy a good working relationship.

What has been said of the Director can also be said of the Mayor and the Business Administrator. Neither appears to have demanded enough information about the status of the plant and the system. The testimony indicates that the Mayor appears to have relied on the Superintendent because of his technical abilities and the Business Administrator appears to have relied on the Superintendent because he believed Klockner had adequate access to the City Council and because he felt he could add little to the budget prepared in the Water Division. Again there appears to have been inadequate assessment of managerial responsibilities on the part of these two officials. They did not ask the hard questions which would have enabled them to comprehend the actual condition of the plant.

As for the City Council, they were denominated "directors" in the utility's Annual Report to the P.U.C., yet none of them had ever seen this document. Furthermore, they never met for the sole purpose of doing the business of the Water Division and they had no subcommittee to do it for them. In short, they treated the utility as part of a department of city government and did not act as the directors of a corporation or utility should.

For these reasons the Board reiterates its recommendation that at a minimum the utility be elevated to full departmental status and that the City Council make an effort to better exercise its oversight responsibilities. At the same time, it might be wise to commission a study of alternate forms of management so that a more worthwhile form of management structure would not be overlooked.

Concluding Remarks

The Trenton Water crisis, seen in its largest dimension, is really an illustration of a problem in society caused by technical and sociological change. More and more, high cost, high capital intensive, long life public service systems are coming into existence. This is the result of technological improvements which give rise to greater expectations of public service, and of laws which govern environmental impact, service quality and the allocation of resources.

Coping with the funding, operation, and the maintenance of these systems is often vested in local governmental units whose interface with the consumer and the voter is intimate, and whose long range perspective on time must realistically be in tune with the election cycle. In the case of the Trenton Water system, previous consumers and taxpayers invested heavily in a necessary long term public service facility. Present consumers, however, are evidently telling their elected officials to keep rates and taxes low and have taken for granted that this

can be done without lowering the quality of service they have been receiving. Inevitably, maintenance and restoration of this long life utility has been deferred, on the theory that it can wait until after the next election and the next, and so on.

This approach raises a question which must be resolved before reaching a long range solution to Trenton's water problems. Do the users of public services from a high cost, long life utility system have an obligation to maintain and restore such systems on a continuous basis, or should they be permitted to use the service at a minimum cost and defer accumulating maintenance to future generations of consumers?

Various responses can be made to this question and some projections can be made as to the outcome likely to occur from these responses.

If Trenton and its suburban water customers opt for the lowest present cost of service and defer maintenance, they can maintain their present relationships and accept occasional service interruptions and service inadequacy in the near term. Basic decisions on investment and service will accrue to future consumers and political administrations.

If Trenton decides to maintain its water system on a continuing basis but its suburban customers disagree and desire to defer maintenance, then the issue will inevitably lead to a major confrontation before the P.U.C. as it would be impractical, if not impossible, to sell to the townships the part of the system located there. Such confrontations would be costly in time, money and good will.

If Trenton and the townships' consumers view their area as an integrated market place and regard adequate quantity and quality of water as an essential ingredient to maintaining and improving the area's overall economic base, some mechanism for joint ownership and control would seem to be a logical solution.

Water is a resource whose adequate supply is becoming a problem. It is easier to obtain, treat and distribute water on an area-wide basis than it is on a political subdivision basis. Currently, water resource planning is going beyond even state boundaries to water sheds and river basins. Necessity is the vehicle of change, and it may be time to view water service to the Trenton area in a larger dimension.

Regardless of the solution chosen by the members of the Trenton system, the Board recommends that an annual technical and management analysis of the system be made. Such analyses will provide vital information to the public on an ongoing basis about the management and economic decisions made with respect to the system, and provide a sound basis for charting the future course of this essential public service.

The Trenton area water system is an asset, owned by the public, that would cost up to $100 million to reproduce at today's prices. The public has a basic right to know if their property is being effectively operated and adequately maintained.

March 29, 1976

COMMENTS OF THE ADVISORY PANEL TO THE COMMISSIONER

Members of the Advisory Panel

Henry Fagin	Professor of Administration Graduate School of Administration University of California Irvine, California
Dr. Owen P. Hall, Jr.	Research Associate Center for Future Research University of Southern California TRW Systems 1 Space Park Redondo Beach, California
William K. Jones	Milton Handler Professor of Trade Regulation School of Law Columbia University New York, New York (Former) Member Public Service Commission of the State of New York
Robert V. Phillips	Consulting Engineer (Former) General Manager and Chief Engineer Department of Water and Power Los Angeles, California
Herman G. Roseman	Senior Vice President National Economic Research Associates, Inc. Consulting Economists New York, New York
Harry C. Ways	Chief, Washington Aqueduct Division Baltimore District, Corps of Engineers Department of the Army

Comments of:
Henry Fagin

1. The Trenton and other operating systems that supply water to the public should be reviewed for what might be called psychology-sensitive factors of operating design. Under the heading, "Technical Matters", reference is made to the need for a review of the entire hydraulic control system. Part of such a review ought to be done by a design team which includes someone experienced in the aspect of industrial design that addresses phychology-sensitive factors. I refer here to the fact that some mechanisms are so designed that their correct operation is intuitively grasped by anyone operating them, while other designs for the same function violate the natural psychological processes of people working under stress in emergency situations. One example of this design failure in the Trenton Water Crisis was the uncertainty as to the correct "off" position of manual valves that activate the suction valve flows to the high lift pumps. Another example was the jerry-built set of valves controlling the 2 1/2 inch water lines that serve the hydraulically pressurized cone and suction valves. The only logic to the exact arrangement of these control valves was their history. But, their arrangement was psychologically confusing and invited human error under stressful conditions.

2. A benefit/cost analysis should be made of the possible raising of the pump room and other operating components of the system so as to enable gravity drainage under all possible flood conditions. It is my understanding that within the recent past, a Delaware River flood as well as the August 1975 pump operation accident caused the inundation of plant facilities, with a multi-million dollar combined cost in damages to the system and to the public. Rebuilding to a higher level on the site or elsewhere should be explored.

3. In addition to the five organizational structure options proposed for comparative analyses, an option 6 should be investigated. This would represent a joint regional authority for Trenton, the three present townships, and additional neighboring water districts. Such an option would extend the logic of present option 4 to embrace a geographic scope based on topographic and scale economics, not limited to the current institutional participants and geographic boundary.

Comments of:
Dr. Owen P. Hall, Jr.

I think the report provides a good overview of the "incident" and identifies some reasonable alternatives. It appears, however, that not enough attention is focused on characterizing the actual benefits and costs of various levels of water services. This seems to me a crucial issue in the whole affair. I would suggest that you consider undertaking such a study in the near future in order to have the data available when specific decisions are made.

The report provides great detail on the "incident" but does not look at the overall implications of water supply throughout the district.

The report does not spell out the costs that will be incurred in providing various levels of water services. A cost/benefit analysis is necessary to develop the basic data.

The report should adopt one specific recommendation regarding the organization of the water district. The current list of several alternatives tends to dilute the impact of the report.

The report does not address the issue of meeting future contingencies. There should be at least a brief description of an emergency backup plan.

Comments of:
William K. Jones

I have reviewed the draft of February 12, 1976, and I believe that it properly reflects the considerations deserving emphasis in relation to the Trenton water crisis. I have no disagreement with any portion of the draft, but I have neither the detailed information nor the expertise to comment on all aspects (notably those pertaining to engineering deficiencies and the chronology of operational events leading to the August 31 breakdown). With respect to matters as to which I feel I have some appropriate background--particularly those pertaining to management, financing and staffing of a water system--I am in agreement with the substance of the report.

Comments of:
Robert V. Phillips

In general, I believe the report is a thoughtful, well written and accurate description and analysis of the various elements, both physical and otherwise, that contributed to the unfortunate events of August 31, 1975. The report properly reflects the thorough discussion held in your office last December 2nd between the members of your Advisory Panel and some of the Board of Experts including Mr. Baxter. It seems to me there is a reassuring consensus on the basic conclusions to be drawn.

There are two basic aspects of the problem described in the report. The first is a detailed account of the malfunction of equipment and personnel that was the immediate cause of the accident. The second is a description of the political, organizational and financial shortcomings that provided the atmosphere in which badly maintained equipment and untrained personnel could develop. The detailed account of the accident itself is important since it demonstrates the degree and pervasiveness of the broader problems. If the report suffers at all, it suffers from a lack of similar detail in describing or substantiating some of the broader shortcomings I have just mentioned. This is not a serious criticism provided it is clear that the report's main purpose is to identify and urge correction of the political, financial and organizational problems and not to prescribe remedies at the pumping plant.

In addition to the above generalizations I have the following specific comments with regard to statements in the report.

The matter of possible need for interconnections with other systems or additional storage is mentioned. I suggest that a standby source would be highly desirable and should be developed. In this connection I suggest that, if not already investigated, the possibility of ground-water storage be explored. This could be a very inexpensive standby even though there is not a large safe yield involved. The primary interest is storage.

In the section of "Internal Management and Personnel Policies" there is a suggestion that, because the employees are civil service, increasing the water revenues would not improve the opportunity to get highly skilled employees. There is no reason, in my opinion, not to set civil service examining procedures and salaries high enough to attract and keep highly qualified employees. The advantage has been well demonstrated.

Comments of:
Herman G. Roseman

The Report of the Board of Experts strongly suggests that inadequate rates led to inadequate finances which, in turn, contributed to poor reliability of service. They also suggest that there was inadequate communication from the Water Division to higher levels in City Government, and that the Water Division had too little political clout to achieve needed improvements.

Although this point of view has a number of congruent areas with my own ideological learnings, it all seems a little too pat. What troubles me is that there seems to have been little effort by the Supervisor to overcome these difficulties. Why? Let me suggest two possible explanations. First, the Superintendent knew very well that any efforts to raise rates, whether through higher rates or City Council appropriations, was likely to run into considerable opposition. Second, there was little incentive to follow anything but the path of least resistance.

One cannot, I think, blame the problem on opponents of rate increases. Their attitude is only natural. Only when the utility makes the effort to persuade these opponents on the basis of a well documented presentation can one blame people for stubborness in the face of facts. Only when the PUC has failed to give the utility approval of necessary rate requests can blame properly fall on the public.

It is clear to me that a privately owned utility at least has the incentive to install plant and to <u>try</u> to get the rates needed to finance it. If you do not seek to increase the incentive to overcome opposition, then you must seek to reduce the scope for opposition. One way is to create an independent water authority which does not answer to the City Council or to the PUC. As you are aware, the great majority of municipally owned electric utilities are not subject to rate regulation. Some of the best run publicly owned utilities, such as TVA and Salt River, are also quite independent of any political body, at least as regards their ordinary operations including capital programs.

I have one related comment on the quality of management. It is my general impression that larger organizations are more able to attract top managerial talent because they offer greater scope for ambition. Thus, I feel that the Trenton Water Works should either be sold to a large holding company or merged into a much larger public water authority if there is to be much hope for major improvement in the quality of management.

Comments of:
Harry C. Ways

I agree with the major conclusions of the Board, as stated in the summary. It is good that the report deals so extensively with the administrative, management and personnel problems contributing to this disaster, for it is in this area that the most wide ranging benefits can be derived from the investigation. The Board is to be commended for emphasizing this area, and devoting their major attention to it. This portion of the report needs only some editing to meet the objectives of the Board.

However, I do believe that engineering deficiencies in the basic design of this water supply system should be discussed in somewhat greater detail. Had these deficiencies not existed, the emergency might never have happended, and if it had, the magnitude of the crisis would have been considerably lessened. These deficiencies should be highlighted, to prompt further review of both new water supply construction and of existing facilities. The Trenton Crisis clearly demonstrates that the potential for disaster can exist, in many cases unsuspected, in major water supply systems. Perhaps it was decided not to consider these aspects further, on the assumption that they were being adequately addressed by others. If so, this should be discussed in greater detail.

For far too long, regulation of water supplies has been limited to the sanitary quality of the water produced. Sanitary surveys are conducted to assure that the system will meet water quality standards, but little attention is paid to the reliability of the system to continually meet the quality needs of the consumers. The Trenton Crisis provides an opportunity to encourage responsible review of plant designs and maintenance standards. The U.S. Environmental Protection Agency is now preparing such standards, under provisions of the Safe Drinking Water Act. There will be resistance to the imposition of these standards when they are promulgated, perhaps from the water works profession itself. The Trenton Crisis presents a clear demonstration of the need for them. The record should show that the plant was not only poorly maintained, but also poorly designed, and that the lack of facilities which should have been provided and could have been provided at minimal cost, was a basic cause of the failure of the Trenton Water System.

These are some of the significant design deficiencies in this plant which should not have existed, and which should be corrected.

a) Adequate provision for overflow from the clear well was not provided. This overflow should not, under any conditions, have discharged into the pump room. A large diameter pipe should have been installed to discharge any clear well overflows to the river, at a level above maximum flood stage.

b) The equipment for normal pump shut-off in this station was poorly designed. The system should have been designed so that the pump motors would not shut off until the cone valves were fully closed. (An emergency closure sequence should be provided to rapidly shut the cone valves in the event of power failure, if it does not now exist.)

c) The hydraulic system provided to operate the suction, cone and discharge valve operating mechanisms was poorly designed. It is questionable whether it was capable of meeting an emergency such as occurred, or whether this failure was due to improper operation and maintenance. However, it was obviously designed in a manner which made it extremely confusing and awkward to operate.

d) The two 48" valves outside the station should have been motorized, with operating push buttons in the station control room and also at the valves in the street.

Any of the above facilities could have been provided for a few thousand dollars. Had one or more of them been in place last September, the Trenton Crisis might have been averted.

With regard to the future integrity of the system, the Board notes that expenditures for emergency repairs will make a "genuine improvement in the overall condition of the plant and reduce the likelihood of a plant and system failure in the immediate future", and also, that "many of these (technical) recommendations are being implemented currently". In the absence of any specific description of these improvements, I am unable to comment on these claims. In the interest of assuring the future reliability of the system, therefore, the specific improvements which have been made should be described. It is even more imperative to define those still to be made, along with a strong recommendation that they be implemented immediately.

There is considerable discussion of the inadequate funding which contributed to the condition of the system at the time of the crisis. However, it is difficult to determine the relationship between amounts required, as requested by the plant engineer, and amounts granted by the city officials. A tabular summary of these numbers for the period 1966 to 1975 would be of considerable significance.

APPENDICES

REPORT ON THE TRENTON

WATER CRISIS

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL

PROTECTION

MAY 1976

APPENDIX A

TRENTON WATER DELIVERY SYSTEM

(by Board of Experts)

The distribution system has 551 miles of pipe of which 182 miles are located within the City of Trenton and 369 miles are located within the townships of Ewing, Lawrence and Hamilton.

There are slightly in excess of 54,000 meters or service connections of which approximately 25,000 are within the City and the balance in the townships.

The reservoir, located 135 feet above and 5,000 feet away from the filtration plant has an absolute capacity of approximately 110 million gallons of which between 85 and 90 million gallons are usable.

Water from the filtration plant, after passing through the 48" header out in front of the plant, passes either into a 30" line to the east and south and directly supplies the gravity fed, low lying areas of the City or into a 48" line west and north into the reservoir. From the reservoir it is pumped by the central pumping station near the reservoir out into the higher elevatons of the City and into the townships. Of course, reservoir water can pass back into low lying City areas if necessary. Out in the system there are five one-million gallon elevated tanks, a water tower near the Mercer County Airport, a standpipe in West Trenton, a water tower near Rider College, a water tower in Mercerville, and a water tower in White Horse.

Users of the system consume 34 to 35 million gallons per day. An extremely low use day would be 20 million gallons and extremely high use day would be 50 million gallons.

The value of the system and its various components has been unofficially estimated at approximately 100 million dollars.

APPENDIX B

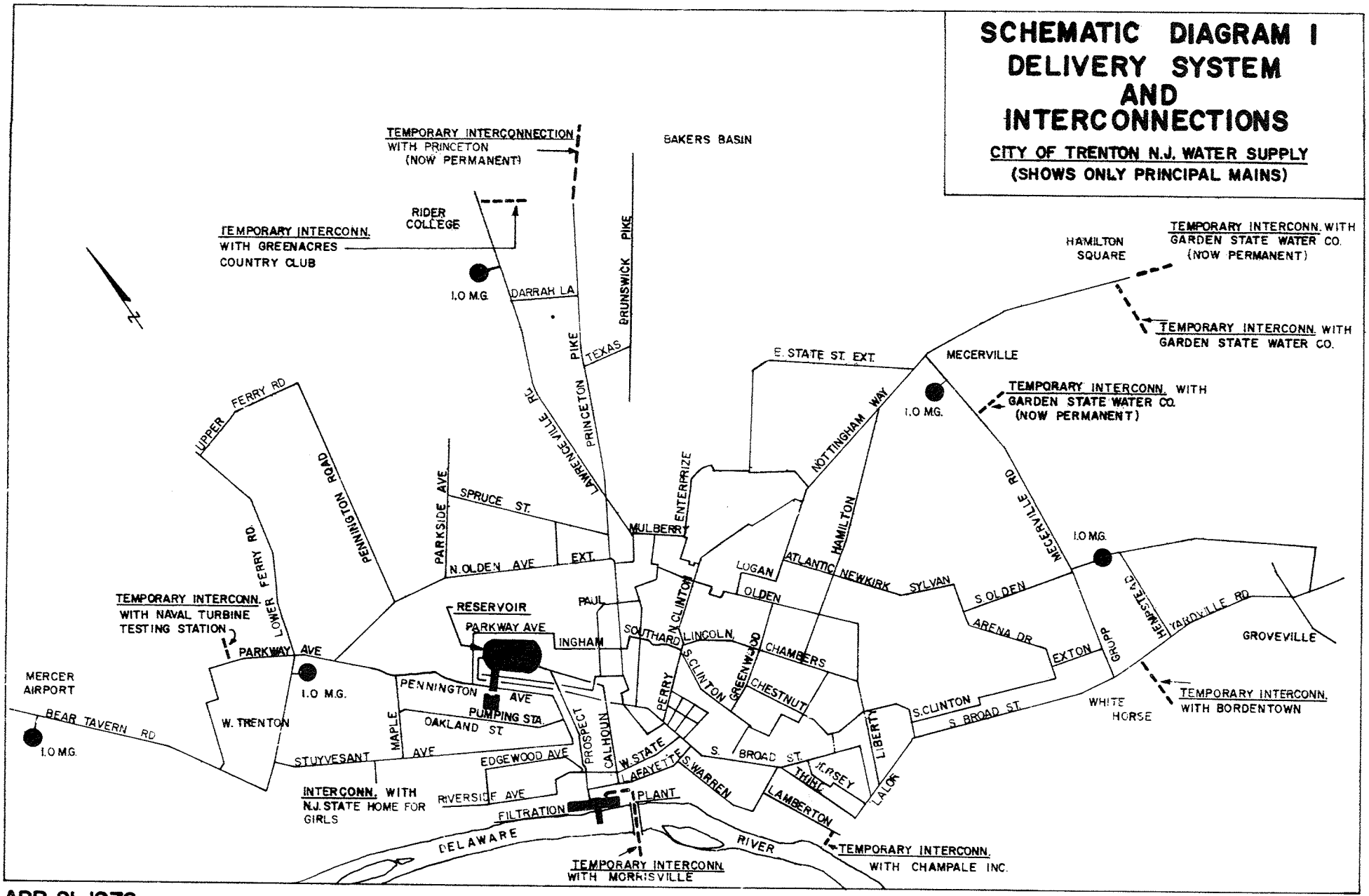
WATER UTILITY

SCHEMATIC DIAGRAMS

(by Department of Environmental Protection)

1. Delivery System and Interconnections
2. Water Flow from Delaware River to Prospect St. Reservoir (Cross-Section)
3. Overhead View of High Lift Pumping Equipment
4. High Lift Pump Room (Cross-Section)
5. Lift Pumps and Cone Valves (Overhead View)

APPENDIX B



APR. 21, 1976

SOURCE – N.J. DIVISION OF WATER RESOURCES, D.E.P.

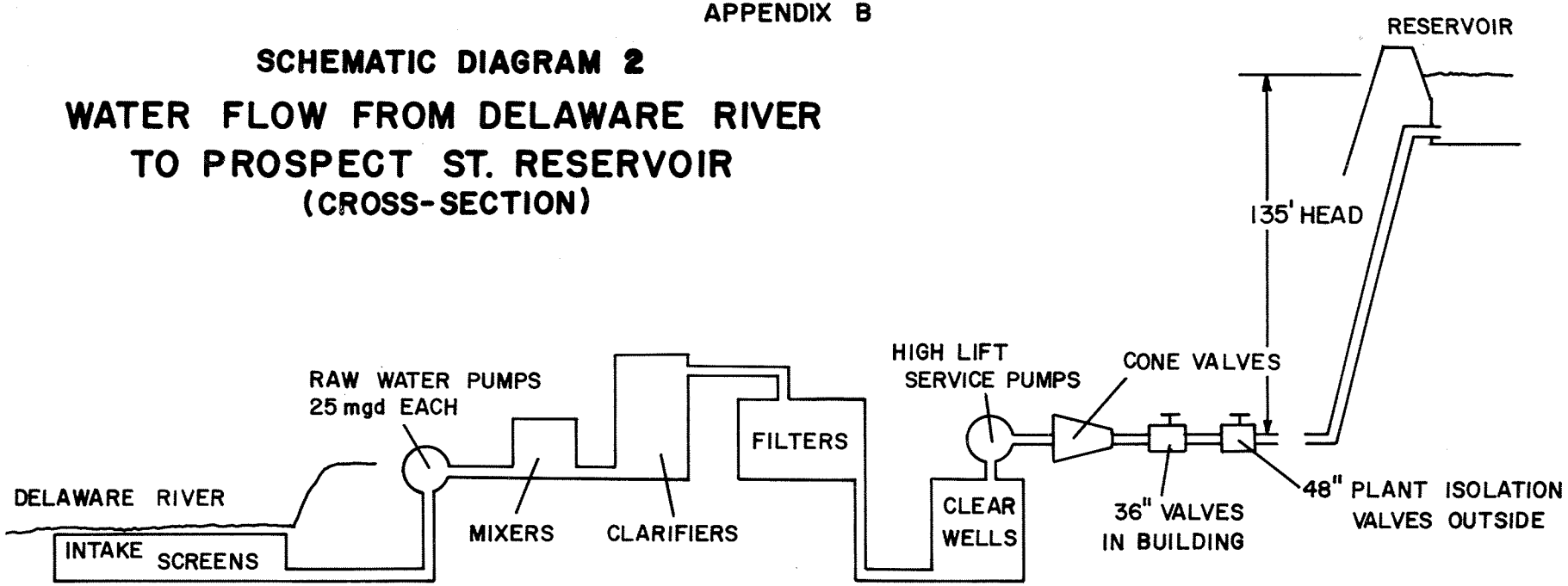
LEGEND

● ELEVATED WATER STORAGE TANKS WITH CAPACITY IN MILLIONS OF GALLONS.

APPENDIX B

SCHEMATIC DIAGRAM 2

WATER FLOW FROM DELAWARE RIVER TO PROSPECT ST. RESERVOIR (CROSS-SECTION)



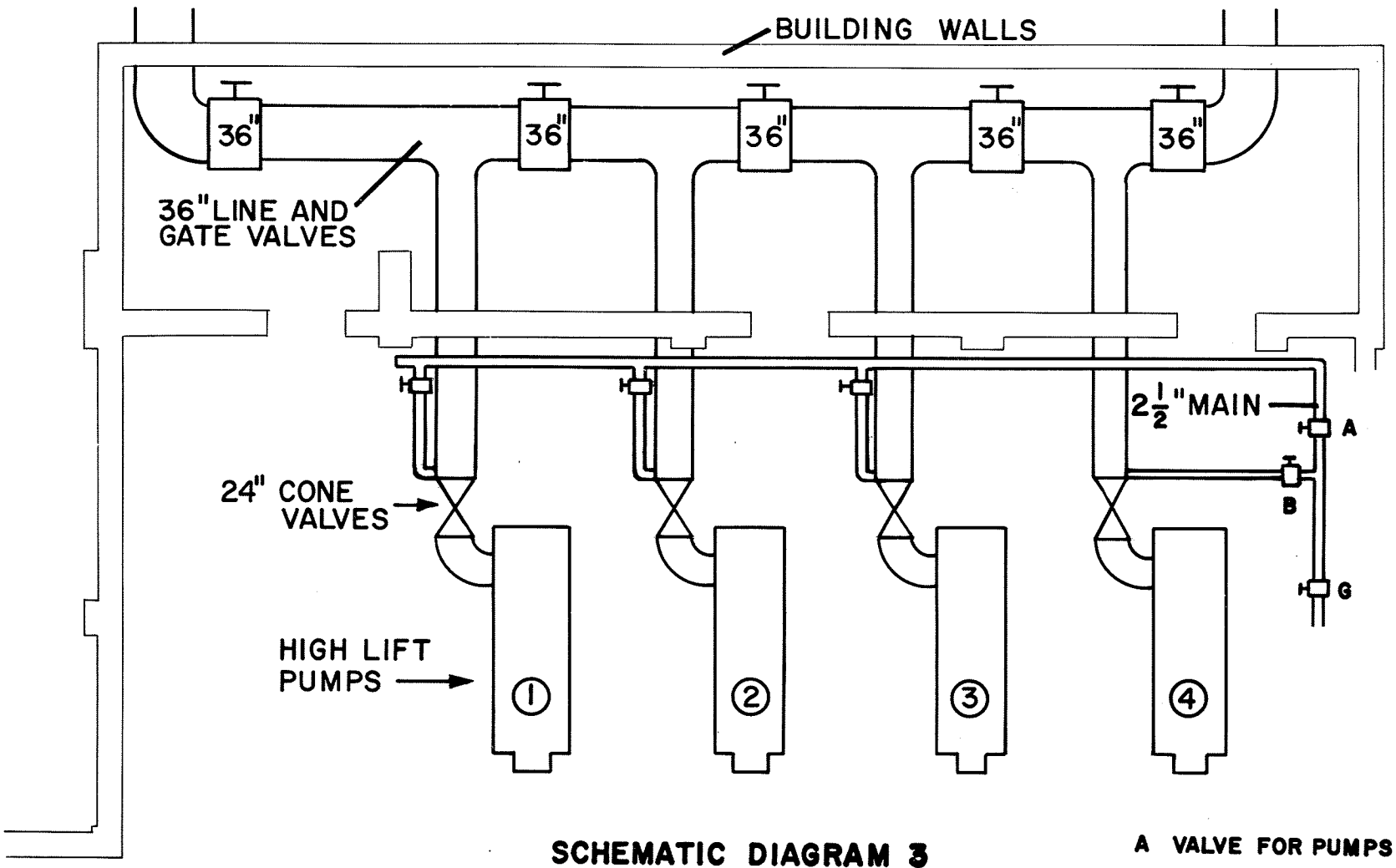
CHEMICAL ADDITION POINTS NOT SHOWN.
ELEVATIONS AND PLANT LAYOUT NOT GIVEN.

NOT TO SCALE

SOURCE - FROM WORKING DRAWING PROVIDED BY D.E.P.

PREPARED BY - BUREAU OF GEOLOGY & TOPOGRAPHY

MAR 23, 1976



SCHEMATIC DIAGRAM 3
OVERHEAD VIEW
OF HIGH LIFT
PUMPING EQUIPMENT

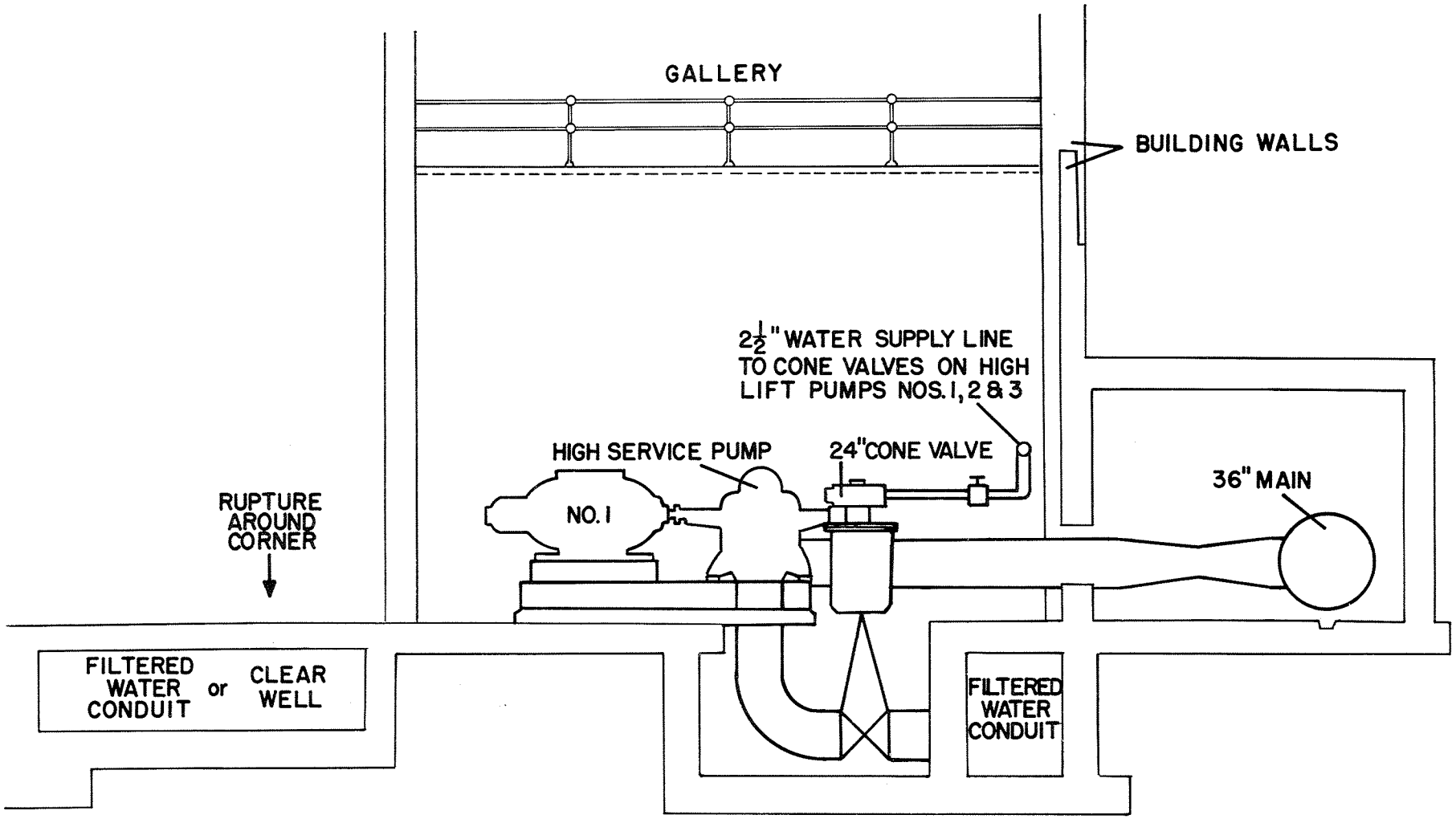
⊗ APPROXIMATE POINT OF FLOOR RUPTURE FROM CLEAR WELL

A VALVE FOR PUMPS 1, 2 & 3
B VALVE FOR PUMP 4
G MASTER SUPPLY VALVE
2 1/2" WATER LINE TO CONTROL CONE VALVES

SOURCE - FROM WORKING DRAWING PROVIDED BY D.E.P.
PREPARED BY - BUREAU OF GEOLOGY & TOPOGRAPHY
APR. 21, 1976

SCHEMATIC DIAGRAM 4

HIGH LIFT PUMP ROOM
(CROSS-SECTION)



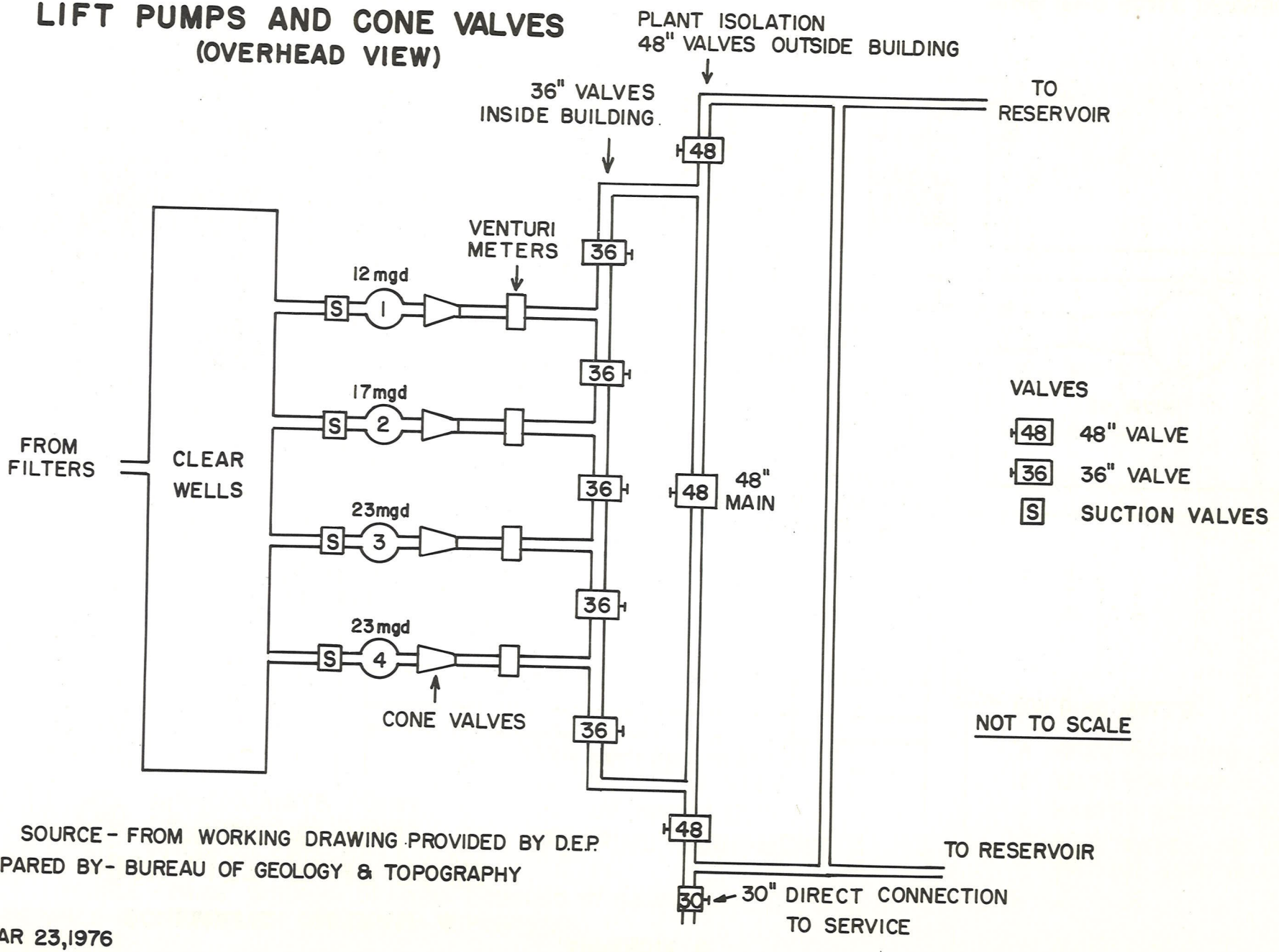
SOURCE - FROM WORKING DRAWING PROVIDED BY D.E.P.

SIMPLIFIED SCALE DRAWING

PREPARED BY - BUREAU OF GEOLOGY & TOPOGRAPHY
APR. 21, 1976

SCHEMATIC DIAGRAM 5

LIFT PUMPS AND CONE VALVES
(OVERHEAD VIEW)



SOURCE - FROM WORKING DRAWING PROVIDED BY D.E.P.
PREPARED BY - BUREAU OF GEOLOGY & TOPOGRAPHY

MAR 23,1976

APPENDIX C

EMERGENCY PROCLAMATIONS AND ORDERS

ISSUED DURING TRENTON WATER CRISIS

9/2/75	11:30 a.m.	Mayor of Trenton proclaimed emergency and requested Governor Byrne to declare emergency.
9/2/75	12:00 noon	Governor Byrne declared emergency.
9/2/75	12:00 noon	Deputy Mayor of Ewing Township declared emergency and prohibited use of water except as authorized.
9/2/75	12:26 p.m.	Mayor of Lawrence Township declared emergency for 24 hours.
9/2/75	1:04 p.m.	Mayor of Trenton prohibited use of water for industrial, commercial and school purposes.
9/2/75	3:04 p.m.	Assistant Director of N.J. Division of Water Resources (DEP) issued "Boil Water" Order.
9/2/75	3:30 p.m.	Mayor of Hamilton Township declared emergency for 24 hours; directed industrial and commercial users to curtail use; prohibited non-essential use of water.
9/2/75	5:00 p.m.	Governor Byrne designated Cabinet responsiblities.
9/2/75	8:35 p.m.	Mayor of Trenton prohibited industrial and commercial use of water except in certain food service establishments.
9/2/75	10:30 p.m.	Deputy Mayor of Ewing Township prohibited use of water by commercial, industrial, public and private establishments except as authorized.
9/3/75	12:26 p.m.	Mayor of Lawrence Township extended emergency for 24 hours.
9/3/75	3:30 p.m.	Mayor of Hamilton Township extended emergency for 24 hours.
9/4/75	6:00 a.m.	Mayor of Lawrence Township extended emergency for 24 hours and closed all Township schools and most commercial and industrial operations serviced by the Trenton water system.
9/4/75	12:00 noon	Mayor of Hamilton Township continued emergency and prohibited non-essential use of water; prohibited industrial use of water; declared violators would be charged as disorderly persons.

APPENDIX C

9/4/75	5:00 p.m.	Deputy Mayor of Ewing Township prohibited use of water except as authorized.
9/5/75	6:00 a.m.	Mayor of Lawrence Township extended emergency for 24 hours.
9/5/75	11:00 p.m.	Mayor of Trenton prohibited non-essential uses and ordered sterilization of water.
9/6/75	6:00 a.m.	Mayor of Lawrence Township extended emergency for 24 hours.
9/6/75	10:00 a.m.	Deputy Mayor of Ewing Township prohibited use of water for drinking, for non-essential purposes and for dishwashing except under Health Department regulations.
9/6/75	12:00 noon	Mayor of Hamilton Township extended emergency for 48 hours.
9/7/75	6:00 a.m.	Mayor of Lawrence Township extended emergency for 24 hours.
9/8/75	12:00 noon	Mayor of Hamilton Township extended emergency to midnight 9/8/75.
9/8/75	5:20 p.m.	Mayor of Trenton lifted most water restrictions except requirements for sterilization of drinking water and prohibition on non-essential uses.
9/8/75	7:30 p.m.	Deputy Mayor of Ewing Township lifted most water restrictions except requirements for sterilization of drinking water and prohibition on non-essential uses.
9/9/75	6:00 a.m.	Mayor of Lawrence Township lifted most water restrictions; continued requirement for sterilization of drinking water and prohibition on non-essential uses for 24 hours.
9/10/75	6:00 a.m.	Mayor of Lawrence Township extended proclamation of 9/9/75 for 24 hours.
9/10/75	10:15 a.m.	Assistant Director of N.J. Division of Water Resources (DEP) rescinded "Boil Water" Order.
9/10/75	8:00 p.m.	Deputy Mayor of Ewing Township lifted water restrictions (including requirement to sterilize water) except prohibition on non-essential uses.
9/11/75	6:00 a.m.	Mayor of Lawrence Township extended proclamation of 9/10/75 for 24 hours.

APPENDIX C

9/12/75	6:00 a.m.	Mayor of Lawrence Township lifted all water restrictions.
9/18/75	6:00 a.m.	Mayor of Lawrence Township prohibited non-essential uses of water for indefinite period.
11/30/75	12:00 noon	Mayor of Lawrence Township rescinded water emergency and all restrictions.
12/4/75	9:03 p.m.	Ewing Township Committee rescinded all proclamations relating to emergency.
3/8/76	11:00 a.m.	Assistant Director of N.J. Division of Water Resources (DEP) rescinded all water restrictions.
3/8/76	12:00 noon	Mayor of Trenton rescinded all emergency regulations.

APPENDIX D

WATER EMERGENCY SAMPLING PROCEDURE AND CONCLUSIONS

(by John Wilford, Assistant Director, Division of Water Resources, N.J. Department of Environmental Protection)

Immediately after it was determined, on September 2, that the incapacity of the Trenton water treatment plant would continue for several days, necessitating the use of emergency wells not normally used for the production of potable water and resulting in depletion of the outlying elevated tanks and the central reservoir, a "Boil Water" Order was issued by the Department of Environmental Protection as a precautionary measure. Sampling of the distribution system also commenced.

There are many potential sources of contamination in a situation of this type. The water from the emergency-utilized wells was of unknown bacteriological quality and it was impossible to properly disinfect the hoses and pumping equipment used by the participating fire companies. As the higher elevations of the system became depleted with water, there was risk that contamination might be drawn into it through illegal cross connections and leaks in the mains.

Seventy sampling points were plotted on a map of the distribution system and located so that all areas would be monitored. They included both transmission main and distribtuion main locations, as well as representative points for the sampling of water being pumped into the Trenton system from outside sources. It was decided to sample each point twice daily. During the depletion stage the determinations were confined to total coliform concentrations, but during the recovery phase they were extended to include fecal coliform determinations in addition. Whenever a position result was obtained, four additional samples were taken from immediately adjacent areas to determine the extent of the contamination. Close communication was maintained with the laboratory of the State Department of Health, which tested the samples, so that the results would be known to the Bureau of Potable Water immediately after they were determined. On the distribution map a continuous record of points without water, chlorine residuals, and bacteriological sampling results was maintained. By this means a total picture of the system could be obtained at any time by reference to a single map.

During the depletion stage each established point was bacteriologically sampled whenever water was available. At no time during the crisis was the system entirely depleted, due to the emergency interconnections, though depletion did occur in the higher elevations. The lower elevations, and those adjacent to the emergency interconnections, remained charged with water, albeit often with insufficient pressure to reach beyond the first floors of homes.

Representative locations were also sampled daily, commencing September 4, for chemical analyses, with particular emphasis in the industrial areas to check on the probability of backflow or siphonage of contaminants due to reduced or negative pressures.

APPENDIX D

After the treatment plant was reactivated on Saturday, September 6, the sampling was intensified. Along with bacteriological testing, the laboratory was asked to determine pH and hardness on each sample. Because of the differing chemical constituents in the water being pumped into the Trenton system it was thus possible to gain a general idea of the origin of the water at various points in the system during the recovery phase.

During the critical period, September 4 through September 10, a total of 755 bacteriological samples and 16 chemical samples were collected. After the system was fully recharged with water, and based on the record of water quality and chlorine residuals, the "Boil Water" Order was lifted on September 10. The intensive bacteriological monitoring was continued for three more days, but with reduced frequency, to insure continued quality of the delivered water. During the next several weeks the water quality continued to be spot-checked throughout the entire system. Fifty-two additional bacteriological samples were collected by the Bureau of Potable Water during the period September 13 through October 14, augmented by 70 samples collected by personnel of the Trenton Water Department.

Of the approximate 400 fecal coliform samples taken, only one produced a positive result and this showed only one colony. Only 35 of the approximate 800 total coliform samples were positive, but all positive samples showed low coliform densities. These positive results were probably more apparent than real because the bottles used for the collection of 18 of the 35 positive samples were sterilized on the same day as one group and, in view of the excellent chlorine residuals which were found, there is suspicion that the batch of bottles had not been properly sterilized. No unusual results were obtained in any of the chemical samples taken.

In the knowledge that a significant proportion of the system became dry, with the undoubted occurrence of negative pressures, it is apparent that the City of Trenton is blessed with a relatively-tight water distribution system and that by virtue of the fact that the area is fully sewered, the existence of contaminants adjacent to the water mains and water service lines is minimal.

APPENDIX E

WATER CRISIS VOLUNTEER ORGANIZATIONS

AAA Trucking Corp.
Albion Volunteer Fire Co.
Alert Communications Team of Mercer County
Allentown Fire Dept.
Ambler Fire Co.
America Fire Co. #4
American Red Cross Trenton Area Chapter
American Red Cross Eastern Union County Chapter
Amwell Valley Fire Co.
Applegarth Volunteer Engine Co. #1
Army Aviation Support Facility Fire Co.
Ashland Fire Co. #1 (Ashland)
Ashland Fire Co. #2 (Cherry Hill)
Associated General Contractors of New Jersey
Atco Volunteer Fire Co.
Atlantic Highlands Fire Dept.
Bay Head Fire Co. #1
Bayville Volunteer Fire Co.
Beach Haven Volunteer Fire Co.
Beachwood Volunteer Fire Co.
Berkshire Springs, Inc.
Beverly City Fire Co.
Beverly Road Fire Co.
Blackwood Fire Co. #1
Blawenburg Fire Co.
Blawenburg Volunteer Fire Co.
Bloomsbury Fire Co.
Bordentown Consolidated Fire Co.
Boy Scouts of America
Breton Woods Fire Co. #1
Bridgeport Volunteer Fire Co.
Bridgeton Fire Dept.
Brielle Fire Dept.
Bristol Consolidated Fire Dept.
Bristol Borough Fire Dept.
Bristol Fire Dept. #2
Bristol Fire Dept. #3
Brookview Volunteer Fire Co.
Bucks County Council of Civil Defense
Bucks Co. Firemarshal
Burlington City Fire Co. #1
Burlington City Fire Co. #2
Burlington City Fire Co. #3
Camden County Civil Defense
Camden County Fire and Ambulance Communications Center
Camden Fire Headquarters
Cape May County Civil Defense and Disaster Control
Capitol View Fire Co. #2
Cedarbrook Fire Co.
Central Monroe Fire Co.
Chalfont Fire Co.
Champale, Inc.
Cherry Hill Fire Co. #1
Chesterfield Fire Co.
Chews Fire Co. #1
Church Road Fire Co.
Cinnaminson Fire Co. #1
Civil Air Patrol Allentown Squadron
Civil Air Patrol New Jersey Wing
Civil Air Patrol Twin Pine Squadron
Civil Defense Preparedness Agency, Region I
Clark Fire Co.
Clementon AA Fire Co.
Coca-Cola Bottling Co. of New York
Colonial Volunteer Fire Co.
Conshohocken Fire Co.
Cornwells Fire Co.
County Lakes Fire Co.
Cropwell Fire Dept.
Croyden Fire Co. #1
De Cou Hose Co.
Defense Personnel Support Center
Delaview Fire Co.
Delaware Valley Citizens Band Radio Club
Derby Fire Co.
Donnelly Memorial Hospital
Eagle Fire Co. (New Hope)
Eagle Fire Co. (Pine Hill)
Eagleswood Fire Co.
Earle N.A.D. Fire Dept.
East Brunswick Fire Co. #1
East Franklin Fire Co. #1
East Franklin Fire Co. #2
East Windsor Township Rescue Squad, Inc.

APPENDIX E

East Windsor Fire Co.
Eatontown Boro Hose and Engine Co. #1
Edgely Fire Co.
Edison Volunteer Fire Co.
Eleventh Zone Emergency Unit
Enterpirse Volunteer Fire Co.
Ewing Township Civil Defense and Disaster Control
Fairless Hills Fire Co.
Fairmont Fire Co.
Falls Township Fire Co.
Florence Fire Co. #1
Florence Station Fire Co.
Fort Washington Fire Co.
4th Naval District
404th Civil Affairs Co., U.S. Army Reserves
Freehold Boro Fire Dept.
Freehold Township Fire Dept.
Gladwyne Fire Co.
Gloucester Heights Fire Co.
Good Intent Fire Co. #3
Goodall Rubber Co.
Gordons Corner Fire Dept.
Green Knoll Fire Co.
Greenacres Country Club
Groveville Fire Co.
Hamilton Fire Co.
Hamilton Township Civil Defense and Disaster Control
Hampton Fire Co.
Hartz Mountain Industries, Inc.
Haycock Township Fire Co.
Helmetta Fire Co.
Hightstown Engine Co. #1
Hi-Nella Fire Co.
High Point Volunteer Fire Co.
Highland Park Fire Co.
Hightstown-East Windsor Civil Defense and Disaster Control
Hillsborough Township Volunteer Fire Co.
Hope Steam Engine Co. #1
Hopewell Fire Dept.
Hopewell Township Civil Defense and Disaster Control
Howell Fire Co. #1
Humane Fire Co.
Hunterdon County Civil Defense and Disaster Control
Island Heights Volunteer Fire Co.
Jackson Mills Volunteer Fire Co. #1
Jackson Township Fire Co. #1
Jamesburg Volunteer Fire Co.
Johnson Truck Rental
Marie Katzenbach School for the Deaf
Kendall Park Fire Co.
Kingston Fire Co.
Lakehurst Volunteer Fire Co.
Lanoka Harbor Volunteer Fire Co. #1
Laucone Harbor Volunteer Fire Co.
Laurelton Volunteer Fire Co.
Laurence Harbor Fire Co.
Lavallette Volunteer Fire Co.
Lawrence Road Fire Co.
Lawrence Township Civil Defense and Disaster Control
Lawrence Township Emergency First Aid Squad
Lawrenceville Fire Co.
Lawrenceville School
Lebanon Township Fire Co.
Leonardo Community Fire Dept.
Levittown Fire Co. #1
Levittown Fire Co. #2
Liberty Rescue Squad
Lincroft Fire Dept.
Linghocken Fire Co.
Lower Southampton Fire Co. #1
Lumberton Fire Co.
Manasquan Volunteer Fire Co.
Manchester Volunteer Fire Co. #1
Manitou Park Fire Co.
Marlton Fire Co.
Marlboro Volunteer Fire Dept.
Martinsville Fire Co.
Masonville Fire Co. #1
Medford Fire Co.
Mercer County Airport Fire Dept.
Mercer County Board of Chosen Freeholders
Mercer County Civil Defense and Disaster Control
Mercer County Community College
Mercer County Fire Marshall
Mercer County Fireman's Association (Ladies Auxiliary)
Mercer County Highway Dept.
Mercer County Improvement Authority
Mercer County Mosquito Extermination Commission

Mercer Engine Co. #3
Mercer Metro
Mercerville Fire Co.
Milford Fire Co.
Millstone Valley Fire Co.
Mission Fire Co.
Mitchell Fire Co. #4
Monmouth Junction Volunteer Fire Co. #1
Montgomery Fire Co. #1 (Belle Mead)
Montgomery Fire Co. #2 (Skillman)
Moorestown Fire Co.
Morganville Independent Volunteer Fire Dept.
Morganville Volunteer Fire Dept.
Mount Holly Canteen
Naval Propulsion Test Center
Navesink Hook and Ladder Co.
Neptune Hose Co. #5
Neptune City Fire Dept.
Neptune Township Fire Dept.
New Brunswick Fire Dept.
New Jersey Bell Telephone Co.
New Jersey Civil Defense and Disaster Control
New Jersey Department of Defense
New Jersey Department of Environmental Protection
New Jersey Department of Health
New Jersey Department of Transportation
New Jersey Public Broadcasting Authority
New Jersey State Training School for Girls
Newportville Fire Co. #1
Newtown Fire Association
Niagara Fire Co. (Burlington)
Niagara Fire Co. (Merchantville)
North Brunswick Fire Dept.
Nottingham Volunteer Fire Co.
Oaklyn Fire Co. #1
Old Bridge Volunteer Fire Co. #1
Old Village Fire Dept.
Oreland Fire Co.
Parkland Fire Co.
Pemberton Boro Fire Co.
Penndel Fire Co.
Pennington Fire Co.
Pennington Road Fire Co.
Pennsauken Fire Co. #2
Philadelphia Street Commission
Philadelphia Water Commission
Pine Beach Volunteer Fire Co. #1
Pine Hill Fire Co. #1
Pioneer Hose Co. #1
Plainsboro Fire Co.
Plainsboro Rescue Squad, Inc.
Plant Engineers Council
Plumsteadville Fire Co.
Point Pleasant Beach Fire Co. #1
Point Pleasant Borough Fire Co. #1
Point Pleasant Borough Fire Co. #2
Princeton Engine Co. #1
Princeton First Aid and Rescue Squad
Princeton Hook & Ladder
Princeton Joint Civil Defense Council (Princeton Borough)
Princeton Joint Civil Defense Council (Princeton Township)
Princeton Junction Fire Co.
Progressive Fire Co.
Prospect Heights Fire Co.
Protection Fire Co.
Quakertown Borough Fire Dept.
Quakertown Fire Co.
Quakertown West End Fire Co.
Rancocas Fire Co.
Rantown Fire Co. Howell #2
Raritan Township Fire Co.
Relief Fire Co. (Burlington Township)
Relief Fire Co. (Mount Holly)
Riverside Fire Co.
Robertsville Volunteer Fire Dept.
Rich-Hill Transportation Trucking
Rockledge Fire Co.
Rocky Hill Fire Co.
Roebling Fire Co.
Runnemede Fire Co. #1
Rusling Hose Co.
Scotch Plains Fire Co.
Seaside Heights Volunteer Fire Co.
Seaside Park Volunteer Fire Co. #1
Sellersville Fire Co.
Sergeantsville Fire Co.
Ship Bottom Volunteer Fire Co.
Sicklerville Fire Co.
Signal 22 Association
Silverton Volunteer Fire Co. #1
Slackwood Volunteer Fire Co.
Slackwood Volunteer Fire Co. (Ladies Auxiliary)
South Old Bridge Fire Co.

APPENDIX E

South River Engine Co. #1
Southampton Fire Co.
Stafford Township Volunteer Fire Co.
Stafford Township Volunteer Fire Co. #1
Starscreen Inc.
Stockton Fire Co.
Surf City Volunteer Fire Co.
Swedesboro Fire Co.
Tansboro Fire Co. #1
Trenton Board of Education
Trenton Civil Defense and Disaster Control
Trenton Emergency Rescue Squad
Trenton Fire Dept.
Trenton Psychiatric Hospital
Trenton Psychiatric Hospital Volunteer Fire Co.
Trenton State College
Trenton Times Newspaper
The Trentonian
Tuckerton Volunteer Fire Co.
Tullytown Fire Co.
Twin "W" First Aid Squad, Inc.
Union Beach Boro Fire Dept.
Union Fire Co. #1 (Morrisville)
Union Fire Co. (Titusville)
Union Rescue Squad
U.S. Marine Air Reserve Training Center (MARTC)
U.S. Marine Air Reserve Training Unit (MARTU)
U.S. Marine Corps
U.S. Marine Corps Reserve Training Center (MCRTC)
U.S. Naval Shipyard
Van Doren Petroleum Carriers
WBUD Radio Station
WHWH Radio Station
WTNJ Radio Station
WTTM Radio Station
Warminster Fire Co.
Warminster Naval Air Developement Center
Warrington Township Fire Co.
Warwick Township Fire Co.
Washington Volunteer Firemen, Inc.
Waterford Volunteer Fire Co.
Welcome Volunteer Fire Co.
West Long Beach Boro Fire Dept.
West Point Fire Co.
West Trenton Volunteer Fire Co.
West Windsor Volunteer Fire Co.
West Tuckerton Fire Co.
White Horse Volunteer Fire Co.
William Penn Fire Co.
Willingboro Fire Co. Station 1615
Willingboro Fire Co. Station 1616
Woodbridge Fire Co. #1
Woodcrest Fire Co.
Woodlynne Fire Co. #1
Wrightstown Fire Co.
Yardley-Makefield Fire Co.

APPENDIX F

BOARD OF EXPERTS: RESOURCE DOCUMENTS INVENTORY

(to be stored in Office of Commissioner,
Department of Environmental Protection)

1. Newspaper Clippings.

2. Buck, Seifert and Jost

   a. Letter Reports of Damage and Recommendations
   b. Drawings of Filtration Plant: Emergency Alterations
   c. Estimated Cost of Remaining Emergency Repair

3. Transcript of Interviews with:

Adams, Henry J. Jr.	-	Director, Civil Defense (Hamilton Township)
Augustyn, John	-	Water Foreman, Water Division (Trenton)
Baxter, Brian	-	Business Administrator (Trenton)
Bushnell, Ellsworth C.	-	Superintendent of Filtration and Treatment, Filtration and Treatment Plant
Conti, Albert	-	Comptroller (Trenton)
Coppola, Ralph	-	Acting Chief Pump Station Operator, Filtration and Treatment Plant
Falcey, William H.	-	Director, Civil Defense and Disaster Control (Mercer County)
Gilsdorf, John	-	Pump Operator, Filtration and Treatment Plant
Holland, Hon. Arthur J.	-	Mayor (Trenton)
Irven, Richard	-	Senior Pump Operator, Filtration and Treatment Plant
Klockner, Lewis, Jr.	-	General Superintendent and Chief Engineer, Water Division
McQuade, William	-	Chief Pump Operator, Filtration and Treatment Plant
Mowat, Hon. Victor	-	(Former) Deputy Mayor (Hamilton Township)
Moyer, William	-	Consultant - Buck, Seifert and Jost
Nerwinski, Hon. Frank P.	-	(Former) Mayor (Lawrence Township)
Ricci, Rocco D.	-	First Deputy Commissioner (DEP)
Tuccillo, Joseph Jr.	-	Director, Department of Public Works (Trenton)
Van Hise, J. Morgan	-	Acting Director, Civil Defense and Disaster Control (New Jersey)
Westwater, James	-	Consultant - Westwater, Gaston and Dunka
Zamonski, Hon. Edward S.	-	(Former) Mayor (Ewing Township)

4. City of Trenton Files

   a. Annual Report of the Trenton Water Works to the Department of Public Utilities for 1974.

b. Five Year Improvement Plan: Organizational Chart of Public Works Department.

c. Documents:

1. Memo to Baxter from Klockner Containing Revised Statutes
2. Municipal Utility Fund Accounting
3. Crane Company Cone Valves Letter
4. Pump Procedures
5. Lists of Priority Repair Projects
6. Pumping Charts

d. Trenton Water Works suburban water rates, schedule of City meter rates and surface pipe and meter installation charges.

e. Section 2-8 of the City of Trenton ordinances.

f. Memo (September 23, 1975) from Klockner to Tuccillo outlining completion dates on present water filtration plant with resolutions authorizing such construction.

g. Report on Rehabilitation and Extension of Water Purification Facilities for the City of Trenton, New Jersey (August 1949) by Havens & Emerson, Consulting Engineers.

h. Inventory and original cost of property in place (December 31, 1963), City of Trenton, N.J., Department of Public Works, Water Division, by Bowe, Albertson & Associates, Inc., and Niles and Niles, and Supplemental Report.

i. Logs of events from Trenton Civil Defense and Disaster Control.

j. Annual reports and budgets of Water Division, Department of Public Works (1970 and 1974).

k. Organization chart showing internal command structure of the Water Division.

l. Agreement between City of Trenton and Local No. 2286 of the American Federation of State, County and Municipal Employees, AFL-CIO.

m. Agreement between City of Trenton and Local No. 2281, Trenton Supervisors, American Federation of State, County and Municipal Employees, AFL-CIO.

n. Emergency directives issued by public officials.

o. Report and list of companies in the support operation.

7. Transcripts of City of Trenton Inquiry.

APPENDIX G

TRENTON FILTRATION PLANT IMPROVEMENTS COMPLETED OR CONTEMPLATED FOLLOWING CRISIS

Information provided by Buck, Seifert & Jost,
Consulting Engineers

REPAIRS IN PROGRESS OR COMPLETED BY CONTRACT

	ITEM	COST
1.	Slab reinforcement and conduit restoration	$135,277
2.	Rehabilitation of electrical systems damaged by flooding	42,000
3.	Rebuilding heating equipment	14,800
4.	Painting pipe gallery, accelators and flocculators	17,850
5.	Reconstruction and rehabilitation of traveling screens	60,670
6.	Repairs to flash mixers, accelators, settling tanks and filters	131,925
7.	Rebuilding and rehabilitation of low lift and high lift pumps and motors	131,944
8.	Repair and rehabilitation of hydraulic cylinders and valves	78,000
9.	Replacement of cone valves with silent check valves	15,200
10.	Purchase of control equipment	20,000
		$647,666

REPAIRS COMPLETED BY PLANT PERSONNEL

1. Reconditioning of two flash mixers
2. Cleaning and reconditioning of carbon tanks and feed equipment
3. Replacement of top 2" of filter sand (80 tons)
4. Reconditioning of all surface wash piping
5. Cleaning and sterilizing west clear wells
6. Painting all piping and valves in west filter gallery

PROPOSED ADDITIONAL REPAIRS RECOMMENDED BY CONSULTING ENGINEERS*

	ITEM	COST
1.	Structural repairs to building	$ 50,000
2.	Painting filter boxes and head house	30,000
3.	Humidity control system and air handling equipment	60,000
4.	Electric work for controls purchased by City	16,000
5.	Automatic controls for traveling water screens	7,500
6.	Two new air pumping units for aeration system	10,000
7.	Two new flash mixers	25,000
8.	Rebuilding two flocculators	100,000
9.	Rehabilitation of settling tank collector systems	50,000
10.	Rehabilitation and improvement of filter wash systems	50,000
11.	Two new booster pumps for hydraulic control system	6,000
12.	New impellor for high lift pump No. 3	20,000
13.	Silent check valves for Central Pump Station	32,000
		$456,500

* Further funds would come from a rate increase or through State approval for the City of Trenton to increase its bonded indebtedness. If only partial funds are made available, priority will be given to those items essential to plant operation (Items 4, 8, 9, 12 and 13).