CAMDEN METROPOLITAN URBAN STUDY

Appendices 3-7

April 1980

VOLUME III

U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

LIST OF REPORTS AND APPENDICES

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COVER — THE COVER PHOTOGRAPH DEPICTS THE OUTSKIRTS OF THE CITY OF CAMDEN WITH THE COOPER RIVER AND ADMIRAL WILSON BOULEVARD. THE PHOTO WAS TAKEN IN JANUARY 1980.

CAMDEN METROPOLITAN URBAN STUDY

VOLUME III

TECHNICAL REPORT APPENDIX

INSTITUTIONAL ARRANGEMENTS & ANALYSIS APPENDIX

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PUBLIC INVOLVEMENT APPENDIX

WATER QUALITY MANAGEMENT;
TRI-COUNTY 208 STUDY APPENDIX

APRIL 1980

CAMDEN METROPOLITAN URBAN STUDY

APPENDIX 3

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

SECTION A

FLOOD DAMAGE SURVEY

SECTION A

FLOOD DAMAGE SURVEY

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SECTION A

FLOOD DAMAGE SURVEY

BACKGROUND

Prior to conducting the flood damage survey, meetings and workshops were held in each county to present a summary of this office's then-current knowledge of flooding problems in the tri-county area and to request assistance in identifying other flood-prone areas. The knowledge of flooding problems was based on past study efforts as described in the Plan of Study as well as that collected in conjunction with the Federal Disaster Assistance Administration of the Department of Housing and Urban Development. At each meeting, a display map of the county was provided to help the attendees pinpoint flood problem areas. In addition, extensive interviews requesting information on location of flood problems, frequency of flooding, type of flooding and total damages were conducted with mayors, county, city and township engineers, and watershed groups.

The first meeting was held on July 31, 1975 in the Camden County Complex Building. Approximately 30 representatives of various townships and/or boroughs from Camden County attended. The primary areas discussed were those having tidal and storm drainage problems.

On August 21, 1975 the second meeting was held at the Freeholders Board Room in the Burlington County office. Twenty-five representatives gathered for the meeting. Local representatives were concerned about the problems of increased development in the upstream portions of the watersheds. It was generally agreed that without proper controls on upstream development, existing flooding problems will be aggravated by increased runoff associated with urbanization.

On August 22, 1975, the Corps of Engineers held the final meeting in the Fine Arts Center Auditorium, Gloucester County Community College. Approximately 20 local representatives were present at the meeting. The local representatives described some of the flooding problems their communities have been experiencing. Considerable concern was expressed regarding future development in the watersheds and its effect on runoff.

Flood problem areas identified at the three meetings and through the interviews were incorporated into the flood damage survey.

CONDUCT OF FLOOD DAMAGE SURVEY

A 1964 flood damage survey of some study area streams, performed under the Camden County Streams Study in 1972, was expanded in this study to include the entire study area and updated to current price levels and conditions in 1975-76. That survey reflected July 1975 conditions and price levels. The price levels were further updated in October 1978 for use in the economic analysis contained in this report. The survey was divided into the following four phases:

- Phase I was an evaluation of the 18 watersheds within the tri-county area to determine their flood potential and a selection of watersheds to be inventoried in detail for flood damages.
- Phase II was a detailed inventory of the watersheds selected in Phase I for damages caused by overbank flooding.
- Phase III was an inventory of the watersheds selected in Phase I for drainage and flood related traffic delay damages.
- Phase IV surveyed the remaining watersheds for potential damages.

Phase I - Evaluation and Selection of Watersheds

The purpose of this evaluation was to provide a basis for

selection of the watersheds which would be studied in detail. The following were considered during the selection process: 1) analysis of the existing flood problems as determined through available data, the three county workshop meetings and subsequent interviews; 2) historical flooding and damage data; 3) where known, percent of the flood plain encroached by residential, commercial and industrial developments; 4) the percentage and acreage of land within each watershed that was already developed.

Based upon the criteria described above, the following watersheds shown in alphabetical order were selected for detailed analysis:

- Big Timber Creek (including Little Timber Basin)
- Cooper River
- Mantua Creek
- Pennsauken Creek
- Pompeston Creek (including Swedes Run)
- Rancocas Creek

Phase II - Detailed Damage Inventory of Six Watersheds

Prior to conducting the field damage inventory, a review of the available flood plain information and flood insurance studies was made. Specifically, the water surface profiles and areas of inundation for various floods, such as the flood of record and 100-year event, were extracted from the flood plain studies. Damage estimates were compiled for residential, commercial-industrial, agricultural and public land use

categories. The manner in which the flood damage survey was conducted for each of the four categories is discussed in the following paragraphs.

Residential Damage. Before residential damages could be determined, the first floor elevation and point of zero damage were obtained for each residence by survey teams. Next, the homes were divided into groups, each group having a similar type of construction, value and damage potential. A typical sample for each group was then interviewed, each sample generally representing from five to ten residences. The interview was used to confirm flood elevations and to estimate damage history and potential. Concurrently, the market value of the sample property minus the value of the land itself was estimated by members of the interview team.

Having established the market value and the first floor elevation, the damage resulting from varying heights of flooding to each group of residences was determined. For each group, both the structural damage, i.e., damage to the structure itself (walls, floors, wiring, plumbing, etc.) and the damage to the contents (furniture, applicances, carpets, etc.) were determined.

Commercial-Industrial Damage. In determining commercial damages, first floor elevations and points of zero damage were obtained as indicated for residences. Damages for commercial-industrial establishment were determined from interviews with management representatives to confirm flood elevations and estimate historical and potential flood losses.

Again, an estimate was made of the damages at varying increments of flood stage. This included the physical damage such as damage to furnishings, fixtures, equipment, stock, material in process, completed products, and clean-up. Business and financial losses such as net loss of normal profit and wages to employees associated with clean-up were also determined.

Agricultural Damage. As a result of field inspections, conversations with soil conservation county agents and a review of available literature, it was determined that agricultural loss suffered from the 100-year flood would be minimal for overbank flow. The flood plains are not actively cultivated and, for the most part, are covered with well-established vegetation, minimizing erosion problems.

Public Damage. Public damage estimates were determined by the same method used for estimating commercial-industrial damages. This category includes damage to highways, railroads, bridges and utilities.

The utilities include damages to sewer treatment facilities, water companies, gas, power and telephone facilities. Sewage treatment plants were obviously susceptible to damage in the 100-year flood and, as a result, were inventoried. Other utility damage information was obtained through telephone contacts. The telephone survey revealed that most facilities in or near the flood plain are waterproofed and damage suffered from the 100-year flood would be minimal.

Each watershed was divided into damage reaches with each

reach having similar hydraulic characteristics and cause of flooding. For each damage reach, a stage-damage curve was prepared. The damage so defined by the curve is a composite of the residential, commercial-industrial, agricultural and public damage for each reach. Figure 3A-1 reflects a typical stage-damage curve for one of the damage reaches. The damage reaches, in turn, were aggregated into damage centers or areas of concentrated damages.

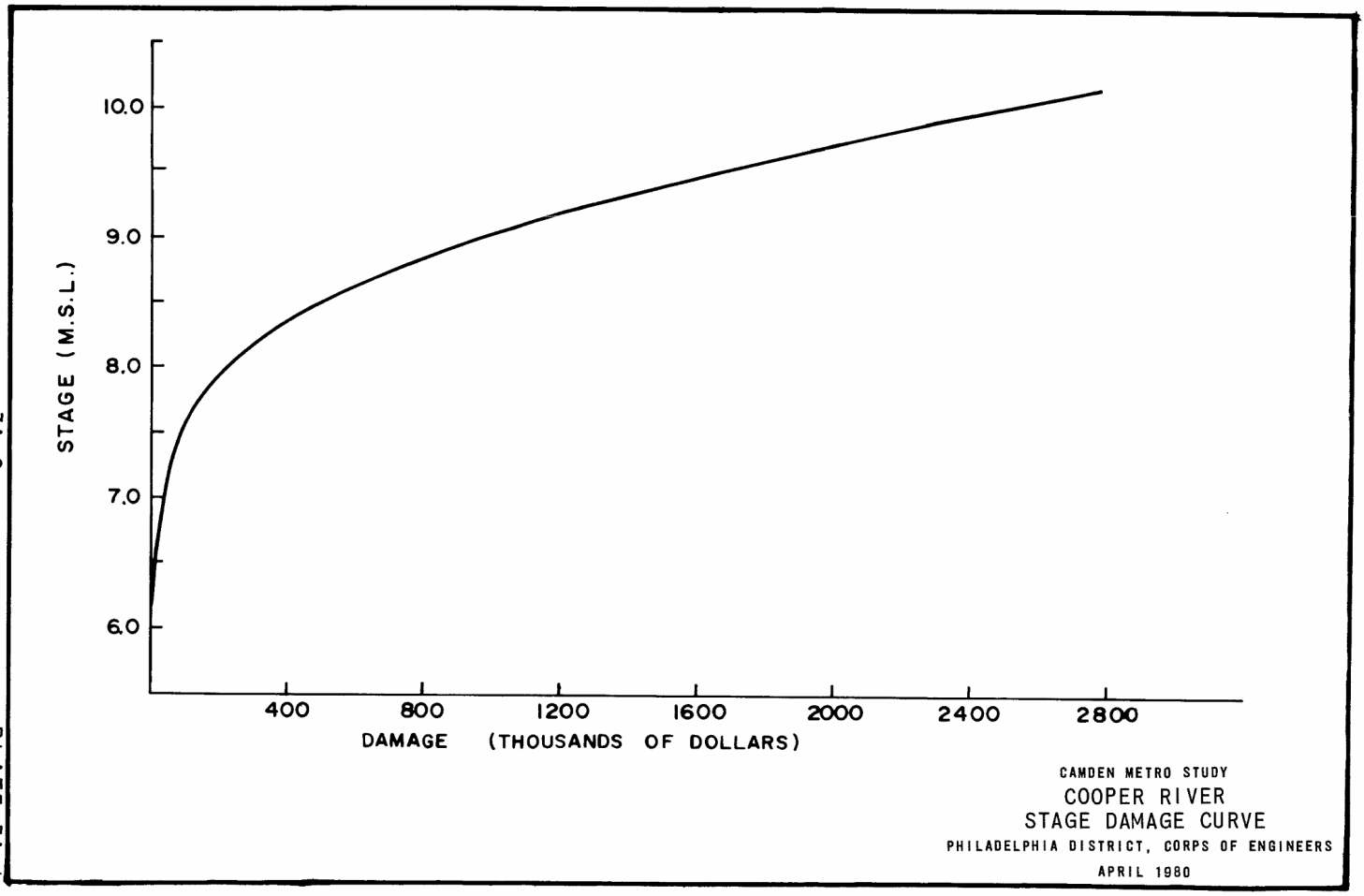
Phase III - Traffic Delay and Drainage Damages

Traffic Delay Study. The traffic delay study quantified economic loss due to flood-related interruptions of traffic flow. The dollar values indicate the comparative severity among the flooded routes.

In the Camden metropolitan area, the relatively flat topography and tidal and fluvial sources of flooding combine to create conditions for traffic congestion during floods. Several major arterials leading to and from the Delaware River bridges are among the more frequently flooded routes.

A review of existing hydrology was conducted to determine those highways which would be inundated during the 100-year flood. Information contained in completed Flood Plain Information and Flood Insurance Reports was used as a guide to identify potential flood-prone highways.

Actual road elevations on as-built plans for roads within the 100-year flood plain were compared to flood levels. The road elevations were determined through the cooperation of the



CAMDEN METRO STUDY
COOPER RIVER
STAGE DAMAGE CURVE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

PLATE 3A-1

New Jersey Department of Transportation. Highways which would have less than one foot of flooding from the 100-year flood were eliminated from further consideration based on the assumption that a detour would not be necessary in those cases.

When highway flooding reached a depth of one foot, it was assumed that traffic was re-routed over the shortest open route by which the motorist could reach the same destination. For the purposes of this study, destinations were assumed to be the intersection at either end of the flooded route, or the nearest major attraction at either end of the flooded route (i.e. the Benjamin Franklin Bridge). Considerations for the selection of an alternate route were as follows:

1) The alternate should be the shortest possible route between the two destinations.

2) All links on the alternate must be on DVRPC's network.

3) Flood-prone routes within a watershed flood simultaneously.

Preliminary alternate routes were determined in the office using U.S.G.S. quadrangle maps. These were modified by reviewing DVRPC's "Route and Intersection File" which revealed those links which were one way or to which there was no access. In several cases this necessitated the identification of an alternate route for each direction of travel.

Various methods currently in use were evaluated to determine the value of travel time. Precise and universally-accepted values of time have not been established. The methods used by

DVRPC involves a comparison of toll roads (or bridges) vs. free roads. The primary advantage of this method is that it represents a conscious decision by the motorist to save time by increasing his costs. The major disadvantage is that factors other than time savings may influence the choice of route (such as the availability of alternative routes).

The time value supplied by DVRPC was updated to 1978 by using the Consumer Price Index. The value in 1978 dollars is $2.20 per person-hour. Also, a regional time factor of $2.50 per hour was used to be added to DVRPC's time value.
Using the methods described previously, a total of 21 flood-prone routes were identified. Five of these routes are in the Cooper River Watershed, five in the big Timber, seven in Pennsauken, and two each in the Pompeston and Mantua Watersheds. The Cooper River Watershed suffers the greatest losses, totaling $93,000 for the 100-year flood.
Drainage Study. This study considered only those problem areas in the six watersheds which are affected by inadequate channel capacity. Two distinct examples of this type of problem are:

- A drainage system which cannot discharge its effluent into a downstream water course because of high stages (in the water course).
- Backwater effect of a downstream water course inundating portions of the area (drained by the drainage system) using the drainage system itself as a conduit.

A third type of drainage problem causes damages but was not

considered in this study since it was beyond the study scope. Problems of this type result from inadequately-sized culverts, storm water lines, etc. Solutions for problems of this type are considered to be a local responsibility.

Areas affected by high stage conditions were identified based on a review of local drainage complaints, information obtained during the meetings, field interviews and newspaper reports of flooding events.

Ten problem areas warranted detailed analysis. Of these areas, only one -- Chandlers Run, a tributary of Cooper River -- experienced significant damages. The total damages at that point, assuming the 100-year high tide to coincide with the 100-year fluvial runoff, an extremely rare combination of events, was estimated to be $230,000.

Phase IV - Assessment of Potential Flood Problems In Remaining Watersheds

This phase considered those flood damages occurring outside the six watersheds selected for the detailed flood damage inventory. While the level of detail for this portion of the damage survey was less than that used for the portion described above, it was adequate for assessing the potential flood damages.

Federal Insurance Administration's (FIA) Flood Hazard Boundary Maps were used to identify and locate potential flood problems. Each area was investigated during field inspections or direct contact with local engineers. Although some areas identified in this phase had significant damages at the 100-year

flood level, damages at lower frequency levels, often including the flood of record, were generally considerably smaller.

Regionalized depth-damage curves developed by the Federal Insurance Administration were used to estimate residential and commercial-industrial damages. Modifications to the curves based on information developed during the detailed portion of the survey were made to reflect the specific regional flood characteristics of southern New Jersey.

For each group of residential properties, the depth of flooding and market value were estimated. Flood damages were then determined by using these factors and the modified depth-damage curves. Commercial-industrial losses were determined by estimating the depth of flooding, square footage of property, type of stock, content and type of structure and referring, once again, to the depth-damage curves. Public, traffic and drainage damages were determined through coordination with local representatives, other available information and experience gained during the detailed flood damage survey.

RESULTS OF THE DAMAGE SURVEY

Table 3A-1 indicates the total damages to residential, commercial-industrial and public properties for the flood of record and the 100-year event for 1975-1976 conditions and October 1978 price levels. It supplements the data shown in the Plan Formulation Appendix for each watershed.

TABLE 3A-1

FLOOD DAMAGES-COMMERCIAL-INDUSTRIAL, RESIDENTIAL AND PUBLIC
(October 1978 Price Level)

Burlington County				
Flood	Commercial-Industrial	Residential	Public	Total
100 yr.	840,000	1,455,000	387,000	$2,682,000
Flood of Record	325,000	1,293,000	23,000	1,641,000
Camden County				
Flood	Commercial-Industrial	Residential	Public	Total
100 yr.	12,183,000	2,416,000	654,000	15,253,000
Flood of Record	1,175,000	619,000	52,000	1,846,000
Gloucester County				
Flood	Commercial-Industrial	Residential	Public	Total
100 yr.	124,000	4,483,000	288,000	4,895,000
Flood of Record	441,000	684,000	55,000	1,180,000
Totals (100 yrs.)	13,147,000	8,354,000	1,329,000	$22,830,000
Totals (Flood of Record)	1,941,000	2,596,000	130,000	$4,667,000

NOTE: The damages shown for the flood of record reflect the combined total damages from the maximum event in each watershed.

SECTION B

PROJECT FEASIBILITY

SECTION B

PROJECT FEASIBILITY

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SECTION B

PROJECT FEASIBILITY

This section briefly presents various structural and non-structural measures that were considered in determining the economic feasibility of projects in the ten top damage centers and in the analysis of the flood warning system.

As described in the Plan Formulation Appendix, the results of these studies were used as a basis for determining if further site-specific investigations were warranted. Each of the studies was not treated at the same level of detail. In some cases, data developed through separate Corps authorities was available and permitted a more thorough review. Examples of this are areas 2 and 6, which were investigated under the Corps' "Small Project Program" and areas 1, 3, 7 and 10 which were considered under a recent Corps study for Camden County in 1972. For area 2, a detailed project report has been completed and is awaiting local assurances. As for area 6, local assurances were not provided, terminating further study efforts. The damage data was updated to current price levels and conditions in 1975-1976 as part of this study. Those areas were reviewed to see if changes in development or Federal guidelines warranted modifications to past recommendations. In addition, in those areas where the B/C ratio was relatively high, a breakdown of costs is provided.

DESCRIPTION OF TEN TOP DAMAGE CENTERS

Cooper River at Pennsauken and Collingswood

The top damage center in the tri-county area is in the Cooper River Watershed located between the Kaighn Avenue tidal dam at the Cooper River Lake and Cuthbert Boulevard. The 100-year flood causes $4,656,000 in damages (see Figure 3B-1). Damages are concentrated in the Airport Industrial Park and residences along the South Park Drive. This damage area was considered for flood protection in the Camden County Streams Report completed by this office in June 1972. The plan of improvement consisted of earth levees and concrete floodwalls. However, no Federal project was justified at that time. Since 1972, this area has been subjected to additional industrial development. At the present time, it is estimated that approximately 25 per cent of the flood-prone area is undeveloped.

In order to provide protection, an earth levee 18,000 feet in length averaging seven feet in height would be required along the left and right banks of the Cooper River. The area protected on the right bank is served by a system of storm sewers. The runoff from these sewers would be intercepted and carried to a pumping station and discharged to the Cooper River.

The itemized first cost for this project is shown in Table 3B-1. As in the previous study, the project would be economically unjustified. Non-structural measures, such as

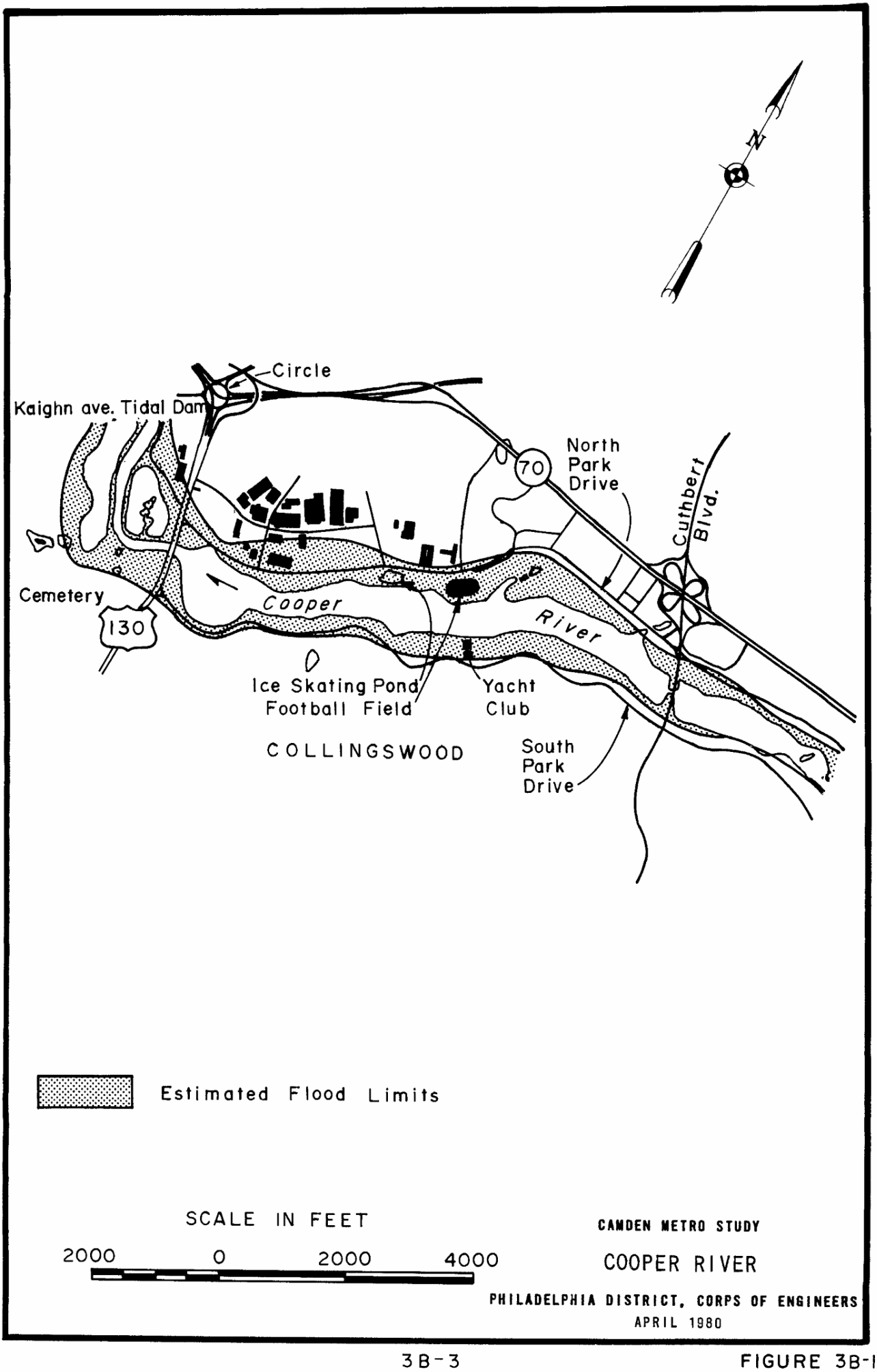

N
Circle
Kaighn ave. Tidal Dam
70
North
Park
Drive
Cuthbert
Blvd.
Cemetery
130
Cooper
River
Ice Skating Pond
Football Field
Yacht
Club
COLLINGSWOOD
South
Park
Drive
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
CAMDEN METRO STUDY
COOPER RIVER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-1

TABLE 3B-1

FIRST COST - LEVEE SYSTEM
DAMAGE AREA #1

ITEM	COST
Clearing	$ 51,800
Excavation	166,500
Embankment	609,000
Compaction	108,000
Filter Material	201,000
Seed and Mulch	72,000
Rip-Rap	1,034,000
Pump Station	300,000
Sub-Total	$2,542,300
Contingencies @ 25%	635,600
Sub-Total	$3,177,900
Engineering, Design	476,700
Supervision and Administration @ 15%	
TOTAL FIRST COST	$3,654,600

flood-proofing, evacuation and flood warning systems, were investigated and found unfeasible and undesirable.

Delaware River at Gibbstown, Greenwich Township

The next damage area, which is located at Gibbstown, Greenwich Township (see Figure 3B-2), has been investigated for flood protection under the authority of the Corps of Engineers Small Project Program. That study involved the feasibility of improving the level of protection presently afforded the area protected by the Gibbstown Dike. The dike is about 4.5 miles long and extends along the Delaware River at an average elevation of ten feet (above sea level datum). The levee protects 4,500 acres of land --530 acres consist of industrial development, 420 acres of residential development (Borough of Gibbstown) and 3,550 acres, or 78 per cent of the total area, of planted fields and marshlands. Because of the failure of the local sponsors to provide the necessary items of local cooperation, study efforts have been terminated. Further effort in this area is not warranted at this time.

Cooper River at the Cities of Camden and Pennsauken

The tidal reach of the Cooper River in the Cities of Camden and Pennsauken is the site of the third damage area. The 100-year flood causes $3,326,000 in damages (see Figure 3B-3). At the present time, approximately ten per cent of the flood-prone area is undeveloped. The most feasible plan of improvement included a combination of levees and floodwalls along the banks of the river, similar to that considered in the Camden County Stream Study. Because of inadequate space for

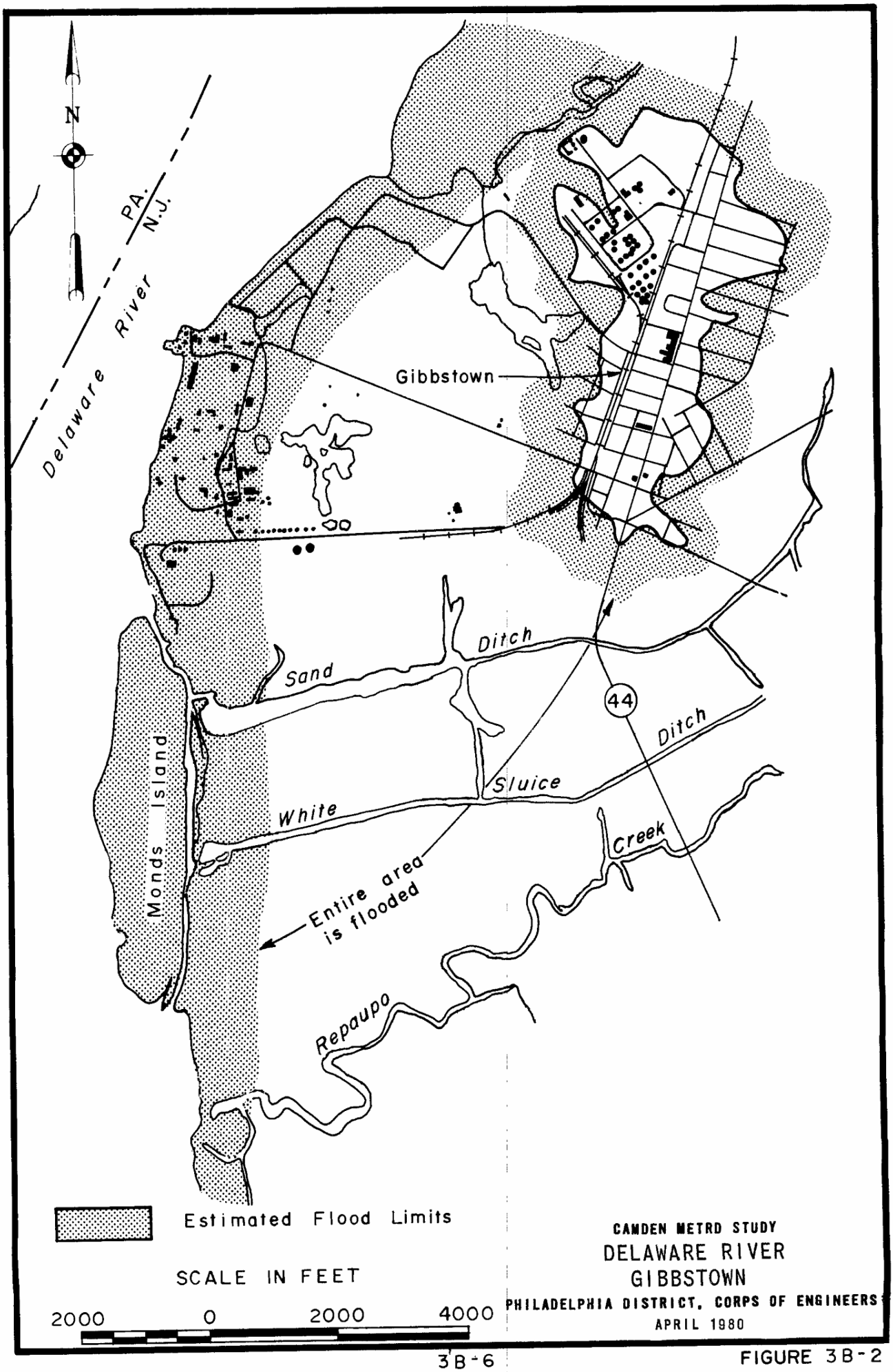

N
PA.
N.J.
Delaware River
Gibbstown
Sand
Ditch
44
Ditch
Sluice
White
Creek
Monds Island
Entire area is flooded
Repaupo
Estimated Flood Limits
SCALE IN FEET
2000
0
2000
4000
CAMDEN METRO STUDY
DELAWARE RIVER
GIBBSTOWN
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-2

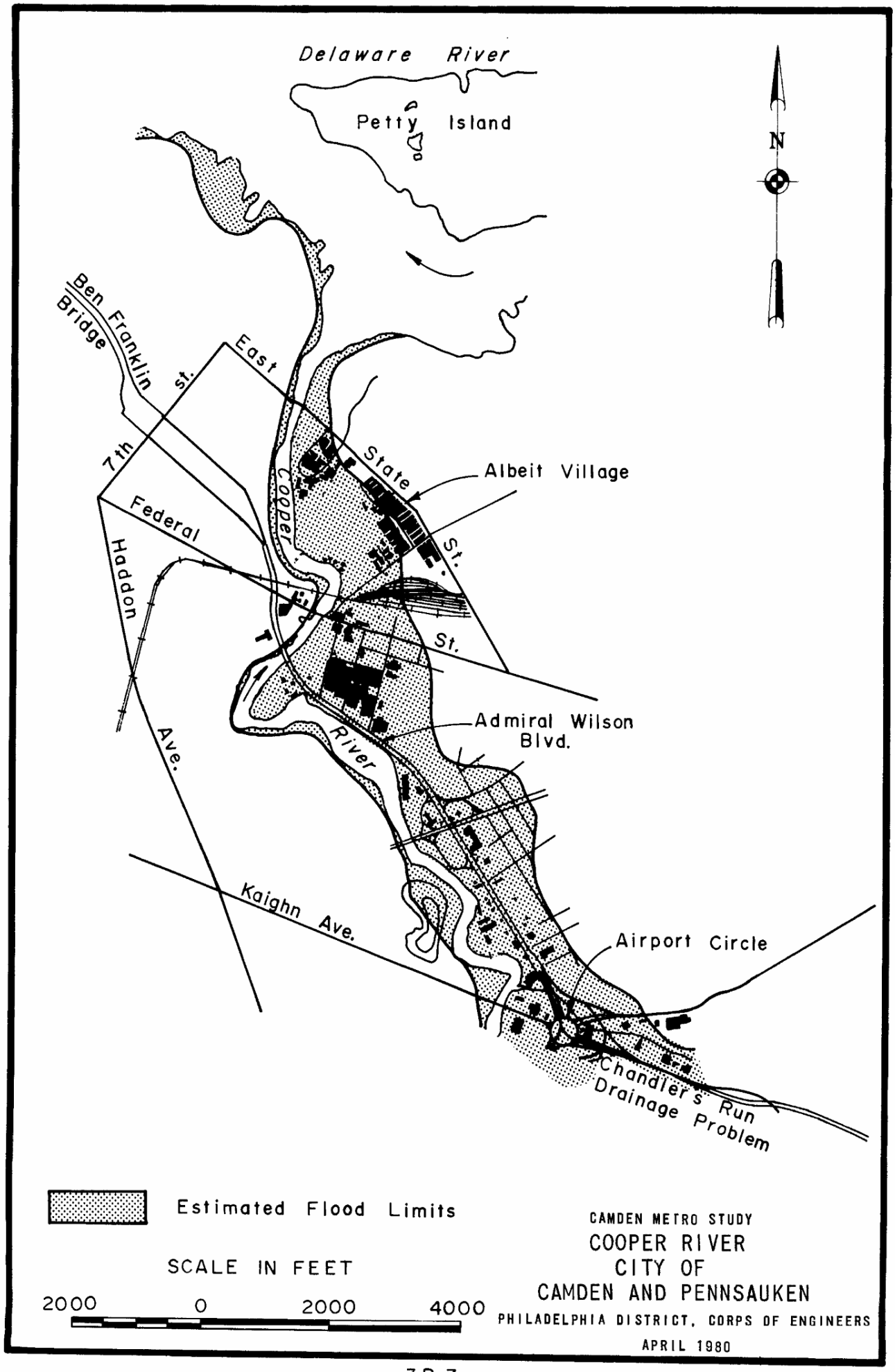

Delaware River
Petty Island
N
Ben Franklin Bridge
East
st.
7th
Federal
Haddon
Ave.
Cooper
River
State
St.
St.
Albeit Village
Admiral Wilson Blvd.
Kaighn Ave.
Airport Circle
Chandler's Run Drainage Problem
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
CAMDEN METRO STUDY
COOPER RIVER
CITY OF
CAMDEN AND PENNSAUKEN
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-3

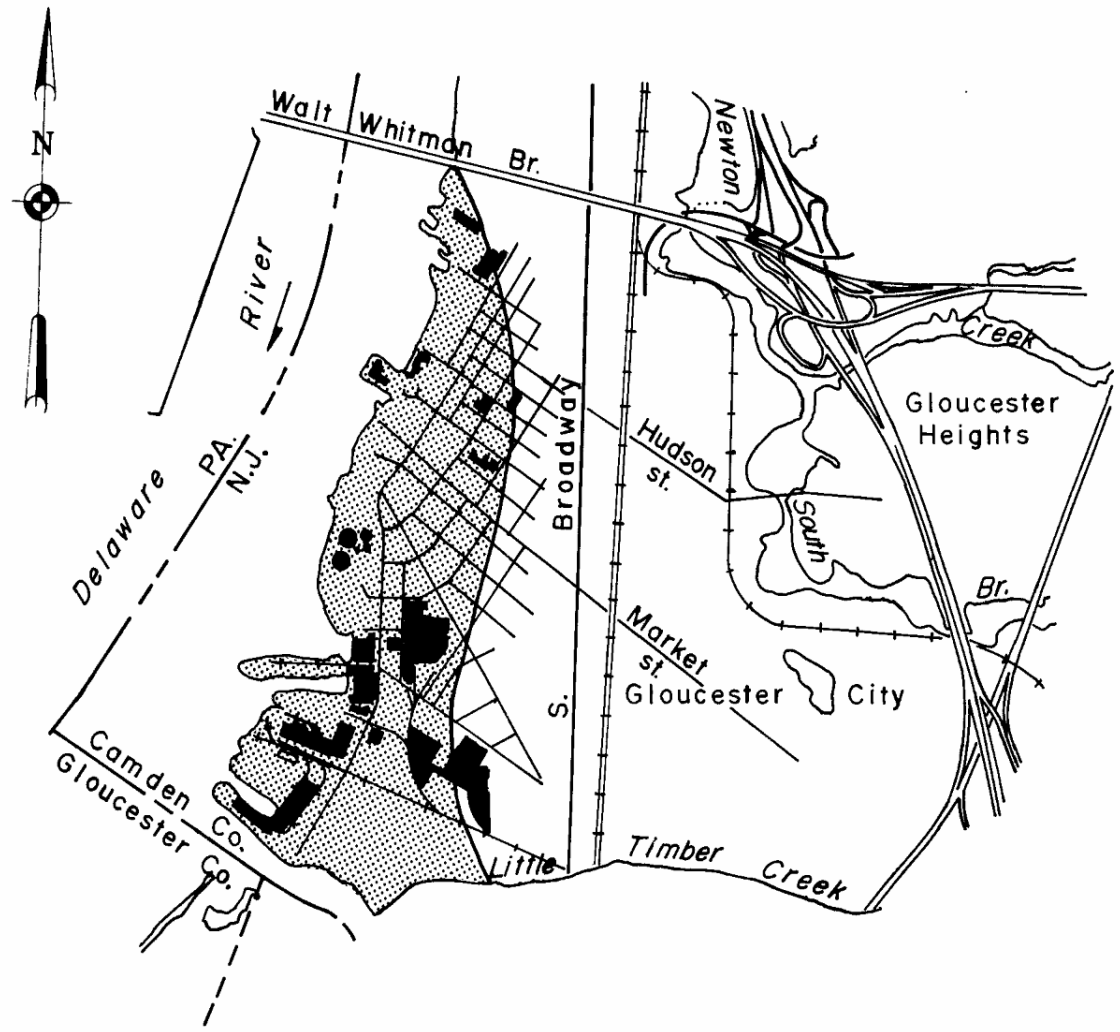
levees in some reaches, floodwalls averaging five feet in height and 6,000 feet in length were considered. For the remaining areas, levees were employed averaging four to seven feet in height and 5,700 feet in length. The above plan was found to be economically unfeasible.

Because of the nature of the damages, primarily to stock and products left in low-lying outdoor storage, flood-proofing is not a reasonable alternative. A flood warning study revealed that the system was unfeasible and not desired by local interests.

Delaware River at Gloucester City

The fourth area, which is in Gloucester County, is located along the Delaware River in Gloucester City. The 100-year flood causes $2,198,000 in damages (see Figure 3B-4). At the present time, approximately 75 per cent of the flood-prone area is occupied by industrial development, with small pockets of residential structures. The remainder of the flood-prone area is undeveloped. Structural and content damages to the industrial development are minimal because the buildings are either flood-proofed or the first floor level is above the 100-year flood levels. Damages incurred are usually attributable to finished products stored outdoors, and to cleanup operations.

Structural improvements considered included a floodwall and bulkheading along the Delaware River, averaging four feet in height and 8,000 feet in length. While the 100-year damages are



Estimated Flood Limits

SCALE IN FEET

2000 0 2000 4000

CAMDEN METRO STUDY

DELAWARE RIVER

GLOUCESTER CITY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3B-4

significant, annual damages are relatively low since recurrent flooding does not cause damage. Refer to Table 3B-2 for the total first cost. Because of the high costs of the relatively long floodwall required and relatively low annual benefits expected, this project is not economically justified. Because of the types of damages incurred, flood-proofing was not a viable alternative. Also, a flood warning system was investigated for this damage area and proved to be unfeasible and undesirable.

Delaware River at the City of Camden

The fifth damage area is also subject to flooding from the Delaware River. The area investigated is located in the City of Camden along the Delaware River stretching from the Benjamin Franklin Bridge to Newton Creek (see Figure 3B-5). Estimated damages from the 100-year flood are $1,681,000. At the present time, approximately 85 per cent of the flood-prone land is under industrial use, with an additional ten per cent undeveloped. The remaining acreage is presently in residential use. Damages are mostly to raw materials and finished products which are stored outdoors. Cleanup costs would also be substantial if a

TABLE 3B-2

FIRST COST - FLOODWALL SYSTEM

DAMAGE AREA #4

ITEM	COST
Excavation	$ 290,000
Subgrade	190,000
Concrete	710,000
Steel	225,000
Backfill	195,000
Sub-Total	$1,610,000
Contingencies @ 25%	403,000
Sub-Total	$2,013,000
Engineering, Design Supervision and Administration @ 15%	$ 302,000
TOTAL FIRST COST	$2,315,000

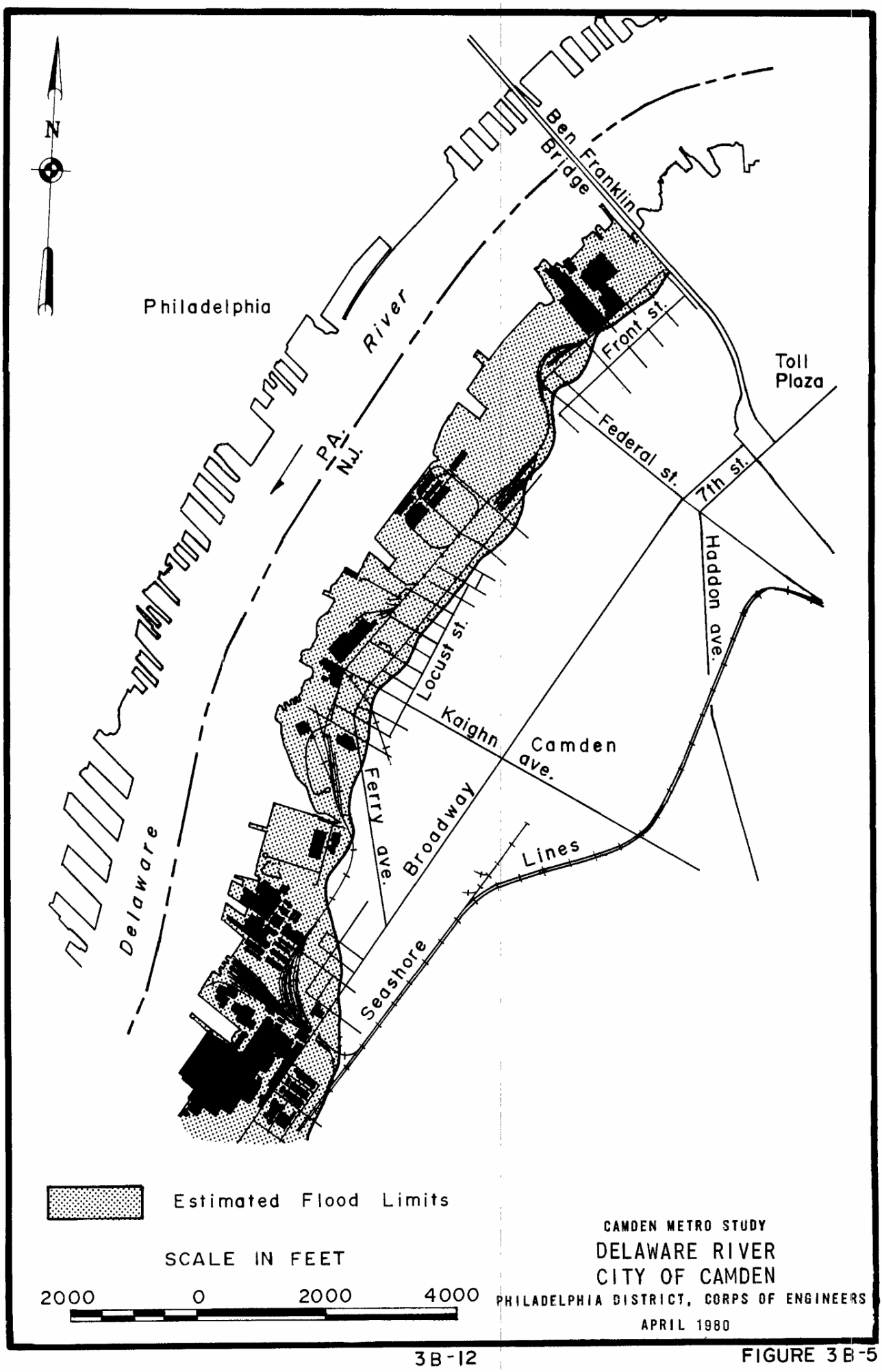

N
Philadelphia
Delaware River
PA.
N.J.
Ben Franklin Bridge
Front st.
Toll Plaza
Federal st.
7th st.
Haddon ave.
Locust st.
Kaighn ave.
Camden
Ferry ave.
Broadway
Lines
Seashore
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
CAMDEN METRO STUDY
DELAWARE RIVER
CITY OF CAMDEN
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-5

100-year flood were to occur. Structural and content damages are minimal as the properties are approximately two to three feet above the ground and above 100-year flood levels. The type of structural and non-structural solutions investigated for this area were similar to those for the Gloucester City damage center and similar conclusions were reached.

Newton Creek at Collingswood and Woodlynne

The sixth damage area, also in Camden County, is situated along North Branch Newton Creek in Collingswood and Woodlynne (see Figure 3B-6). This area has been investigated for flood protection under the authority of the Corps of Engineers Small Project Program. A reconnaissance study recommended the construction of a tidal barrier with flap gates. The tidal barrier would be 150 feet long with a top width of ten feet. This plan appeared feasible at the reconnaissance level of detail. Further detailed studies are being pursued under the authority of the Corps of Engineers Small Project Program pending local assurances.

Pochack Creek in Pennsauken Township

Pennsauken Township along the Pochack Creek near U.S. Route 130 is the site of the seventh priority damage area based upon potential damages to existing development within the 100-year flood plain (see Figure 3B-7). Damages incurred by the 100-year flood event would amount to $422,000. At the present time, approximately 70 per cent of the flood-prone area is under industrial use, with the remaining lands divided between residential and developable land.

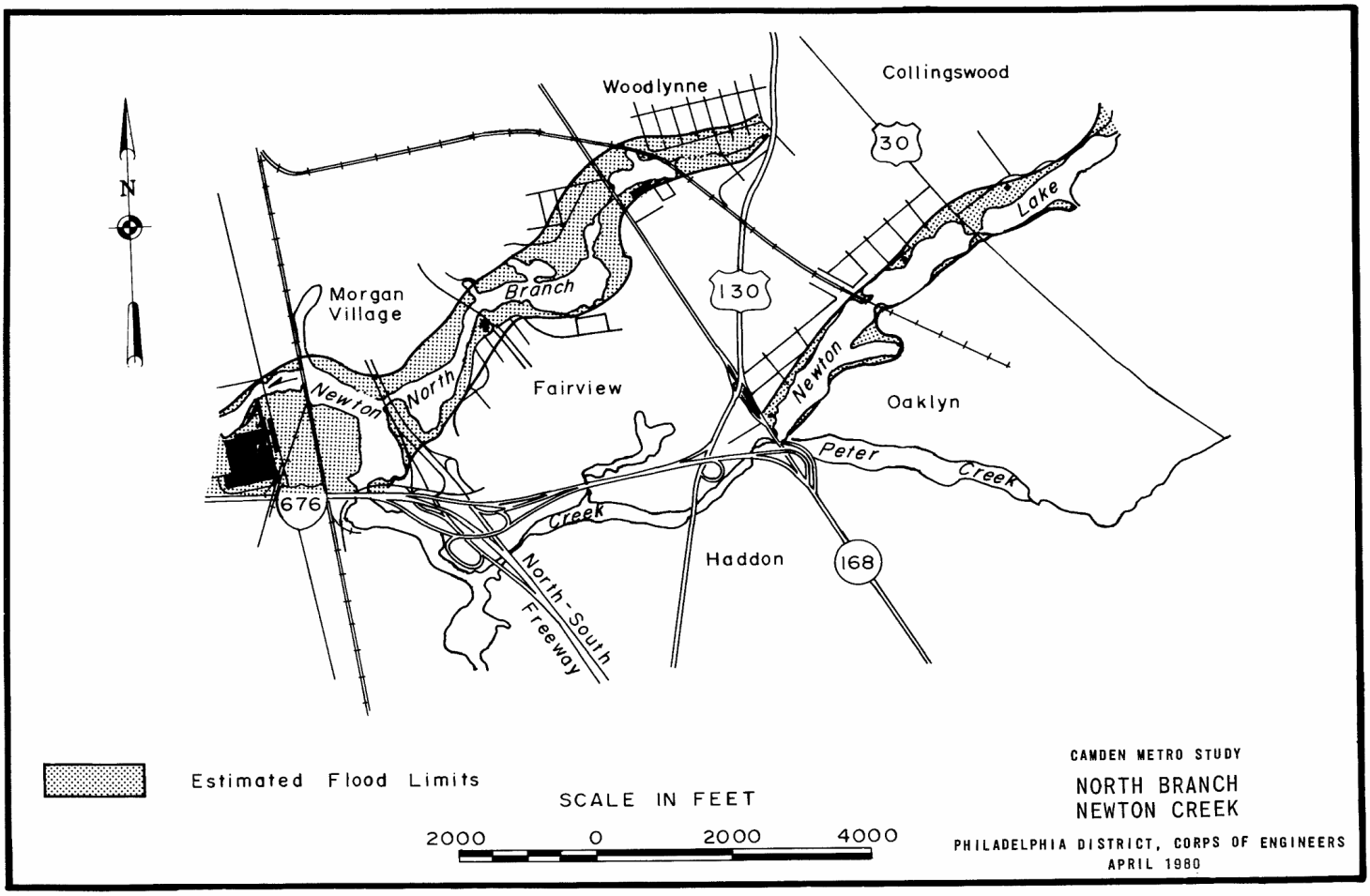

Woodlynne
Collingswood
30
Lake
N
Morgan
Village
Branch
130
Newton
North
Fairview
Newton
Oaklyn
Peter
Creek
676
Creek
Haddon
168
North-South
Freeway
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
CAMDEN METRO STUDY
NORTH BRANCH
NEWTON CREEK
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-6

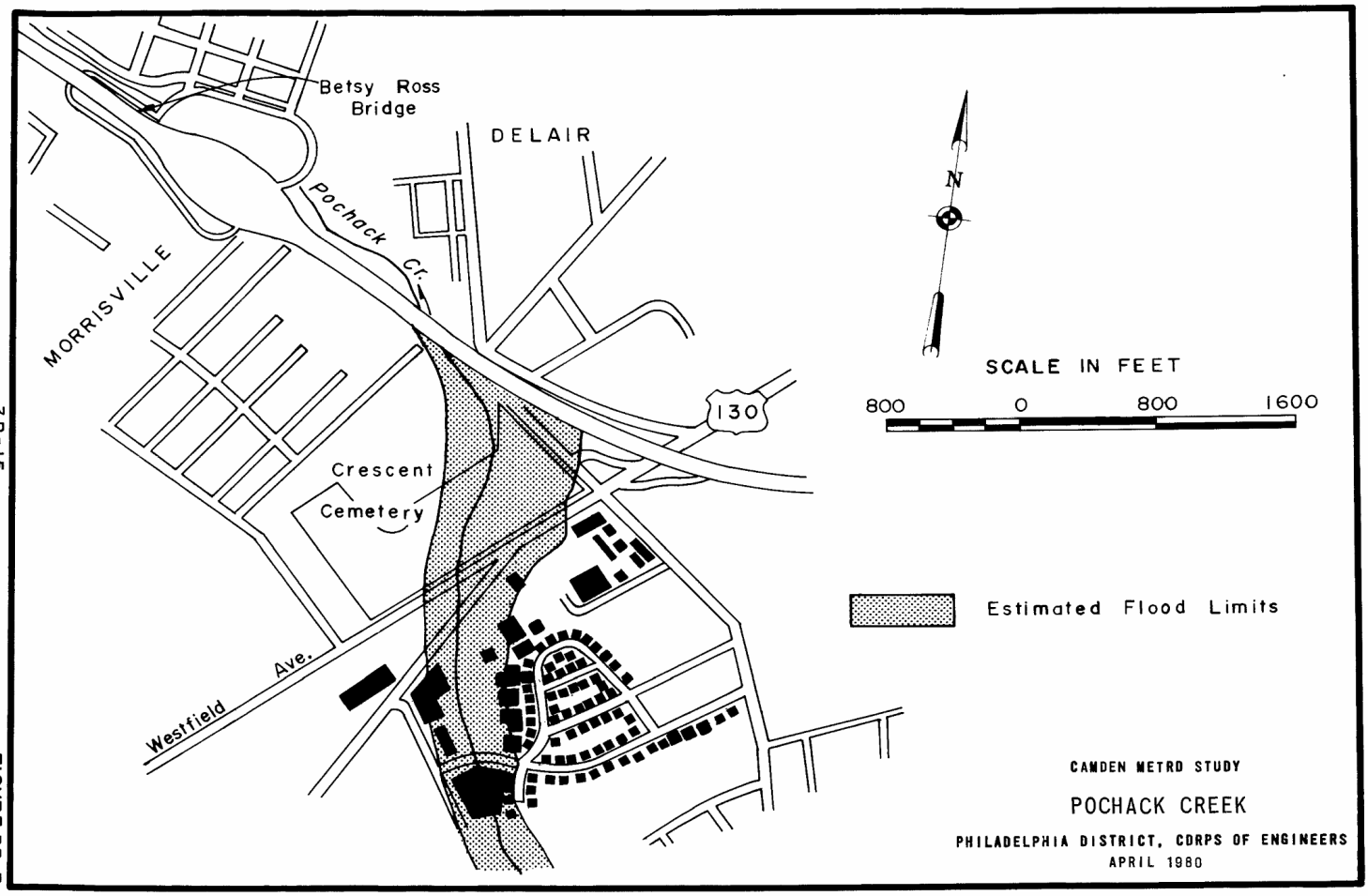

Betsy Ross
Bridge
DELAIR
Pochack Cr.
MORRISVILLE
130
Crescent
Cemetery
Westfield Ave.
N
SCALE IN FEET
800 0 800 1600
Estimated Flood Limits
CAMDEN METRO STUDY
POCHACK CREEK
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-7

After considering various measures, the most feasible plan was a reinforced concrete box culvert. That plan would permit the passage of runoff and eliminate the ponding that occurs in the vicinity of the Industrial Park near U.S. Route 130. These alternatives were found to be economically unjustified.

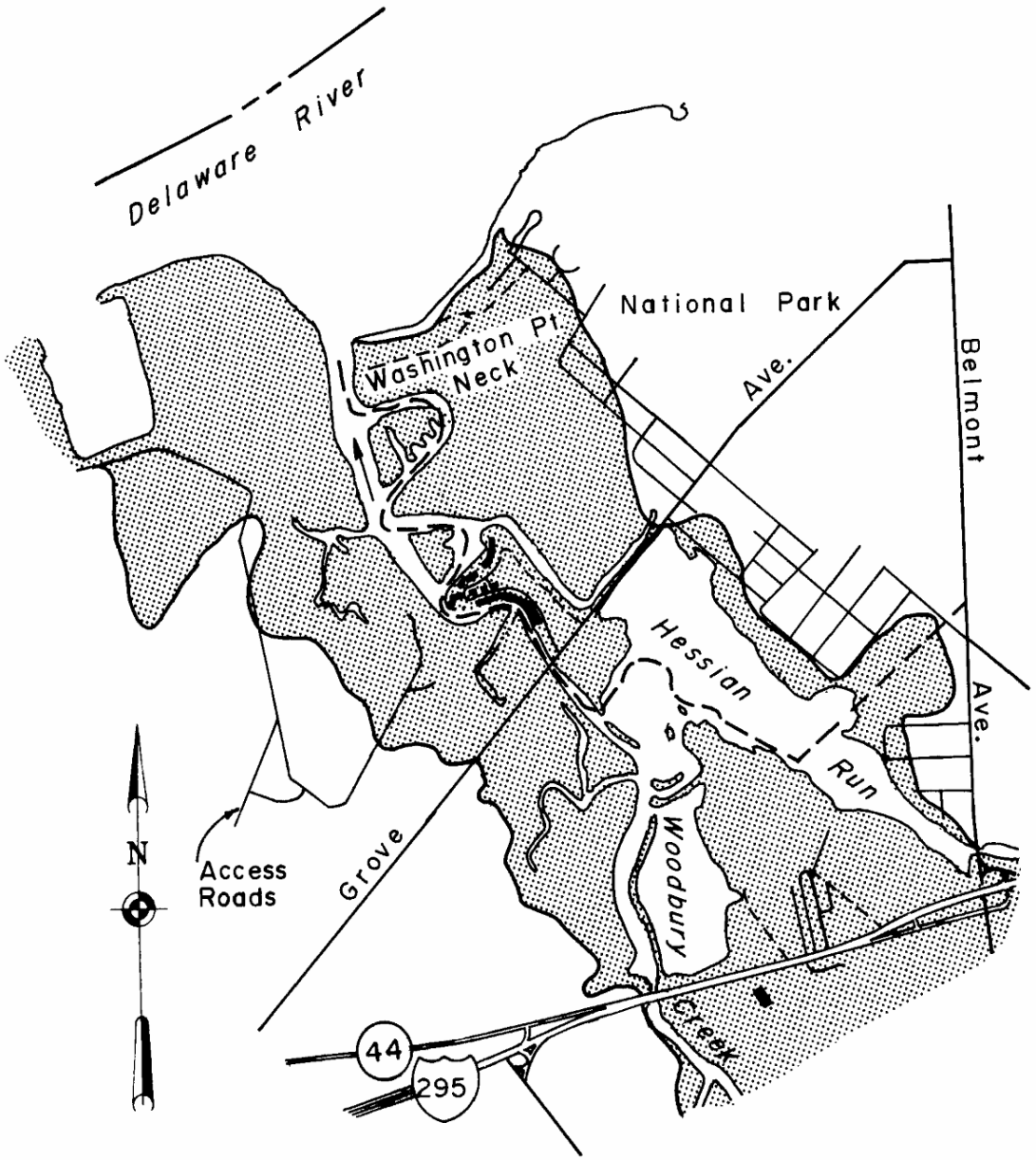
Woodbury Creek at National Park

The eighth priority damage area lies along Woodbury Creek, near its confluence with the Delaware River (see Figure 3B-8). The damages resulting from the 100-year flood amount to $377,000 and primarily involve residential properties in the National Park area. At the present time, approximately 30 per cent of the flood-prone area is in residential use, with the remaining acreage in marshland.

Some of the measures considered included levees, floodwalls, a tide gate, evacuation and flood-proofing. The levee system was the most feasible flood protection scheme for this location. The levee would be located on the right and left banks of Woodbury Creek averaging seven feet in height and extending from the mouth to the vicinity of Grove Avenue. The analysis indicated that these alternatives were not economically feasible.

Mantua Creek at West Deptford, Deptford, and Mantua Townships

The ninth damage area investigated is located on the main stem of the Mantua Creek in Gloucester County. Damages, which amount to $358,000 for the 100-year flood, are predominantly located in the Mantua Terrace area (see Figure 3B-9). At the present time, approximately 80 per cent of the flood-prone area



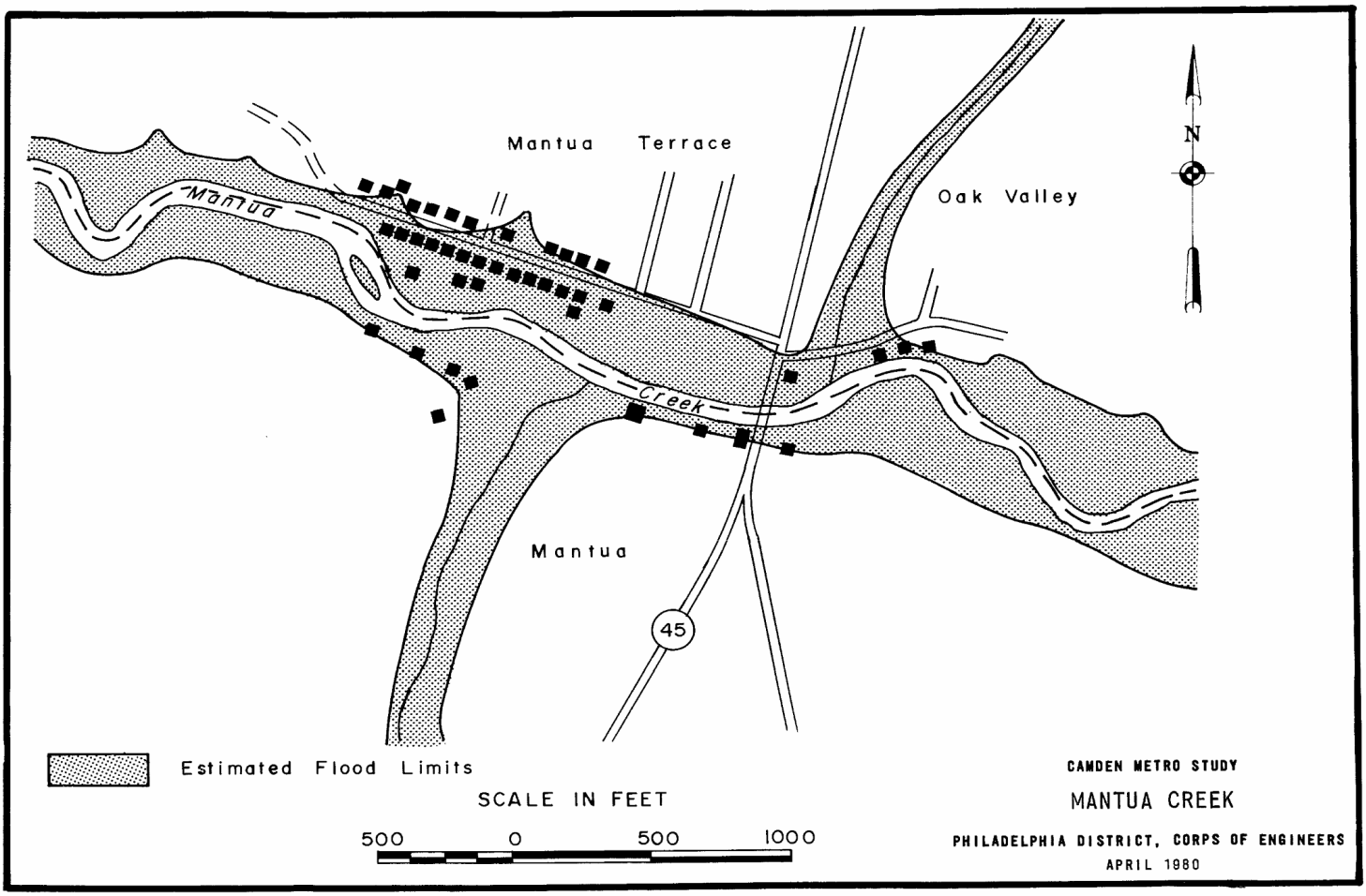
CAMDEN METRO STUDY

WOODBURY CREEK

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3B-8



3B-18

FIGURE 3B-9

is in residential use, with the remaining lands undeveloped.

The most economical plan consisted of an earth levee located along the right bank below the Route 45 bridge. The levee would average nine feet in height and be 1,850 feet long. Non-structural alternatives included raising first floor elevations above the 100-year flood level for the residential properties in the Mantua Terrace area. The economic analysis indicated that these alternatives are not economically feasible.

Cooper River at Cherry Hill and Haddonfield Townships

The last damage center, which lies in the Cooper River Basin in Cherry Hill and Haddonfield townships in Camden County, extends from Kresson Road to the Pennsylvania-Reading Seashore Lines Railroad Bridge (see Figure 3B-10). Total damages for the 100-year flood amount to $332,000. At the present time, approximately 50 per cent of the flood-prone area is in commercial use, with ten per cent in residential use. The remaining acreage is undeveloped.

The alternatives included the modification of the Kresson Road bridge to increase the hydraulic efficiency, earth levees along both banks of the Cooper River and evacuation. These alternatives were found to be economically unfeasible.

In addition to the above areas, a reconnaissance report has been completed by this office on the main stem of the Rancocas Creek at Delran and Riverside townships in Burlington County.

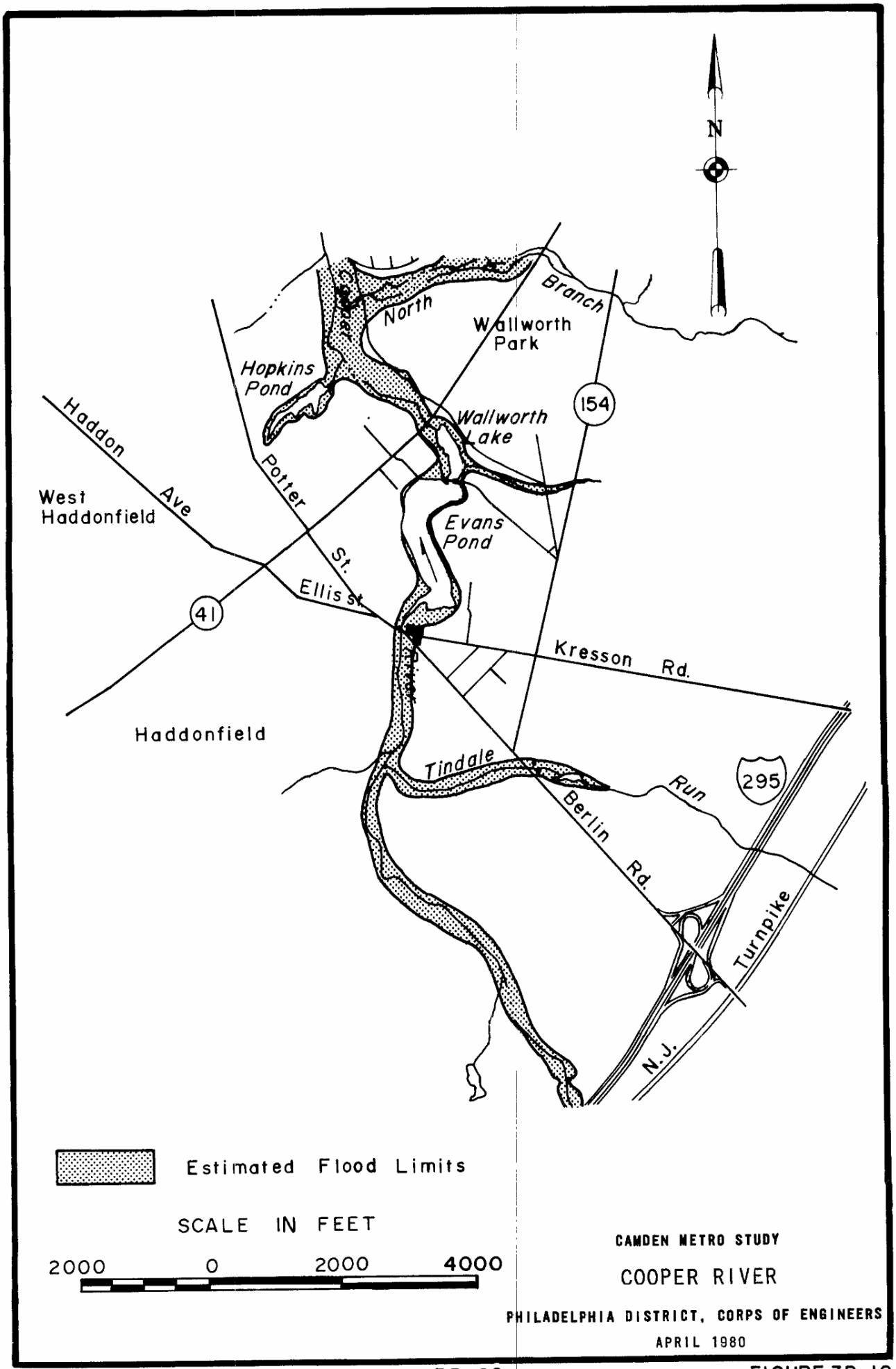

N
North
Branch
Wallworth
Park
Hopkins
Pond
154
Wallworth
Lake
Haddon
Ave
West
Haddonfield
Potter
St.
Evans
Pond
Ellis st
41
Kresson Rd.
Haddonfield
Tindale
Run
295
Berlin
Rd.
Turnpike
N.J.
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
CAMDEN METRO STUDY
COOPER RIVER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-10

That report was prepared under the authority of the Corps of Engineers' Small Project Program. The area investigated is located near the confluence of the Rancocas Creek and the Delaware River and extends from the mouth to the Penn-Central Railroad Bridge (see Figure 3B-11). The most feasible plan consisted of an earth levee system 7,700 feet in length. That plan was also found to be economically unfeasible.

ECONOMIC CONSIDERATIONS

The development of costs and benefits followed standard Corps of Engineers' practice. On the cost side, the value of all goods and services used in the construction of the project are estimated. On the benefit side, damages prevented by the project are estimated.

Annual Benefits

Average annual benefits were determined by correlating the stage-damage relationship under 1975-1976 conditions and October 1978 prices with probable future frequency of flood stages. A sample damage-frequency curve is shown on Figure 3B-12. Refer to Table 3B-3 for the summary of costs and benefits for the selected plan.

Annual Cost

The estimated cost of each project was disaggregated on an annual basis using an economic life of 50 years and an interest rate of 6-7/8 per cent.

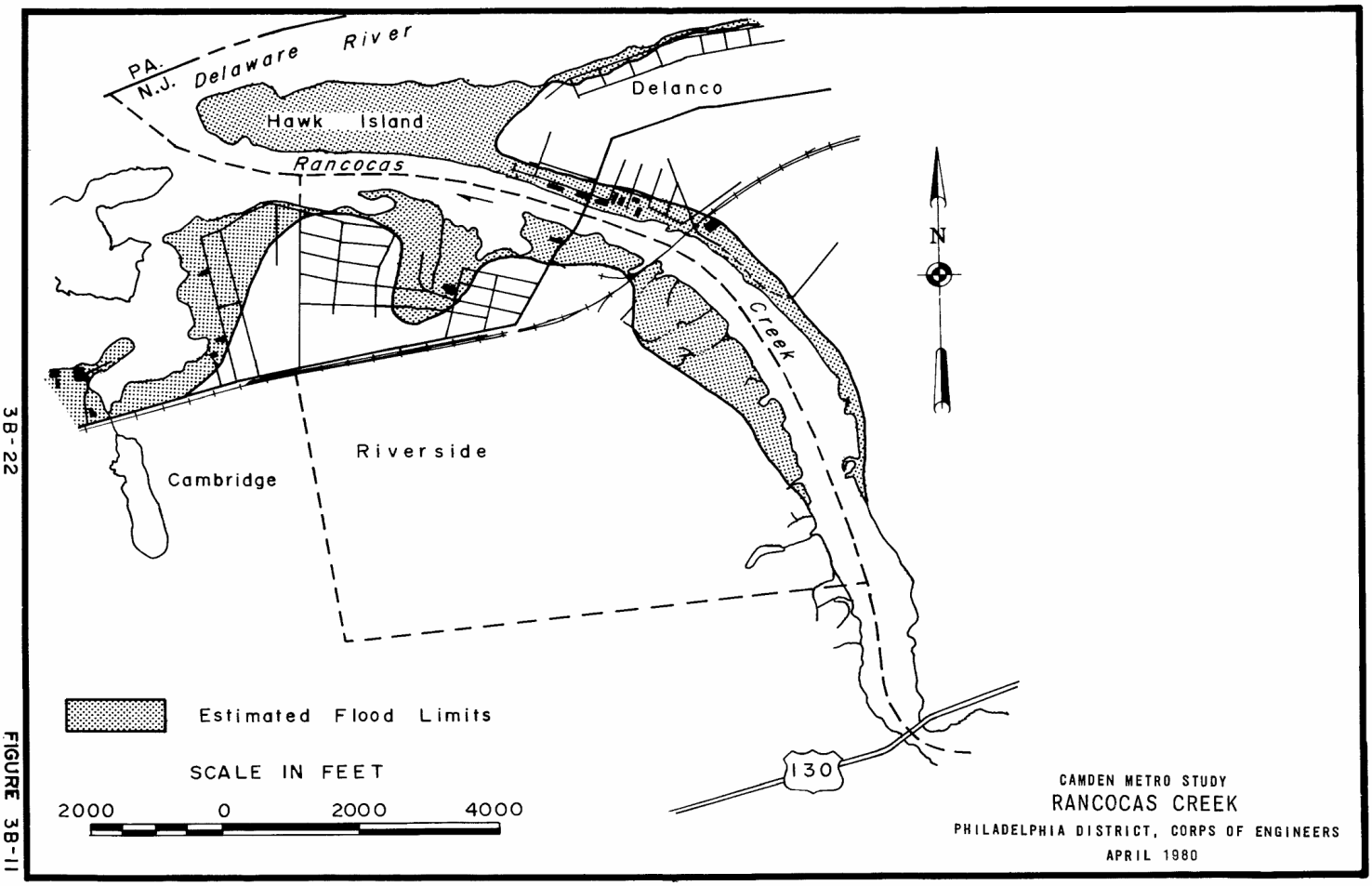

PA.
N.J. Delaware River
Hawk Island
Delanco
Rancocas
Creek
N
Cambridge
Riverside
Estimated Flood Limits
SCALE IN FEET
2000 0 2000 4000
130
CAMDEN METRO STUDY
RANCOCAS CREEK
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-11

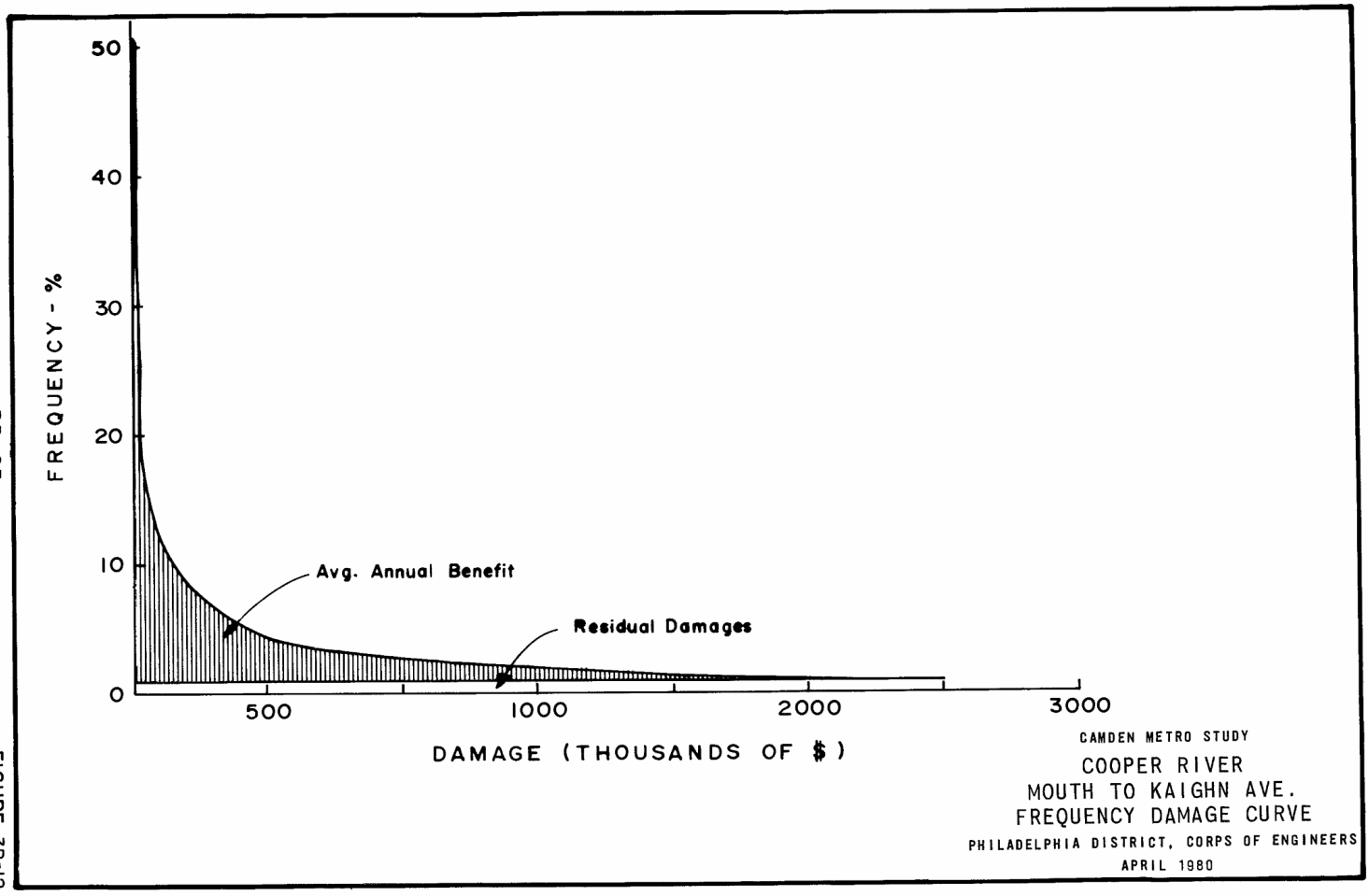

50
40
30
20
10
0
FREQUENCY - %
Avg. Annual Benefit
Residual Damages
500
1000
2000
3000
DAMAGE (THOUSANDS OF $)
CAMDEN METRO STUDY
COOPER RIVER
MOUTH TO KAIGHN AVE.
FREQUENCY DAMAGE CURVE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3B-12

TABLE 3B-3

BENEFIT-COST SUMMARY OF ALTERNATIVES
(Costs and Benefits at October 1978 Price Level)

Damage Area	Selected Plan	Average Annual Cost	Average Annual Benefit	B/C
#1	Levee	$261,000	$174,000	.7
#2	Levee	150,000	1,092,000	7.3
#3	Levee and Floodwall	255,000	81,000	.3
#4	Flood and Bulkhead	165,000	116,000	.7
#5	Floodwall	269,000	84,000	.3
#6	Tidegate	56,000	68,000	1.2
#7	Box Culvert	25,000	11,000	.5
#8	Levee	88,000	24,000	.3
#9	Levee	39,000	18,000	.5
#10	Levee and Bridge Modification	93,000	14,000	.2

FLOOD WARNING SYSTEM STUDY

Background

The flood warning system was considered to determine its feasibility and local interest.

Prior to conducting the flood warning study, this office contacted the regional and local offices of the National Weather Service requesting information on the role of the NWS in the flood forecasting, prediction methods and the associated cost of each component of the system. Additional information on possible evacuation plans were obtained from the county Civil Defense office.

The National Weather Service, a component of the Commerce Department's National Oceanic and Atmospheric Administration, issues flood forecasts and warnings when it is anticipated that enough rain will fall to cause rivers to overflow their banks or that tropical hurricanes or other high wind conditions will produce high stages in the tidal areas. The NWS broadcasts flood watches over the Civil Defense and other local radio stations. These advance warnings are provided on a regional basis. There is no arrangement for advance prediction of floods on a specific local basis.

Description

Essentially, a local flood warning system is three-pronged: flood forecasting, a stream elevation sensor system and flood preparedness planning.

Flood forecasting, like weather forecasting, involves monitoring of weather conditions and systems moving toward an affected area. The National Weather Service has an extensive network of high-powered weather radars to monitor areas of rain as storms grow or diminish in size and intensity. Hydrologists use radar data to estimate the rate of rainfall, times of beginning and ending and extent of areal coverage.

The sensor system has three main elements, linked together by electrical circuitry: the automatic water level sensor at a point on the river, an intermediate station several miles away to provide power to the sensor and a community-alarm station from which warnings can be spread quickly to the public.

The sensor has an enclosed float device which, when lifted by a critical level of rising water, activates an electrical current. This device can be anchored to a bridge support. When rising water triggers the device, the signal is carried to the intermediate station and finally to a continuously-manned station, such as police or fire stations located in the concerned community.

After being notified, the director of Civil Defense sends observers to the stream. The observers' task is to check the streams at the various gage locations and to report actual conditions to the Civil Defense headquarters. This early warning allows Civil Defense personnel time to determine whether or not to execute its flood evacuation plan.

Should the plan be put into effect, Civil Defense teams would contact local and county officials as well as emergency officers, such as fire and police departments, hospitals and the Red Cross. These local contacts would, in turn, notify property owners in the flood plain. Time is the most important factor in executing the plan, since sufficient time must be allowed for property owners to move damageable goods above the anticipated flood levels.

The final component of an early flood warning system is flood preparedness planning. Specifically, Civil Defense representatives would meet with local officials to evaluate and improve the current flood plain evacuation plan and practices.

Technical Analysis and Design

Technical evaluation of the flood forecasting system for the study area consisted of identifying and considering information for choosing and developing a system. These tasks were as follows:

(1) determination of the desired level of performance of a flood forecasting system.

(2) identification and limitation of the present flood forecasting system.

(3) identification of those elements which are required to upgrade the present system.

(4) determination of responsibilities for implementation and operation of the system.

(5) determination of costs and benefits for systems of varying sophistication.

(6) identification of the hydrologic characteristics of the study area.

Economic Analysis

The costs for improving the flood warning system in the study area and for supplementing existing preparedness plans depend on the degree of thoroughness and sophistication of the ultimate warning system. The cost for each component is listed below and summarized in Table 3B-4.

(1) Flood Forecasting

NWS wire service	$60/month
Development of flood forecasting procedures and training of observers and forecasters by NWS	$5800

Sensor gage installation	$9300
(Maintenance cost)	$ 500/yr

(2) Moving of Damageable Goods

Moving Cost	$388,600

(3) Flood Preparedness Planning

Preparedness Plan Development	$16,200
Updating Preparedness Plan	$ 3,500/yr

TABLE 3B-4

SUMMARY OF ESTIMATED ANNUAL COSTS
(October 1978 Price Level)

Total Investment	$420,000
Total Annual Charges	
Interest and Amortization @ 6-7/8%	$ 30,000
Operation and Maintenance	$ 4,700
TOTAL	$ 35,000

Annual Benefits

Benefits for a system were derived only from the prevention of flood damage to moveable property. Some contents (such as machinery) cannot be moved within the warning time available and are therefore considered "immovable". NWS records of damages averted due to forecasting and warning have been maintained since 1903. Based on that information, damages prevented annually have been approximately ten per cent of the total annual damages. Using this relationship, the average annual benefit is estimated as $18,000.

The benefit-to-cost ratio for this plan is 0.5. This ratio does not include the false alarms that can occur. If taken into account, the effect would be to increase the costs and therefore reduce the BCR.

Local Interests

The plan considered was coordinated and discussed with county officials and property owners as it was developed. It was the consensus of the property owners that the flood warning system is not preferable. Generally, two common reasons were given by the property owners: 1) high moving costs and 2) no space to temporarily store goods.

Conclusion

Based on current technical and economic data, the flood warning system is economically unfeasible for the study area. The lack of interest on the part of the property owners confirms the undesirability of a flood warning system for the study area at the present time.

SECTION C

URBANIZATION ANALYSIS

SECTION C

URBANIZATION

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SECTION C

URBANIZATION ANALYSIS

BACKGROUND

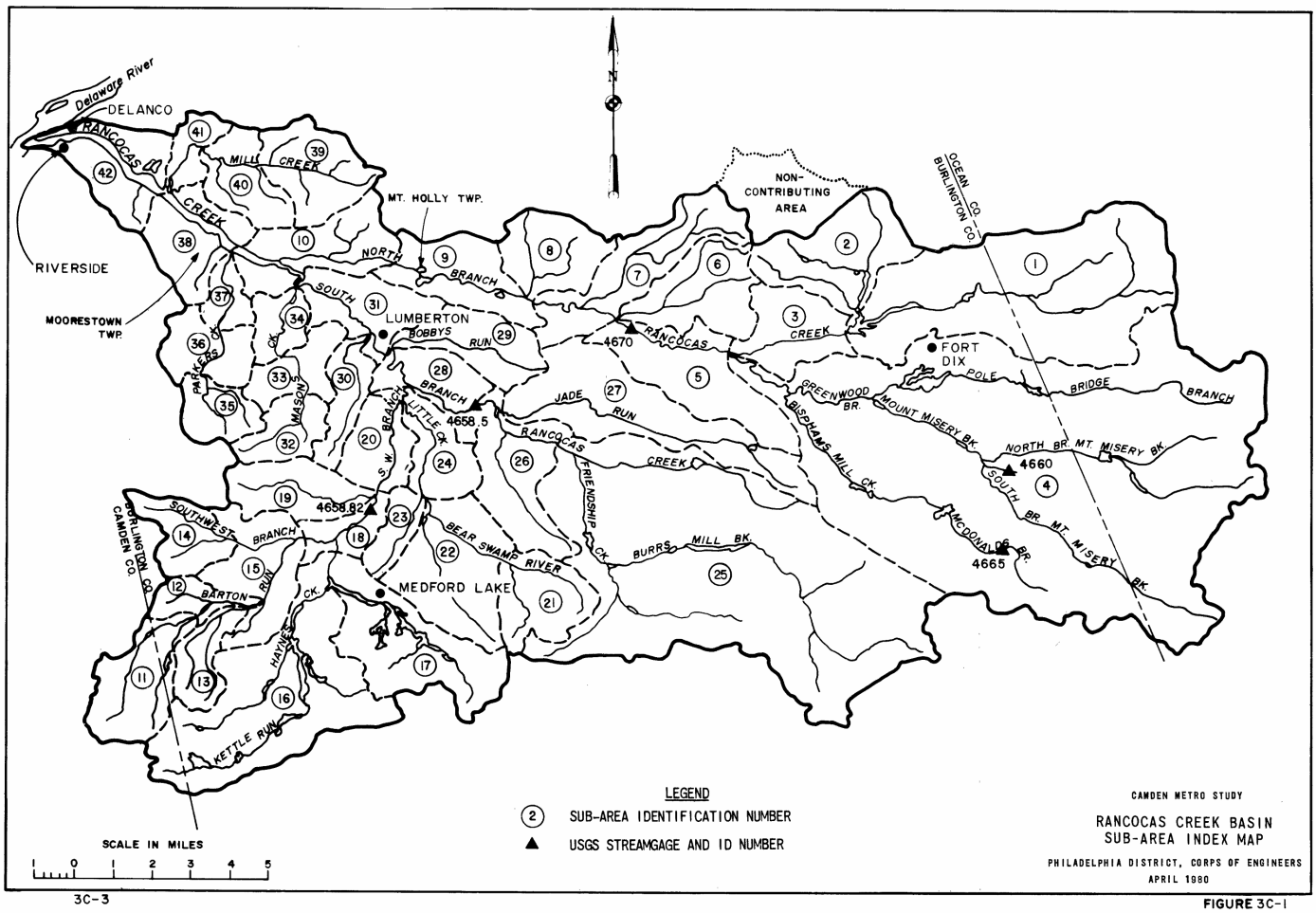
Hydrologic studies were conducted to determine the effects that potential future development would have on the flooding problems in the Rancocas, Cooper and Mantua watersheds. The HEC-1 Flood Hydrograph Package, Generalized Computer Program 723-100, was used for these analyses. This section describes the methodology, assumptions and procedures used in conducting the hydrologic studies and findings.

Periods of maximum runoff occur in summer and fall months when thunderstorm activity is high. Average annual runoff for the 1921-1975 period of gaged flow for the North Branch of Rancocas Creek at Pemberton was 21 inches, and for the 1961-1975 period, gaged flow for the South Branch at Vincentown was 24 inches. This difference in runoff is probably a result of the higher per cent of forest cover on the North Branch. Average annual runoff for the 1963-1975 period of gaged flow for Cooper River at Haddonfield was 26.6 inches. For the Mantua Creek, the average annual runoff is 25.8 inches at the Pitman gage.

STREAM GAGES

There are three continuous recording stream gages and two crest stage gages in operation within the Rancocas Creek Basin. One of the crest gages was a continuous recorder for part of its period of record. Figure 3C-1 shows the location of these gages and pertinent data are presented in the tabulation which follows:

USGS Index No.	Station Name and Location	Drainage Area (sq. mi.)	Period of Record (yrs)	Maximum Event of Record (cfs)
4658.5	South Branch Rancocas Creek at Vincentown. Gage datum 13.17 ft. msl.	53.3	1961-1975	11/9/72 1,110
4665	McDonalds Branch in Lebanon State Forest. Gage datum 117.73 ft. msl.	2.31	1953-Pres	8/25/58 35
4670	North Branch Rancocas Creek at Pemberton. Gage datum 31.19 ft. msl.	111	1921-Pres	8/31/39 1,730
4658.82	Southwest Branch Rancocas Creek at Medford. (Crest gage)	33.8	1975-Pres	9/25/75 4,600
4660	Middle Branch Mount Misery Brook in Lebanon State Forest. Gage datum 99.71 ft. msl. (Crest gage 1967-now)	2.73	1952-Pres	5/29/68 50



LEGEND

(2) SUB-AREA IDENTIFICATION NUMBER

▲ USGS STREAMGAGE AND ID NUMBER

CAMDEN METRO STUDY

RANCOCAS CREEK BASIN
SUB-AREA INDEX MAP

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-1

There are one continuous recording stream gage and three crest stage gages in operation within the Cooper River Basin. The location of these gages is shown in Figure 3C-2 and pertinent data are presented below.

USGS Index No.	Station Name and Location	Drainage Area (sq. mi.)	Period of Record (yrs)	Maximum Event of Record (cfs)
4671.5	Cooper River at Haddonfield, N.J. Gage datum 9.29 ft. msl.	17.4	1963-Pres	8/28/71 3,300
4671.3	Cooper River at Kirkwood, N.J. Datum of gage is 57.82 ft. msl. (crest gage)	5.14	1964-Pres	8/10/67 390
4671.6	North Branch Cooper River near Marlton, N.J. Datum of gage is 36.36 ft. msl. (crest gage)	5.33	1964-Pres	1/14/68 320
4671.8	North Branch Cooper River at Ellisburg, N.J. Datum of gage is 9.80 ft. msl. (crest gage)	10.4	1964-Pres	8/28/71 1,000

There are one crest stage gage and one recording gage in operation in the Mantua Creek Basin. These are shown in Figure 3C-3 and the tabulation which follows:

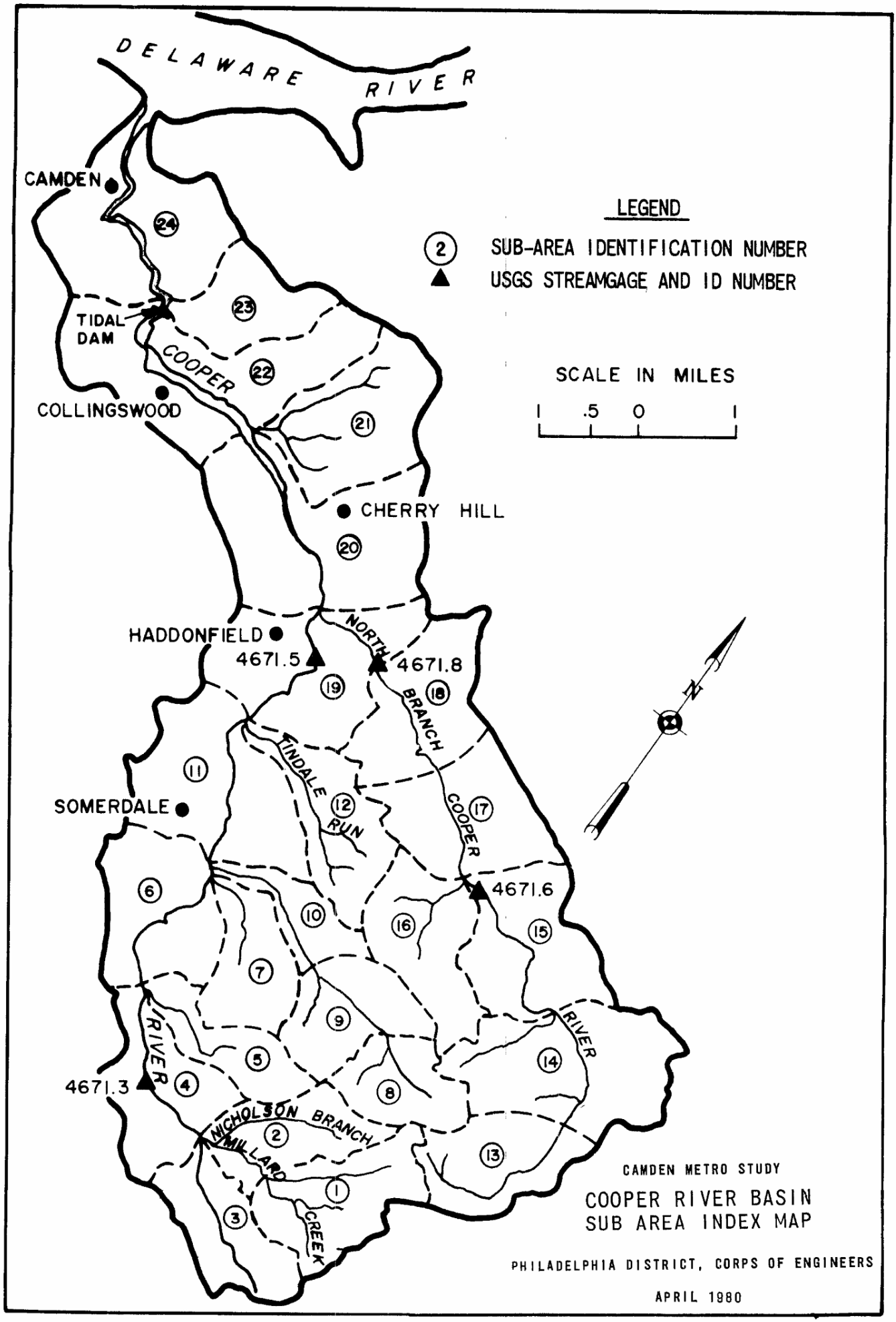

DELAWARE RIVER
CAMDEN
TIDAL DAM
COOPER
COLLINGSWOOD
CHERRY HILL
HADDONFIELD
4671.5
4671.8
NORTH BRANCH
TINDALE RUN
SOMERDALE
COOPER
4671.6
RIVER
RIVER
4671.3
NICHOLSON BRANCH
MILLARD
CREEK
LEGEND
2 SUB-AREA IDENTIFICATION NUMBER
USGS STREAMGAGE AND ID NUMBER
SCALE IN MILES
1 .5 0 1
N
CAMDEN METRO STUDY
COOPER RIVER BASIN
SUB AREA INDEX MAP
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-2

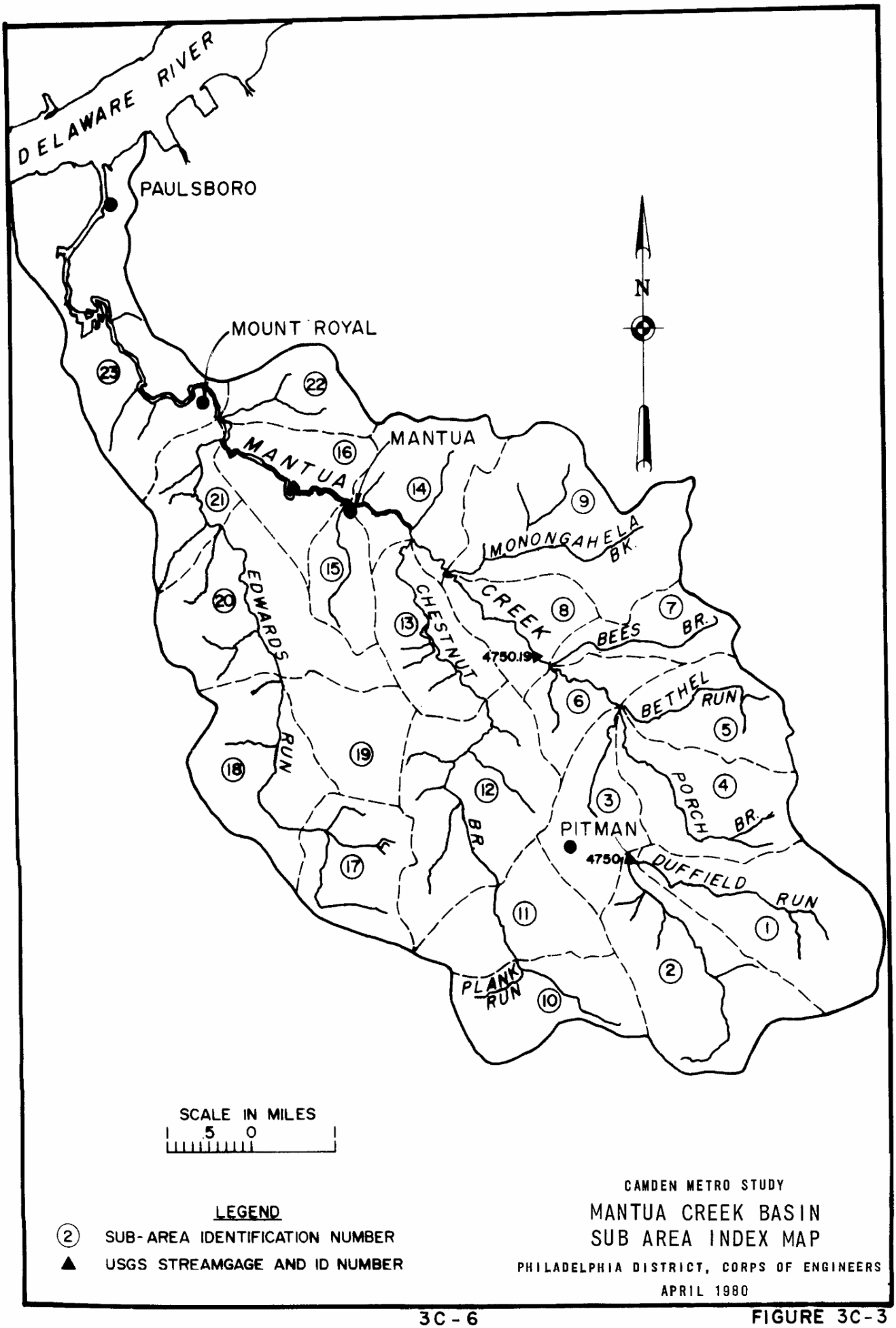

DELAWARE RIVER
PAULSBORO
MOUNT ROYAL
MANTUA
MANTUA
MONONGAHELA BK.
CREEK
CHESTNUT
EDWARDS
RUN
BEES
BR.
BETHEL
RUN
PORCH
BR.
PITMAN
4750.19
4750
DUFFIELD
RUN
PLANK
RUN
BR.
N
SCALE IN MILES
5 0
LEGEND
(2) SUB-AREA IDENTIFICATION NUMBER
▲ USGS STREAMGAGE AND ID NUMBER
CAMDEN METRO STUDY
MANTUA CREEK BASIN
SUB AREA INDEX MAP
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-3

USGS Index No.	Station Name and Location	Drainage Area (sq. mi.)	Period of Record (yrs)	Maximum Event of Record (cfs)
4750	Mantua Creek at Pitman	6.05	1940-Pres	9/1/40 4,200
4750.19	Mantua Creek at Salina, N.J. (crest gage)	14.2	1975-Pres	7/15/75 650

MODEL DEVELOPMENT

The general procedures used to develop and analyze basin hydrology are outlined in Table 3C-1. The hydrologic studies consisted of two general tasks: modelling the basin for existing conditions and projecting future hydrologic conditions due to urbanization. Model development included comparison to historic flood events to insure a proper level of calibration.

Study Area Map

Each basin was subdivided into sub-areas representing significant tributaries, stream gage points or areas of existing or forecasted urban development where peak discharges and discharge-frequency curves were needed. These are shown on Figures 3C-1, 2 and 3.

Storms of Record

Seven storms were selected for analysis. The storms selected were 14-15 January 1968; 27 July 1969; 14 April 1970; 26-27 August 1971; 8-9 November 1972; 14-15 November 1972; and 20-22 December 1973.

TABLE 3C-1

HYDROLOGIC MODELLING SUMMARY OF THE
RANCOCAS, COOPER AND MANTUA BASINS

- The basins were subdivided as follows:

  42 sub-areas for Rancocas Creek
  24 sub-areas for Cooper River
  23 sub-areas for Mantua Creek

- Discharge-frequency curves were developed at gaged locations using log Pearson Type III distribution in accordance with Water Resources Council Guidelines.

- Each sub-area's drainage area, slope, stream length, imperviousness and per cent of area covered by lakes and swamps was determined.

- Unit hydrograph and loss-rate coefficients were estimated for each sub-area.

- Routing criteria were developed.

- Hydrologic basin models were developed using HEC-1.

- The HEC-1 models were calibrated by using historic storms.

- The Standard Project Storm was developed for each basin according to the U.S. Army Corps of Engineers EM 1110-2-1411 (CEB No. 52-8).

- Rainfall distributions having recurrence intervals of two, ten, 50, and 100 years were developed using U.S. Weather Bureau Technical Paper No. 40.

- Rainfall and adopted loss rates were input into the hydrologic model and discharges were computed for various frequencies at index locations.

- Frequency curves from observed flows and HEC-1 results were compared. The latter was adjusted to the former.

- Unit hydrograph parameters and loss rates were modified to account for urbanization, and the effect of this adjustment on flood peaks was evaluated.

Isohyetal maps were developed for the storms and were used to estimate sub-area average rainfall depths. Several typical examples of the isohyetal maps and the flood hydrographs are shown in Figures 3C-4, 3C-5 and 3C-6.

Discharge-Frequency Analysis at Gaged Sites

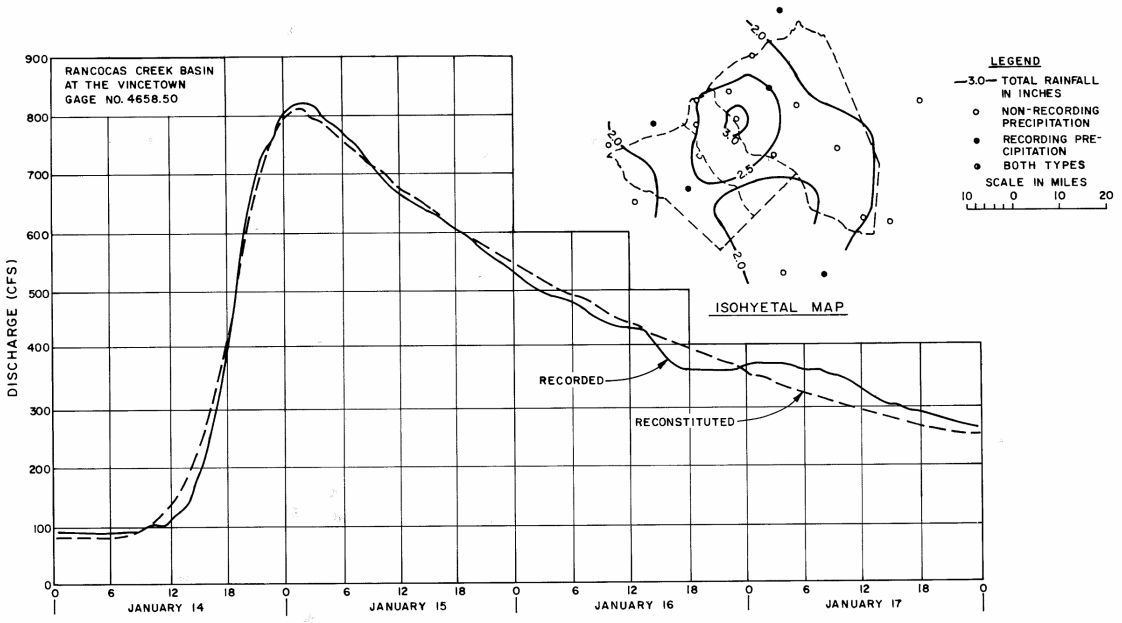
Discharge-frequency analyses were conducted on the annual maximum discharge series following procedures contained in the Water Resources Council Guidelines Bulletin No. 17. A regional skew of 0.3 was adopted for all basins from a skew study of the State of New Jersey conducted by HEC for the Philadelphia District. A typical discharge-frequency curve from this analysis is shown on Figure 3C-7.

Unit Hydrograph Parameters

Hydrologists of the Camden Metropolitan Urban Study team conducted a study of unit hydrograph characteristics of observed hydrographs at gages in and near the three basins. Results and recommendations from this study are contained in "Southwestern New Jersey Unit Hydrograph Study" dated 17 August 1977. This effort used the optimization technique of HEC-1 as a basis to estimate the unit hydrographs and loss rates used for each sub-area. The regression equation developed relates the sum of time of concentration (TC) and recession characteristics (R) to physical and man-made parameters in the following way:

$$TC + R = 21 \left(\frac{DA}{S}\right)^{.22} (ST)^{.33} (K)^{-.28}$$

where:

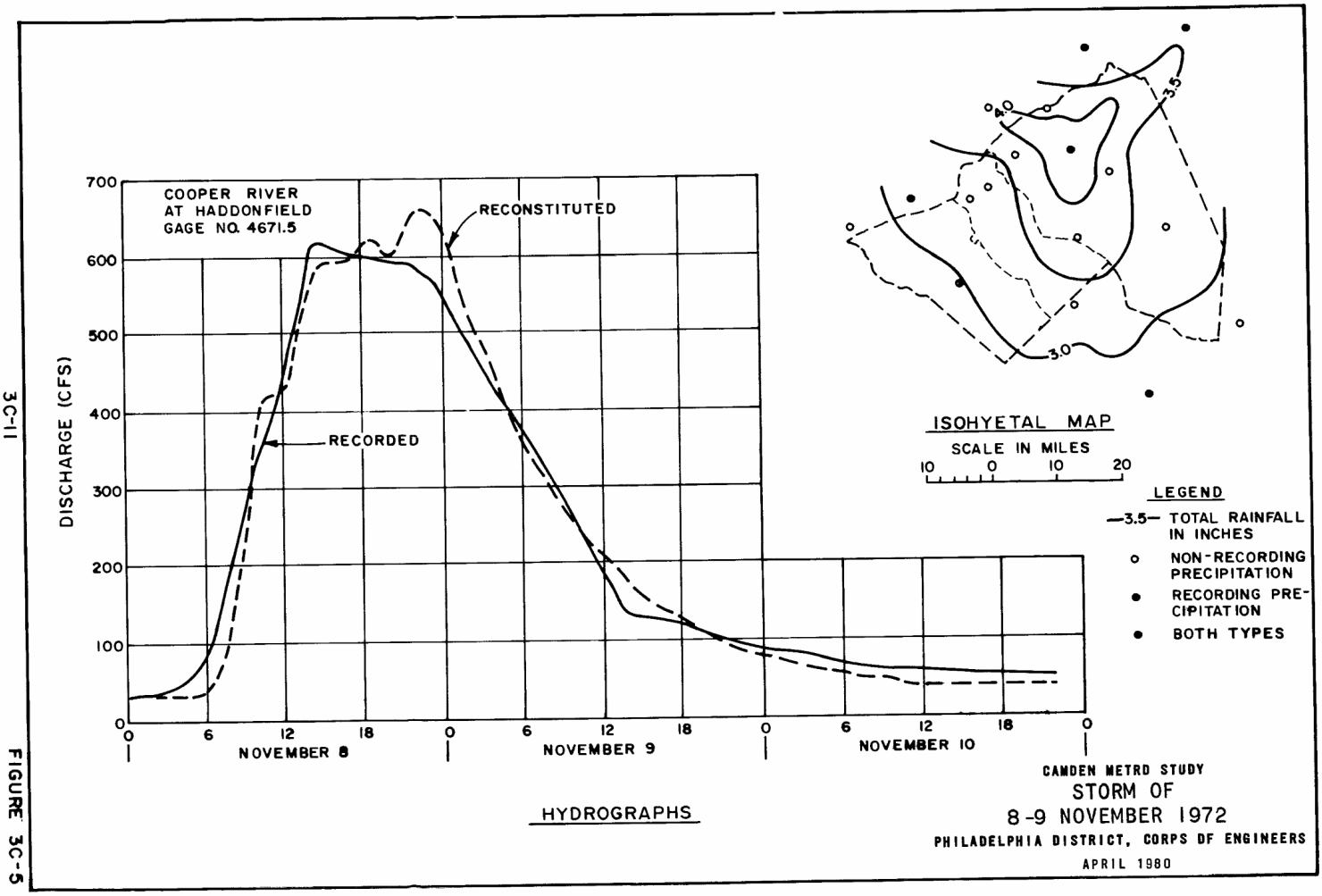


CAMDEN METRO STUDY

STORM OF
14-15 JANUARY 1968

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-4



3C-11

FIGURE 3C-5

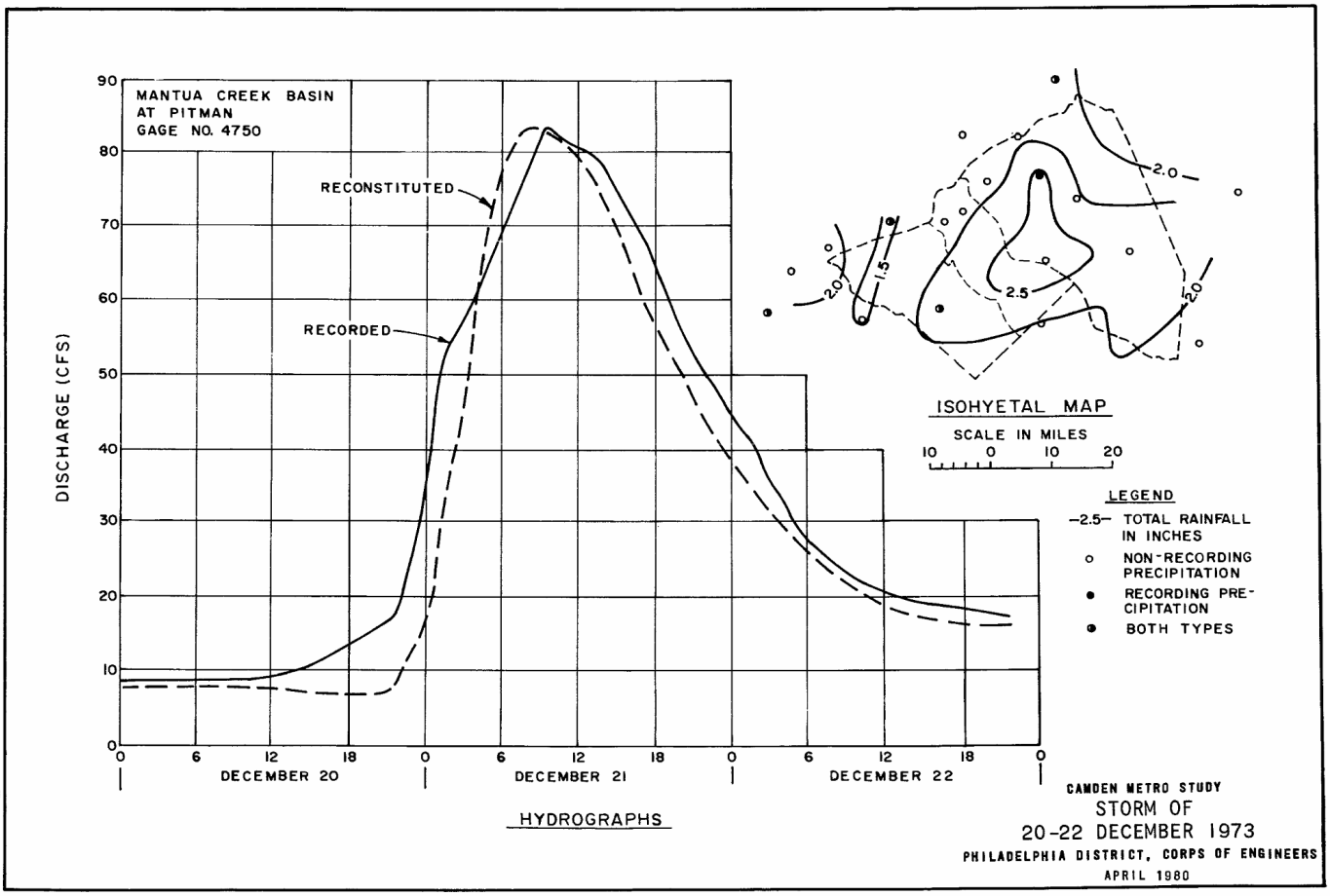
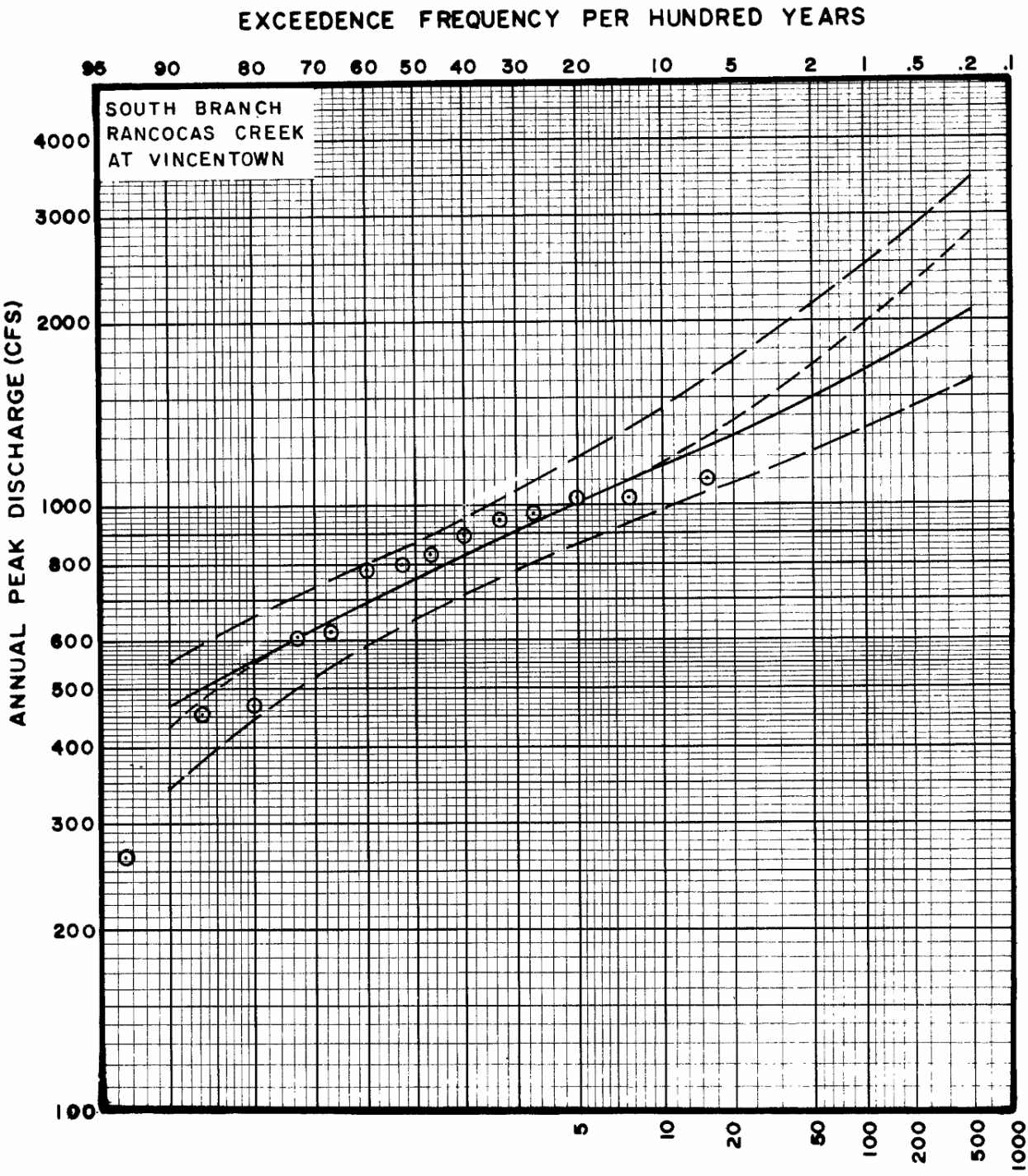

MANTUA CREEK BASIN
AT PITMAN
GAGE NO. 4750
RECONSTITUTED
RECORDED
DISCHARGE (CFS)
90
80
70
60
50
40
30
20
10
0
0
6
12
18
0
6
12
18
0
6
12
18
0
DECEMBER 20
DECEMBER 21
DECEMBER 22
HYDROGRAPHS
2.0
1.5
2.0
2.5
2.0
ISOHYETAL MAP
SCALE IN MILES
10 0 10 20
LEGEND
-2.5- TOTAL RAINFALL IN INCHES
NON-RECORDING PRECIPITATION
RECORDING PRECIPITATION
BOTH TYPES
CAMDEN METRO STUDY
STORM OF
20-22 DECEMBER 1973
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-6



LEGEND

⊙ RECORDED ANNUAL PEAKS
——— ADOPTED FREQUENCY CURVE
– – – EXPECTED PROBABILITY CURVE
— — — .05 AND .95 CONFIDENCE LIMITS

ADOPTED STATISTICS

	LOG
MEAN	2.895
STD DEV	.130
SKEW	.300

14 YEARS OF OBSERVED DATA

CAMDEN METRO STUDY

DISCHARGE-FREQUENCY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-7

TC = Time in hours from end of rainfall to point of inflection on the recession side of the hydrograph.

R = Recession defined as the ratio of the discharge at the inflection point on the recession limb of the hydrograph divided by the rate of change in discharge (slope of the recession curve) at that point.

DA = Drainage area in square miles

S = Slope of watercourse (ft/mi) between points 10 and 85 per cent distance along the total watercourse length.

ST = Per cent of the drainage area covered by lakes and swamps.

K = 1+0.3I where I is the per cent of the drainage area which is considered to be impervious.

Tables 3C-2, 3C-3 and 3C-4 present the physical data and unit hydrograph parameters adopted for each sub-area.

Routing Parameters

Channel storage and lake storage vs. discharge relations were estimated for each channel reach between sub-area combining points. A channel reach index number was assigned by designation of a four digit number, the first two digits representing the upstream point and the second two digits representing the downstream point. For example, on Figure 3C-2, the channel reach from Tindale Road at the downstream end of sub-area 12 to the confluence with the North Branch of Cooper River sub-area 19, would be identified by an index number 1219, the next reach as 1920, etc. Channel storage vs. discharge relations were developed from backwater profile computations.

TABLE 3C-2
SUBAREA PHYSICAL AND UNITGRAPH CHARACTERISTICS
RANCOCAS CREEK BASIN, N.J.

Subarea Index Number	Drainage Area D.A.	1970 Population	Population Density D	Imperviousness I	Slope S 10-85	Lakes & Swamps St	TC+R	R/(TC+R)	TC	R
	(sq mi)		(per sq mi)	(%)	(ft/mi)	(%)	(hrs)		(hrs)	(hrs)
1	23.6	4110	174	4.4	9.0	27	92*	.55	42	50
2	7.36	820	111	3.3	14.8	2	19	.58	8	11
2a	5.47				12.7					
3	4.92	1610	327	7.4	14.3	6	22	.60	9	13
4	74.1	6060	82	2.8	5.8	17	119*	.55	54	65
5	8.05	1950	242	5.5	5.3	7	33	.65	12	21
6	6.08	1360	224	5.2	20.1	.5	10	.70	3	7
7	7.95	10980	1380	15	8.4	2	16	.75	4	12
8	4.97	1200	241	5.4	13.2	.5	10	.75	3	7
9	5.66	2820	489	8.5	2.1	5	31	.75	8	23
10	6.24	2580	413	7.5	5.8	10	32	.75	8	24
11	5.60	1550	277	6.0	23.2	2	15	.75	3	12
12	1.89	1430	757	11	12.7	3	13	.75	3	10
13	2.81	1270	451	7.9	22.7	19	25	.75	6	19
14	3.44	4350	1265	14	14.3	.5	7.7	.75	1.9	5.8
15	6.17	4030	653	10	7.4	7	26	.75	7	19
16	16.4	3350	204	4.8	11.6	14	42	.75	10	32
17	10.0	5150	515	8.6	10.6	7	28	.78	6	22

TABLE 3C-2 (Cont'd)
SUBAREA PHYSICAL AND UNITGRAPH CHARACTERISTICS
RANCOCAS CREEK BASIN, N.J.

Subarea Index Number	Drainage Area D.A.	1970 Population	Population Density D	Imperviousness I	Slope S 10-85	Lakes & Swamps St	TC+R	$\frac{R}{TC+R}$	TC	R
	(sq mi)		(per sq mi)	(%)	(ft/mi)	(%)	(hrs)		(hrs)	(hrs)
18	2.22	1820	820	11	7.9	3	15	.75	4	11
19	4.64	340	73	2.5	6.3	.5	13	.75	3	10
20	3.67	700	190	4.6	5.3	.6	13	.75	3	10
21	5.02	990	197	4.7	13.2	18	34	.78	7	27
22	8.76	1320	151	4.1	21.2	14	33	.78	7	26
23	2.03	200	99	3.1	10.0	.5	9.8	.75	2.4	7.4
24	4.09	650	159	4.2	6.9	.5	12	.75	3	9
25	46.1	3430	74	2.5	5.3	20	77	.78	17	60
26	6.72	770	115	3.4	4.2	.9	18	.78	4	14
27	11.8	1660	141	3.8	6.3	9	40	.65	14	26
28	4.04	600	149	4.0	3.2	2	22	.70	7	15
29	4.76	1210	254	5.5	10.6	.5	11	.75	3	8
30	2.35	850	362	6.9	12.7	.6	8.9	.75	2.2	6.7
31	5.50	3240	589	9.4	8.4	16	33	.75	8	25
32	3.05	490	160	4.2	15.8	.7	10	.75	2.5	7.5
33	3.15	730	232	5.2	11.6	.5	9.7	.75	2.4	7.3
34	2.38	410	172	7	7.9	2	16	.75	4	12

TABLE 3C-2 (Cont'd)
SUBAREA PHYSICAL AND UNITGRAPH CHARACTERISTICS
RANCOCAS CREEK BASIN, N.J.

Subarea Index Number	Drainage Area D.A.	1970 Population	Population Density D	Imperviousness I	Slope S 10-85	Lakes & Swamps St	TC+R	$\frac{R}{TC+R}$	TC	R
	(sq mi)			(%)	(ft/mi)	(%)				
35	2.83	440	155	4.1	19.0	.5	8.8	.75	2.2	6.6
36	3.58	1340	374	7.0	9.0	2	16	.75	4	12
37	1.87	930	479	8.4	15.8	4	15	.75	4	11
38	5.17	7200	1392	15	14.8	10	22	.75	5	17
39	5.41	640	118	3.4	12.1	.5	12	.75	3	9
40	4.04	21750	5380	30	17.4	.5	6.4	.75	1.6	4.8
41	1.91	15200	7960	38	16.9	7	12	.75	3	9
42	6.06	14000	2310	19	8.5	17	29	.75	7	22
Total	341.86									

$$I = 0.117D^{0.792 - 0.039 \log D}$$

$$TC+R = 21 (DA/S)^{.22} (St)^{.33} (1+.3I)^{-.28}$$

* These values reflect a 50 percent increase over the regional values as required to reconstitute observed hydrographs at the Pemberton gage.

TABLE 3C-3
SUBAREA PHYSICAL AND UNITGRAPH CHARACTERISTICS
COOPER RIVER BASIN, N.J.

Subarea Index Number	Drainage Area D.A.	1970 Population	Population Density per sq mi D	Imperviousness I	Slope S 10-85	Lakes & Swamps St	TC+R	R / TC+R	TC	R
	(sq mi)			(%)	(ft/mi)	(%)	(hrs)		(hrs)	(hrs)
1	1.50	860	573	9.0	35	6	13	.76	3.1	9.9
2	1.10	1470	1336	15	35	1	6.1	.76	1.5	4.6
3	1.50	2010	1340	15	54	2	7.4	.76	1.8	5.6
4	2.00	2560	1280	14	19	3	12	.76	2.9	9.1
5	.74	840	1135	13	30	.7	5.3	.76	1.3	4.0
6	1.36	6180	4544	28	22	.7	5.4	.76	1.3	4.1
7	.70	3260	4657	28	32	.1*	3.8	.76	.9	2.9
8	1.20	420	350	6.7	56	.8	6.2	.76	1.5	4.7
9	1.46	1930	1322	14	41	.5	5.1	.76	1.2	3.9
10	.84	2270	2702	21	34	.1*	4.2	.76	1.0	3.2
11	1.80	5660	3144	23	12	.6	6.6	.76	1.6	5.0
12	1.90	2030	1068	13	32	.5	5.8	.76	1.4	4.4
13	1.38	130	94	3.0	31	1	8.8	.76	2.1	6.7
14	2.48	1720	694	10	36	.8	7.3	.76	1.8	5.5
15	1.81	2840	1569	16	9	.1*	7.2	.76	1.7	5.5
16	1.13	1720	1522	16	47	.1*	4.5	.76	1.1	3.4
17	1.30	2300	1769	17	38	2	7.6	.76	1.8	5.8
18	2.30	6480	2817	22	14	.4	6.4	.76	1.5	4.9
19	2.40	8330	3471	24	38	3	9.1	.76	2.2	6.9
20	2.41	15890	6593	33	17	3	10	.76	2.4	7.6
21	1.51	5230	3464	24	28	.1*	4.9	.76	1.2	3.7
22	2.38	21490	9029	39	12	10	15	.76	3.6	11.4
23	1.40	10580	7557	36	29	.1*	4.3	.76	1.0	3.3
24	3.30	41020	12430	45	10	5	13	.76	3.1	9.9
Total	39.90									

*.5 used as minimum value

$I = 0.117D^{0.792 - 0.039 \log D}$

$TC+R = 21 (DA/S)^{.22} (St)^{.33} (1+.3I)^{-.28}$

TABLE 3C-4
SUBAREA PHYSICAL AND UNITGRAPH CHARACTERISTICS
MANTUA CREEK BASIN, N.J

Subarea Index Number	Drainage Area D.A.	1970 Population	Population Density D	Imperviousness I	Slope S 10-85	Lakes & Swamps St	TC+R	$\frac{R}{TC+R}$	TC	R
	(sq mi)		(per sq mi)	(%)	(ft/mi)	(%)	(hrs)		(hrs)	(hrs)
1	3.0	410	137	3.8	27	3.9	16.4	.64	5.9	10.5
2	3.1	1910	616	9.4	19	3.0	13.9	.64	5.0	8.9
3	1.7	4200	2470	20.3	45	1.3	6.4	.64	2.3	4.1
4	2.6	1240	477	8.1	35	2.3	11.0	.64	4.0	7.0
5	1.8	210	117	3.5	30	0.2	5.5	.64	2.0	3.5
6	1.2	600	500	8.4	70	6.2	11.0	.64	4.0	7.0
7	1.5	580	342	7.9	27	3.7	13.2	.53	4.7	8.4
8	1.6	4390	2740	21.4	32	0.1	2.9	.69	1.0	1.9
9	3.2	3920	1220	13.9	14	2.2	12.4	.64	4.5	7.9
10	2.2	3280	1490	15.4	27	0.7	6.6	.64	2.7	4.2
11	2.0	5270	2640	20.9	40	1.7	7.4	.64	2.7	4.7
12	3.7	2330	630	9.5	41	0.4	6.3	.64	2.3	4.0
13	2.1	980	467	8.0	35	1.9	9.9	.64	3.6	6.3
14	2.0	7890	3940	25.8	36	2.3	8.0	.64	2.9	5.1
15	1.1	1130	1030	12.6	38	0.2	3.6	.64	1.3	2.3
16	1.9	110	50	2.2	20	0.5	8.6	.64	3.1	5.5
17	2.0	480	240	5.4	37	2.2	10.9	.64	3.9	7.0
18	2.6	380	146	4.0	36	0.6	8.0	.64	2.9	5.1
19	1.6	390	244	5.4	33	1.2	8.8	.64	3.2	5.6
20	3.4	2850	838	11.2	28	1.0	8.7	.64	3.1	5.6
21	1.4	470	328	6.5	31	0.2	4.6	.64	1.7	2.9
22	1.2	70	58	2.2	20	0.1	4.6	.64	1.7	2.9
23	4.0	1140	285	6.0	12	0.1	5.8	.64	2.1	3.7
TOTAL	50.9									

$$I = 0.117D^{0.792-0.039 \log D}$$

$$TC+R = 21\,(DA/S)^{.22}\,(St)^{.33}\,(1+.3I)^{-.28}$$

Lake water surface reaches on the main channel were treated as channel reaches, while storage located within a sub-area was reflected in the unit hydrographs for the area. Storage characteristics for each channel reach are presented in Tables 3C-5, 3C-6 and 3C-7.

Frequency Storm

Storms of various frequencies were developed for all three basins. The storms chosen were the Standard Project Storm (SPS) and those with recurrence intervals of 100, 50, ten and two years. (The Mantua model does not include the 50-year event). The SPS rainfall depth and distribution for the three basins were developed using EM 1110-2-1411 procedures. The SPS precipitation index for all basins is 10.8 inches, for 200 square miles and 24 hours.

The 100, 50, ten and two-year storms were developed using U.S. Weather Bureau Technical Paper No. 40. Adjustments were made to convert the curves to an annual series basis. Because of the wide range of drainage areas at index points of interest, it was concluded that hourly rainfall distribution and area adjustments should be made. The rainfall distributions that were used for each of the storms are shown on Tables 3C-8, 3C-9, and 3C-10.

Expected Probability Adjustment

The expected probability adjustment is designed to correct for bias in estimated exceedence frequencies (or magnitudes of flow for given frequencies) due to use of a small sample in

TABLE 3C-5
CHANNEL ROUTING RELATIONS
RANCOCAS CREEK BASIN, N.J.

ROUTING REACH	STORAGE (S) IN Ac. Ft. - DISCHARGE (Q) IN c.f.s.									
0201	S =	0	300	475	656	842	1030	1230	1640	
	Q =	0	75	175	360	590	1300	4800	17000	
0103	S =	40	80	120	260	460	760	1200		
	Q =	0	50	200	700	1800	3800	6600		
0405	S =	85	110	150	170	250	340	410	590	860
	Q =	0	250	550	800	1050	2500	3600	4800	7700
0607	S =	0	80	190	500	990	1550	2170	2870	3630
	Q =	0	130	440	1010	1930	3150	4670	6470	8580
0809	S =	250	380	440	500	700	800	1000	1700	
	Q =	0	600	1000	1400	2400	3000	4000	10400	
0910	K = 6 X = 0									
1112	S =	0	11	31	77	149	260	400	580	792
	Q =	1	66	267	699	1418	2510	4050	6090	8700
1312	No route									
1215	S =	0	35	60	113	228	417	680	1010	
	Q =	0	180	325	570	1000	1710	2760	4220	
1415	S =	0	35	60	113	228	417	680	1010	
	Q =	0	180	325	570	1000	1710	2760	4220	
1616	S =	600	824	1060	1300	1560	1830			
	Q =	0	120	340	620	1560	2940			
1717	S =	600	824	1060	1300	1560	1830			
	Q =	0	120	340	620	1560	2940			
1718	S =	0	20	67	290	673	1110	1610		
	Q =	0	60	275	885	2210	4170	6740		
1518	S =	0	25	80	354	812	1340	1942		
	Q =	0	60	275	885	2210	4170	6740		
1920	S =	0	165	480	900	1430	2080			
	Q =	0	500	2275	5075	8850	13600			
2122	S =	0	60	120	230	460	860	1440		
	Q =	0	400	1000	2160	3920	6670	10700		
2324	S =	0	130	270	460	700	1020	1440	1850	2400
	Q =	0	380	980	1840	2950	4340	6030	8040	10400
2024	K = 1 X = 0									
2526	S =	0	90	185	320	500	720	1000	1300	1650
	Q =	0	315	710	1380	2260	3360	4700	6270	8100
2628	S =	0	250	620	1220	2090	3230	4610		
	Q =	0	410	1540	3670	6660	10540	15500		
2428	S =	0	100	250	490	840	1300	1840		
	Q =	0	410	1540	3670	6660	10540	15500		
2931	S =	0	185	400	790	1780	3300	5000	6770	
	Q =	0	310	1000	2120	4050	7300	11900	17600	
3233	K = 1 X = .2									
3334	K = 1.5 X = 0									
3410	K = 4 X = 0									
3536	K = 1 X = 0									
3637	K = 1.6 X = 0									
3738	K = 4 X = 0									
3940	K = 2 X = 0									
4041	K = 2 X = 0									
4142	K = 8 X = 0									

TABLE 3C-6
CHANNEL ROUTING RELATIONS
COOPER RIVER BASIN, N.J.

ROUTING REACH	STORAGE (S) IN Ac. Ft. - DISCHARGE (Q) IN c.f.s.									
Millard Creek										
0102	S = 0	63	90	112	166	216	243	274		
	Q = 0	100	200	400	1000	1500	1750	2000		
Cooper River										
0304	S = 0	90	150	210	870					
	Q = 0	250	500	1000	6000					
0506	S = 0	37	75	140	430	935	1460			
	Q = 0	1000	1500	2000	4000	7500	11000			
1011	S = 0	215	394	555	788	1040	1650			
	Q = 0	2000	4000	5000	6000	7500	11000			
1219	S = 0	170	340	510	612	765	986	1090	1360	1560
	Q = 0	1500	4000	7500	9000	10000	11000	12000	16000	18500
1920	S = 0	876	1160	1420	1750	2190	2560	2960	3280	
	Q = 0	1000	2000	7000	12000	16000	18500	20000	21000	
2122	S = 0	1400	1720	1940	2360	2690	3120	3660	4300	
	Q = 0	1000	2000	5500	12000	14500	17000	19000	21000	
2324	S = 0	1080	1480	1760	2020	2300	2700	3320	4050	5130
	Q = 0	1000	2000	7000	10500	12500	14500	17000	19000	21000
Tributary 1										
0809	S = 0	27	54	81	108	157	184	205	265	394
	Q = 0	450	800	1050	1150	1200	1250	1350	1700	2600
0910	S = 0	43	86	129	172	249	292	327	421	628
	Q = 0	450	800	1050	1150	1200	1250	1350	1700	2600
North Branch Cooper River										
1314	S = 0	7	29	72	93	129	174			
	Q = 0	200	500	1100	1400	1900	2600			
1415	S = 0	45	98	136	272	306	431	579		
	Q = 0	300	700	900	1350	1600	2700	4000		
1617	S = 0	25	75	138	244	325	500	631	944	
	Q = 0	400	800	1200	1800	2200	3000	3600	5200	
1718	S = 0	105	168	266	392	448	532	658	756	861
	Q = 0	800	1200	1600	1900	2200	2800	3800	4800	6200
1819	S = 0	81	153	216	288	351	468			
	Q = 0	700	1400	2200	3400	4600	6800			

TABLE 3C-7
CHANNEL ROUTING RELATIONS
MANTUA CREEK BASIN, N.J.

ROUTING REACH	STORAGE (S) IN Ac. Ft. - DISCHARGE (Q) IN c.f.s.									
Mantua Creek										
02103	S = 0	100	160	170	215	300	390	500	680	1000
	Q = 0	250	500	1000	1500	2500	3500	4500	6000	8000
07108	S = 0	50	120	220	330	510	725	940	1200	1500
	Q = 0	250	500	1000	1500	2500	3500	4500	6000	8000
15116	S = 640	685	780	880	990	1220	1500	1900	2300	3100
	Q = 0	1000	2000	3000	4000	6000	8000	10000	12000	15000
21123	S = 4550	4550	4600	4700	4850	5000	5100	5400	6000	7600
	Q = 0	500	1500	3500	5000	6000	7000	9000	12800	20000
Chestnut Branch										
11111	S = 110	120	135	152	166	185	205	220	240	325
	Q = 0	100	200	400	600	1000	1500	2000	2500	4000
11112	S = 0	10	22	36	67	99	162	240	450	700
	Q = 0	118	250	400	700	1000	1500	2000	3000	4000
1213	S = 63	64	78	109	143	205	280	363	570	1100
	Q = 0	200	400	700	1000	1500	2000	2500	3500	6000
Edwards Run										
1718	S = 0	12	350	435	520	600	800	1000	1800	2850
	Q = 0	120	600	800	1000	1200	1600	2000	3000	4000
19120	S = 0	12	110	120	140	165	200	280	400	900
	Q = 0	150	1000	1200	1500	1750	2000	2500	3000	4000
2021	S = 160	200	240	260	280	340	410	610	850	1500
	Q = 0	400	800	1000	1200	1600	2000	3000	4000	6000

TABLE 3C-8

RAINFALL DISTRIBUTION FOR HYPOTHETICAL EVENTS
HOURLY RAINFALL IN INCHES
RANCOCAS CREEK BASIN, N.J.

	(50 Percent Chance Event)						(10 Percent Chance Event)						(2 Percent Chance Event)						(1 Percent Chance)					
Area (sq mi)	1	25	50	100	200	400	1	25	50	100	200	400	1	25	50	100	200	400	1	25	50	100	200	400
Hour	HOURLY RAINFALL IN INCHES																							
1	.02	.03	.02	.02	.02	.02	.05	.06	.05	.05	.05	.06	.06	.08	.06	.07	.07	.07	.06	.07	.06	.06	.06	.07
2	.02	.03	.02	.02	.02	.02	.05	.07	.05	.05	.05	.06	.06	.08	.07	.07	.07	.07	.06	.08	.06	.06	.06	.07
3	.02	.03	.02	.02	.03	.03	.05	.07	.05	.05	.05	.06	.07	.09	.07	.07	.07	.08	.06	.08	.06	.06	.06	.07
4	.02	.03	.02	.02	.03	.03	.05	.07	.05	.05	.06	.06	.07	.09	.07	.07	.07	.08	.06	.08	.06	.06	.07	.07
5	.03	.04	.03	.03	.03	.03	.06	.07	.06	.06	.06	.06	.07	.09	.07	.07	.07	.08	.06	.08	.06	.07	.07	.07
6	.03	.04	.03	.03	.03	.03	.06	.07	.06	.06	.06	.06	.07	.09	.07	.07	.07	.08	.06	.08	.07	.07	.07	.07
7	.07	.04	.06	.07	.07	.06	.08	.07	.09	.09	.10	.09	.13	.08	.12	.13	.15	.15	.16	.10	.15	.17	.18	.18
8	.07	.04	.07	.07	.07	.06	.09	.07	.09	.10	.10	.10	.13	.08	.13	.14	.16	.15	.17	.10	.15	.17	.18	.18
9	.07	.05	.07	.07	.07	.07	.09	.08	.10	.10	.10	.10	.14	.09	.13	.14	.16	.16	.17	.12	.15	.18	.18	.18
10	.08	.06	.08	.08	.09	.09	.11	.08	.13	.14	.15	.15	.16	.12	.17	.17	.17	.16	.20	.15	.20	.20	.22	.21
11	.08	.06	.08	.08	.09	.10	.12	.09	.13	.14	.15	.15	.17	.13	.18	.18	.17	.16	.20	.16	.20	.20	.22	.21
12	.08	.06	.09	.09	.10	.10	.12	.09	.14	.15	.16	.15	.17	.13	.18	.18	.18	.17	.20	.16	.25	.22	.22	.22
13	.10	.09	.10	.10	.10	.11	.16	.17	.16	.15	.17	.15	.25	.24	.24	.23	.25	.23	.25	.25	.26	.28	.29	.28
14	.15	.15	.15	.17	.15	.16	.23	.25	.27	.29	.30	.29	.30	.31	.34	.36	.36	.36	.25	.39	.42	.42	.41	.39
15	.31	.34	.36	.36	.35	.35	.50	.55	.60	.60	.57	.57	.70	.76	.81	.81	.77	.77	.70	.78	.85	.84	.81	.84
16	1.32	1.16	1.05	.95	.88	.84	2.28	2.01	1.81	1.64	1.52	1.46	2.90	2.55	2.31	2.09	1.94	1.86	3.30	2.90	2.62	2.38	2.20	2.11
17	.22	.23	.25	.24	.25	.25	.31	.31	.34	.34	.36	.36	.40	.43	.46	.46	.48	.49	.50	.53	.56	.56	.58	.59
18	.10	.12	.13	.13	.14	.12	.19	.20	.23	.23	.20	.22	.25	.27	.29	.30	.28	.27	.30	.28	.30	.30	.30	.30
19	.04	.05	.04	.04	.04	.05	.08	.11	.08	.09	.09	.09	.10	.14	.11	.11	.11	.12	.09	.14	.10	.10	.10	.11
20	.04	.05	.04	.04	.04	.04	.08	.11	.08	.08	.09	.09	.10	.13	.10	.11	.11	.12	.09	.13	.09	.10	.10	.11
21	.04	.05	.04	.04	.04	.04	.08	.10	.08	.08	.08	.09	.10	.13	.10	.10	.11	.12	.09	.13	.09	.10	.10	.11
22	.03	.05	.04	.04	.04	.04	.08	.10	.08	.08	.08	.09	.10	.13	.10	.10	.10	.11	.09	.13	.09	.09	.10	.10
23	.03	.05	.03	.04	.04	.04	.08	.10	.08	.08	.08	.09	.10	.13	.10	.10	.10	.11	.09	.13	.09	.09	.10	.10
24	.03	.05	.03	.04	.04	.04	.07	.10	.08	.08	.08	.08	.10	.13	.10	.10	.10	.11	.09	.13	.09	.09	.09	.10
TOTAL	3.00	2.90	2.85	2.79	2.75	2.72	5.15	5.00	4.89	4.79	4.71	4.68	6.70	6.50	6.37	6.23	6.13	6.08	7.40	7.18	7.03	6.88	6.77	6.72

TABLE 3C-9

RAINFALL DISTRIBUTION FOR HYPOTHETICAL EVENTS
HOURLY RAINFALL IN INCHES
COOPER RIVER BASIN, N.J.

	(50 Percent Chance Event)			(10 Percent Chance Event)			(2 Percent Chance Event)			(1 Percent Chance)			SPS
Area (sq mi	1	25	50	1	25	50	1	25	50	1	25	50	25
Hour	HOURLY RAINFALL IN INCHES												
1	.02	.03	.02	.05	.06	.05	.06	.08	.06	.06	.07	.06	.08
2	.02	.03	.02	.05	.07	.05	.06	.08	.06	.06	.08	.06	.08
3	.02	.03	.02	.05	.07	.05	.07	.09	.07	.06	.08	.06	.08
4	.02	.03	.02	.05	.07	.05	.07	.09	.07	.06	.08	.06	.08
5	.03	.04	.03	.06	.07	.06	.07	.09	.07	.06	.08	.06	.08
6	.03	.04	.03	.06	.07	.06	.07	.09	.07	.06	.08	.07	.08
7	.07	.04	.06	.08	.07	.09	.13	.08	.12	.16	.10	.15	.25
8	.07	.04	.07	.09	.07	.09	.13	.08	.13	.17	.10	.15	.25
9	.07	.05	.07	.09	.08	.10	.14	.09	.13	.17	.12	.15	.25
10	.08	.06	.08	.11	.08	.13	.16	.12	.17	.20	.15	.20	.25
11	.08	.06	.08	.12	.09	.13	.17	.13	.18	.20	.16	.20	.25
12	.08	.06	.09	.12	.09	.14	.17	.13	.18	.20	.16	.25	.25
13	.10	.09	.10	.16	.17	.16	.25	.24	.24	.25	.25	.26	.95
14	.15	.15	.15	.23	.25	.27	.30	.31	.34	.35	.39	.42	1.14
15	.31	.34	.36	.50	.55	.60	.70	.76	.81	.70	.78	.85	1.43
16	1.32	1.16	1.05	2.28	2.01	.81	2.90	2.55	2.31	3.30	2.90	2.62	3.62
17	.22	.23	.25	.31	.31	.34	.40	.43	.46	.50	.53	.56	1.33
18	.10	.12	.13	.19	.20	.23	.25	.27	.29	.30	.28	.30	1.05
19	.04	.05	.04	.08	.11	.08	.10	.14	.11	.09	.14	.10	.15
20	.04	.05	.04	.08	.11	.08	.10	.13	.10	.09	.13	.09	.15
21	.04	.05	.04	.08	.10	.08	.10	.13	.10	.09	.13	.09	.15
22	.03	.05	.04	.08	.10	.08	.10	.13	.10	.09	.13	.09	.15
23	.03	.05	.03	.08	.10	.08	.10	.13	.10	.09	.13	.09	.15
24	.03	.05	.03	.07	.10	.08	.10	.13	.10	.09	.13	.09	.15
Total	3.00	2.90	2.85	5.15	5.00	4.89	6.70	6.50	6.37	7.40	7.18	7.03	12.40

TABLE 3C-10

RAINFALL DISTRIBUTION FOR HYPOTHETICAL EVENTS
HOURLY RAINFALL IN INCHES
MANTUA CREEK BASIN, N.J.

	(50 Percent Chance Event)				(10 Percent Chance Event)				(1 Percent Chance)				SPS			
AREA (SQ MI)	1	10	20	50	1	10	20	50	1	10	20	50	1	10	20	50
Hour	HOURLY RAINFALL IN INCHES															
1	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.14	.14	.13	.13
2	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.14	.14	.13	.13
3	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.14	.14	.13	.13
4	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.15	.15	.15	.14
5	.04	.04	.04	.04	.05	.05	.05	.05	.09	.09	.09	.09	.15	.15	.15	.14
6	.04	.04	.04	.04	.05	.05	.05	.05	.09	.09	.09	.09	.15	.15	.15	.14
7	.13	.13	.13	.12	.20	.20	.19	.19	.25	.25	.24	.24	1.05	1.04	1.02	.98
8	.14	.14	.14	.13	.20	.20	.19	.19	.30	.30	.29	.28	1.27	1.25	1.22	1.18
9	.35	.35	.34	.33	.50	.50	.49	.47	.80	.79	.78	.76	1.59	1.57	1.53	1.47
10	1.50	1.49	1.45	1.41	2.35	2.33	2.29	2.23	3.35	3.32	3.26	3.17	4.00	3.96	3.86	3.72
11	.25	.25	.24	.24	.25	.25	.24	.24	.35	.35	.34	.33	1.49	1.48	1.44	1.38
12	.13	.13	.13	.12	.20	.20	.19	.19	.25	.25	.24	.24	1.16	1.15	1.12	1.08
13	.09	.09	.09	.08	.14	.14	.14	.13	.19	.19	.19	.18	.15	.15	.15	.14
14	.09	.09	.09	.08	.14	.14	.14	.13	.19	.19	.19	.18	.15	.15	.15	.14
15	.08	.08	.08	.08	.13	.13	.13	.12	.18	.18	.18	.17	.15	.15	.15	.14
16	.08	.08	.08	.08	.13	.13	.13	.12	.18	.18	.18	.17	.14	.14	.13	.13
17	.08	.08	.08	.08	.13	.13	.13	.12	.18	.18	.18	.17	.14	.14	.13	.13
18	.08	.07	.08	.08	.13	.13	.13	.12	.18	.18	.18	.17	.14	.14	.13	.13
19	.04	.04	.04	.04	.05	.05	.05	.05	.09	.09	.09	.09	.14	.14	.13	.13
20	.04	.04	.04	.04	.05	.05	.05	.05	.09	.09	.09	.09	.14	.14	.13	.13
21	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.14	.14	.13	.13
22	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.13	.13	.12	.12
23	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.13	.13	.13	.12
24	.03	.03	.03	.03	.05	.05	.05	.05	.08	.08	.08	.08	.13	.13	.12	.12
Total	3.40	3.38	3.33	3.19	5.10	5.08	4.99	4.85	7.40	7.36	7.25	7.06	13.11	13.00	12.63	12.18

computing the statistics of mean and standard deviation.

This bias results from the fact that errors can occur in estimating flow because of uncertainty in the statistics. As a result, the plot of magnitude (for a given frequency) vs. frequency is no longer symmetrical about the frequency ordinate. Figure 3C-7 illustrates this effect; the magnitudes of the one per cent chance of exceedence with and without the expected probability adjustment are 1980 and 1660, respectively.

The non-symmetry is a mathematical extension of the concept that at, for example, a frequency of one per cent, there is only a chance of .01 probability units in error on the high side but 0.99 probability units of error on the low side. The adjustment is computed by integration of the distribution of errors about the frequency ordinate and results in increasing the magnitude of values for given frequencies.

The philosophy of the expected probability adjustment is important, since computation of the sum of the expected values of a large number of projects (the average annual value) is biased in the direction of underestimating the total value if the expected probability adjustment is not made. For example, if the expected economic value of a large number of projects were computed and each analysis was based on 20 years of equivalent record, in the absence of the adjustment the value would be underestimated by as much as 20 per cent.

Normally, the policy of the Corps is to use the expected probability adjustment in formulating alternatives for providing flood protection. However, the expected probability adjustment has not been adopted uniformly by all Federal, state and local agencies and part of the objectives of this study are to "Achieve Full Coordination With Affected Public Agencies" and to "Achieve Certification by State and Federal Agencies Where Appropriate".

Population Projections

The year 2000 population projections described in the Background Information Appendix were incorporated into DVRPC's model to project future population by census tract. This series of models was then adapted to "demand centers". Allocations were then made by demand center to the various minor civil divisions within the study area. The demand centers, which are divided by township, highway and stream boundaries, do not coincide with the hydrologic sub-areas. Therefore, the demand center population data was disaggregated by use of a weighted percentage to population, and these values were allocated to each sub-area in a particular demand center. Future population growth in the various municipalities was assumed to occur around the existing population centers.

Once population was allocated, the population density (D) was determined by dividing the population by the area of each sub-area. These population density figures were then used to estimate the per cent of impervious surface by use of a

regression equation developed in "Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization", Special Report 38, by Stephen J. Stankowski, U.S. Geological Survey, 1974. This report relates the per cent of impervious area to population density in the following relationship:

$$I = 0.117D^{0.792 - 0.039 \log D}$$

where

I = Per cent Impervious
D = Population Density per Square Mile

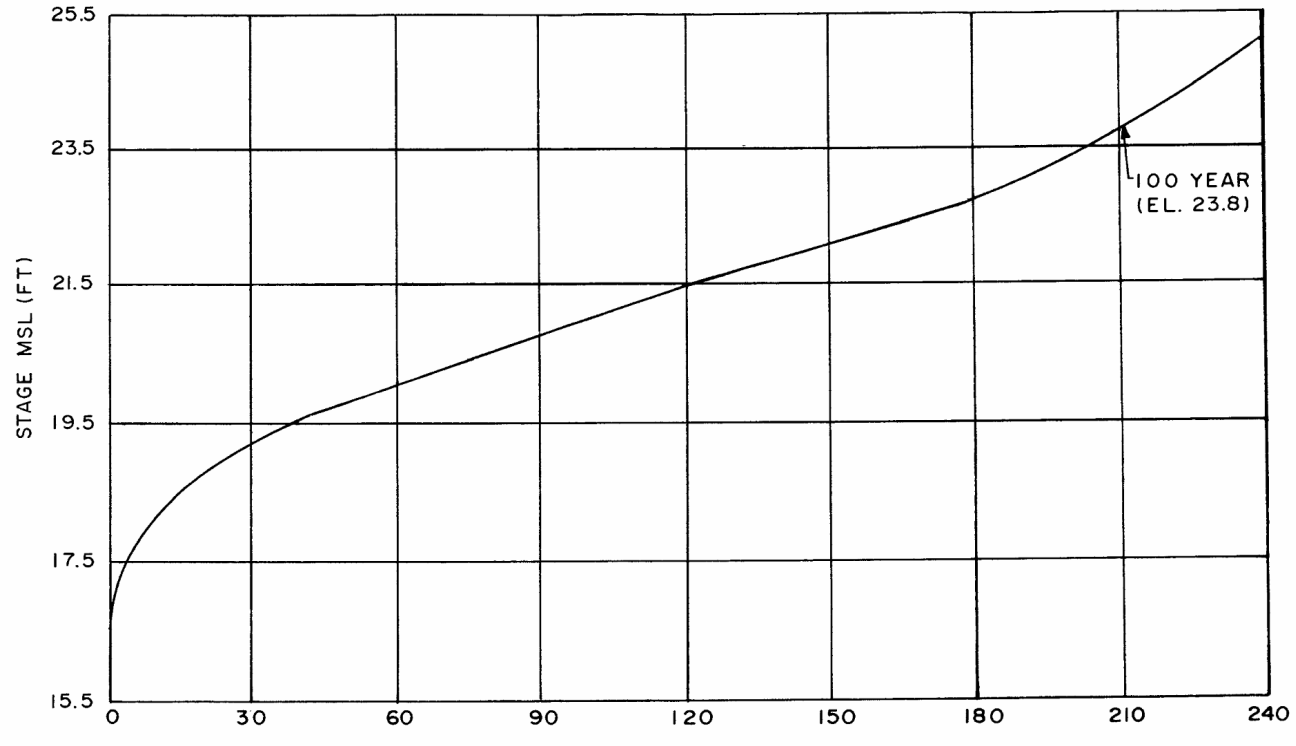
Model Modification to Reflect Urbanization

Once the models were calibrated, that is, the computed discharges from the model were matched to discharges obtained from independent gage analysis (for the 1970 population), the models were used for further studies. A series of economic analyses was performed for the existing damage centers within each basin. The purpose of the analysis was to see if flood damages would increase significantly as a result of the future increases in discharges. For each damage center, a stage-damage curve was developed to show the amount of damages at various water surface elevations. Stage-discharge curves were developed from the backwater runs done previously by the Corps Flood Plain Management Service and Hydraulics branches for the Federal Insurance Administration. Based on data from the hydrologic model, annual exceedence probability-discharge curves were developed. The combination of these three curves leads to a

fourth, known as the damage-frequency curve. (Figures 3C-8 through 3C-11 show examples of each of the previously-mentioned curves).

Rather than inputing the precipitation data for various hypothetical storms, the Rancocas and Cooper models used ratios of the 100-year event (including the 100-year event itself) to establish the average annual damages at each damage location. The Mantua model used ratios of the ten-year event for the same purpose.

With the economic effects for the 1970 population computed for all existing damage centers, the damages were determined for those same areas using the two future population figures mentioned earlier. Unit hydrographs were modified to reflect this urbanization. (Most of the sub-areas increased in population density and therefore the imperviousness increased). Particular unit hydrograph parameters were mathematically related to physiographic characteristics for existing and future conditions. Results of the regression analysis indicated that TC and R values are directly affected by changing impervious rates. Tables 3C-11, 3C-12 and 3C-13 show the impervious rates, TC and R values as they change for the 1970, 2000 and maximum 2000 year population figures for all three models.



CAMDEN METRO STUDY
COOPER RIVER BASIN
(SUB-AREA 12)
STAGE-DAMAGE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3-C8

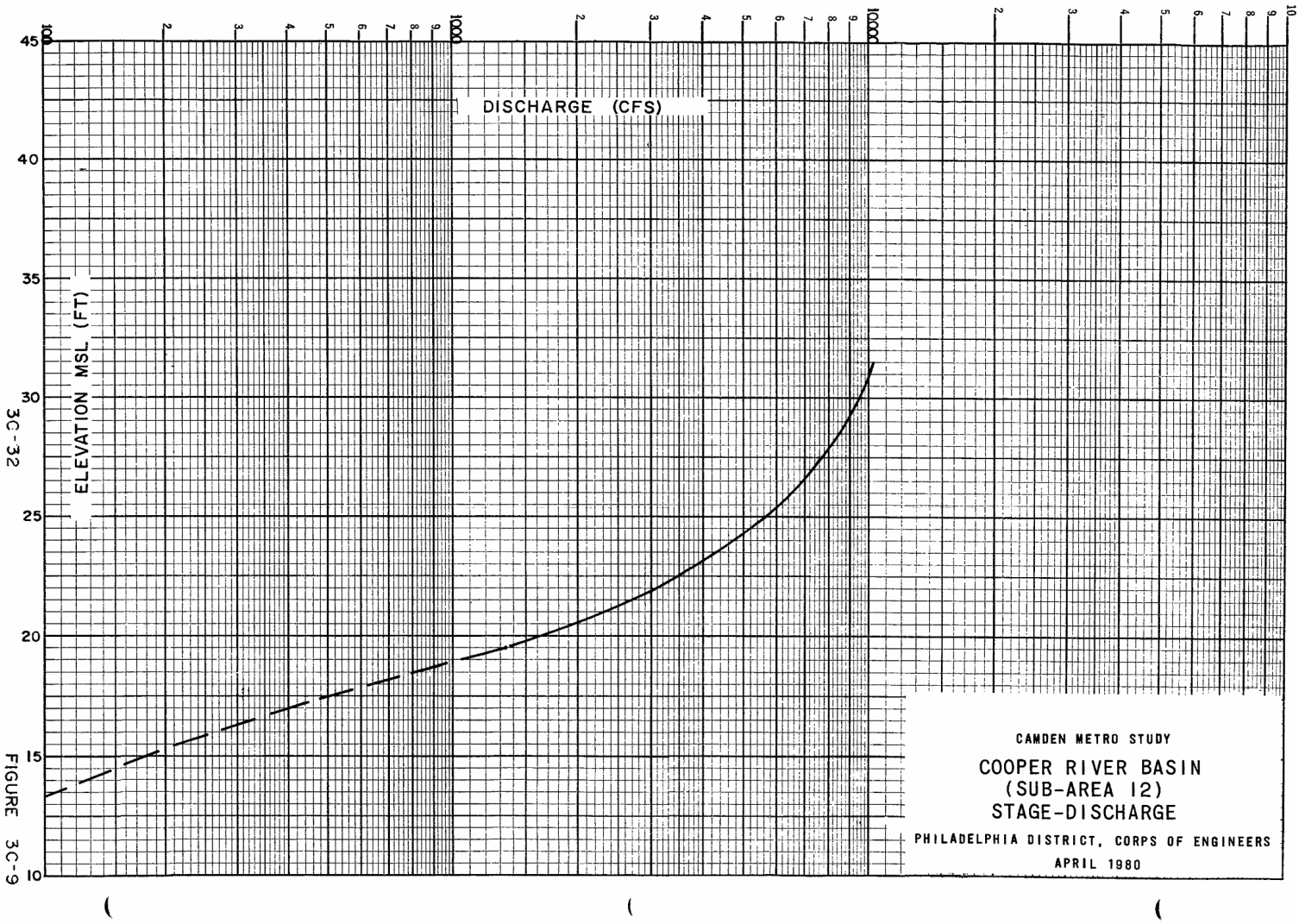

DISCHARGE (CFS)
ELEVATION MSL (FT)
100
1000
10000
45
40
35
30
25
20
15
10
CAMDEN METRO STUDY
COOPER RIVER BASIN
(SUB-AREA 12)
STAGE-DISCHARGE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-9

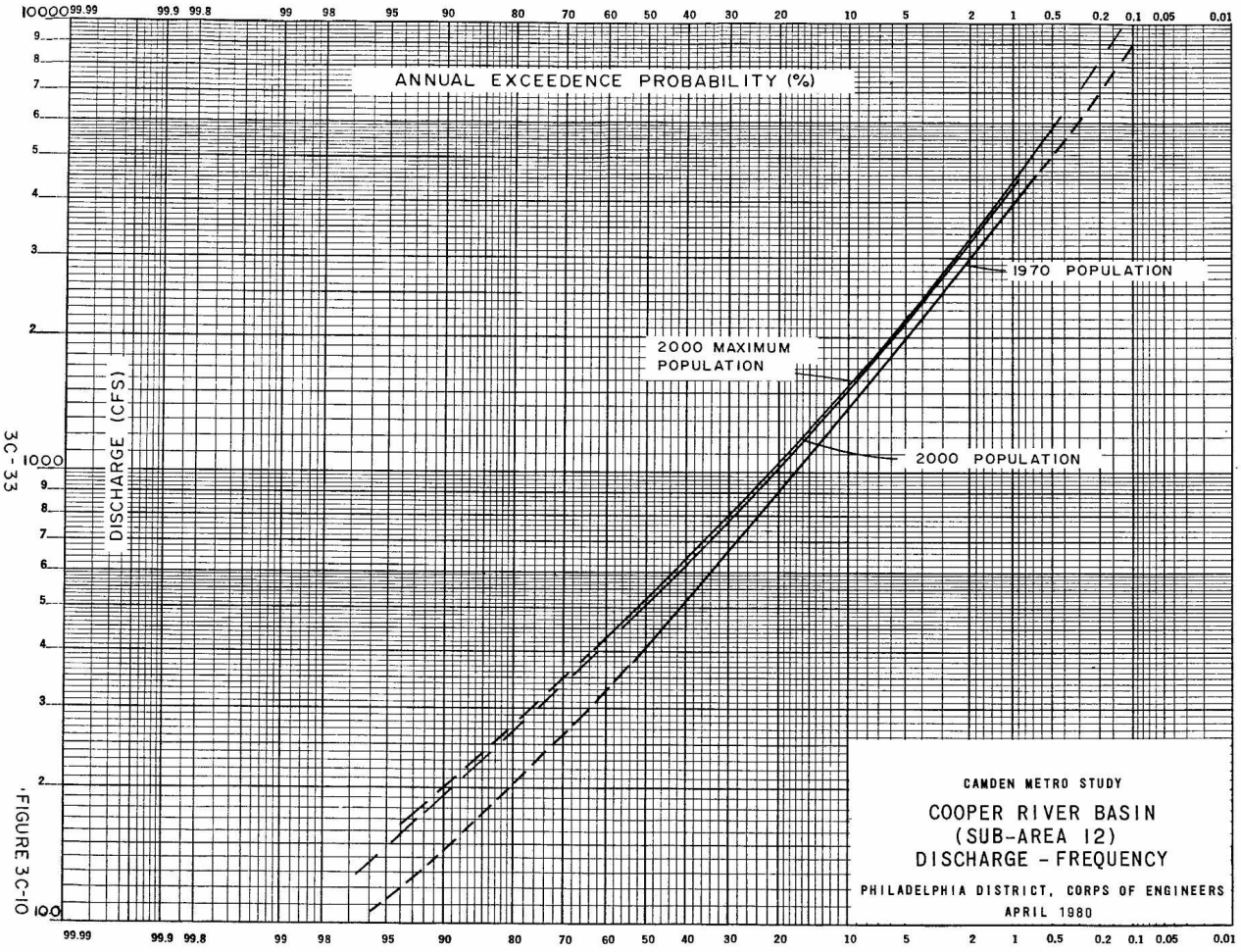
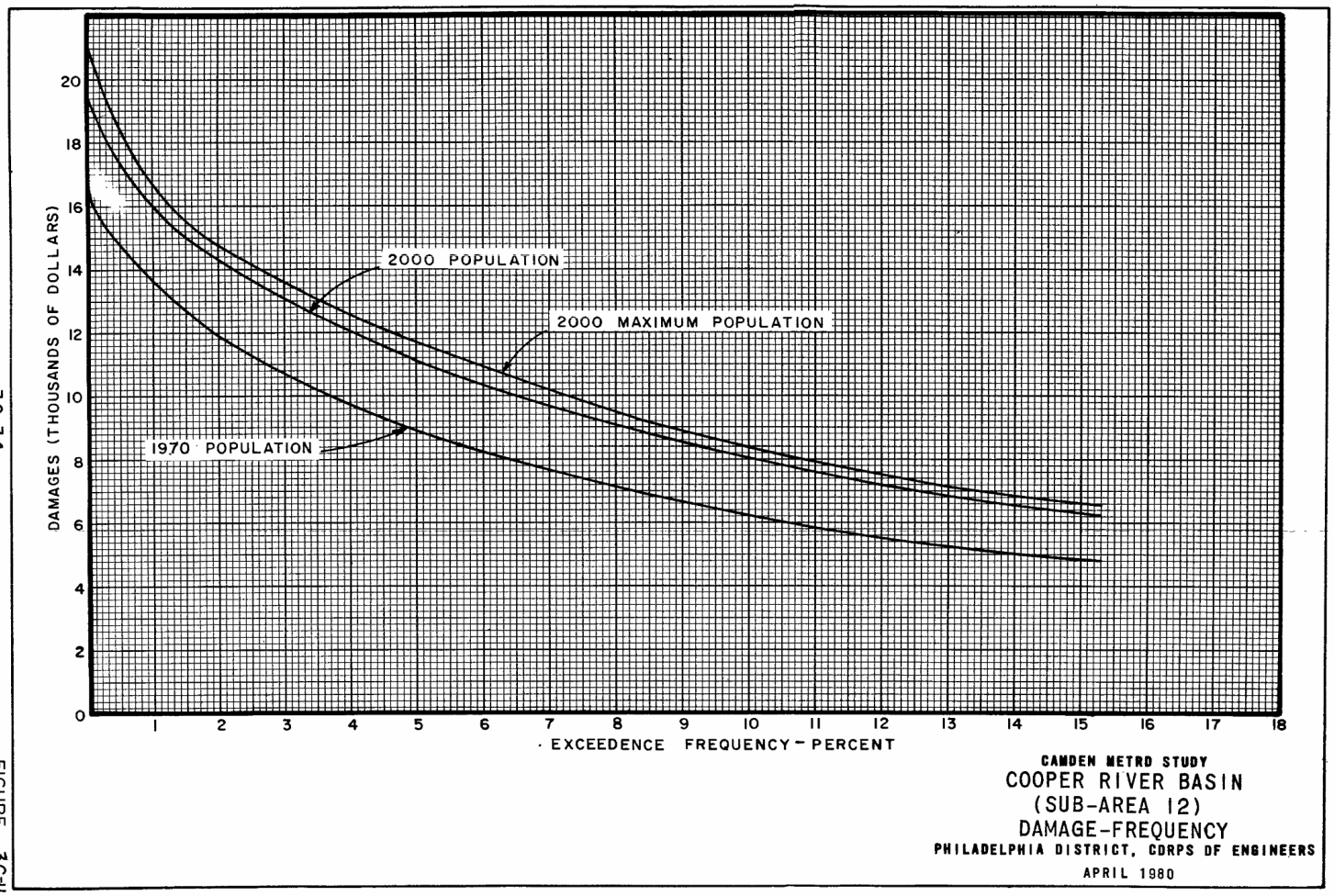

ANNUAL EXCEEDENCE PROBABILITY (%)
DISCHARGE (CFS)
1970 POPULATION
2000 MAXIMUM POPULATION
2000 POPULATION
CAMDEN METRO STUDY
COOPER RIVER BASIN
(SUB-AREA 12)
DISCHARGE - FREQUENCY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-10



CAMDEN METRO STUDY
COOPER RIVER BASIN
(SUB-AREA 12)
DAMAGE-FREQUENCY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-11

TABLE 3C-11
IMPERVIOUS RATES AND HYDROGRAPH PARAMETERS
RANCOCAS CREEK BASIN, N.J.

Subarea Index No.	Drainage Area (D.A.) (sq.mi.)	Imperviousness 1970 (%)	Imperviousness Year 2000 (%)	Imperviousness Max 2000 (%)	TC 1970 (hrs.)	TC Year 2000 (hrs.)	TC Max 2000 (hrs.)	R 1970 (hrs.)	R Year 2000 (hrs.)	R Max 2000 (hrs.)
1	23.60	4.4	5.1	8.3	42	40.1	36	50	49.0	45
2	7.36	3.3	4.0	5.5	8	7.6	7	11	10.6	10
2a	5.47									
3	4.92	6.4	9.3	15.0	9	8.3	8	13	12.4	11
4	74.10	2.8	3.7	6.1	54	51.3	47	65	62.7	58
5	8.05	5.5	8.1	12.1	12	10.9	10	21	20.1	18
6	6.08	5.2	8.2	12.6	3	2.7	2	7	6.4	6
7	7.95	14.8	15.1	16.4	4	4.0	4	12	12.0	12
8	4.97	5.4	7.2	13.2	3	2.5	2	7	7.0	7
9	5.66	8.5	20.3	24.6	8	6.4	6	23	19.3	18
10	6.24	7.5	8.1	8.1	8	8.0	8	24	24.0	24
11	5.60	6.0	9.9	10.2	3	3.0	3	12	10.0	10
12	1.89	11.0	14.9	18.6	3	3.1	3	10	9.2	9
13	2.81	7.9	11.5	14.4	6	5.8	6	19	17.3	16
14	3.44	14.1	19.9	23.6	1.9	1.8	1.7	5.9	5.3	5.1
15	6.17	10.0	13.3	16.5	7	6.1	6	19	18.3	7
16	16.40	4.8	7.1	7.0	10	9.8	10	32	29.5	29
17	10.00	8.6	9.1	10.0	6	6.0	6	22	21.3	21
18	2.22	11.0	14.6	12.2	4	3.6	4	11	10.6	11
19	4.64	2.5	4.9	6.1	3	3.0	3	10	9.1	9
20	3.67	4.6	8.6	10.6	3	2.9	3	10	8.6	8
21	5.02	4.7	6.8	7.1	7	7.1	7	27	25.2	25
22	8.76	4.1	5.4	6.6	7	6.9	7	24	24.6	23
23	2.03	3.4	6.1	7.6	2.2	2.2	2	6.3	6.6	6.3
24	4.09	4.2	5.9	7.5	3	2.8	3	8	8.4	8
25	46.10	2.5	3.8	5.0	17	16.1	15	60	57.3	55
26	6.72	3.4	4.2	6.5	4	3.9	4	14	14.0	13
27	11.80	3.8	4.5	7.3	14	13.7	13	26	25.5	23
28	4.04	4.0	5.3	6.3	7	6.4	6	15	14.9	15

TABLE 3C-11 (Cont'd)
IMPERVIOUS RATES AND HYDROGRAPH PARAMETERS
RANCOCAS CREEK BASIN, N.J.

Subarea Index No.	Drainage Area (D.A.) (sq.mi.)	Imperviousness 1970 (%)	Imperviousness Year 2000 (%)	Imperviousness Max 2000 (%)	TC 1970 (hrs.)	TC Year 2000 (hrs.)	TC Max 2000 (hrs.)	R 1970 (hrs.)	R Year 2000 (hrs.)	R Max 2000 (hrs.)
29	4.76	5.5	7.3	8.7	3	2.5	3	8	7.6	7
30	2.35	6.9	9.7	10.5	2.2	2.1	2.1	6.7	6.3	6.1
31	5.50	9.4	11.0	11.0	8	8.0	8	25	24.0	24
32	3.05	4.2	6.6	7.7	2.1	4.0	2.3	6	7.2	6.7
33	3.15	5.2	6.2	6.2	2.4	2.3	2.3	7.3	7.0	7
34	2.38	4.7	6.1	6.2	4	3.8	4	12	11.4	11
35	2.83	4.1	8.1	8.1	2.2	2.0	2	6.6	5.8	5.8
36	3.58	7.0	11.5	11.5	4	3.6	4	12	10.6	10
37	1.87	8.4	13.8	13.7	4	3.3	3	11	9.8	10
38	5.17	15.0	16.8	16.9	5	5.4	5	17	16.1	16
39	5.41	3.4	6.6	6.7	3	2.6	3	9	7.7	7
40	4.04	30.0	30.8	30.8	1.6	1.6	1.6	4.8	4.7	4.7
41	1.91	38.0	37.3	37.3	3	3.1	3	9	9.2	9
42	6.06	19.0	21.4	22.7	7	7.1	7	22	21.2	21

TABLE 3C-12

IMPERVIOUS RATES AND HYDROGRAPH PARAMETERS

COOPER RIVER BASIN, N.J.

Subarea Index No.	Drainage Area (D.A.) (sq. mi.)	Imperviousness (%)			TC (hrs.)			R (hrs.)		
		1970	Year 2000	Max 2000	1970	Year 2000	Max 2000	1970	Year 2000	Max 2000
1	1.50	9	11.6	12.2	3.1	3.0	3.0	9.9	9.5	9.3
2	1.10	15	21.5	22.9	1.5	1.3	1.3	4.6	4.3	4.2
3	1.50	15	18.9	19.6	1.8	1.7	1.7	5.6	5.4	5.3
4	2.00	15	24.2	24.9	2.9	2.4	2.4	9.1	7.8	7.7
5	.74	13	26.0	28.4	1.3	1.1	1.1	4.0	3.4	3.3
6	1.36	28	35.6	36.0	1.3	1.2	1.2	4.1	3.9	3.9
7	.70	28	33.0	34.7	.9	.9	.9	2.9	2.8	2.7
8	1.20	6.7	14.0	15.3	1.5	1.3	1.2	4.7	4.0	4.0
9	1.46	14	19.0	20.0	1.2	1.1	1.1	3.9	3.6	3.6
10	.84	21	22.0	22.7	1.0	1.0	1.0	3.2	3.2	3.2
11	1.80	23	23.8	24.7	1.6	1.6	1.5	5.0	4.9	4.9
12	1.90	13	19.4	20.1	1.4	1.2	1.2	4.4	4.0	4.0
13	1.38	3	5.2	5.8	2.1	1.9	1.9	6.7	6.2	6.1
14	2.48	10	13.4	14.9	1.8	1.7	1.6	5.5	5.2	5.1
15	1.81	16	20.4	21.2	1.7	1.6	1.6	5.5	5.2	5.1
16	1.13	16	19.0	19.7	1.1	1.0	1.0	3.4	3.3	3.3
17	1.30	17	20.6	21.3	1.8	1.7	1.7	5.8	5.5	5.5
18	2.30	22	22.3	23.2	1.5	1.4	1.4	4.9	4.5	4.4
19	2.40	24	25.8	26.8	2.2	2.2	2.1	6.9	6.8	6.8
20	2.41	33	35.5	36.6	2.4	2.4	2.4	7.6	7.5	7.4
21	1.51	24	24.9	25.7	1.2	1.2	1.2	3.7	3.6	3.6
22	2.38	39	39.7	40.7	3.6	3.6	3.6	11.4	11.4	11.4
23	1.40	36	36.6	37.4	1.0	1.0	1.0	3.3	3.3	3.3
24	3.30	45	45.0	46.1	3.1	3.1	3.1	9.9	9.9	9.9

TABLE 3C-13

IMPERVIOUS RATES AND HYDROGRAPH PARAMETERS

MANTUA CREEK BASIN, N.J.

Subarea Index No.	Drainage Area (D.A.) (sq. mi.)	Imperviousness 1970 (%)	Imperviousness Year 2000 (%)	Imperviousness Max 2000 (%)	TC 1970 (hrs.)	TC Year 2000 (hrs.)	TC Max 2000 (hrs.)	R 1970 (hrs.)	R Year 2000 (hrs.)	R Max 2000 (hrs.)
1	3.0	3.8	4.8	4.8	5.9	5.7	5.7	10.7	10.1	10.1
2	3.1	9.4	11.1	11.1	5.0	4.8	4.8	8.9	8.6	8.6
3	1.7	20.2	21.7	21.7	2.3	2.3	2.3	4.1	4.0	4.0
4	2.6	8.1	10.1	10.1	4.0	3.8	3.8	7.1	6.8	6.8
5	1.8	3.5	8.4	8.4	2.0	1.7	1.7	3.5	3.0	3.0
6	1.2	8.4	10.2	10.7	4.0	3.8	3.8	7.0	6.8	6.7
7	1.5	7.9	9.5	9.5	4.7	4.6	4.6	8.4	8.1	8.1
8	1.6	21.4	24.9	25.1	1.0	1.0	1.0	1.9	1.8	1.8
9	3.2	13.9	16.2	16.2	4.5	4.3	4.3	7.9	7.7	7.7
10	2.2	15.4	17.7	17.7	2.4	2.3	2.3	4.2	4.1	4.1
11	2.0	20.9	22.0	22.0	2.7	2.6	2.6	4.7	4.7	4.7
12	3.7	9.5	10.5	10.8	2.3	2.2	2.2	4.0	3.9	3.9
13	2.1	8.0	9.7	10.5	3.6	3.4	3.4	6.3	6.1	6.0
14	2.0	25.8	29.9	30.5	2.9	2.8	2.7	5.1	4.9	4.9
15	1.1	12.6	15.1	16.3	1.3	1.3	1.2	2.3	2.2	2.2
16	1.9	2.2	5.4	6.1	3.1	2.7	2.7	5.5	4.9	4.7
17	2.0	5.4	7.3	7.8	3.9	3.7	3.7	7.0	6.7	6.5
18	2.6	4.0	5.5	5.7	2.9	2.7	2.7	5.1	4.9	4.8
19	1.6	5.4	7.3	7.9	3.2	3.0	3.0	5.6	5.3	5.2
20	3.4	11.2	13.9	15.0	3.1	3.0	3.0	5.6	5.3	5.2
21	1.4	6.5	7.5	9.2	1.7	1.6	1.5	2.9	2.9	2.8
22	1.2	2.2	5.5	6.3	1.7	1.4	1.4	2.9	2.6	2.5
23	4.0	5.4	7.5	9.0	2.1	2.0	1.9	3.7	3.5	3.4

Modelling Results

The impact of urbanization on the three basins was calculated by the mathematical models. The computer analysis revealed that future urbanization has a relatively greater effect on the more frequent flood events. Figure 3C-12 shows the effect urbanization would have on a hydrograph for a sample sub-area in the Cooper River basin.

Tables 3C-14, 3C-15 and 3C-16 show the effects of urbanization on the ten and 100-year discharges for the three basins at each node.

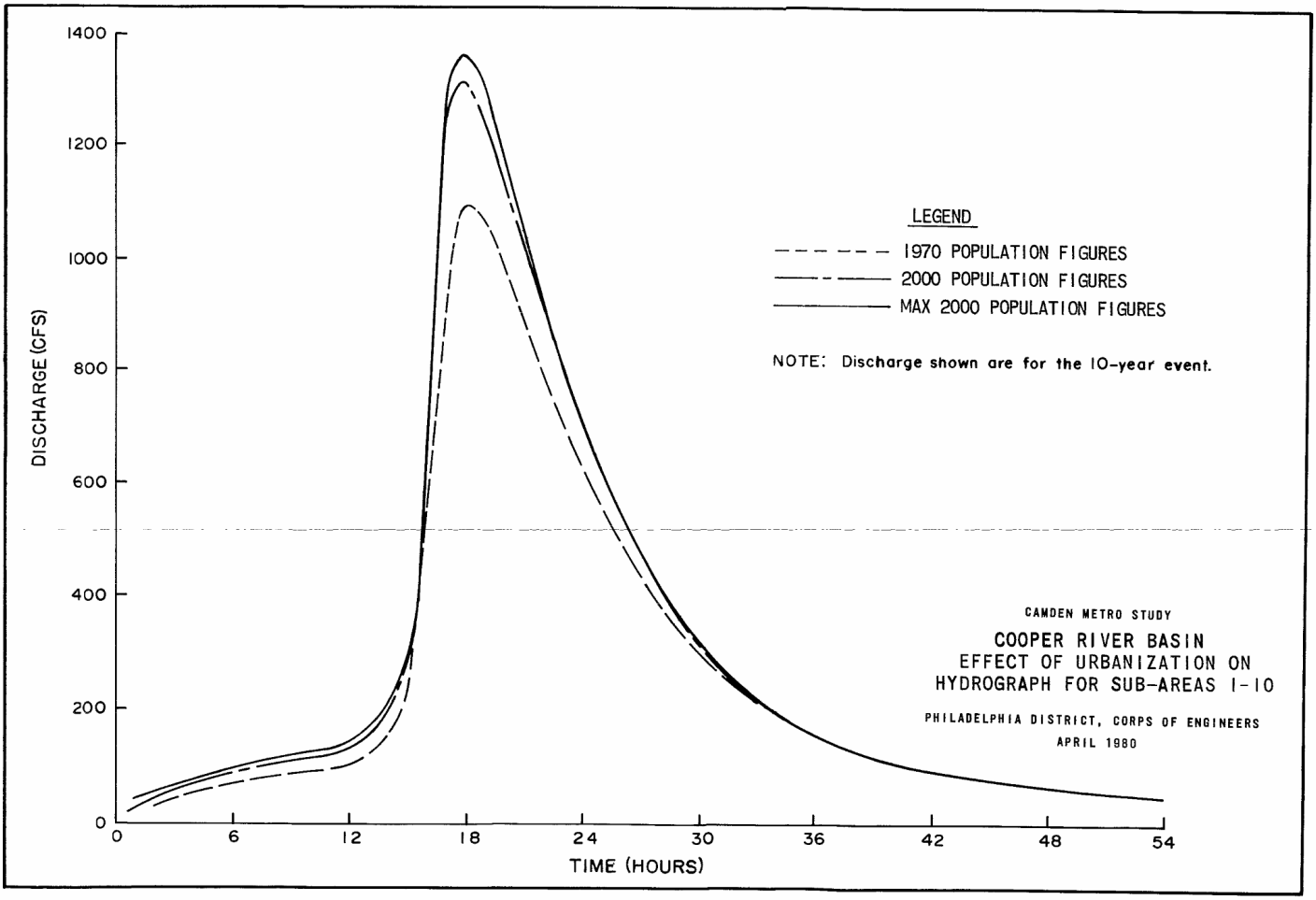

1400
1200
1000
800
600
400
200
0
DISCHARGE (CFS)
0
6
12
18
24
30
36
42
48
54
TIME (HOURS)
LEGEND
1970 POPULATION FIGURES
2000 POPULATION FIGURES
MAX 2000 POPULATION FIGURES
NOTE: Discharge shown are for the 10-year event.
CAMDEN METRO STUDY
COOPER RIVER BASIN
EFFECT OF URBANIZATION ON
HYDROGRAPH FOR SUB-AREAS 1-10
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3C-12

TABLE 3C-14
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
RANCOCAS CREEK BASIN, N.J.

Subareas (Inclusive)	10-Year Peak Flow					100-Year Peak Flow				
	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
1	402	418	481	3.98	19.65	659	684	780	3.79	18.36
2	554	574	629	3.61	13.54	925	958	1044	3.57	12.86
1-2 (In Flow)	627	653	716	4.15	14.19	1027	1070	1166	4.19	13.53
1-2 (out-Flow)	425	442	503	4.00	18.35	722	752	864	4.16	19.67
3	335	366	428	9.25	27.76	554	600	693	8.30	25.09
1-3	453	471	534	3.97	17.88	813	853	992	4.92	22.02
4	901	953	1073	5.77	19.09	1474	1554	1739	5.43	17.48
1-4	1289	1357	1536	5.28	19.16	2099	2208	2482	5.19	18.25
5	359	392	455	9.19	26.74	593	642	739	8.26	24.62
1-5	1350	1423	1620	5.41	20.00	2207	2323	2616	5.26	18.53
6	775	857	992	10.58	28.00	1288	1401	1614	8.77	25.31
1-6	1360	1433	1620	5.37	19.12	2216	2332	2625	5.23	18.46
7	717	718	728	0.14	1.53	1164	1165	1178	0.08	1.20
1-7	1350	1423	1609	5.41	19.19	2213	2331	2629	5.33	18.80
8	636	664	728	4.40	14.47	1057	1087	1183	2.84	11.92
1-8	1713	1763	1875	2.92	9.46	2662	2738	2899	2.85	11.92
9	262	356	395	35.88	50.76	429	569	626	32.63	45.92
1-9	1810	1944	2100	7.40	16.02	2820	3033	3270	7.55	15.96
10	275	277	277	0.73	0.73	451	454	454	0.66	0.66
1-10	1741	1867	2022	7.24	16.14	2724	2901	3128	6.50	14.83
11	477	574	576	20.34	20.75	788	943	945	19.67	19.92
12	199	220	231	10.55	16.08	325	357	373	9.85	14.77
11-12	598	704	716	17.73	19.73	988	1158	1174	17.21	18.83
13	157	177	194	12.74	23.57	258	288	314	11.63	21.70
11-13	737	862	886	16.96	20.22	1218	1414	1448	16.09	18.88
14	578	646	678	11.76	17.30	940	1041	1086	10.74	15.53
11-15	1311	1469	1544	12.05	17.77	2105	2340	2451	11.16	16.44
16	533	590	595	10.69	11.63	877	966	976	10.15	11.29
17	493	509	521	3.25	5.08	808	834	851	3.22	5.32
16-17	582	625	634	7.39	8.93	1010	1083	1105	7.23	9.41
18	208	225	211	8.17	1.44	341	363	344	6.45	0.88
11-18	1372	1515	1577	10.42	14.94	2270	2478	2565	9.16	13.00
19	441	487	497	10.43	12.70	736	809	824	9.92	11.96
11-19	1535	1696	1763	10.49	14.85	2527	2750	2845	8.82	12.58
20	358	417	451	16.48	25.98	594	688	740	15.82	24.58
11-20	1607	1769	1836	10.08	14.25	2668	2903	2997	8.81	12.33
21	197	215	217	9.14	10.15	326	353	356	8.28	9.20
22	349	372	399	6.59	14.33	579	613	658	5.87	13.64
23	255	293	309	14.90	21.18	421	481	507	14.25	20.43
21-23	653	696	730	6.58	11.79	1084	1184	1200	5.90	10.70

TABLE 3C-14 (Cont'd)
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
RANCOCAS CREEK BASIN, N.J.

Subareas (Inclusive)	10-Year Peak Flow					100-Year Peak Flow				
	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
24	430	457	487	6.28	13.26	716	759	804	6.00	12.29
21-24	784	837	879	6.76	12.12	1330	1408	1473	5.86	10.75
11-24	2209	2415	2512	9.33	13.72	3659	3971	4113	8.53	12.41
25	728	778	828	6.87	13.74	1035	1107	1180	6.95	14.01
26	436	439	482	0.69	10.55	634	639	702	0.79	10.72
25-26	839	896	963	6.79	14.78	1208	1292	1385	6.95	14.65
27	391	401	460	2.56	17.65	564	579	665	2.66	17.91
25-27	1153	1223	1339	6.07	16.13	1661	1765	1933	6.26	16.38
28	253	262	266	3.56	5.14	421	434	438	3.09	4.04
11-28	3189	3435	3548	7.71	14.39	5076	5447	5770	7.31	13.67
29	554	596	630	7.58	13.72	919	975	1039	6.09	13.06
11-29	3294	3544	3756	7.59	14.03	5259	5628	5951	7.02	13.16
30	337	364	376	8.01	11.57	552	595	613	7.79	11.05
11-30	3340	3540	3807	7.49	13.98	5337	5713	6034	7.05	13.06
31	241	254	254	5.39	5.39	393	413	413	5.09	5.09
11-31	3199	3415	3594	6.75	12.35	5099	5435	5707	6.59	8.59
32	377	403	435	6.90	15.38	620	660	712	6.45	14.84
33	406	428	428	5.42	5.42	667	703	703	5.04	5.04
32-33	718	753	783	4.87	9.05	1195	1250	1297	4.60	8.54
34	195	205	211	5.13	8.21	323	338	350	4.64	8.36
32-34	799	842	873	5.38	9.26	1331	1395	1445	4.81	8.56
11-34	3333	3554	3733	6.63	12.00	5331	5671	5947	6.38	11.56
1-34	4843	5170	5488	6.75	13.32	7658	8140	8634	6.29	12.74
35	399	459	459	15.04	15.04	658	754	754	14.59	14.59
36	299	349	360	16.72	20.40	494	569	589	15.18	19.23
35-36	635	744	751	17.17	18.27	1048	1220	1230	16.41	17.37
37	171	204	202	19.30	18.13	281	331	328	17.79	16.73
35-37	709	810	816	14.25	15.09	1176	1330	1339	13.10	13.86
1-37	4989	5316	5634	6.55	12.93	7882	8360	8850	6.06	12.28
38	348	369	373	6.03	7.18	563	594	601	5.51	6.75
39	562	657	701	16.90	24.73	938	1076	1161	14.71	23.77
40	860	876	876	1.86	1.86	1366	1390	1391	1.76	1.86
39-40	1092	1188	1193	8.79	9.25	1750	1906	1925	8.91	10.00
41	265	270	274	1.89	3.40	415	421	429	1.44	3.37
39-41	1171	1252	1271	6.92	8.54	1877	2005	2034	6.82	8.36
1-41	5122	5436	5731	6.13	11.89	8063	8522	8975	5.69	11.31
42	335	354	362	5.67	8.06	435	563	574	29.42	31.95
1-42	4889	5179	5450	5.93	11.47	7677	8098	8522	5.48	11.01

TABLE 3C-15
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
COOPER RIVER BASIN, N.J.

Subareas (Inclusive)	10-Year Peak Flow					100-Year Peak Flow				
	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
1	126	135	139	7.14	10.32	332	346	353	4.22	6.33
2	181	214	221	18.23	22.10	438	485	495	10.73	13.01
1-2	198	227	234	14.65	18.18	494	518	528	4.86	6.88
3	218	232	237	6.42	8.72	534	551	559	3.18	4.68
1-3	412	447	459	8.50	11.41	1022	1062	1079	3.91	5.58
4	155	212	217	36.77	40.00	474	555	562	17.08	18.56
1-4	376	447	460	18.88	22.34	1217	1320	1339	8.46	10.02
5	111	158	167	42.34	50.45	335	402	412	20.00	22.99
1-5	434	531	546	22.35	25.81	1412	1557	1584	10.27	12.18
6	250	294	294	17.60	17.60	624	672	672	7.69	7.69
1-6	602	734	750	21.93	24.58	1730	1876	1899	8.44	9.77
7	173	188	196	8.67	13.29	428	442	453	3.27	5.84
1-7	706	872	893	23.51	26.49	1947	2124	2152	9.09	10.53
8	134	182	190	35.82	41.79	457	542	556	18.60	21.66
8-9	318	392	404	23.27	27.04	1036	1134	1151	9.46	11.10
9	230	269	274	16.95	19.13	685	748	749	9.19	9.34
8-10	393	458	470	16.54	19.59	1168	1246	1255	6.68	7.45
10	177	179	182	1.12	2.82	475	476	477	0.21	0.42
1-10	1089	1317	1350	20.94	23.97	3097	3345	3379	8.01	9.11
11	256	263	269	2.73	5.07	692	703	709	1.58	2.45
1-11	1179	1378	1410	16.88	19.59	3430	3677	3709	7.20	8.13
12	255	320	323	25.49	26.67	779	885	887	13.61	13.86
1-12	1363	1595	1630	17.02	19.59	4008	4296	4335	7.19	8.16
13	112	125	128	11.61	14.29	413	441	447	6.78	8.23
14	266	293	303	10.15	13.90	868	907	918	4.49	5.70
13-14	366	408	421	11.48	15.03	1201	1271	1288	5.83	7.24
15	217	234	247	7.83	13.82	644	652	684	1.24	6.21
13-15	454	506	528	11.45	16.30	1453	1500	1531	3.23	5.37
13-16	587	646	675	10.05	14.99	1877	1940	1992	3.36	6.13

TABLE 3C-15 (Cont'd)
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
COOPER RIVER BASIN, N.J.

Subareas (Inclusive)	10-Year Peak Flow					100-Year Peak Flow				
	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
17	155	170	171	9.67	10.32	450	470	471	4.44	4.66
13-17	656	715	741	8.99	12.96	1914	1973	2009	3.08	4.96
18	323	354	365	9.59	13.00	886	949	967	7.11	9.14
13-18	802	859	887	7.11	10.60	2094	2129	2155	1.67	2.91
19	282	293	300	3.90	6.38	743	755	762	1.61	2.55
1-19 1/	2186	2456	2517	12.35	15.14	6368	6751	6830	6.01	7.26
20	297	310	318	4.37	7.07	701	713	723	1.71	3.13
1-20	1530	1804	1862	17.91	21.70	6645	7068	7167	6.37	7.86
21	288	297	301	3.13	4.51	752	768	770	2.13	2.39
1-21	1566	1839	1900	17.43	21.33	6916	7366	7466	6.51	7.95
22	230	232	235	0.86	2.17	505	506	508	0.19	0.59
1-22	911	1022	1051	12.18	15.37	6504	6776	6875	4.18	5.70
23	349	351	354	0.57	1.43	798	799	800	0.13	0.25
1-23	912	1026	1055	12.50	15.68	6635	6910	7037	4.14	6.06
24	390	390	396	0.00	1.53	816	816	819	0.00	0.25
1-24	799	876	897	9.64	12.27	6358	6745	6874	6.09	8.12

1/ Discharges downstream of Subarea 19 are significantly affected by storage in Cooper River Lake formed by tidal dam.

TABLE 3C-16
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
MANTUA CREEK BASIN, N.J.

Subareas (Inclusive)		10-Year Peak Flow					100-Year Peak Flow				
		1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
1		185	198	198	7.03	7.03	654	687	687	5.04	5.04
2		246	263	263	6.91	6.91	790	819	819	3.67	3.67
1-2		424	449	449	5.90	5.90	1436	1485	1485	3.41	3.41
3		303	316	316	4.29	4.29	831	846	846	1.80	1.80
1-3		386	405	405	4.92	4.92	1137	1166	1166	2.55	2.55
4		241	261	261	8.30	8.30	793	830	830	4.66	4.66
5		276	318	318	15.22	15.22	950	1038	1038	8.35	8.35
1-5		817	896	896	9.67	9.67	2618	2762	2762	5.50	5.50
6		123	129	131	4.88	6.50	374	386	391	3.21	4.54
1-6		918	998	999	8.71	8.82	2953	3078	3082	4.23	4.37
7		128	135	135	5.47	5.47	406	418	418	2.95	2.95
1-7		1027	1100	1101	7.11	7.20	3309	3416	3421	3.23	3.38
8		519	559	559	7.71	7.71	1367	1407	1407	2.93	2.93
1-8		893	956	957	7.05	7.17	3000	3078	3081	2.60	2.70
9		301	318	318	5.65	5.65	911	934	934	2.52	2.52
1-9		1154	1231	1232	6.67	6.67	3835	3925	3928	2.35	2.42
10		356	375	375	5.34	5.34	1045	1070	1070	2.39	2.39
11		321	324	324	.93	.93	867	874	874	.81	.81
10-11	1/	674	696	696	3.26	3.26	1905	1938	1938	1.73	1.73
10-11	2/	599	620	620	3.50	3.50	1844	1852	1852	.43	.43
12		567	580	589	2.29	3.88	1809	1848	1850	2.15	2.27
10-12		897	916	924	2.12	3.01	2944	2979	2980	1.19	1.22
13		219	230	236	5.02	7.76	714	738	747	3.36	4.62
10-13		1016	1039	1052	2.26	3.54	3154	3178	3184	.76	.95
14		317	346	349	9.15	10.09	808	843	850	4.33	5.20
1-14		2327	2457	2469	5.59	6.10	7450	7633	7640	2.46	2.55
15		275	290	300	5.45	9.09	809	831	846	2.72	4.57
1-15		2412	2544	2555	5.47	5.93	7762	7940	7940	2.29	2.29
16		195	225	236	15.38	21.02	713	783	807	9.82	13.18
1-16		2436	2572	2587	5.58	6.19	7775	7916	7920	1.81	1.86

TABLE 3C-16 (Cont'd)
URBANIZATION ANALYSIS
COMPARISON OF CUMULATIVE EFFECTS
MANTUA CREEK BASIN, N.J.

Subareas (Inclusive)	10-Year Peak Flow					100-Year Peak Flow				
	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000	1970 Peak Flow	Year 2000 Peak Flow	Max 2000 Peak Flow	% Change 1970 to Year 2000	% Change 1970 to Max 2000
17	183	195	202	6.56	10.38	619	647	662	4.52	6.95
18	291	312	317	7.22	8.93	1020	1071	1087	5.00	6.57
17-18	407	417	422	2.46	3.68	1219	1242	1258	1.89	3.20
19	175	184	189	5.14	8.00	597	618	626	3.52	4.86
17-19	579	598	608	3.28	5.01	1810	1855	1878	2.49	3.76
20	402	429	447	6.72	11.19	1272	1319	1337	3.69	5.11
17-20	838	897	927	7.04	10.62	2865	2968	3006	3.59	4.92
21	250	255	276	2.00	10.40	826	840	876	1.69	6.05
17-21	870	918	946	5.52	8.73	2746	2819	2839	2.66	3.39
22	197	240	251	21.83	27.41	705	800	820	13.47	16.31
1-22	3268	3441	3482	5.29	6.55	10558	10772	10796	2.03	2.25
23	609	640	665	5.09	9.19	2057	2127	2148	3.40	4.42
1-23	3469	3662	3715	5.56	7.09	10748	10943	10958	1.81	1.95

1/ Discharges are for upstream Alcyon Lake Dam.
2/ Discharges are for downstream Alycon Lake Dam.

SECTION D

PHYSICAL CONDITIONS

SECTION D

PHYSICAL CONDITIONS

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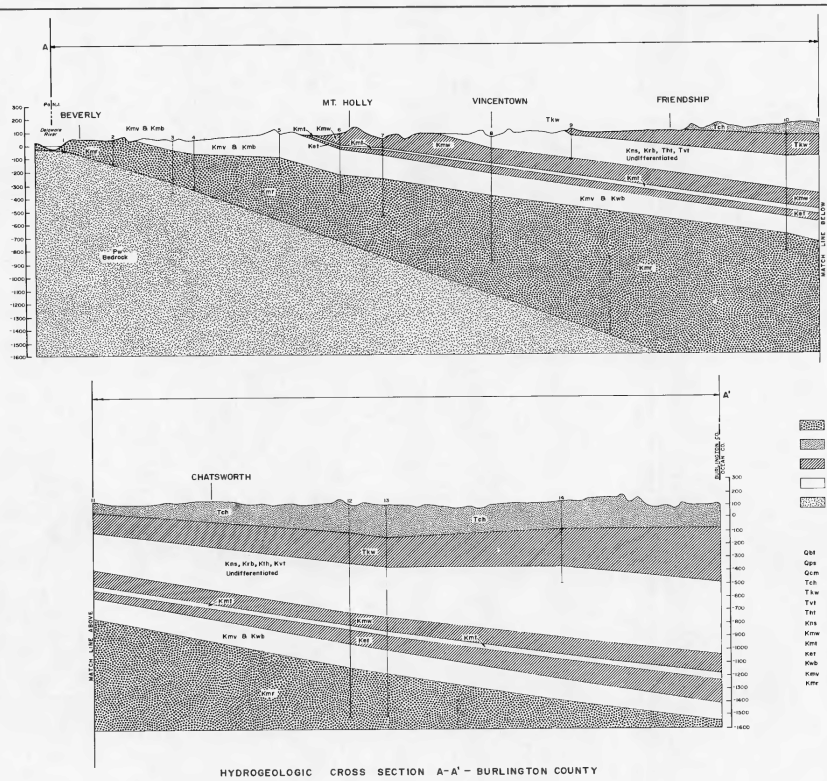
SECTION D

PHYSICAL CONDITIONS

GENERAL

Almost all of the water supplied in the study area comes from wells drilled into one of the four major aquifers in the geologic network. They are the Raritan-Magothy, Englishtown, Mt. Laurel-Wenonah, and Kirkwood-Cohansey formations. Aquifers which contribute a minor percentage of the total water supply are the Cape May, Wissahickon, Merchantville, Navesink, Vincetown and Hornerstown systems. These formations act for the most part as confining layers to the principal aquifers. Other confining layers are the Red Bank, Manasquan, Marshalltown and Woodbury formations. The following paragraphs provide a description of the geologic characteristics of the major aquifers. A description of their water yield characteristics appears in Section E. Figures 3D-1 and 3D-2 show a cross-sectional view of the aquifer system. Figures 3D-3 through 3D-6 show the outcrop areas of this system.



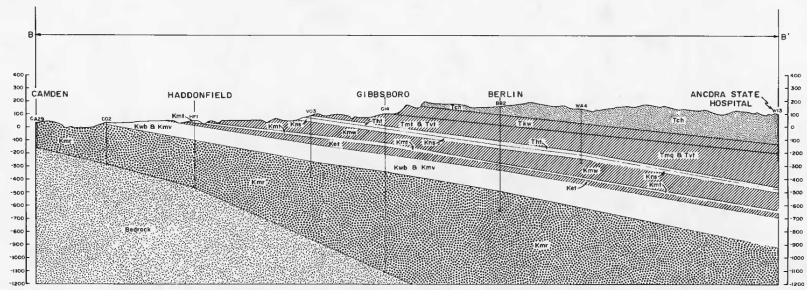
CROSS SECTION LOCATION

HYDROGEOLOGIC CROSS SECTION A-A' - BURLINGTON COUNTY

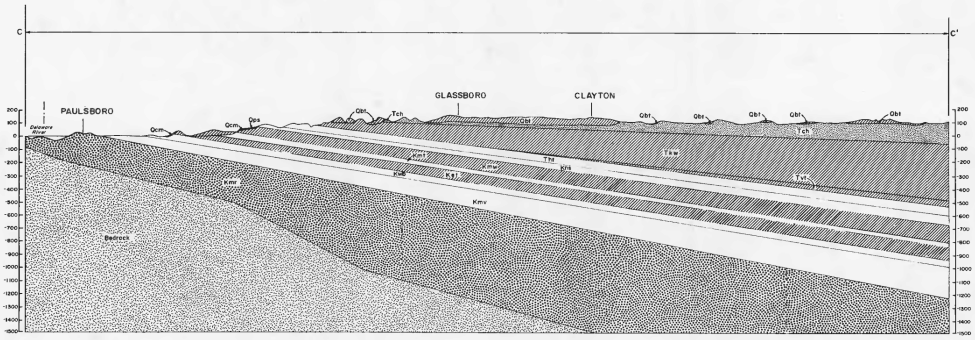
SCALE IN MILES
0 1 2

CAMDEN METRO STUDY
HYDROGEOLOGIC CROSS SECTIONS
BURLINGTON COUNTY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-1



HYDROGEOLOGIC CROSS SECTION B-B'- CAMDEN COUNTY



HYDROGEOLOGIC CROSS SECTION C-C'- GLOUCESTER COUNTY

CROSS SECTION LOCATION

LEGEND OF SECTIONS

Tch	Cohansey Sand and Younger Sediments
Tkw	Kirkwood Formation
Tmq & Tvt	Manasquan and Vincentown Formations Undifferentiated
Thf	Hornerstown Sand
Kns	Navesink Formation
Kmw	Mt Laurel Sand and Wenonah Formation
Kmt	Marshalltown Formation
Ket	Englishtown Formation
Kwb & Kmv	Woodbury Clay and Merchantville Formation
Kmr	Magothy - Raritan Formations and Potomac Group

LEGEND OF SECTIONS

Qbf	Bridgeton Formation
Qps	Pennsauken Formation
Qcm	Cape May Formation
Tch	Cohansey Sand
Tkw	Kirkwood Formation
Tvt	Vincentown Formation
Thf	Hornerstown Sand
Kns	Navesink Formation
Kmw	Mount Laurel Sand & Wenonah Formation
Kmt	Marshalltown Formation
Ket	Englishtown Formation
Kwb	Woodbury Clay
Kmv	Merchantville Formation
Kmr	Magothy - Raritan Formation

Aquifer where wells yield up to 1,400 GPM

Aquifer where wells yield up to 800 GPM

Aquifer where wells yield up to 200 GPM

Confining Bed

Bedrock

SCALE IN MILES

0 1 2

CAMDEN METRO STUDY

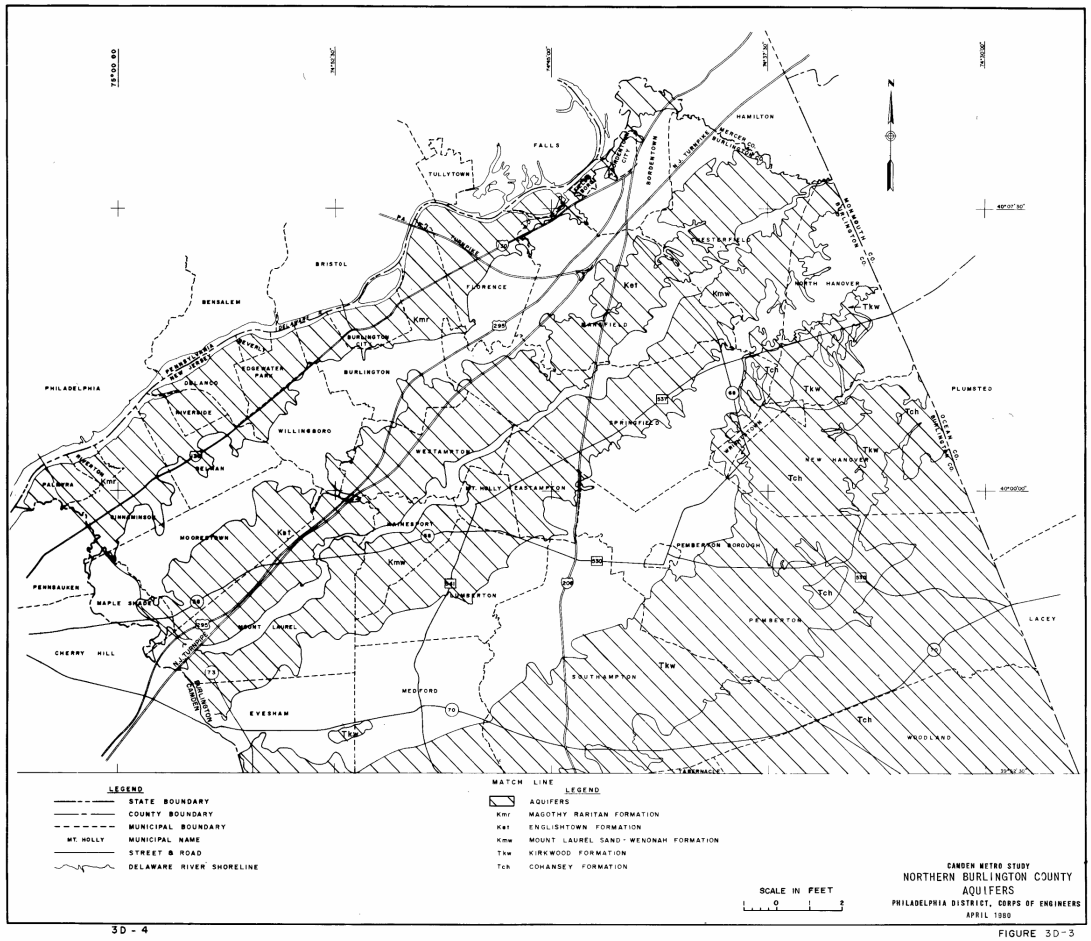
HYDROGEOLOGIC CROSS SECTIONS

CAMDEN & GLOUCESTER COUNTIES

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3D-2



CAMDEN METRO STUDY
NORTHERN BURLINGTON COUNTY
AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-3

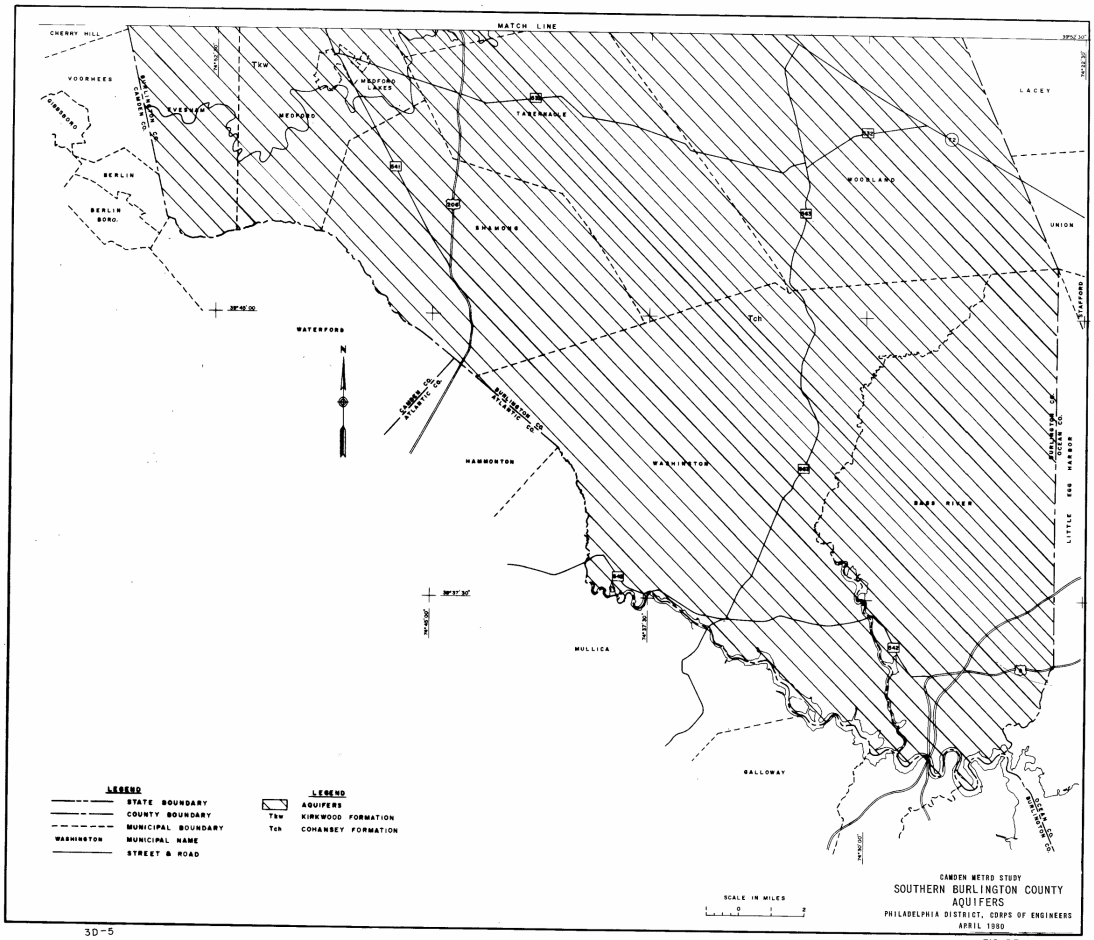
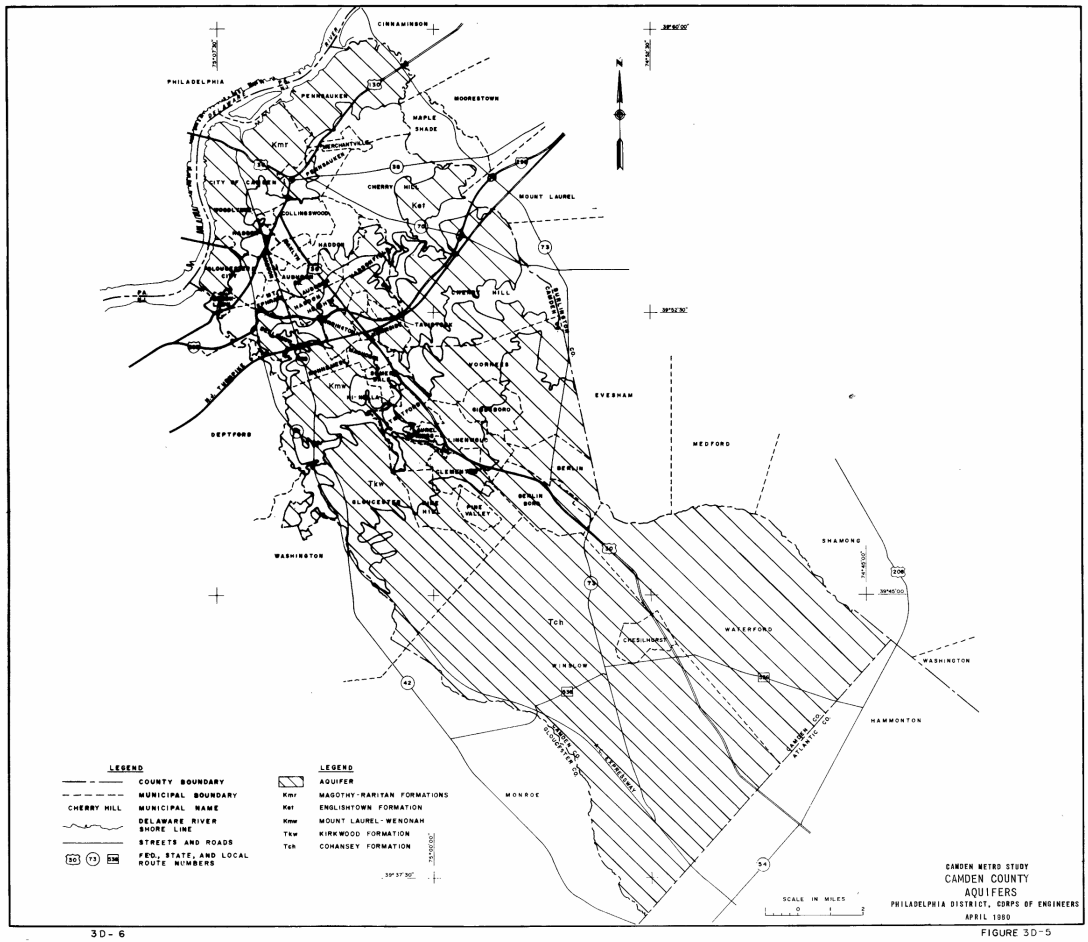

MATCH LINE
CHERRY HILL
VOORHEES
TKW
MEDFORD LAKES
MEDFORD
EVESHAM
TABERNACLE
LACEY
WOODLAND
UNION
BERLIN
BERLIN BORO.
SHAMONG
WATERFORD
TCH
STAFFORD
HAMMONTON
WASHINGTON
BASS RIVER
LITTLE EGG HARBOR
MULLICA
GALLOWAY
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
WASHINGTON MUNICIPAL NAME
STREET & ROAD
LEGEND
AQUIFERS
Tkw KIRKWOOD FORMATION
Tch COHANSEY FORMATION
SCALE IN MILES
0
2
CAMDEN METRO STUDY
SOUTHERN BURLINGTON COUNTY
AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-4



CAMDEN METRO STUDY
CAMDEN COUNTY
AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-5

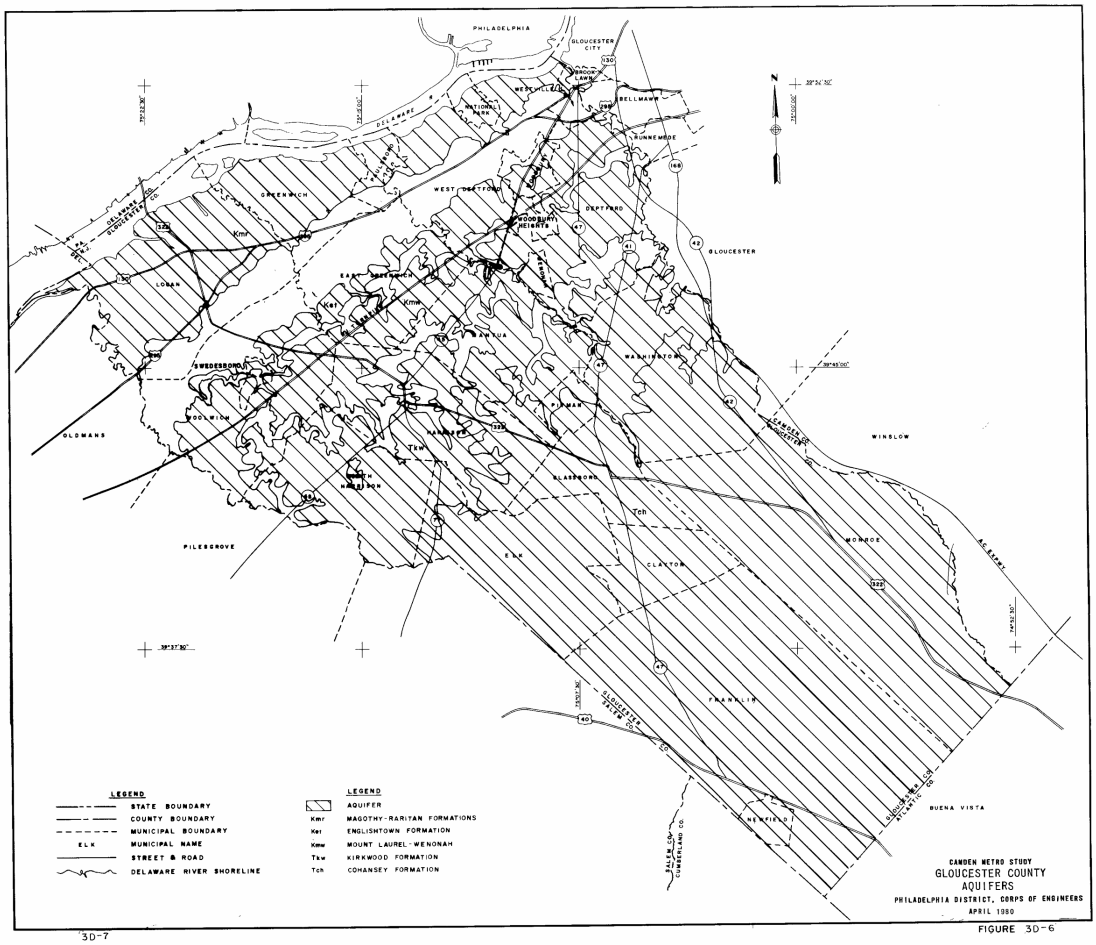

PHILADELPHIA
GLOUCESTER CITY
BROOKLAWN
BELLMAWR
RUNNEMEDE
WESTVILLE
NATIONAL PARK
DELAWARE
GREENWICH
WEST DEPTFORD
DEPTFORD
WOODBURY HEIGHTS
GLOUCESTER
LOGAN
EAST GREENWICH
SWEDESBORO
WOODBURY
WASHINGTON
OLDMANS
HARRISON
WINSLOW
GLASSBORO
PILESGROVE
ELK
CLAYTON
MONROE
FRANKLIN
MULLICA HILL
BUENA VISTA
NEWFIELD
SALEM CO.
CUMBERLAND CO.
GLOUCESTER CO.
ATLANTIC CO.
CAMDEN CO.
Kmw
Ker
Tkw
Tch
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
ELK MUNICIPAL NAME
STREET & ROAD
DELAWARE RIVER SHORELINE
LEGEND
AQUIFER
Kmw MAGOTHY-RARITAN FORMATIONS
Ker ENGLISHTOWN FORMATION
Kmw MOUNT LAUREL-WENONAH
Tkw KIRKWOOD FORMATION
Tch COHANSEY FORMATION
CAMDEN METRO STUDY
GLOUCESTER COUNTY
AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-6

RARITAN–MAGOTHY FORMATION

The most important geologic unit in the study area is the Raritan-Magothy Formation. This unit is the major hydrologic unit of the study area. Although they are two distinct geologic formations, the Raritan and Magothy are often considered as one formation due to their similar hydrologic characteristics. They are the two oldest and lowermost formations and were deposited in a non-marine environment differentiating them from the younger sediments in the tri-county area. The Raritan and Magothy beds outcrop along the Delaware River extending northward into Raritan Bay and southward into New Castle County, Delaware. The upper surface of the Raritan-Magothy aquifer dips about 40 feet per mile. The lower surface which lies on top of bedrock, the Wissahickon Formation, dips about 90 feet per mile. The thickness of the formation reaches a maximum of 500 feet in Gloucester County, 850 feet in Camden County and 2000 feet in Burlington County.

The Raritan and Magothy are composed of light-colored sand, silt clay and some gravel. Clay beds are typical with lignite and pyrite beds often present. In the outcrop area the formation is normally separated into an upper unit of Magothy sands and a middle and lower unit of Raritan sands. The upper unit averages 140 feet in thickness and is hydraulically

connected with overlying deposits. Phreatic conditions occur in the outcrop of the formation. In addition, artesian conditions occur in the lower units of the aquifer's outcrop area. Artesian conditions also occur in areas where the Raritan-Magothy is overlain by other geological formations. The phreatic and artesian conditions are interspersed with clay beds, but interconnections occur frequently. Differentiation of the two aquifer zones ceases southeast of the outcrop area and the sands combine.

Since much of the outcrop of the Raritan-Magothy is densely populated and industrialized, it is the most heavily pumped aquifer in the study area. The Raritan-Magothy aquifer has exceptional yield capabilities. Wells have yielded up to 1,400 gallons per minute (gpm). One index of an aquifer's yield potential, specific capacity, is the rate of yield which is sustained when the head (or pressure expressed as the height artesian water would rise in a well) is drawn down by one foot. The average specific capacity of the Raritan-Magothy aquifer is 20 gpm for one foot of drawdown.

The quality of water from the Raritan-Magothy aquifer system is generally good except for iron and maganese, two substances frequently encountered in concentrations above potable water standards set by NJDEP and the U.S. Public Health Service. Total iron concentrations, limited in the standards to 0.3 milligrams per liter (mg/l), exceed 5 mg/l in areas of high

population density and pumpage near the outcrop zone. Similarly, sodium, magnesium, chloride, sulfate and nitrate are commonly twice the concentration in the outcrop zone than in downdip areas. This is a reflection of general contamination. The concentration of total dissolved solids in downdip areas is less than 150 mg/l, sufficient to affect taste and create hardness problems during washing and cooking. Hardness appears to be from two sources. Around Camden City, groundwater seems to be affected by infiltration of contamination from the surface and from infiltration of Delaware River water. In southern Gloucester County there is a saltwater/freshwater boundary which was apparently established at the time the sediments were deposited. More detailed water quality data, along with recommendations for improving the quality level, is available through the Section 208 Wastewater Management Study.

ENGLISHTOWN FORMATION

The Englishtown Formation outcrops in an irregular belt southeast of the Raritan-Magothy, and is separated from the latter by the Merchantville Formation and the Woodbury Clay confining beds. This formation, which is almost absent in southern portions of the study area, has its maximum thickness--120 feet--in southern Camden County. In the outcrop area, the formation is characteristically composed of

fine-grained quartz sand and, on the average, the usable water-bearing aquifer zones range in thickness up to about 60 feet. In some areas clay beds are interspersed with the sand formations and prohibit productive drilling of the aquifer. Outside of the outcrop area the formation acts as an artesian system which is confined by the overlaying Marshalltown Formation.

The Englishtown Formation, a minor aquifer in terms of total supply capability, is important locally. Relatively few domestic wells tap this aquifer and these are mostly shallow wells (ranging in depth from 50 feet to 150 feet) located in a narrow band two miles to four miles from the outcrop area. Several water supply systems tap the formation including two wells of the Clementon Water Department in Camden County and those at Fort Dix and Marlton in Burlington County. Total pumpage in 1976 was estimated at 4.3 million gallons per day (mgd). Although there are too few wells available to give good yield data, one of the Clementon wells is reported to yield 500 gpm, a substantial pumpage rate.

The Englishtown Formation is capped by the Marshalltown Formation, a thick bed of sandy clay which becomes increasingly sandy and permeable downdip. If the Englishtown were more heavily pumped, substantial leakage would occur through this confining layer. Data collected from a few wells in the outcrop zone indicate that water quality is good except for high iron

concentrations. The water is soft to moderately hard, with measured dissolved solids concentrated ranging from 45 to 233 mg/l. The hardness is apparently due to calcium and magnesium derived from vertical leakage from overlying recharge areas.

MOUNT LAUREL-WENONAH FORMATION

The Mount Laurel and Wenonah formations are hydraulically connected and function as a single aquifer. The formations outcrop in a variable belt southeast of the Marshalltown Formation which serves as the chief confining layer between the Englishtown and Mount Laurel-Wenonah aquifers. The 100-square-mile outcrop zone parallels the Delaware River, varying from one-half to three miles in width. The Wenonah is slightly clayish sand with thin local beds of silt and clay, and the Mount Laurel is characterized by localized cementation by iron oxides. Shell fragments intermixed in the unit indicate that the aquifer is primarily of marine origin. Its thickness ranges up to 100 feet and is fairly consistent throughout.

Above the Mount Laurel-Wenonah Formation lies a series of five formations which serve as confining layers. These formations are the Navesink, Red Bank, Hornerstown, Vincentown and Manasquan. They are mostly clayish sands. Each formation is generally less than 50 feet thick and together they provide about 200 feet of separation between Mount Laurel-Wenonah and

the overlying Kirkwood-Cohansey units.

Mount Laurel-Wenonah is of considerable importance as a water supply. However, in contrast to the highly permeable Raritan-Magothy, this aquifer is only moderately permeable. The specific capacity is from 5.0 gpm to 6.0 gpm of yield for one foot head drawdown, less than a third the specific capacity of the Raritan-Magothy. Yields up to 500 gpm are obtained from public well systems in Camden and Gloucester counties. These yields are sufficient for most public or industrial uses. Utilization of this aquifer is highest in Burlington County, where an estimated 8.1 million gallons of a total 11.6 million gallons withdrawn is supplied by the Mount Laurel-Wenonah.

Water from the Mount Laurel-Wenonah aquifer is generally of good chemical quality except for high concentrations of iron and moderately high hardness. The high iron concentrations are associated with water in or near the outcrop area. The hard or mineralized water is common where heavy pumpages induce vertical leakage from overlying confining layers. A shallow well in the outcrop area showed high chloride and nitrate concentrations.

KIRKWOOD-COHANSEY FORMATION

The Cohansey Formation is the second most important aquifer in the region since it has only undergone minimal development and is unconfined. Recharge into the Cohansey comes directly

from runoff and rainfall on its permeable surface.

The Cohansey crops out in the southern half of Burlington County and eastern Camden and Gloucester counties, underlying a total of about 655 square miles. Although overlain in places by recent deposits, the Bridgeton and Cape May formations, the Cohansey is a water-table aquifer. The upper third of the formation is composed of sandy silt while the lower two-thirds consists of thick gravelly quartz sand beds and thinner silt beds. Thickness of the Cohansey Formation varies up to 250 feet depending on local topography and in its outcrop area decreases to a fine layer. Drawdown under confined conditions is extreme when compared to artesian aquifers.

Although they are two distinct formations, the Cohansey Formation is often grouped with the Kirkwood Formation and they are known as the Kirkwood-Cohansey Formation. The Kirkwood is not a notably good aquifer and is not significantly utilized. Since the Kirkwood Formation has a comparatively low-yield, wells within reach of the the Kirkwood often tap the high-yielding Cohansey. Only a few domestic wells, drawing an estimated 100 gpm, are fed by the Kirkwood Formation, and most of these wells are located in the outcrop zone. Even in the outcrop zone, the formation has such low yields that, in some locations, wells must often be drilled into the deeper Mount Laurel-Wenonah Formation.

The Cohansey is a water-table aquifer supplying about 22.6 mgd. Since development pressures have not yet reached this area, only two mgd are supplied to public industrial systems. However, the aquifer could sustain 700 gpm to 1,000 gpm pumpage by large users.

The few water samples available show that water quality in the Kirkwood-Cohansey Formation, except for high iron concentrations, is currently good-to-excellent. Hardness is low (less than 30 mg/l) and dissolved solids at less than 140 mg/l, are well within recommended levels. Exposed at the surface or overlain by relatively thin, permeable sediments, the Cohansey is vulnerable to pollution from man's activities.

EXISTING WELLS

In order to assist local concerns, a list of wells in use in the study area has been compiled. The wells and aquifers have been located in a large-scale mapping procedure. The primary source of this information was the United States Geological Survey's (USGS) well records which were developed in coordination with New Jersey's Department of Environmental Protection (NJDEP). The records consist of individual well descriptions and pumpage data up to and including the year 1973 for all wells in the study area. Verification included contacting NJDEP and auditing its files to determine if any discrepancies existed in the information.

In some instances, individual purveyors were contacted in order to further evaluate the reliability of the information. The records, indexed by county, are available in the District Office.

The original information collected was supplemented with the locations of additional wells installed between 1973 and 1976. The identification of wells is limited to those wells requiring a diversion grant from the state, that is, wells which can exceed 100,000 gallons per day withdrawal, and those wells of similar size which predate the state reporting system.

Lists of all mapped wells are included in Tables 3D-1 through 3D-17. These contain pertinent information about the well including owner, local name and location given in latitude and longitude.

Mapping of well locations was divided into three map sets. The first set of maps shows well locations and, consequently, use of the Raritan-Magothy aquifer. The Raritan-Magothy accounts for over 80 per cent of the total groundwater withdrawal. Analysis of the water supply potential of the area therefore concentrated on the development and increased use of wells in that aquifer. Figures 3D-7 through 3D-10 display these wells.

The second set of maps shows well locations in aquifers other than the Raritan-Magothy. These include the Englishtown, Mt. Laurel-Wenonah and Kirkwood-Cohansey. For the purpose of

TABLE 3D-1
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03- 38	03- 38	40	4	4	74	55	20	DELA VALLEY W C	DVWC 15
	03- 37	40	04	05	74	55	17	DELA VALLEY WC	DVWC 16
03- 40	03- 40	40	9	9	74	42	28	OCEAN SPRAY INC	OCEAN 1
	03- 39	40	09	19	74	42	11	JRSYMAID DAIRY	2-OCEAN SPRAY
03- 41	03- 41	40	08	46	74	42	12	BORDENTOWN WD	GILDER FIELD
03- 50	03- 50	40	5	37	74	50	40	BURLINGTON C WD	BCWD 8
	03- 47	40	05	41	74	50	43	BURLINGTON C WD	BCWD 4
	03- 48	40	05	40	74	50	48	BURLINGTON C WD	BCWD3 52
	03- 49	40	05	38	74	50	53	BURLINGTON C WD	BCWD 2
	03- 52	40	05	36	74	50	51	BURLINGTON C WD	BCWD1 52
	03- 53	40	05	35	74	50	45	BURLINGTON C WD	BCWD 5
	03- 54	40	05	34	74	50	50	BURLINGTON C WD	BCWD 6
	03- 55	40	05	32	74	50	43	BURLINGTON C WD	BCWD 7
	03- 57	40	04	55	74	51	21	BURLINGTON C WD	BCWD1 43
	03- 58	40	04	53	74	51	21	BURLINGTON C WD	BCWD3 49
03- 56	03- 56	40	5	14	74	50	20	US PIPE	US PIPE 1
03- 60	03- 60	40	6	32	74	49	4	NAT GYPSUM CO	1
	03- 59	40	04	12	74	51	57	INDUSTRIAL VAL	INDUST 1
	~~03- 61~~	~~40~~	~~06~~	~~32~~	~~74~~	~~49~~	~~04~~	~~NATIONAL GYPSUM~~	~~NAT GYP2~~
	03- 62	40	06	32	74	49	04	NATIONAL GYPSUM	NAT GYP3
03- 64	03- 64	40	06	17	74	49	20	HOOKER CHEM CO	HOOKER 2-R
	03- 65	40	06	12	74	48	53	HOOKER CHEM CO	PROD-1
03- 72	03- 72	40	5	24	74	49	51	HERCULES POWDER	HERCULES 1
	03- 70	40	5	35	74	49	41	HERCULES POWDER	HERCULES 2
	03- 71	40	5	25	74	49	38	HERCULES POWDER	HERCULES 3
	03-648	40	05	25	74	49	53	HERCULES POWDER	
03- 74	03- 74	40	05	20	74	48	33	DONALD,WILLIAM	DONALD
03- 83	03- 83	40	4	4	74	53	1	TENNECO PLASTIC	TENNECO 5
	03- 73	40	05	22	74	52	47	TENNECO PLASTIC	TENNECO2
	03- 75	40	4	21	74	52	57	TENNECO PLASTIC	TENNECO 3
	03- 76	40	4	18	74	53	11	TENNECO PLASTIC	TENNECO 6
	03- 77	40	4	18	74	52	57	TENNECO PLASTIC	TENNECO 1
	03- 78	40	4	18	74	52	50	TENNECO PLASTIC	TENNECO 4
	03- 80	40	4	9	74	52	47	TENNECO PLASTIC	TENNECO 6 1971
03- 85	03- 85	40	3	42	74	49	48	MASONIC HOME	MASONIC 1
	03- 86	40	03	40	74	49	42	MASONIC HOME	MASONIC2
03- 87	03- 87	40	3	38	74	52	45	MURPHY, CAROL	FOX HILL FARM
03- 89	03- 89	40	3	31	74	53	16	HEISLER, ALBERT	

TABLE 3D-1 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	03- 88	40	3	31	74	53	17	HEISLER,EDGAR B	HEISLER 1
03- 91	03- 91	40	3	24	74	51	52	HEAL,CHARLES JR	HEAL
03- 92	03- 92	40	3	20	74	49	38	KELLER, EARL R	ERK 1
03- 97	03- 97	40	03	13	74	50	04	BURLINGTON TWP	3-1974
03- 99	03- 99	40	2	54	74	52	47	CANNULI,ANTHONY	
	03- 98	40	3	1	74	52	42	PINO, FRANK	
03-105	03-105	40	9	34	74	40	19	NJS REFORMATORY	NJSR 4
	03-106	40	09	34	74	40	19	NJS REFORMATORY	NJSR 5
03-111	03-111	40	7	3	74	38	32	CHESTRFD SCHOOL	1
03-122	03-122	40	0	50	74	58	49	AIR REDUCTION	AIRCO 1
	03-120	40	0	55	74	58	45	HOEGANAES IRON	HOEGANAES
03-123	03-123	40	0	12	75	0	13	RIVERTON CLUB	COUNTRY CLUB
03-125	03-125	40	0	2	75	0	44	DELA VALLEY W C	DVWC 27
	03-124	40	0	2	75	0	44	DELA VALLEY W C	RIVERTON 13
03-126	03-126	39	59	45	75	0	11	RIVERTON CLUB	COUNTRY CLUB 2
03-128	03-128	39	59	38	74	58	10	DELA VALLEY W C	DVWC 26
	03-127	39	59	38	74	58	10	DELA VALLEY W C	RIVERTON 14
03-129	03-129	39	59	29	74	59	22	DELA VALLEY W C	DVWC 12-POMONA
	03-130	39	59	29	74	59	22	DELA VALLEY WC	DVWC 10
03-132	03-132	39	59	4	75	0	9	DELA VALLEY W C	DVWC 28
	03-131	39	59	6	75	0	6	DELA VALLEY W C	STEPHENS OR
03-134	03-134	40	2	41	74	55	46	CHANT, HARRY R	CHANT 1
03-136	03-136	40	2	7	74	58	31	AMICO SAND	AMICO
03-139	03-139	40	1	26	74	56	47	DELA VALLEY W C	FAIRVIEW ST
03-140	03-140	40	1	22	74	58	7	DELA VALLEY W C	DVWC 19
03-141	03-141	40	1	9	74	57	10	HOLY CROSS H S	HIGH SCHOOL
03-142	03-142	40	1	5	74	57	34	DELA VALLEY W C	DVWC 23
	03-143	40	01	05	74	57	34	DELA VALLEY WC	DVWC 24
	03-144	40	00	55	74	57	32	MILLSIDE FARMS	3
03-150	03-150	40	3	18	74	54	38	DELA VALLEY W C	DVWC 32

TABLE 3D-1 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	WELL OWNER	WELL NAME
03-151	03-151	40	3	15	74	54	8	DELA VALLEY W C	DVWC 22
03-152	03-152	40	3	10	74	53	17	DELA VALLEY W C	DVWC 21
03-153	03-153	40	3	9	74	54	32	HEAL, JOHN W	
03-155	03-155	40	2	49	74	54	18	JAMAH CORP	CAR WASH 1
	03-154	40	02	52	74	54	22	BLYLER,EARL R	
03-156	03-156	40	2	8	74	54	34	CRAMP, MARTIN C	CRAMP 1
03-159	03-159	39	54	30	74	57	6	EVESHAM M U A	EMUA 3
	03-160	39	54	12	74	56	18	ROBERTS,BYRON T	ROBERTS 2
03-162	03-162	39	53	44	74	55	3	EVESHAM M U A	EMUA 2
03-163	03-163	39	53	36	74	54	40	EVESHAM M U A	EMUA 1
03-167	03-167	39	52	46	74	53	26	INDIAN SPNG G C	ISGC 1
	03-166	39	52	47	74	51	57	EVESHAM TMUA	5-1973
03-169	03-169	39	52	33	74	54	18	EVESHAM M U A	EMUA 4
	03-170	40	08	15	74	44	15	STEPAN CHEM	2
03-176	03-176	40	7	3	74	48	32	FLORENCE TWP WD	FTWD 4
	03-173	40	07	12	74	48	42	FLORENCE TWP WD	FTWD 4
	03-174	40	07	07	74	48	45	FLORENCE TWP WD	FTWD 2
	03-175	40	07	04	74	48	38	FLORENCE TWP WD	FTWD 3
03-179	03-179	40	6	6	74	47	34	HUNT BROTHERS	CIRCUS
03-182	03-182	40	5	46	74	48	39	GRIFFIN PIPE CO	GRIFFIN B
	03-181	40	5	50	74	48	55	GRIFFIN PIPE CO	GRIFFIN A
03-183	03-183	40	5	32	74	48	33	WORKMAN, JAMES	WORKMAN 1
03-184	03-184	40	5	9	74	48	22	D-J CANNULI	CANNULI
03-188	03-188	39	57	50	74	51	07	FRED WORTH & SN	WORTH
03-191	03-191	39	58	30	74	48	3	MCGRAWEDISON CO	TEST 1
03-197	03-197	39	57	20	74	48	22	LUMBERTON L W S	LLWS 2
	03-195	39	57	21	74	48	21	LUMBERTON L W S	LLWS 1
03-205	03-205	40	6	32	74	42	34	INDUSTRIAL PARK	TURNPIKE JCTN
03-210	03-210	40	5	15	74	41	9	SCHOOL DISTRICT	N BURL CO HIGH
03-213	03-213	40	4	12	74	43	23	COLUMBUS W C	CWC 2

TABLE 3D-1 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	03-675	40	04	12	74	43	23	COLUMBUS WC	COLUMBUS 3-69
03-222	03-222	39	56	28	74	58	34	MAPLE SHADE W D	MSWD 7
	03-220	39	56	28	74	58	34	MAPLE SHADE WD	MSWD 1
	03-221	39	56	28	74	58	34	MAPLE SHADE WD	MSWD 6
03-235	03-235	39	55	9	74	51	2	JOHNSON, W E JR	JOHNSON NEW
	03-234	39	55	9	74	51	2	JOHNSON, W E JR	JOHNSON
03-237	03-237	39	54	30	74	48	50	MEDFORD LEAS	1-1972
03-238	03-238	39	54	13	74	49	22	MEDFORD W C	MWC 3
03-239	03-239	39	53	16	74	49	46	MEDFORD W C	MWC 4(1968)
03-241	03-241	39	52	9	74	50	43	LAKES W C	LWC 3
03-252	03-252	39	59	36	74	54	54	MOORESTOWN T WD	MTWD 4
	03-253	39	59	36	74	54	46	MOORESTOWN TWP	SUPPLY 8
03-257	03-257	39	58	55	74	54	48	RCA	BLDG 117
03-263	03-263	39	58	35	74	56	43	MOORESTOWN F C	FIELD CLUB 1
03-264	03-264	39	58	34	74	59	10	MOORESTOWN T WD	7-1969
	03-262	39	58	38	74	59	5	CAMPBELL SOUP	CAMPBELL 1
03-267	03-267	39	57	53	74	58	28	PITTS GLASS CO	PPG 1
03-272	03-272	39	57	2	74	58	7	MOORESTOWN T WD	MTWD 3
	03-269	39	57	04	74	58	18	MOORESTOWN T WD	1 1923
	03-270	39	57	02	74	58	07	MOORESTOWN T WD	MTWD 5
	03-271	39	57	02	74	58	07	MOORESTOWN T WD	MTWD 6
03-281	03-281	39	59	17	74	47	5	MOUNT HOLLY W C	MHWC 4
	03-276	39	59	36	74	46	55	MOUNT HOLLY WC	MHWC 6
	03-277	39	59	35	74	46	51	MOUNT HOLLY W C	MHWC 3
	03-278	39	59	33	74	46	52	MOUNT HOLLY WC	MHWC1 25
	03-280	39	59	28	74	46	59	MOUNT HOLLY W C	MHWC 2
03-283	03-283	39	59	23	74	51	33	RANCOCAS WDS WC	RWWC 1
	03-282	39	59	23	74	51	33	RANCOCAS WDS WC	RWWC 2
03-287	03-287	39	58	50	74	53	18	NJ TURNPIKE AU	4N-1
	03-288	39	58	50	74	53	18	NJ TURNPIKE AU	4N-2
03-289	03-289	39	57	28	74	55	4	NJ TURNPIKE AU	MAINT 2
03-292	03-292	39	58	44	74	52	41	LARCHMONT FARMS	C W HAINES 1
	03-291	39	58	45	74	52	40	HAINES, WM JR	FARM WELL 1

TABLE 3D-1 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03-293	03-293	39	58	30	74	53	2	HAINES, WM JR	FARM WELL 2
03-304	03-304	39	56	7	74	56	43	MT LAUREL MUA	MLWC 1
	03-303	39	56	08	74	56	44	MT LAUREL MUA	MLWC 2
03-306	03-306	39	55	53	74	57	36	FELOWSHIP MOTOR	HOLIDAY INN
03-308	03-308	39	55	52	74	57	3	NJ TRNPKE AUTH	INTERCHANGE 4
03-311	03-311	39	55	25	74	54	16	RUDDEROW, J E	SPRING VALLEY
03-316	03-316	40	2	16	74	36	7	US AIR FORCE	MCGUIRE A
03-317	03-317	40	1	50	74	34	28	US AIR FORCE	MCGUIRE C
03-318	03-318	40	1	41	74	35	25	US AIR FORCE	MCGUIRE D
03-319	03-319	40	1	38	74	37	53	US ARMY FT DIX	FORT DIX 3
03-320	03-320	40	1	29	74	36	56	US ARMY FT DIX	FORT DIX 2
03-321	03-321	40	1	6	74	37	20	US ARMY FT DIX	FORT DIX 5
03-322	03-322	40	0	34	74	36	21	US ARMY FT DIX	FORT DIX 1
03-323	03-323	39	59	49	74	36	55	US ARMY FT DIX	FORT DIX 4
03-331	03-331	40	05	46	74	34	46	LAROCHE	1974
03-335	03-335	40	3	0	74	35	17	US AIR FORCE	MCGUIRE B
03-347	03-347	39	58	39	74	42	49	PERMUTIT CORP	IONAC CHEM 2
	03-348	39	58	39	74	42	49	PERMUTIT CORP	I CHEM 3
03-362	03-362	39	57	55	74	32	39	PEMPERTON TWPWD	6-1972
	03-363	39	57	55	74	33	29	PEMPERTON TWPWD	7-1972
03-381	03-381	40	2	10	74	56	58	DELA VALLEY W C	DVWC 29
	03-380	40	2	10	74	56	58	DELA VALLEY W C	DVWC 17
03-382	03-382	40	2	9	74	57	40	FLORENCE THREAD	FTC 39
	03-379	40	2	12	74	57	47	RIVERSIDE INDUS	CENTER 2
03-385	03-385	40	1	32	74	57	42	GOODRICH RUBBER	BFG 3
	03-384	40	01	37	74	57	38	GOODRICH RUBBER	BFG 2
03-413	03-413	40	3	28	74	46	36	INTERSTATE S-P	INTERSTATE 1
03-580	03-580	40	1	57	74	48	20	BC COUNTRY CLUB	CLUB 1

TABLE 3D-1 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03-583	03-583	40	01	22	74	51	41	CAMPBELL SOUP	RANCOCAS 1
03-585	03-585	40	0	41	74	50	49	INDUCTOTHERM	INDUCT 1
03-586	03-586	40	0	41	74	48	9	MOUNT HOLLY W C	MHWC 5
03-589	03-589	40	3	20	74	53	20	LEVITT AND SONS	LEVITTMARK
03-590	03-590	40	3	8	74	53	41	LEVITT AND SONS	GARDEN PLAZA 1
03-592	03-592	40	2	50	74	53	21	WILLINGBORO MUA	WMUA 5
03-598	03-598	40	2	25	74	54	2	WILLINGBORO MUA	WMUA 1
	03-597	40	02	27	74	54	14	WILLINGBORO MUA	
03-603	03-603	40	1	55	74	53	8	WILLINGBORO MUA	WMUA 2 (DCB23)
	03-601	40	1	58	74	53	7	WILLINGBORO MUA	WMUA 7
03-606	03-606	40	1	52	74	54	35	WILLINGBORO MUA	WMUA 4
03-608	03-608	40	1	39	74	53	25	WILLINGBORO MUA	WMUA 3
03-610	03-610	40	1	22	74	53	8	WILLINGBORO MUA	WMUA 6
03-612	03-612	40	00	54	74	53	42	LEVITT & SON GC	NO. 1
03-647	03-647	40	03	26	74	49	35	BURLINGTON TWP	
03-649	03-649	40	03	27	74	49	34	BURLINGTON TWP	
03-650	03-650	39	57	25	74	59	15	MAPLE SHADE WD	
	03-217	39	57	28	74	59	17	MAPLE SHADE W D	MSWD 4
	03-218	39	57	25	74	59	14	MAPLE SHADE WD	MSWD 5
03-651	03-651	40	00	38	75	01	39	DELA VALLEY W C	
	03-338	40	0	39	75	1	34	DELA VALLEY W C	RIVERTON 11
	03-339	40	00	38	75	01	41	DELA VALLEY WC	RIVTON.9

TABLE 3D-2
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04- 3	04- 3	39	52	31	75	03	11	NJ WATER CO	BARRINGTON 5
04- 6	04- 6	39	52	0	75	2	52	WEYERHAEUSER CO	1
04- 7	04- 7	39	51	46	75	2	54	OWENS CORNING	CORNING 1
04- 9	04- 9	39	52	21	75	6	33	BELLMAWR B W D	BBWD 3
	04- 8	39	52	22	75	6	32	BELLMAWR B W D	BBWD 1
	04- 10	39	52	19	75	06	41	BELLMAWR BWD	BBWD 2
04- 12	04- 12	39	51	51	75	5	33	BELLMAWR B W D	BBWD 4
04- 15	04- 15	39	47	38	74	56	14	BERLIN WATER D	BWD 10
	04- 14	39	47	38	74	56	14	BERLIN WATER D	BWD 9
	04- 22	39	46	48	74	56	22	BERLIN WD	11-1972
04- 28	04- 28	39	52	43	75	7	24	BROOKLAWN B W D	BBWD NEW WELL
	04- 26	39	52	44	75	7	27	BROOKLAWN B W D	BBWD 3
	04- 27	39	52	44	75	07	27	BROOKLAWN BWD	BBWD 2
	04- 29	39	52	42	75	07	25	BROOKLAWN BWD	LEGION
04- 46	04- 46	39	57	15	75	5	19	NJ WATER CO	CAMDEN DIV 52
	04- 41	39	57	18	75	05	07	H.KOHNSTAMM CO	6
	04- 43	39	57	16	75	5	7	H KOHNSTAMM CO	3
	04- 44	39	57	16	75	05	07	H.KOHNSTAMM CO	4
	04- 45	39	57	16	75	05	07	H.KOHNSTAMM CO	5
	04- 47	39	57	15	75	05	17	NJ WATER CO	CAM.DV44
04- 50	04- 50	39	57	6	75	5	53	CAMDEN CITY W D	CITY 16
	04- 31	39	57	32	75	05	32	NJ WATER CO	CAM.DV27
	04- 32	39	57	28	75	05	20	NJ WATER CO	CAM.DV48
	04- 33	39	57	26	75	05	18	NJ WATER CO	CAM.DV50
	04- 34	39	57	25	75	05	21	NJ WATER CO	CAM.DV49
	04- 35	39	57	22	75	05	23	NJ WATER CO	CAM.DV46
	04- 37	39	57	20	75	05	13	NJ WATER CO	CAM.DV51
	04- 38	39	57	19	75	05	17	NJ WATER CO	CAM.DV45
	04- 40	39	57	18	75	05	13	NJ WATER CO	CAM.DV47
	04- 42	39	57	16	75	6	8	CAMDEN CITY W D	CITY 15
	04- 49	39	57	7	75	6	15	CAMDEN CITY W D	CITY 14
04- 54	04- 54	39	56	52	75	6	7	CAMDEN CITY W D	CITY 10
	04- 51	39	56	59	75	6	10	CAMDEN CITY W D	CITY 9
	04- 53	39	56	59	75	06	10	CAMDEN CITY WD	CY9-1924
04- 56	04- 56	39	56	41	75	5	46	CONCORD CHEM	1
04- 60	04- 60	39	56	38	75	6	22	CAMDEN CITY W D	CITY 1A
	04- 61	39	56	38	75	06	22	CAMDEN CITY WD	CY1-1922
04- 62	04- 62	39	56	37	75	06	33	BALT MKTS	2

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04- 64	04- 64	39	56	30	75	6	1	R M HOLLINGSHD	1
04- 65	04- 65	39	56	17	75	7	10	CAMDEN CITY W D	CITY 12
04- 67	04- 67	39	56	14	75	6	33	CAMDEN CITY W D	CITY 5-1937
	04- 66	39	56	15	75	6	33	CAMDEN CITY W D	CITY 5N
	04- 68	39	56	14	75	06	33	CAMDEN CITY WD	CY5-1928
04- 71	04- 71	39	56	2	75	7	44	PUBLIC SERV E-G	PSEGC 7
	04- 69	39	56	4	75	7	35	PUBLIC SERV E G	6 REPLACEMENT
	04- 70	39	56	3	75	7	36	PUBLIC SERV E-G	PSEGC 8
04- 74	04- 74	39	55	57	75	6	29	CAMDEN CITY W D	CITY 3A
	04- 72	39	55	57	75	06	29	CAMDEN CITY WD	CY3-1922
	04- 73	39	55	57	75	06	29	CAMDEN CITY WD	CY3-1934
04- 79	04- 79	39	55	50	75	7	29	CAMDEN CITY W D	CITY 2B
04- 80	04- 80	39	55	46	75	5	33	CAMDEN CITY W D	CITY 17
	04- 76	39	55	52	75	5	35	CAMDEN CITY W D	CITY 13
04- 84	04- 84	39	55	40	75	7	42	CAMDEN CITY W D	CITY 8A
	04- 85	39	55	40	75	07	42	CAMDEN CITY WD	CITY 8
04- 86	04- 86	39	55	39	75	6	30	W JERSEY HDSP	W JERSEY HDSP1
	04- 81	39	55	41	75	6	22	CAMDEN CITY W D	CITY 4
	04- 82	39	55	41	75	06	22	CAMDEN CITY WD	CY4-1935
	04- 83	39	55	41	75	06	22	CAMDEN CITY WD	CY4-1922
04- 90	04- 90	39	55	32	75	7	20	GALLAGHERS WHSE	EVRSN LVRNG 2
	04- 88	39	55	34	75	07	24	GALLAGHERS WHSE	LVRNG 3
	04- 89	39	55	34	75	07	24	GALLAGHERS WHSE	LVRNG 1
	04- 91	39	55	32	75	07	19	GALLAGHERS WHSE	LVRNG 6
	04- 92	39	55	30	75	07	19	GALLAGHERS WHSE	LVRNG 4
	04- 93	39	55	30	75	07	19	GALLAGHERS WHSE	LVRNG 5
04- 94	04- 94	39	55	28	75	5	38	A N STOLLWRECK	2
04- 95	04- 95	39	55	27	75	6	46	CAMDEN CITY W D	CITY 6N
04- 98	04- 98	39	55	12	75	6	40	CAMDEN CITY W D	CITY 11
04-101	04-101	39	55	7	75	7	29	MAFCO	2
04-105	04-105	39	54	57	75	6	40	CAMDEN CITY W D	CITY 7N
	04-103	39	54	57	75	6	41	CAMDEN CITY W D	CITY 7
	04-104	39	54	57	75	06	41	CAMDEN CITY WD	CY7-1928
04-107	04-107	39	54	49	75	7	16	SO JRSY PORT CM	NY SHIP 6

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	04-108	39	54	49	75	07	16	NY SHIPBUILDING	1
	04-109	39	54	49	75	07	16	NY SHIPBUILDING	2
	04-110	39	54	49	75	07	16	NY SHIPBUILDING	3
	04-112	39	54	47	75	07	11	NY SHIPBUILDING	4
	04-113	39	54	47	75	07	11	NY SHIPBUILDING	5
	04-114	39	54	47	75	07	11	NY SHIPBUILDING	8
	04-115	39	54	35	75	07	20	SO JRSY PORT CM	SHIP PW1
	04-116	39	54	35	75	07	20	NY SHIPBUILDING	9
04-119	04-119	39	56	16	75	0	27	NJ WATER CO	COLUMBIA 22
	04-120	39	56	15	75	00	27	NJ WATER CO	COL. 24
	04-125	39	56	03	75	00	31	NJ WATER CO	COL. 31
04-124	04-124	39	56	6	75	1	48	GS RACING ASSOC	CHRY HLL INN 2
	04-123	39	56	6	75	1	48	GS RACING ASSOC	CHRY HLL INN 1
04-134	04-134	39	55	2	75	2	21	N J NATIONAL GD	1
04-135	04-135	39	54	55	74	59	29	NJ WATER CO	KINGSTON 25
	04-136	39	54	55	74	59	29	NJ WATER CO	KINGS.28
	04-137	39	54	55	74	59	24	NJ WATER CO	KINGS.27
04-140	04-140	39	54	41	75	1	4	NJ WATER CO	ELLISBURG 16
	04-139	39	54	42	75	1	3	NJ WATER CO	ELLISBURG 13
	04-141	39	54	38	75	01	07	NJ WATER CO	ELLISBURG 23
04-149	04-149	39	53	56	74	57	8	NJ WATER CO	OLD ORCHARD 37
	04-148	39	53	56	74	57	08	NJ WATER CO	O.ORCH38
	04-150	39	53	56	74	57	08	NJ WATER CO	O.ORCH36
04-156	04-156	39	53	8	75	0	15	NJ TURNPIKE AU	SERVICE 3S-2
04-159	04-159	39	52	52	74	59	43	NJ WATER CO	BRNG 44,45,46
	04-160	39	52	52	74	59	43	NJ WATER CO	BRNG 46
	04-161	39	52	52	74	59	43	NJ WATER CO	BRNG 45
04-162	04-162	39	52	38	75	0	30	HUSSMAN REFRIDG	HUSSMAN
04-168	04-168	39	51	50	74	59	13	WOODCREST CT CL	CLUB 2
	04-167	39	51	50	74	59	16	WOODCREST CT CL	CLUB 1
04-171	04-171	39	48	32	74	59	15	CLEMENTON WD	7
04-175	04-175	39	55	22	75	4	32	COLLINGSWOOD WD	CWD 3
	04-174	39	55	26	75	04	24	COLLINGSWOOD WD	CWD 5
	04-176	39	55	21	75	04	32	COLLINGSWOOD WD	CWD 4
	04-177	39	55	19	75	04	32	COLLINGSWOOD WD	CWD 2R
	04-178	39	55	15	75	04	36	COLLINGSWOOD WD	CWD 1R
	04-179	39	55	06	75	05	07	FRIENDSHIP DAIR	DAIRY 1
04-181	04-181	39	54	26	75	5	14	COLLINGSWOOD WD	CWD 7

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	04-182	39	54	26	75	05	14	COLLINGSWOOD WD	CWD 6
04-186	04-186	39	50	02	74	58	51	NJ WATER CO	41-1972
04-191	04-191	39	49	45	74	58	55	NJ WATER CO	43-1972
04-197	04-197	39	53	49	75	6	51	GLOUCESTER C WD	GCWD 40
	04-195	39	53	59	75	06	54	GLOUCESTER CWD	GCWD 41
	04-207	39	53	43	75	06	52	GLOUCESTER CWD	GCWD 42
04-222	04-222	39	53	8	75	7	44	NJ ZINC CO	4-DEEP
	04-212	39	53	22	75	07	57	HARSHAW CHEM CO	HARSHAW4
	04-213	39	53	22	75	07	51	HARSHAW CHEM CO	HARSHAW2
	04-214	39	53	21	75	7	47	HARSHAW CHEM CO	HARSHAW 3
	04-215	39	53	18	75	07	55	HARSHAW CHEM CO	HARSHAW1
	04-217	39	53	14	75	7	49	NJ ZINC CO	1-DEEP
	04-218	39	53	14	75	07	49	NJ ZINC CO	1R-1973
	04-219	39	53	13	75	8	4	NJ ZINC CO	3-DEEP
	04-220	39	53	8	75	7	57	NJ ZINC CO	2-DEEP
	04-221	39	53	8	75	7	49	NJ ZINC CO	5-DEEP
04-225	04-225	39	50	30	75	3	47	NJ WATER CO	OTTERBROOK 29
	04-226	39	50	30	75	03	47	NJ WATER CO	OTBR 39
	04-227	39	50	28	75	03	44	NJ WATER CO	OTBR 34
04-242	04-242	39	48	29	75	3	47	SUN TEMP INDUST	
04-245	04-245	39	48	6	75	4	26	GAR ST WC-BLKWD	BLACKWOD DIV 2
04-248	04-248	39	47	59	75	1	58	GAR ST WC-BLKWD	BLACKWOD DIV 6
04-250	04-250	39	47	54	75	3	43	GAR ST WC-BLKWD	BLACKWOD DIV 3
	04-249	39	47	58	75	04	02	GAR ST WC	BLKWD 7-1974
04-251	04-251	39	47	39	75	2	27	GLOU TWP BD ED	LEWIS SCHOOL
04-253	04-253	39	47	18	75	3	41	GARDEN STATE WC	PEOPLES 1
04-256	04-256	39	47	12	75	4	13	CAMDEN COUNTY	LAKELAND 2
	04-254	39	47	16	75	4	20	CAMDEN COUNTY	LAKELAND 1
04-257	04-257	39	47	12	75	02	20	SOCIETY DIVINE	
04-278	04-278	39	54	4	75	2	2	HADDONFIELD W D	LAKE ST WELL
04-279	04-279	39	53	33	75	1	32	HADDONFIELD W D	RULON
	04-280	39	53	24	75	01	38	HADDONFIELD WD	CREEK 3
04-282	04-282	39	53	22	75	1	54	HADDONFIELD W D	LAYNE 2
	04-283	39	53	22	75	01	47	HADDONFIELD	HWD 2

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	04-284	39	53	17	75	01	41	HADDONFIELD WD	HWD 4
04-286	04-286	39	52	48	75	4	33	NJ WATER CO	EGGBERT 18
	04-285	39	52	48	75	4	33	NJ WATER CO	EGGBERT 6
	04-287	39	52	47	75	04	32	NJ WATER CO	EGGBT 35
04-296	04-296	39	52	31	75	3	14	NJ WATER CO	HADDON 20
	04-289	39	52	42	75	3	20	NJ WATER CO	HADDON 11
	04-290	39	52	40	75	3	24	NJ WATER CO	HADDON 14
	04-291	39	52	40	75	3	18	NJ WATER CO	HADDON 12
	04-292	39	52	38	75	3.	17	NJ WATER CO	HADDON 30
	04-293	39	52	38	75	3	16	NJ WATER CO	HADDON 15
	04-294	39	52	37	75	03	20	NJ WATER CO	HD HTS10
	04-295	39	52	37	75	03	20	NJ WATER CO	NJW 3
04-297	04-297	39	54	44	75	3	16	MILGRAM THEATER	WESTMONT
04-299	04-299	39	54	36	75	2	52	DY-DEE SERVICE	1
	04-298	39	54	36	75	2	52	DY-DEE SERVICE	REPLACEMENT
04-301	04-301	39	54	12	75	3	38	HADDON TWP W D	HTWD 4
	04-300	39	54	16	75	3	36	HADDON TWP BD E	HADDON TWP HS1
04-304	04-304	39	54	3	75	3	22	HADDON TWP W D	HTWD 2
	04-302	39	54	06	75	03	17	HADDON TWP WD	HTWD 1-R
	04-303	39	54	06	75	03	17	HADDON TWP WD	HTWD 1
	04-305	39	53	59	75	03	22	HADDON TWP WD	HTWD 3
04-306	04-306	39	53	51	75	3	13	GREEN VALLEY FM	FARM 2
04-308	04-308	39	49	28	75	0	24	NJ WATER CO	LAUREL 13
	04-307	39	49	28	75	00	27	NJ WATER CO	LAUREL15
04-320	04-320	39	51	34	75	2	29	NJ WATER CO	MAGNOLIA 16
	04-317	39	51	35	75	02	46	OWENS CORNING	2
	04-319	39	51	34	75	2	30	NJ WATER CO	MAGNOLIA 33
04-322	04-322	39	56	52	75	3	7	MERCH-PENNS W C	WOODBINE 1
04-323	04-323	39	56	27	75	04	04	MERCH-PENNS WC	1R-1971
	04-385	39	56	28	75	4	6	MERCH-PENNS W C	BROWNING 2A
	04-387	39	56	27	75	04	04	MERCH-PENNS WC	BROWN 1
	04-389	39	56	21	75	04	05	MERCH-PENNS WC	BROWNRD2
04-335	04-335	39	59	25	75	02	30	KINGSTON TRAP	TRAP RK IND 2
	04-334	39	59	25	75	02	30	KINGSTON TRAP	TRAP RK IND 1
04-336	04-336	39	59	23	75	3	0	CAMDEN CITY W D	MORRIS 10
	04-325	39	59	43	75	02	12	CAMDEN CITY WD	MORRIS 1
	04-326	39	59	40	75	02	30	CAMDEN CITY WD	MORR.5NA

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	04-327	39	59	39	75	02	29	CAMDEN CITY WD	MORRIS 5
	04-328	39	59	38	75	02	22	CAMDEN CITY WD	MORRIS 2
	04-329	39	59	34	75	02	29	CAMDEN CITY WD	MORRIS3A
	04-332	39	59	29	75	02	53	CAMDEN CITY WD	MORRIS 4
	04-333	39	59	29	75	02	53	CAMDEN CITY WD	MORRIS4A
	04-338	39	59	16	75	03	03	CAMDEN CITY WD	MORRIS 7
	04-340	39	59	10	75	03	07	CAMDEN CITY WD	MORRIS 8
	04-341	39	59	06	75	03	13	CAMDEN CITY WD	MORRIS 9
	04-342	39	59	02	75	03	18	CAMDEN CITY WD	MORRIS 6
04-343	04-343	39	59	2	75	1	53	MERCH-PENNS W C	NATIONAL HWY 1
04-347	04-347	39	58	48	75	3	47	CAMDEN CITY W D	DELAIR 1
	04-345	39	58	53	75	03	48	CAMDEN CITY WD	DELAIR 3
	04-346	39	58	51	75	03	55	CAMDEN CITY WD	DELAIR 2
04-363	04-363	39	58	7	75	3	53	PENNSAUKEN TWP	SWIM POOL WELL
04-365	04-365	39	58	2	75	1	17	MERCH PENNS W C	PARK AVE 1
	04-364	39	58	02	75	01	17	MERCH-PENNS WC	PARK AVE 2
	04-366	39	58	01	75	01	19	MERCH-PENNS WC	PARK AV3
	04-367	39	58	00	75	01	25	MERCH-PENNS WC	PARK AV4
	04-368	39	58	00	75	01	15	MERCH-PENNS WC	PK.AVRP6
	04-369	39	57	58	75	01	20	MERCH-PENNS WC	PARK AV5
	04-370	39	57	58	75	01	15	MERCH-PENNS WC	PK.AVRP4
04-374	04-374	39	57	52	75	4	11	MERCH-PENNS W C	DELA GARDEN 1A
	04-372	39	57	52	75	04	11	MERCH-PENNS WC	DELA.GD1
	04-373	39	57	52	75	04	11	MERCH-PENNS WC	DELA.GD1
04-375	04-375	39	57	43	75	4	48	PRECISION STEEL	1962 WELL
04-382	04-382	39	57	11	75	2	20	MERCH-PENNS W C	MARION 2
	04-379	39	57	20	75	02	25	MERCH-PENNS WC	MARION 1
04-392	04-392	39	47	26	74	59	11	PINE HILL MUA	PHMUA 2-1972
04-398	04-398	39	46	41	74	59	9	PINE HILL M U A	PHMUA 1
04-406	04-406	39	51	33	75	4	55	TRAP ROCK IND	3
	04-405	39	51	34	75	04	54	TRAP ROCK CO	2
04-407	04-407	39	51	28	75	3	50	EASTERN RECORD	EASTERN 1
04-410	04-410	39	50	55	75	4	18	NJ WATER CO	RUNNEMEDE 7
	04-409	39	50	56	75	04	17	NJ WATER CO	RUNMED19
04-411	04-411	39	50	41	75	0	53	NJ WATER CO	SOMERDALE 14
04-412	04-412	39	52	37	75	1	22	TAVISTOCK CLUB	COUNTRY CLUB 1

TABLE 3D-2 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04-415	04-415	39	51	29	74	59	6	NJ WATER CO	VOORHEES 21
04-418	04-418	39	51	28	74	59	54	NJ WATER CO	ASHLAND TER 32
	04-416	39	51	28	74	59	54	NJ WATER CO	ASHTER9R
	04-417	39	51	28	74	59	54	NJ WATER CO	ASH TER9
	04-419	39	51	24	74	59	52	NJ WATER CO	ASHLAN17
04-504	04-504	39	53	35	75	07	33	ATLANTIC ICE CO	
04-512	04-512	39	58	40	75	03	09	CAMDEN CITY WD	6-75
	04-348	39	58	45	75	03	17	CAMDEN CITY WD	PUCHACK3
	04-349	39	58	45	75	3	12	CAMDEN CITY W D	PUCHACK 1
	04-352	39	58	42	75	03	12	CAMDEN CITY WD	PUCHACK2
	04-353	39	58	39	75	03	06	CAMDEN CITY WD	PUCHACK4
	04-355	39	58	35	75	03	08	CAMDEN CITY WD	PUCHACK5
	04-356	39	58	30	75	03	10	CAMDEN CITY WD	PUCHACK 4R

TABLE 3D-5
WELLS IN THE RARITAN-MAGOTHY AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
08- 3	08- 3	39	39	12	75	5	22	CLAYTON W D	CWD 3
	08- 1	39	40	12	75	05	57	CLAYTON WD	4-1973
08- 4	08- 4	39	51	15	75	7	6	DEPTFORD TP MUA	4
08- 12	08- 12	39	48	39	75	9	11	DEPTFORD T MUA	1
	08- 10	39	49	34	75	06	53	DEPTFORD TWP MU	DPTFD 3
	08- 17	39	48	11	75	09	13	DEPTFORD TMA	DTMA 2
08- 19	08- 19	39	47	46	75	5	11	DEPTFORD T MUA	5-1971
08- 21	08- 21	39	46	28	75	8	13	WOODBURY W D	SEWELL 1A
	08- 20	39	46	28	75	08	13	WOODBURY WD	SEWELL 2
	08- 22	39	46	28	75	08	13	WOODBURY WD	SEWELL2A
	08- 23	39	46	27	75	08	13	WOODBURY WD	SEWELL 1
08- 26	08- 26	39	47	55	75	13	27	E GREENWICH W D	EGWD 2
	08- 25	39	47	57	75	13	34	E GREENWICH WD	EGWD 1
08- 37	08- 37	39	39	58	75	12	37	MOOD RICHARD J	1
08- 61	08- 61	39	42	5	75	7	53	GLASSBORO W D	GWD 3
	08- 58	39	43	08	75	07	02	GLASSBORO WD	GWD 4
	08- 59	39	42	41	75	06	42	GLASSBORO WD	GWD 2
	08- 60	39	42	08	75	06	42	GLASSBORO WD	GWD 1
08- 62	08- 62	39	41	47	75	7	14	OWENS ILLINOIS	OWENS 1
08- 73	08- 73	39	50	27	75	15	3	MOBIL OIL CO	MOBIL 41
	08- 64	39	50	36	75	15	01	MOBIL OIL CO	MOBIL 47
	08-209	39	50	44	75	15	03	MOBIL OIL CO	MOBIL 33
08- 80	08- 80	39	50	16	75	17	38	E I DUPONT	REPAUNO 20
	08- 75	39	50	25	75	17	57	E I DUPONT	REPAUNOC
	08- 76	39	50	22	75	17	29	E I DUPONT	REPAUNOG
	08- 78	39	50	21	75	17	40	E I DUPONT	REPAUNOJ
	08- 79	39	50	21	75	17	30	E I DUPONT	REPAUNOH
08- 84	08- 84	39	50	5	75	15	23	MOBIL OIL CO	MOBIL 45
	08- 81	39	50	12	75	15	20	MOBIL OIL CO	MOBIL 40
	08- 87	39	49	58	75	15	45	MOBIL OIL CO	MOBIL 43
	08- 88	39	49	58	75	15	12	MOBIL OIL CO	MOBIL 44
	08- 89	39	49	56	75	15	21	MOBIL OIL CO	MOBIL 46
08- 97	08- 97	39	49	48	75	16	39	HERCULES CHEM	GIBBSTOWN 2
	08- 92	39	49	52	75	16	53	HERCULES CHEM	GIBBS 1
	08-106	39	49	40	75	17	09	HERCULES CHEM	4 1970
08-109	08-109	39	49	36	75	17	47	E I DUPONT	REPAUNO NITR3

TABLE 3D-3 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	08-100	39	49	45	75	17	36	E I DUPONT	REPAUNO1
	08-101	39	49	45	75	17	17	E I DUPONT	REPAUNO 5
	08-102	39	49	44	75	17	35	E I DUPONT	REPAUNO 2
	08-103	39	49	44	75	17	34	E I DUPONT	REPAUNO 6
	08-105	39	49	44	75	17	11	E I DUPONT	REPAUNO 4
	08-110	39	49	36	75	17	47	E I DUPONT	REPAUND 3
08-112	08-112	39	49	32	75	17	22	GREENWICH T W D	GTWD 1
08-113	08-113	39	49	19	75	16	2	GREENWICH T W D	GTWD 3
08-117	08-117	39	48	51	75	15	26	GREENWICH T W D	GTWD 2
08-119	08-119	39	44	50	75	14	00	VASALLI JOSEPH	VASALLI 1
08-120	08-120	39	45	1	75	12	29	SCHOOL DISTRICT	CLEARVIEW HS 1
08-122	08-122	39	44	8	75	13	30	SO JERSEY W C	SJWC 3
	08-121	39	44	08	75	13	30	SO JERSEY WC	SJWC 1
08-124	08-124	39	43	46	75	9	59	LEONARD,WM	LEONARD 5
08-145	08-145	39	47	57	75	23	30	MONSANTO CHEM	3
08-147	08-147	39	47	55	75	21	8	PENNS GROVE W C	BRIDGEPORT 2
	08-146	39	47	55	75	21	08	PENNS GROVE W C	BRDG PT1
08-154	08-154	39	47	33	75	23	51	MONSANTO CHEM	BRIDGEPORT W2
	08-153	39	47	36	75	23	44	MONSANTO CHEM	BRIDGEPORT E1
08-158	08-158	39	47	15	75	20	48	ROLLINS PURLE	1
08-168	08-168	39	46	11	75	21	20	PURELAND WATER	1-1973
08-175	08-175	39	45	35	75	20	54	GLOUCESTER CCC	3-1973
08-182	08-182	39	47	32	75	10	36	MANTUA WATER CO	MWC 3
	08-180	39	47	38	75	10	25	MANTUA WATER CO	MWC 1
08-183	08-183	39	47	12	75	10	8	MANTUA WATER CO	MWC 2
08-184	08-184	39	46	36	75	11	15	EDENWOOD W C	EWC 1
08-185	08-185	39	46	29	75	8	59	SEWELL W C	SWC 2
08-187	08-187	39	46	2	75	8	23	SEWELL W C	SWC 1
08-189	08-189	39	45	43	75	7	46	INVERSAND CO	#2
08-193	08-193	39	44	30	75	9	11	PITMAN CNTY CLB	COUNTRY CLUB 1

TABLE 3D-3 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
08-194	08-194	39	43	49	75	9	9	MADERA HARRY	1
08-202	08-202	39	51	56	75	10	53	NATIONAL PK W D	NPWD 2
	08-203	39	51	46	75	10	53	NATIONAL PK WC	NPWC 1
08-206	08-206	39	50	57	75	13	47	OLIN CORP	OLIN#2 (PCHEM)
	08-208	39	50	51	75	13	49	OLIN CORP	OLIN 1 (PCHEM)
08-210	08-210	39	50	23	75	14	42	PAULSBORO W D	PWD 2
	08-211	39	50	23	75	14	42	PAULSBORO W D	PWD 3
08-213	08-213	39	49	50	75	14	22	PAULSBORO W D	PWD 5
08-214	08-214	39	49	31	75	14	49	PAULSBORO W D	PWD 4
	08-215	39	49	21	75	14	19	PAULSBORO WD	6-1973
08-217	08-217	39	44	27	75	7	43	PITMAN W D	PWD P3
08-219	08-219	39	44	5	75	7	45	PITMAN W D	PWD P1
	08-218	39	44	11	75	7	45	PITMAN W D	PWD P2
08-220	08-220	39	43	42	75	7	53	PITMAN W D	PWD PG1
08-235	08-235	39	45	10	75	18	38	DEL MONTE CORP	9
	08-232	39	45	12	75	18	30	DEL MONTE CORP	6
	08-233	39	45	11	75	18	35	DEL MONTE CORP	5
08-238	08-238	39	44	34	75	18	43	SWEDESBORO B WD	SBWD 3
	08-236	39	44	38	75	18	33	SWEDESBORO B WD	SBWD 2
	08-237	39	44	37	75	18	35	SWEDESBORO B WD	SBWD 1
08-244	08-244	39	45	48	75	4	6	WASHINGTN T MUA	4-1972
	08-245	39	45	46	75	4	0	WASHINGTN T MUA	WTMUA 3
08-247	08-247	39	45	33	75	3	23	WASHINGTON TMUA	WTMUA 2
08-251	08-251	39	45	20	75	2	18	WASHINGTON TMUA	WTMUA 1
08-253	08-253	39	45	17	75	3	0	WASHINGTON TMUA	8(BELS LK WC2)
08-259	08-259	39	44	33	75	2	50	WASHINGTON TMUA	6(FRIES MLS 1)
08-265	08-265	39	43	35	75	3	43	SMITH,F	2
	08-264	39	43	42	75	04	32	WASHINGTON TMUA	5-1973
08-269	08-269	39	47	51	75	9	12	WENONAH WATER D	WWD 2
	08-270	39	47	43	75	09	02	WENONAH WATER D	WWD 1
08-277	08-277	39	52	7	75	9	30	TEXAS OIL CO	EAGLE POINT 2

TABLE 3D-3 (Cont'd)
WELLS IN THE RARITAN-MAGOTHY AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	08-273	39	52	22	75	9	18	TEXAS OIL CO	EAGLE POINT 3
	08-274	39	52	21	75	8	56	TEXAS OIL CO	EAGLE POINT 5
	08-275	39	52	16	75	9	15	TEXAS OIL CO	EAGLE POINT 1
	08-276	39	52	13	75	9	36	TEXAS OIL CO	EAGLE POINT 4
08-281	08-281	39	51	53	75	9	46	TEXAS OIL CO	EAGLE POINT 6
	08-278	39	52	00	75	09	47	TEXACO	7-1973
08-282	08-282	39	51	40	75	9	52	W DEPTFORD T WD	WDTWD 2
	08-283	39	51	07	75	09	46	W DEPTFORD WD	6-1973
08-291	08-291	39	50	32	75	12	41	PENNWALT CORP	418
	08-289	39	50	33	75	12	33	PENNWALT CORP	417
08-295	08-295	39	50	2	75	10	5	POLYREZ CO	POLYREZ 1
	08-296	39	50	02	75	10	05	POLYREZ CO	POLYREZ2
08-300	08-300	39	49	39	75	10	07	WESTWOOD GC	1-1973
08-312	08-312	39	49	17	75	13	7	SHELL CHEM CO	SHELL 2
	08-309	39	49	19	75	12	56	SHELL CHEM CO	SHELL 4
	08-310	39	49	19	75	12	56	SHELL CHEM CO	SHELL 3
	08-311	39	49	17	75	13	7	SHELL CHEM CO	SHELL 1
08-313	08-313	39	49	13	75	11	05	W DEPTFORD WD	5-1973
08-314	08-314	39	49	12	75	10	26	W DEPTFORD T WD	WDTWD 3
08-319	08-319	39	48	21	75	10	26	W DEPTFORD T WD	WDTWD 4
08-320	08-320	39	52	21	75	7	37	WESTVILLE W D	WWD 4
	08-321	39	52	21	75	07	37	WESTVILLE WD	WWD 3
	08-322	39	52	21	75	07	37	WESTVILLE WD	WWD 1
	08-323	39	52	16	75	07	39	WESTVILLE WD	5-1971
08-325	08-325	39	50	44	75	9	7	WOODBURY W D	TATUM 4
08-326	08-326	39	50	17	75	9	28	WOODBURY W D	PARKING LOT 3
08-327	08-327	39	49	50	75	9	9	WOODBURY W D	RAILROAD 5
08-328	08-328	39	48	58	75	08	45	WOODBURY HGTS	1
08-331	08-331	39	44	38	75	19	14	DEL MONTE	10
08-336	08-336	39	43	48	75	21	10	MAUGERI,JOSEPH	MAUGERI J1

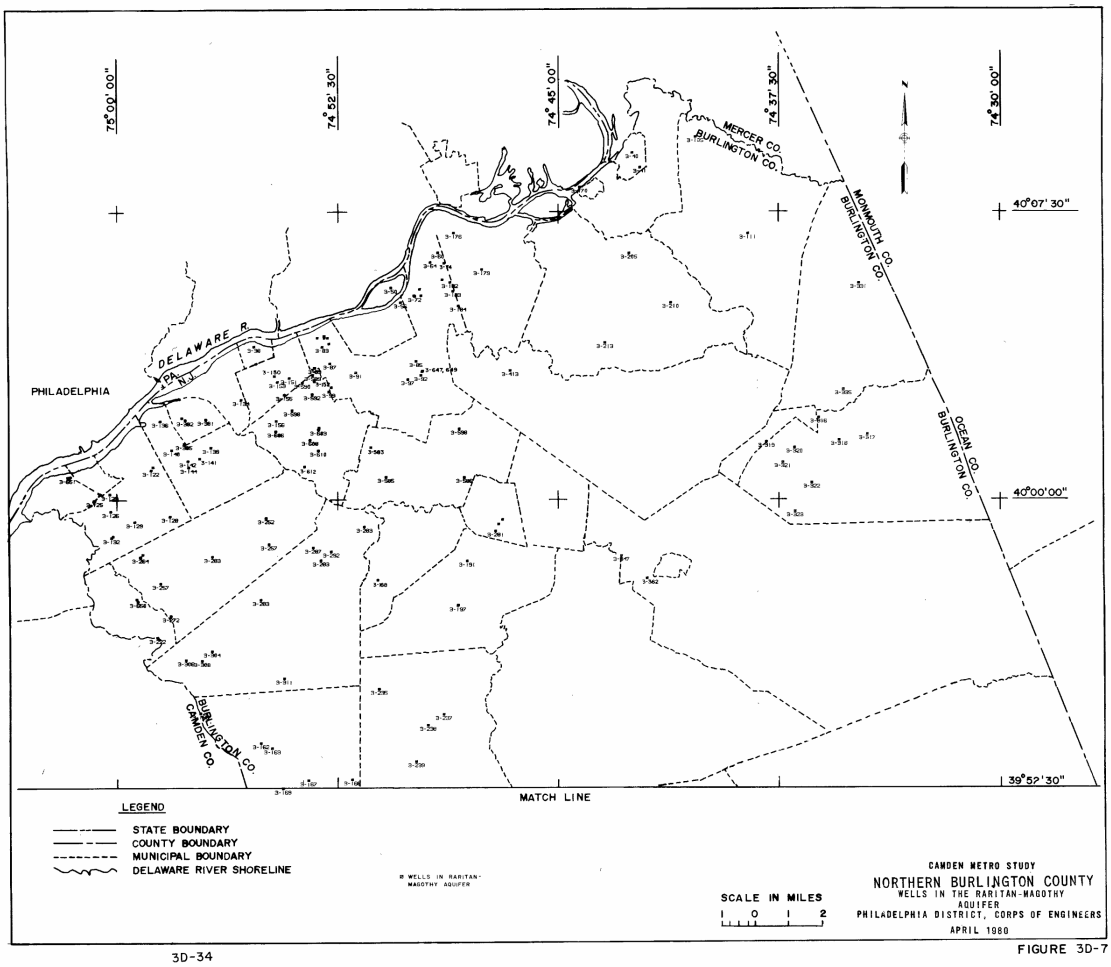

75°00'00"
74°52'30"
74°45'00"
74°37'30"
74°30'00"
40°07'30"
40°00'00"
39°52'30"
PHILADELPHIA
DELAWARE R.
PA.
N.J.
MERCER CO.
BURLINGTON CO.
MONMOUTH CO.
BURLINGTON CO.
OCEAN CO.
BURLINGTON CO.
BURLINGTON CO.
CAMDEN CO.
MATCH LINE
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
WELLS IN RARITAN-MAGOTHY AQUIFER
SCALE IN MILES
0
2
CAMDEN METRO STUDY
NORTHERN BURLINGTON COUNTY
WELLS IN THE RARITAN-MAGOTHY AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-7

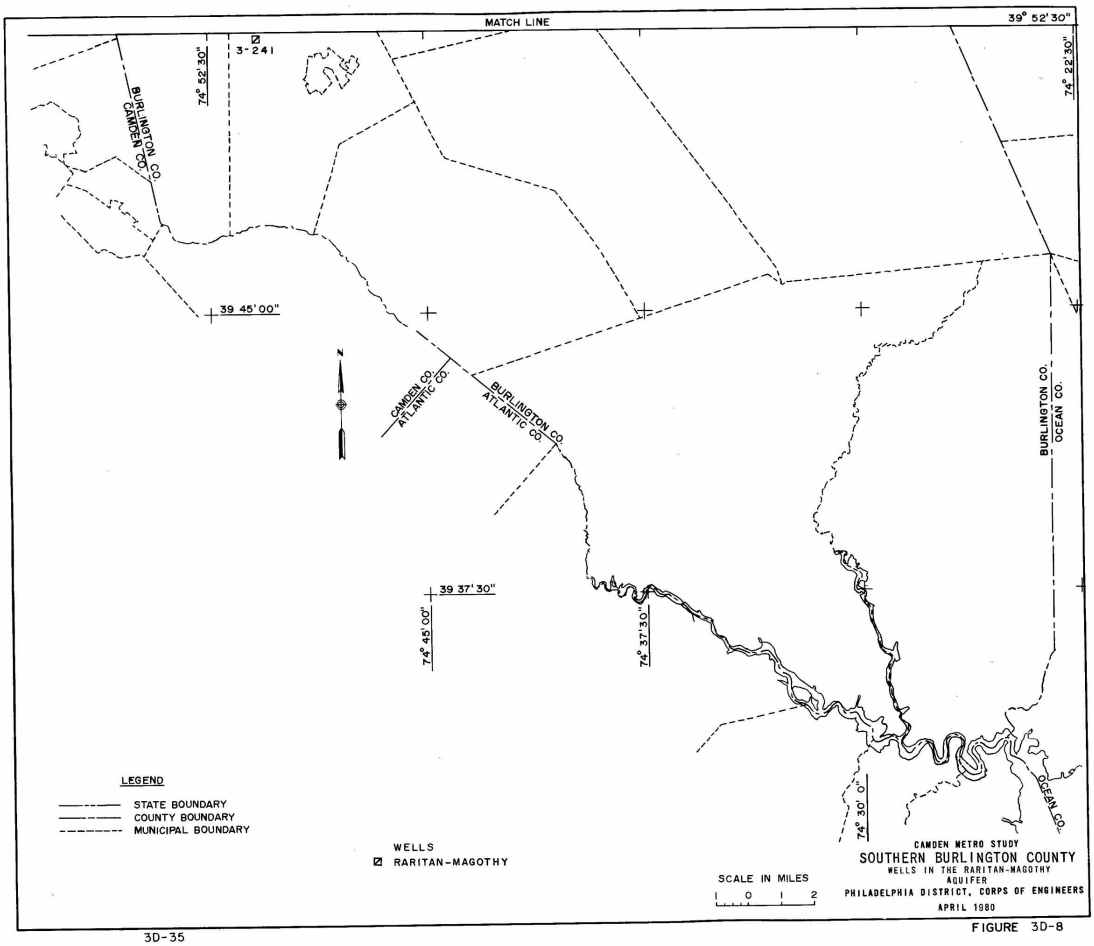

MATCH LINE
39° 52' 30"
3-241
74° 52' 30"
74° 22' 30"
BURLINGTON CO.
CAMDEN CO.
39 45' 00"
N
CAMDEN CO.
ATLANTIC CO.
BURLINGTON CO.
ATLANTIC CO.
BURLINGTON CO.
OCEAN CO.
39 37' 30"
74° 45' 00"
74° 37' 30"
74° 30' 0"
OCEAN CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
WELLS
RARITAN-MAGOTHY
SCALE IN MILES
1 0 1 2
CAMDEN METRO STUDY
SOUTHERN BURLINGTON COUNTY
WELLS IN THE RARITAN-MAGOTHY
AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-8

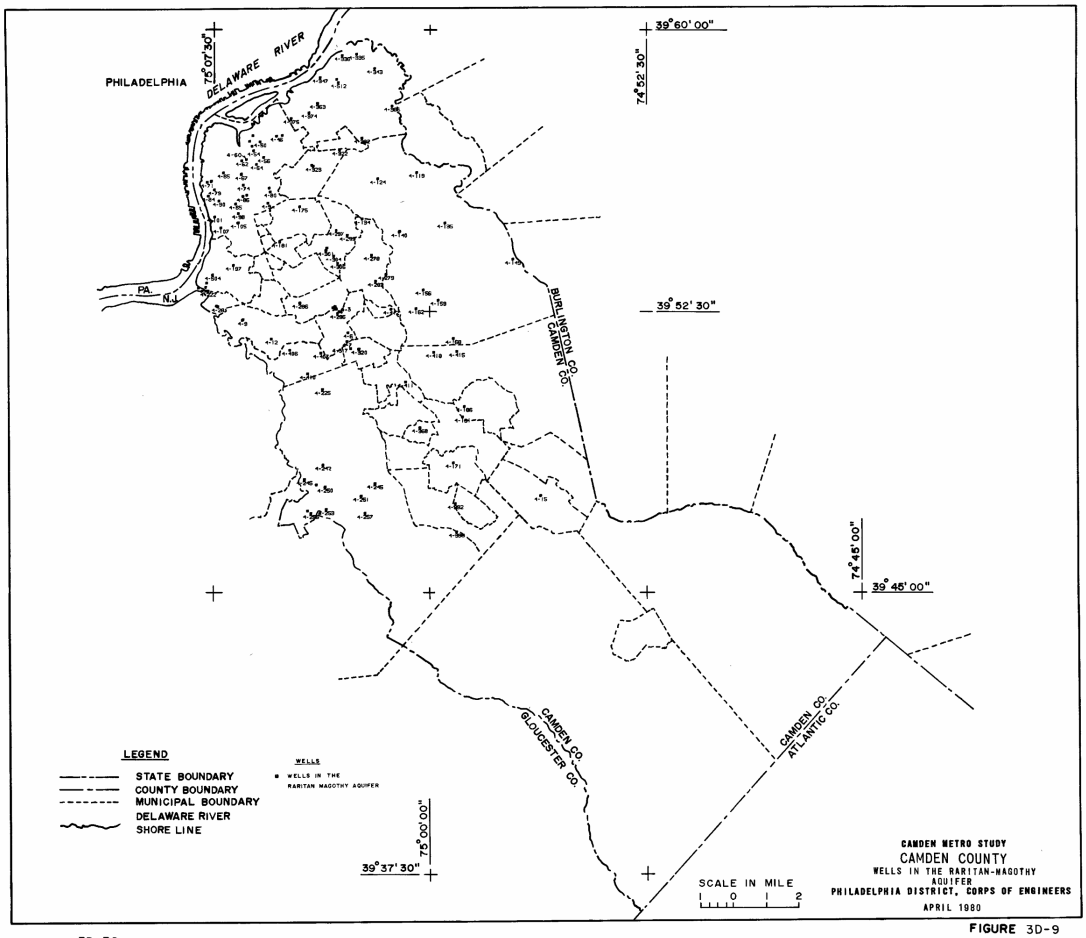

PHILADELPHIA
DELAWARE RIVER
75°07'30"
39°60'00"
74°52'30"
39°52'30"
74°45'00"
39°45'00"
39°37'30"
75°00'00"
PA.
N.J.
BURLINGTON CO.
CAMDEN CO.
CAMDEN CO.
GLOUCESTER CO.
CAMDEN CO.
ATLANTIC CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORE LINE
WELLS
WELLS IN THE RARITAN MAGOTHY AQUIFER
SCALE IN MILE
0
2
CAMDEN METRO STUDY
CAMDEN COUNTY
WELLS IN THE RARITAN-MAGOTHY AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-9

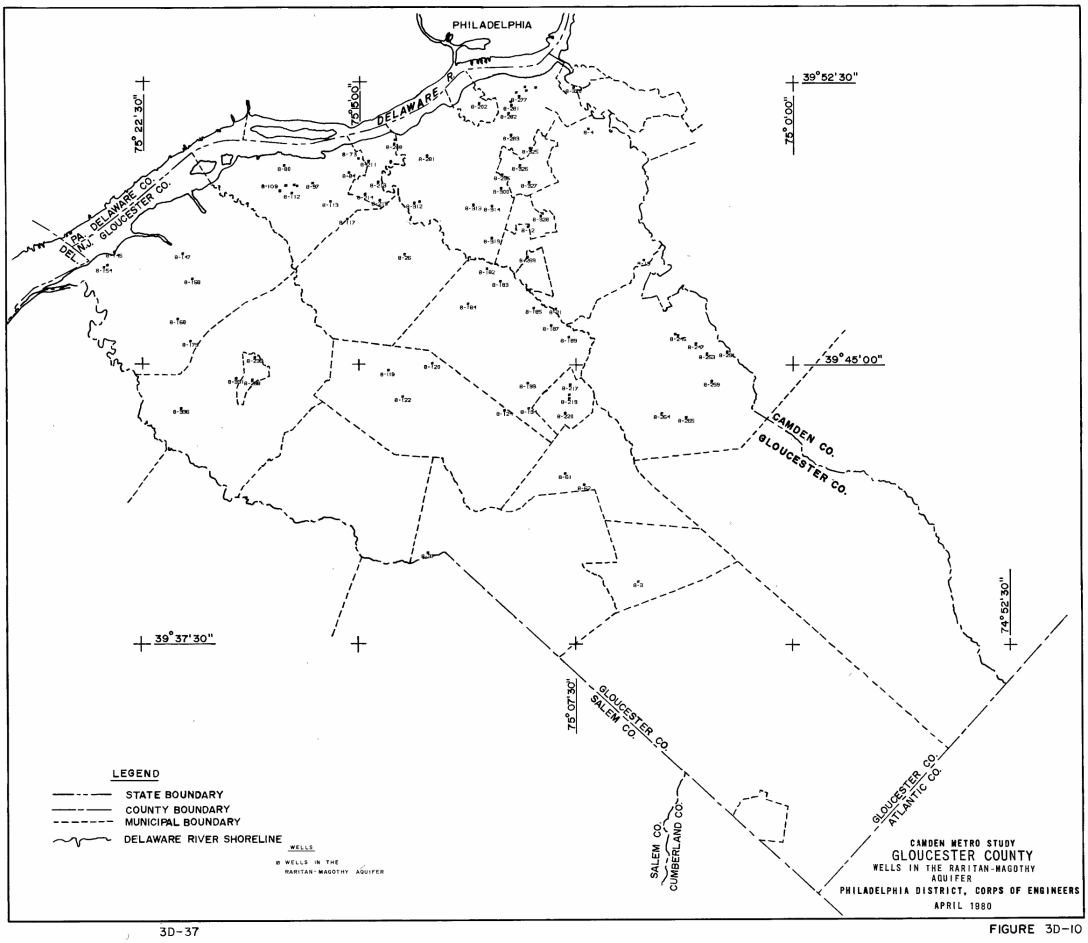

PHILADELPHIA
DELAWARE R.
75° 22' 30"
75° 15' 00"
39° 52' 30"
74° 0' 00"
PA. DELAWARE CO.
DEL. N.J. GLOUCESTER CO.
39° 45' 00"
CAMDEN CO.
GLOUCESTER CO.
39° 37' 30"
74° 52' 30"
75° 07' 30"
GLOUCESTER CO.
SALEM CO.
SALEM CO.
CUMBERLAND CO.
GLOUCESTER CO.
ATLANTIC CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
WELLS
WELLS IN THE RARITAN-MAGOTHY AQUIFER
CAMDEN METRO STUDY
GLOUCESTER COUNTY
WELLS IN THE RARITAN-MAGOTHY AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-10

this analysis, these were considered of secondary concern since only a small percentage of the total water demand is presently being supplied from these sources. Their potential on a regional basis is limited by their size and production capabilities. Figures 3D-11 through 3D-14 display these wells.

The third set of maps deals with locating irrigation wells in the study area. Pumpage from those wells was considered a constant for purposes of analysis. Most of those wells are pumped only on a seasonal basis and, as an annual average, represent only a small percentage of the total demand. Regardless of total pumpage, peaks in withdrawal from all wells can severely influence the pumping capabilities of adjacent wells, and therefore well locations play a primary role in this analysis. Figures 3D-15 through 3D-18 display these wells.

Individual locations for wells were taken from USGS data; however, the numbering system was devised by the Corps of Engineers as a simplified version of the USGS identification system. In some instances the number refers to a group of wells in the same proximity and located in the same aquifer. All wells mapped were those known to exist in 1976 even though USGS pumpage records were only available to 1973. As a supplement to the maps, computer programs were developed to list wells according to their mapping identification number for each of the three counties. These programs were also used to list pumpage records and give a complete identification and inventory of all wells.

TABLE 3D-4
WELLS IN KIRKWOOD-COHANSEY AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03-374	03-374	39	56	22	74	28	55	J J WHITE CO	IRRIGATION 1
03-376	03-376	39	53	11	74	34	59	NJS SCH-N LISBN	RZ-1972
03-391	03-391	39	47	09	74	39	52	JAMESBURG PRSON	1W10 PRISON
03-431	03-431	39	50	34	74	42	42	RUSSO,ANTHONY	2
03-575	03-575	39	36	50	74	34	27	GREEN BANK SFN	
03-634	03-634	39	50	11	74	30	30	SUPERIOR ZINC	ZINC 1
03-639	03-639	39	47	57	74	33	59	DEMARCO ENT	2-1971

TABLE 3D-5
WELLS IN MT. LAUREL-WINONAH AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03-243	03-243	39	51	46	74	51	02	LAKES W C	LWC 2
03-245	03-245	39	51	12	74	51	23	TAUNTON LAKE WC	1
03-340	03-340	39	58	26	74	41	08	PEMBERTON WD	PBWD 1
03-341	03-341	39	58	13	74	39	50	SUNBURY VILLAGE	SVWC 1
03-342	03-342	39	58	12	74	40	59	PEMBERTON WD	PBWD 2
03-343	03-343	39	58	01	74	41	20	PEMBERTON WD	PBWD 3
03-350	03-350	39	58	35	74	35	11	PEMBERTON TWP W	DPTWD 2
03-351	03-351	39	58	21	74	34	09	PEMBERTON TWP W	PTWD 2
03-353	03-353	39	58	15	74	38	40	BURLINGTON CO I	5-1972
03-355	03-355	39	58	07	74	38	37	BURLINGTON CO I	BUR CO INST 3
03-357	03-357	39	58	02	74	38	25	BURLINGTON CO I	
03-356	03-356	39	58	06	74	34	52	PEMBRTON TWP WD	PTWD 1
03-365	03-365	39	57	52	74	34	52	PEMBRTON TWP WD	PTWD 4
03-370	03-370	39	57	07	74	32	46	PEMBRTON TWP WD	CTRY LKS 5
03-372	03-372	39	56	51	74	41	23	LAKE VALLEY WC	LVWC 1
03-373	03-373	39	56	30	74	39	55	GOWER,HARVEY	GOWER
03-375	03-375	39	55	53	74	38	22	BUSH,FRANCIS	BUSH
03-408	03-408	39	55	39	74	43	14	VINCETOWN WC	VINCETOWN
03-410	03-410	39	53	42	74	42	53	HAMPTON LAKE WC	HLWC 1
03-427	03-427	39	51	14	74	45	42	ALLEN,AMOS	TRAILER PARK1

TABLE 3D-6
WELLS IN ENGLISHTOWN AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03-189	03-189	39	57	48	74	51	06	FRED WORTH-SONS	1
03-187	03-187	39	57	53	74	51	15	FRED WORTH-SONS	WORTH 1
03-192	03-192	39	58	04	74	48	13	ELEC PART SPEC1	ELECTRONIC P2
03-312	03-312	39	55	21	74	53	44	RUDDEROW,J E	SPRING VALLEY
03-325	03-325	39	59	41	74	32	47	FORT DIX	FORT DIX 9
03-326	03-326	39	59	10	74	32	30	FORT DIX	FORT DIX 7
03-327	03-327	39	58	59	74	31	22	FORT DIX	FORT DIX 11
03-354	03-354	39	58	14	74	34	38	REILLY	REILLY
03-359	03-359	39	57	56	74	38	14	BURL C C COLLEG	BURLINGTONCCI
03-411	03-411	39	53	30	74	42	37	HAMPTON LAKE WC	HLWC 2

TABLE 3D-7
WELLS IN MINOR MISCELLANEOUS AQUIFER
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
03- 24	03- 24	39	39	45	74	31	26	HARRISVILLE	1W1
03-432	03-432	39	50	17	74	38	53	BIRCHES CRNBERY	BIRCHES 2
03-433	03-433	39	48	58	74	37	46	BIRCHES CRNBERY	BIRCHES 1
03-558	03-558	39	38	44	74	38	55	STATE OF N J	BATSTO 2-1972
03- 36	03- 36	40	04	06	74	55	19	DELA VALLEY W C	DVWC 2
03-337	03-337	40	00	40	75	01	35	DELA VALLEY W C	DVWC U
03-378	03-378	40	02	24	74	57	29	RIVERSIDE ALLOY	
	03-377	40	02	24	74	57	29	RIVERSIDE ALLOY	

TABLE 3D-8
WELLS IN COHANSEY AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04- 17	04- 17	39	47	38	74	56	14	BERLIN WATER D	BWD 5
04-273	04-273	39	45	09	74	59	58	US ARMY	
04-274	04-274	39	44	30	74	59	58	US ARMY	
04-396	04-396	39	46	49	74	58	33	PINE HILL M U A	PHMUA 3
04-453	04-453	39	44	49	74	55	40	FORMEGLI CORP	
04-454	04-454	39	44	46	74	54	18	BD OF EDUCATION	EDGEWOOD JRHI
04-455	04-455	39	44	43	74	54	34	CAMDEN CO R H S	REGIONAL HS 1
04-458	04-458	39	44	33	74	54	45	AMERICAN TELEPH	TELEGRAPH 1
04-460	04-460	39	44	17	74	55	38	CERTAIN TEED ST	1
	04-459	39	44	23	74	55	40	CERTAIN TEED ST	2
04-461	04-461	39	44	00	74	59	59	N TOMASELLA	1
04-463	04-463	39	43	32	74	57	40	WINSLOW W C	PROD 2
04-464	04-464	39	43	26	74	58	56	JOSEPH VOLPA	
04-469	04-469	39	42	48	74	57	10	WINSLOW W C	PROD 1
04-475	04-475	39	42	30	74	52	29	WINSLOW BD ED	1
04-477	04-477	39	42	25	74	58	07	WINSLOW W C	3-1973
04-478	04-478	39	42	21	74	54	12	A K BROWN JR	1
04-488	04-488	39	41	05	74	51	32	ANGORA STA HOSP	ASH 3
	04-487	39	41	08	74	51	21	ANGORA STA HOSP	S
04-495	04-495	39	40	15	74	50	30	M&R REFRACTORY	1
04-497	04-497	39	39	46	74	51	02	SJ TRANSIT MIX	1
04-502	04-502	39	38	51	74	50	14	SCORDO,ANTHONY	SCORDO 1

TABLE 3D-9
WELLS IN MT. LAUREL-WENONAH AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	WELL OWNER	WELL NAME
04- 18	04- 18	39	47	38	74	56	14	BERLIN WATER D	BWD 8
	04- 16	39	47	38	74	56	14	BERLIN WATER D	BWD 1
04- 20	04- 20	39	47	05	74	54	44	OWENS CORNING	1
04-184	04-184	39	50	15	74	57	52	LUCAS PAINT CO	MAIN
04-194	04-194	39	49	23	74	57	14	US AIR FORCE	RADAR 2
04-246	04-246	39	48	06	75	04	26	GAR ST WC-BLKWD	BLKWD DIV 5
04-252	04-252	39	47	19	75	01	46	ROBERT BENNETT	MONARCH BOILR
04-258	04-258	39	47	11	75	04	18	CAMDEN COUNTY	LAKELAND FNT
	04-255	39	47	14	75	04	10	CAMDEN COUNTY	LAKELAND 3
04-259	04-259	39	47	02	75	03	21	MYRA LORING	
04-264	04-264	39	46	18	75	02	35	H A SANDBERG	
04-267	04-267	39	46	07	75	00	31	GLOUCESTER TWP	BD OF EDUCATN
04-313	04-313	39	49	27	75	00	24	NJ WATER CO	LAUREL 1
	04-310	39	49	28	75	00	21	NJ WATER CO	LAUREL 8
	04-311	39	49	28	75	00	21	NJ WATER CO	LAUREL 10
	04-312	39	49	27	75	00	25	NJ WATER CO	LAUREL 4
04-395	04-395	39	46	49	74	58	33	PINE HILL MUA	PHMUA 2
04-399	04-399	39	46	38	74	58	50	L CAMDEN CO REG	OVERBROOK HS1
04-401	04-401	39	47	22	74	58	10	PINE VALLEY G C	GOLF CLUB
04-403	04-403	39	47	02	74	58	24	PINE VALLEY G C	GOLF CLB 1-49
04-413	04-413	39	51	48	74	56	15	THOMAS DECAU	1
04-421	04-421	39	51	08	74	56	48	HE MUSCHLET	
04-422	04-422	39	51	07	74	58	54	R H DOBBS	
04-424	04-424	39	50	36	74	55	36	JOHN MCCARTHY	
04-429	04-429	39	49	22	74	56	33	NJ WATER CO	ELM TREE 26
04-434	04-434	39	46	18	74	54	13	IVYSTONE W W	WATER WK 3-65
	04-433	39	46	18	74	54	13	IVYSTONE WW	WATER WKS2-62
04-450	04-450	39	45	22	74	56	25	JOHNS-MANVILLE	1

TABLE 3D-9 (Cont'd)
WELLS IN MT. LAUREL-WENONAH AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
	04-449	39	45	22	74	56	25	JOHNS-MANVILLE	2

TABLE 3D-10
WELLS IN ENGLISHTOWN AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04-154	04-154	39	53	31	74	59	20	ROSS,AB	1
04-163	04-163	39	52	29	74	57	22	HAROLD SNYDER	1
04-172	04-172	39	48	32	74	59	15	CLEMENTON ND	CWD 6
	04-170	39	48	32	74	59	15	CLEMENTON ND	CWD 8
04-173	04-173	39	48	07	74	58	06	CLEMENTON ND	CWD 9
04-233	04-233	39	49	22	75	02	45	ECKELS,JOSEPH J	1952
04-244	04-244	39	48	15	75	03	56	AMANDWS CARLTON	
04-447	04-447	39	45	32	74	56	23	JOHNS-MANVILLE	3

TABLE 30-11
WELLS IN MINOR MISCELLANEOUS AQUIFER
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
04-485	04-485	39	41	29	74	50	55	ANCORA FARM	POOR FARM
04-492	04-492	39	40	57	74	51	59	ANCORA STA HOSP	2
04-493	04-493	39	40	44	74	52	04	ANCORA STA HOSP	1
04-260	04-260	39	46	58	75	03	05	P HENDRICKS	
04-270	04-270	39	45	58	75	02	10	E G HOTHD	
04-272	04-272	39	45	12	75	01	45	WALTER JOHNSON	

TABLE 3D-12
WELLS IN COHANSEY AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
08- 2	08- 2	39	39	14	75	05	19	CLAYTON W D	CWD 3
08- 38	08- 38	39	39	52	75	08	59	HUGHES,WILSON	
08- 39	08- 39	39	37	51	75	01	07	FREESE BROS	
08- 45	08- 45	39	35	06	74	57	54	PEETS GLADIOLA	
08- 46	08- 46	39	35	02	75	01	44	MONGELLUZZO,LOU	3-1965
08- 49	08- 49	39	34	32	75	00	32	LESHAY,JOHN	LESHAY
08- 51	08- 51	39	33	46	75	01	27	TIRELLI,MICHAEL	1-1969
08- 52	08- 52	39	33	04	74	59	48	FABRIZIO,A	FABRIZIO
08- 56	08- 56	39	31	49	74	57	52	SCAPELLATO BROS	SCAPELLATO 2
08-198	08-198	39	40	58	74	59	25	MONROE TWP MUA	MTMUA 5-1967
08-199	08-199	39	40	50	74	59	58	VIOLET PACKING	2
08-204	08-204	39	32	54	75	01	21	NEWFIELD WD	NWD 3
08-268	08-268	39	42	35	75	04	27	SMITH,FRED	1964 WELL
08-342	08-342	39	40	52	74	59	30	MONROE TWP MUA	

TABLE 3D-13
WELLS IN MT. LAUREL-WINONAH AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
08-125	08-125	39	43	37	75	10	18	LEONARD,WILLIAM	4
08-127	08-127	39	43	16	75	10	02	HERITAGE & SONS	1

TABLE 3D-14
WELLS IN MINOR MISCELLANEOUS AQUIFER
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME
GA- 41	GA- 41	39	36	48	75	06	50	CLEMICK	1
GA-200	GA-200	39	39	44	74	59	34	LESHAY BROS	1965 WELL
GA-258	GA-258	39	44	39	75	04	42	WASHINTON T B E	WT BD ED 1970

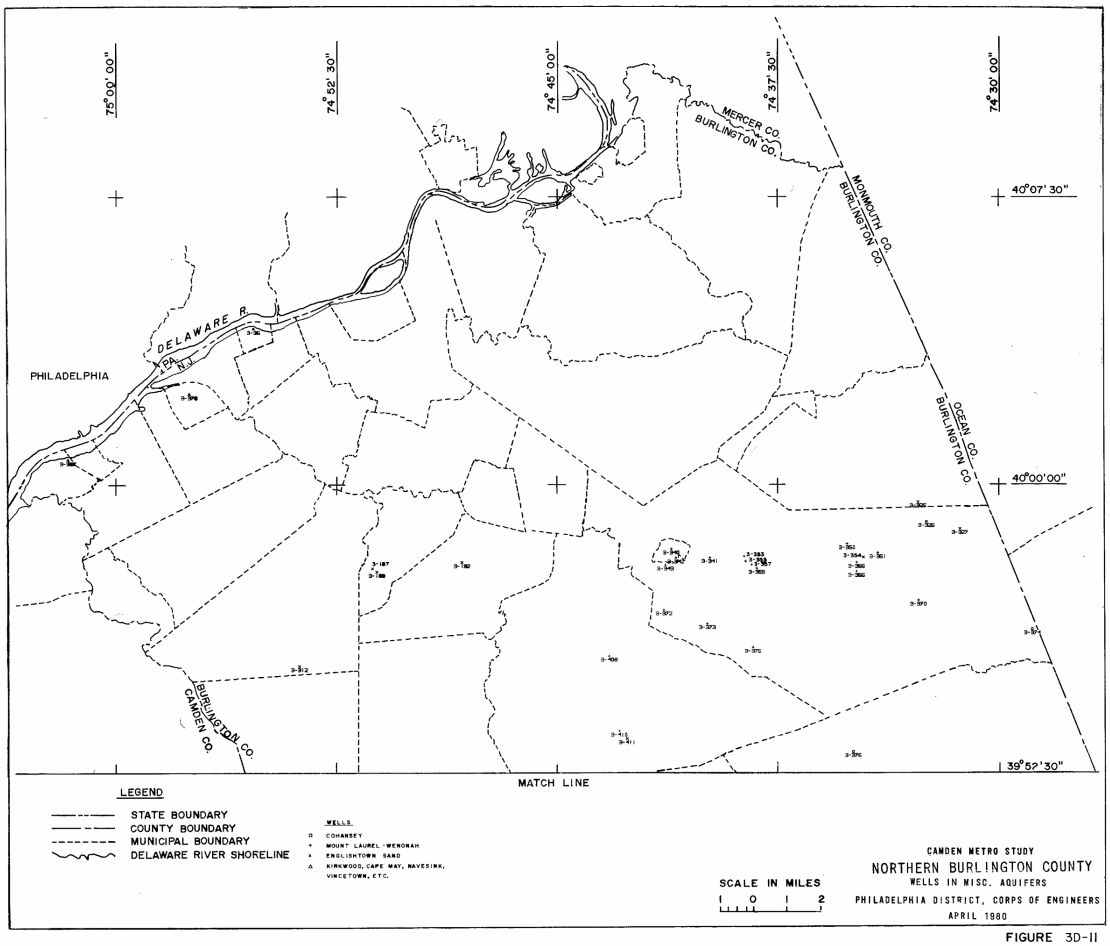

75°00'00"
74°52'30"
74°45'00"
74°37'30"
74°30'00"
40°07'30"
40°00'00"
39°52'30"
DELAWARE R.
PHILADELPHIA
PA.
N.J.
MERCER CO.
BURLINGTON CO.
MONMOUTH CO.
BURLINGTON CO.
OCEAN CO.
BURLINGTON CO.
BURLINGTON CO.
CAMDEN CO.
MATCH LINE
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
WELLS
COHANSEY
MOUNT LAUREL-WENONAH
ENGLISHTOWN SAND
KIRKWOOD, CAPE MAY, NAVESINK, VINCETOWN, ETC.
SCALE IN MILES
0
1
2
CAMDEN METRO STUDY
NORTHERN BURLINGTON COUNTY
WELLS IN MISC. AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-11

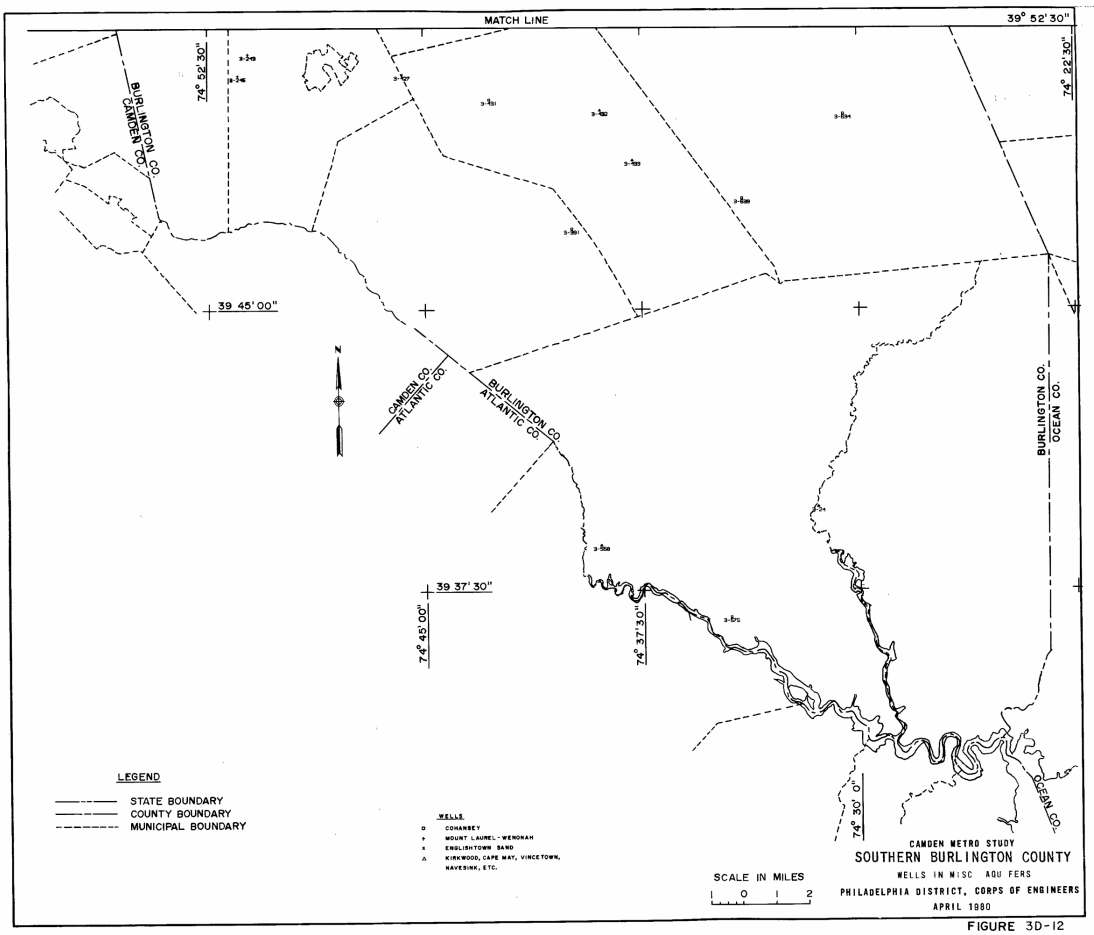

MATCH LINE
39° 52' 30"
74° 52' 30"
74° 22' 30"
BURLINGTON CO.
CAMDEN CO.
39 45' 00"
CAMDEN CO.
ATLANTIC CO.
BURLINGTON CO.
ATLANTIC CO.
BURLINGTON CO.
OCEAN CO.
39 37' 30"
74° 45' 00"
74° 37' 30"
74° 30' 00"
OCEAN CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
WELLS
COHANSEY
MOUNT LAUREL - WENONAH
ENGLISHTOWN SAND
KIRKWOOD, CAPE MAY, VINCETOWN, NAVESINK, ETC.
SCALE IN MILES
0 1 2
CAMDEN METRO STUDY
SOUTHERN BURLINGTON COUNTY
WELLS IN MISC AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-12

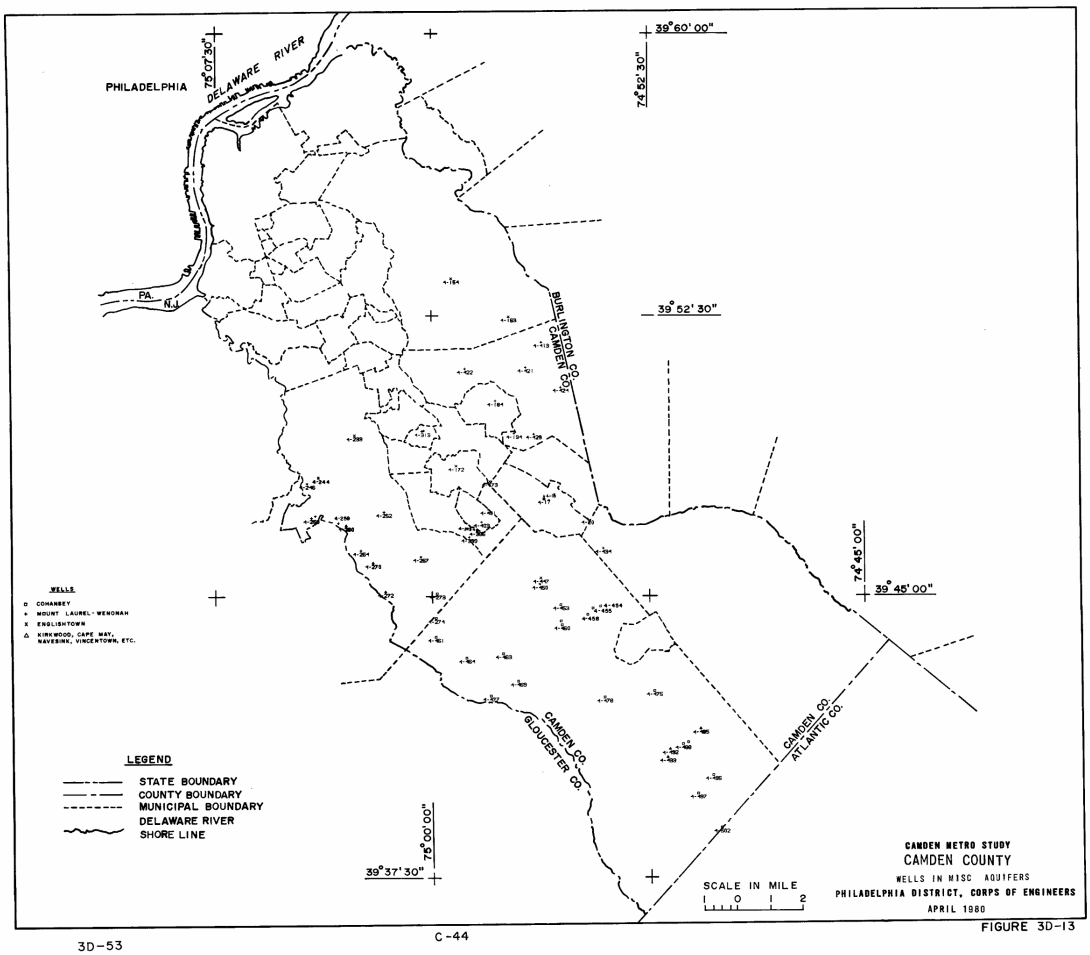

PHILADELPHIA
DELAWARE RIVER
75°07'30"
39°60'00"
74°52'30"
PA
NJ
BURLINGTON CO.
CAMDEN CO.
39°52'30"
74°45'00"
39°45'00"
WELLS
CohansEY
MOUNT LAUREL - WENONAH
ENGLISHTOWN
KIRKWOOD, CAPE MAY, NAVESINK, VINCENTOWN, ETC.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER
SHORE LINE
CAMDEN CO.
GLOUCESTER CO.
CAMDEN CO.
ATLANTIC CO.
75°00'00"
39°37'30"
SCALE IN MILE
0
1
2
CAMDEN METRO STUDY
CAMDEN COUNTY
WELLS IN MISC AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-13

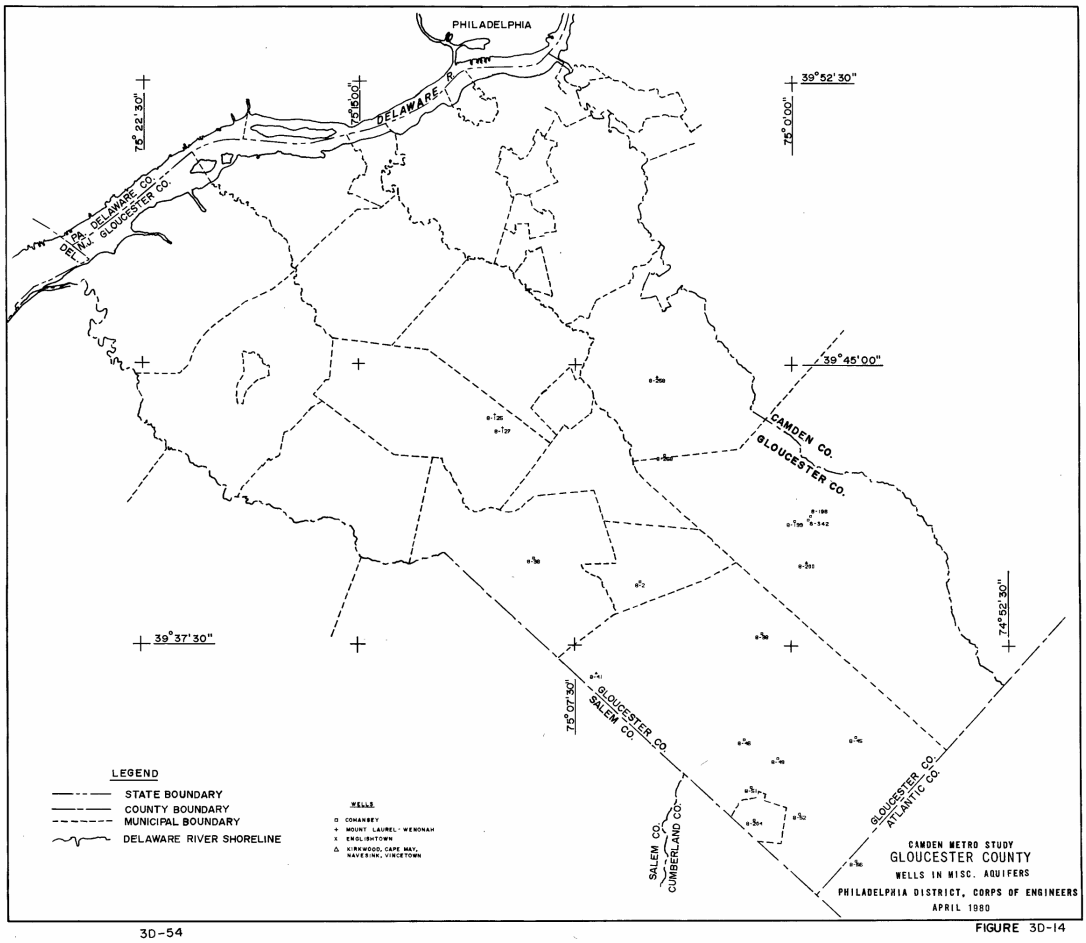

PHILADELPHIA
DELAWARE R.
PA. DELAWARE CO.
N.J. GLOUCESTER CO.
75° 22' 30"
75° 15' 00"
39° 52' 30"
75° 0' 00"
39° 45' 00"
CAMDEN CO.
GLOUCESTER CO.
39° 37' 30"
74° 52' 30"
75° 07' 30"
GLOUCESTER CO.
SALEM CO.
SALEM CO.
CUMBERLAND CO.
GLOUCESTER CO.
ATLANTIC CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
WELLS
COHANSEY
MOUNT LAUREL - WENONAH
ENGLISHTOWN
KIRKWOOD, CAPE MAY, NAVESINK, VINCETOWN
CAMDEN METRO STUDY
GLOUCESTER COUNTY
WELLS IN MISC. AQUIFERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-14

TABLE 3D-15
IRRIGATION WELLS IN ALL AQUIFERS
BURLINGTON COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME	AQUIFER
03- 68	03- 68	40	05	42	74	48	41	COLUMBUS METAL	COLUMBUS	MGRR
03- 87	03- 87	40	03	38	74	52	45	MURPHY,CAROL	FOX HILL FARM	MGRR
03- 89	03- 89	40	03	31	74	53	16	HEISLER,ALBERT		MGRR
	03- 88	40	03	31	74	53	17	HEISLER,EDGAR B	HEISLER 1	MGRR
03- 91	03- 91	40	03	24	74	51	52	HEAL,CHARLES JR	HEAL	MGRR
03- 92	03- 92	40	03	20	74	49	38	KELLER,EARL B	EBK 1	MGRR
03- 98	03- 98	40	03	01	74	52	42	PINO,FRANK		MGRR
03- 99	03- 99	40	02	54	74	52	47	CANNULI,ANTHONY		MGRR
03-106	03-106	40	09	34	74	40	19	NJS REFORMATORY	NJSR 5	MGRR
03-108	03-108	40	08	21	74	38	45	D ANGELO,WM	WILKENS FARM1	MGRR
03-123	03-123	40	00	12	75	00	13	RIVERTON CLUB	COUNTRY CLUB	MGRR
03-126	03-126	39	59	45	75	00	11	RIVERTON CLUB	2	MGRR
03-134	03-134	40	02	41	74	55	46	CHANT,HARRY R	CHANT1	MGRR
03-143	03-143	40	01	09	74	57	10	HOLY CROSS H S	HIGH SCHOOL	MGRR
03-153	03-153	40	03	09	74	54	32	HEAL,JOHN W		MGRR
03-154	03-154	40	02	52	74	54	22	BLYLER,EARL R		MGRR
03-156	03-156	40	02	08	74	54	34	CRAM P,MARTIN C	CRAMP 1	MGRR
03-160	03-160	39	54	12	74	56	18	ROBERTS,BYRON T	ROBERTS 2	MGRR
03-167	03-167	39	52	46	74	53	26	INDIAN SPNG G C	ISGC 1	MGRR
03-180	03-180	40	06	02	74	47	56	HARRIS NURSEY	HARRIS	MGRR
03-184	03-184	40	05	09	74	48	22	D-J CANNULI	CANNULI	MGRR
	03- 74	40	05	20	74	48	33	DONALD,WILLIAM	DONALD	MGRR
03-189	03-189	39	57	48	74	51	06	FRED WORTH-SONS	1	MGRR
	03-187	39	57	53	74	51	15	FRED WORTH-SONS	WORTH 1	MGRR
	03-188	39	57	50	74	51	07	FRED WORTH-SONS	WORTH	MGRR
03-235	03-235	39	55	09	74	51	02	JOHNSON,W E JR	JOHNSON NEW	MGRR
	03-234	39	55	09	74	51	02	JOHNSON,W E JR	JOHNSON	MGRR
03-261	03-261	39	58	40	74	57	00	FIRST PRES CH	1964	MGRR

TABLE 3D-15 (Cont'd)
IRRIGATION WELLS IN ALL AQUIFERS
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME	AQUIFER
03-263	03-263	39	58	35	74	56	43	MOORESTOWN F C	FIELD CLUB 1	MGRR
03-292	03-292	39	58	44	74	52	41	LARCHMONT FARMS	C W HAINES 1	MGRR
	03-291	39	58	45	74	52	40	HAINES,WM JR	FARM WELL 1	MGRR
03-293	03-293	39	58	30	74	53	02	HAINES,WM JR	FARM WELL 2	MGRR
03-311	03-311	39	55	25	74	54	16	RUDDEROW, J E	SPRING VALLEY	MGRR
03-373	03-373	39	56	30	74	39	55	GOWER,HARVEY	GOWER	MLRW
03-374	03-374	39	56	22	74	28	55	J J WHITE CO	IRRIGATION 1	CKKD
03-375	03-375	39	55	53	74	38	22	BUSH,FRANCIS	BUSH	MLRW
03-383	03-383	40	01	58	74	57	10	RIVERSIDE P SCH		MGRR
03-392	03-392	39	45	06	74	43	14	ABRAMS,EVERETT		PLCC
03-414	03-414	40	03	24	74	39	51	TALLMAN,I W	TALLMAN 1	MGRR
03-418	03-418	40	02	56	74	41	11	HELIS,WM G	STOCK FARM 3	MGRR
03-431	03-431	39	50	34	74	42	42	RUSSO,ANTHONY	2	CNSY
	03-430	39	50	36	74	42	43	RUSSO,ANTHONY	1	CNSY
03-432	03-432	39	50	17	74	38	53	BIRCHES CRNBERY	BIRCHES 2	KRKD
03-433	03-433	39	48	58	74	37	46	BIRCHES CRNBERY	BIRCHES 1	KRKD
03-575	03-575	39	36	50	74	34	27	GREEN BANK SFN		CNSY
03-580	03-580	40	01	57	74	48	20	BC COUNTRY CLUB	1	MGRR
03-583	03-583	40	01	22	74	51	41	CAMPBELL SOUP	RANCOCAS # 1	MGRR
03-612	03-612	40	00	54	74	53	42	LEVITT AND SONS	GOLF COURSE 1	MGRR
03-639	03-639	39	47	57	74	33	59	DEMARCO ENT	2-1971	CNSY

TABLE 3D-16
IRRIGATION WELLS IN ALL AQUIFERS
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME	AQUIFER
08- 35	08- 35	39	40	18	75	08	55	HUGHES,EARL	2-1964	CNSY
	08- 32	39	40	25	75	08	51	HUGHES,WILSON J		CNSY
	08- 33	39	40	22	75	09	02	HUGHES,WILSON J	1965 WELL	CNSY
	08- 34	39	40	19	75	08	55	HUGHES,EARL	1-1964	CNSY
08- 37	08- 37	39	39	58	75	12	37	MOOD RICHARD J	1	MGRR
08- 38	08- 38	39	39	52	75	08	59	HUGHES,WILSON J		CNSY
08- 39	08- 39	39	37	51	75	01	07	FREESE BROS		CNSY
08- 40	08- 40	39	37	37	75	06	00	SCHOBER,F JR	1	CNSY
08- 41	08- 41	39	36	48	75	06	50	CLEMICK,A	1	KRKD
08- 45	08- 45	39	35	06	74	57	54	PEETS GLADIOLA		CNSY
08- 46	08- 46	39	35	02	75	01	44	MONGELLUZZO,LOU	3-1965	CNSY
08- 48	08- 48	39	34	48	74	56	13	FERRUCCI BROS	1966 WELL	CNSY
08- 49	08- 49	39	34	32	75	00	32	LESHAY,JOHN	LESHAY	CNSY
08- 51	08- 51	39	33	46	75	01	27	TIRELLI,MICHAEL	1-1969	CNSY
08- 52	08- 52	39	33	04	74	59	48	FABRIZIO,A	FABRIZIO	CNSY
08- 53	08- 53	39	32	53	74	59	08	DANKO,JOHN	1	CNSY
08- 56	08- 56	39	31	49	74	57	52	SCAPELLATO BROS	SCAPELLATO 2	CNSY
	08- 55	39	31	49	74	57	52	SCAPELLATO BROS	SCAPELLATO 1	CNSY
08- 57	08- 57	39	31	48	74	58	22	CIFALOGLIO,S	1	CKKD
08-119	08-119	39	44	50	75	14	00	VASALLI,JOSEPH	VASALLI 1	MGRR
08-125	08-125	39	43	37	75	10	18	LEONARD,WM	4	MLRW
	08-124	39	43	46	75	09	59	LEONARD,WM	LEONARD 5	MGRR
08-127	08-127	39	43	16	75	10	02	HERITAGE & SONS	1	MLRW
08-193	08-193	39	44	30	75	09	11	PITMAN CNTY CLB	COUNTRY CLUB1	MGRR
08-194	08-194	39	43	49	75	09	09	MADERA HARRY	1	MGRR
08-200	08-200	39	39	44	74	59	34	LESHAY BROS	1965 WELL	KRKD
08-222	08-222	39	43	28	75	08	31	ZEE,J W	P-544	MLRW
08-258	08-258	39	44	39	75	04	42	WASHINGTN T B E	WT BD ED 1970	KRKD

TABLE 3D-16 (Cont'd)
IRRIGATION WELLS IN ALL AQUIFERS
GLOUCESTER COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME	AQUIFER
08-265	08-265	39	43	35	75	03	43	SMITH,F	2	MGRR
08-268	08-268	39	42	35	75	04	27	SMITH,FRED	1964 WELL	CNSY
08-300	08-300	39	49	39	75	10	07	WESTWOOD GOLF C	1-1973	MGRR
08-337	08-337	39	43	46	75	21	10	MAUGERI,SAL	MAUGERI SI	MGRR

TABLE 3D-17
IRRIGATION WELLS IN ALL AQUIFERS
CAMDEN COUNTY

PLOTTED WELL NUMBER	WELL #	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	WELL OWNER	WELL NAME	AQUIFER
04-124	04-124	39	56	06	75	01	48	GS RACING ASSOC	CHRY HLL INN2	MGRR
04-132	04-132	39	55	14	75	02	13	GARDEN STATE PK	RACE TRACK	MGRR
04-147	04-147	39	54	06	74	58	41	ARNOLD PALMER	DRIVING RANGE	MGRR
04-183	04-183	39	50	15	74	57	52	LUCAS PAINT CO	STEAM PUMP	MLRW
04-300	04-300	39	54	16	75	03	36	HADDON TWP RD E	HADDON TWP HS	MGRR
04-306	04-306	39	53	51	75	03	13	GREEN VALLEY FM	FARM 2	MGRR
04-399	04-399	39	46	38	74	58	50	L CAM COREG	OVERBRK HS 1	MLRW
04-407	04-407	39	51	28	75	03	50	EASTERN RECORD	EASTERN 1	MGRR
04-412	04-412	39	52	37	75	01	22	TAVISTOCK CLUB	COUNTRY CLUB1	MGRR
04-413	04-413	39	51	48	74	56	15	THOMAS DECAU	1	MLRW
04-437	04-437	39	46	13	74	53	53	AL GIORDANO	1	PLCC
04-441	04-441	39	43	41	74	51	17	BRIDGE VIEW FAR	1	PLCC
04-443	04-443	39	42	43	74	49	18	E A CAPOFERRI	1	PLCC
.0-444	.0-444	39	42	29	74	49	41	E A CAPOFERRI	2	PLCC
04-461	04-461	39	44	00	74	59	59	N TOMASELLA	1	PLCC
04-464	04-464	39	43	26	74	58	56	JOSEPH VOLPA		PLCC
04-478	04-478	39	42	21	74	54	12	A K BROWN JR	1	PLCC
04-496	04-496	39	39	57	74	49	40	JOSEPH DEMEGLIO	1	PLCC
04-502	04-502	39	38	51	74	50	14	SCORDO,ANTHONY	SCORDO 1	CNSV
04-510	04-510	39	40	23	74	50	04	RUGGERO,GEORGE		CNSV

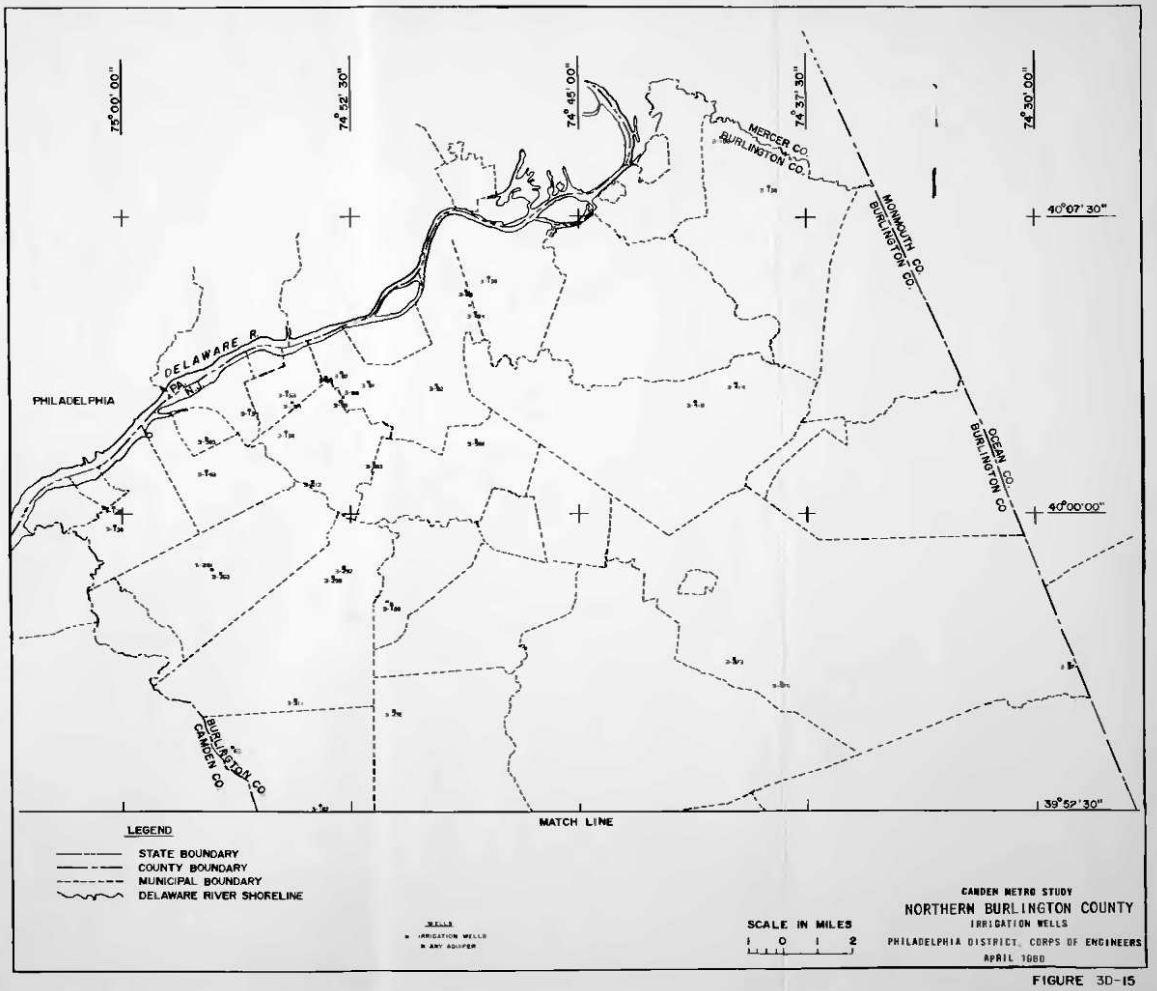

75°00'00"
74°52'30"
74°45'00"
74°37'30"
74°30'00"
40°07'30"
40°00'00"
39°52'30"
DELAWARE R.
PHILADELPHIA
PA
NJ
MERCER CO.
BURLINGTON CO.
MONMOUTH CO.
BURLINGTON CO.
OCEAN CO.
BURLINGTON CO.
BURLINGTON CO.
CAMDEN CO.
MATCH LINE
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
SCALE IN MILES
0
1
2
CAMDEN METRO STUDY
NORTHERN BURLINGTON COUNTY
IRRIGATION WELLS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-15

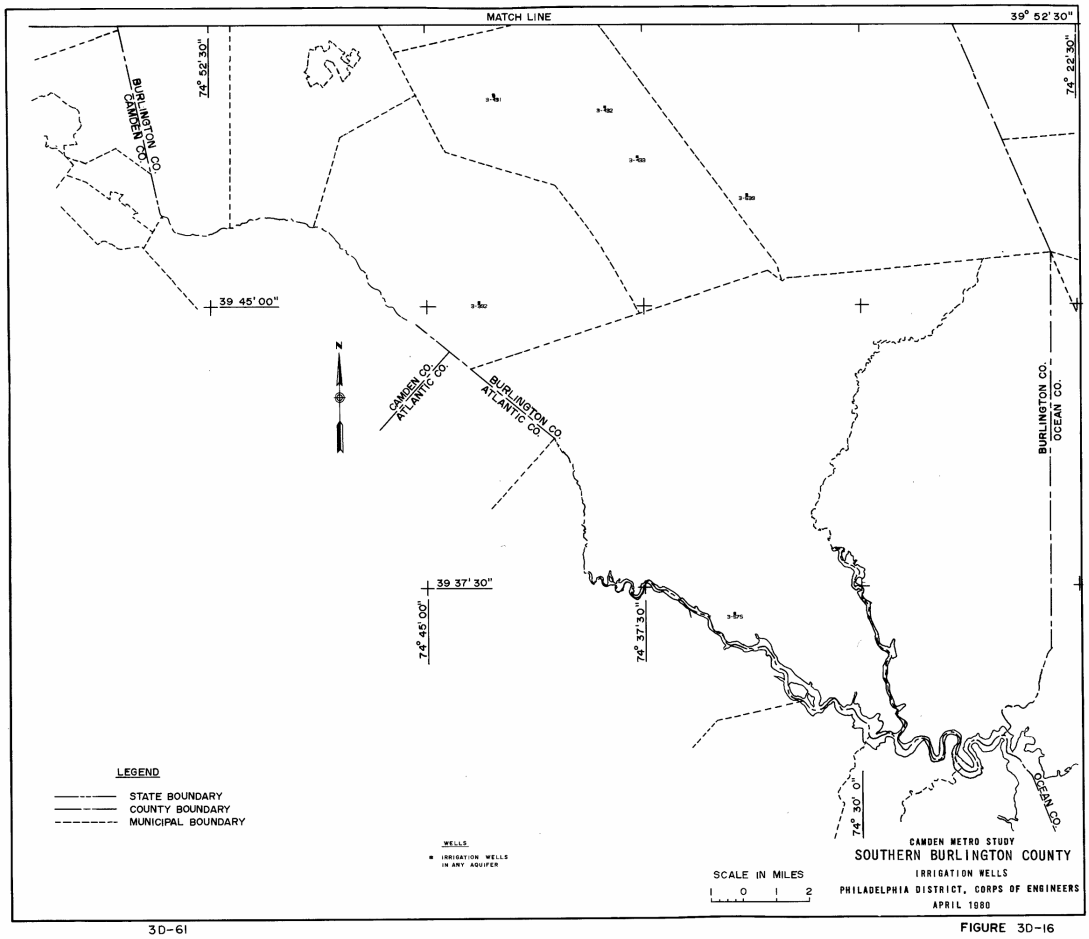
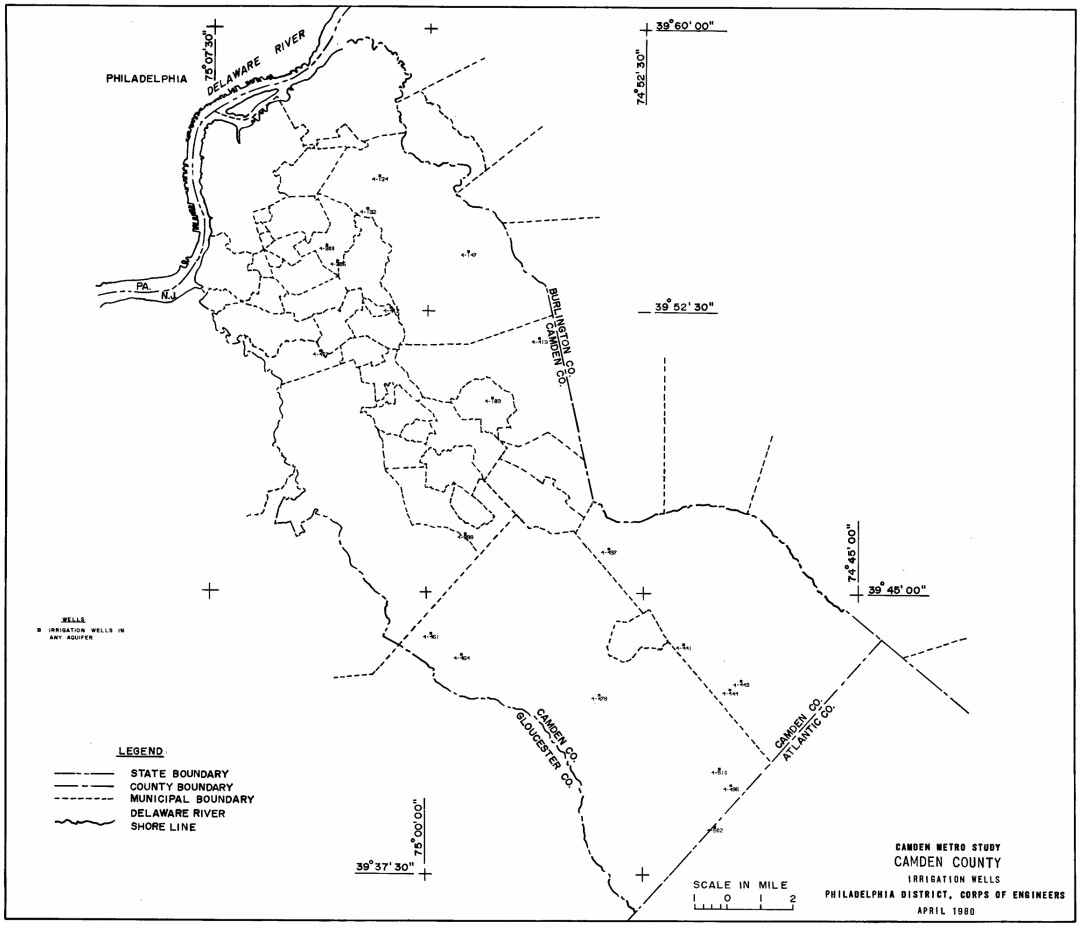

MATCH LINE
39° 52' 30"
74° 52' 30"
74° 22' 30"
BURLINGTON CO.
CAMDEN CO.
39 45' 00"
CAMDEN CO.
ATLANTIC CO.
BURLINGTON CO.
ATLANTIC CO.
BURLINGTON CO.
OCEAN CO.
39 37' 30"
74° 45' 00"
74° 37' 30"
74° 30' 0"
OCEAN CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
WELLS
IRRIGATION WELLS IN ANY AQUIFER
SCALE IN MILES
0
1
2
CAMDEN METRO STUDY
SOUTHERN BURLINGTON COUNTY
IRRIGATION WELLS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-16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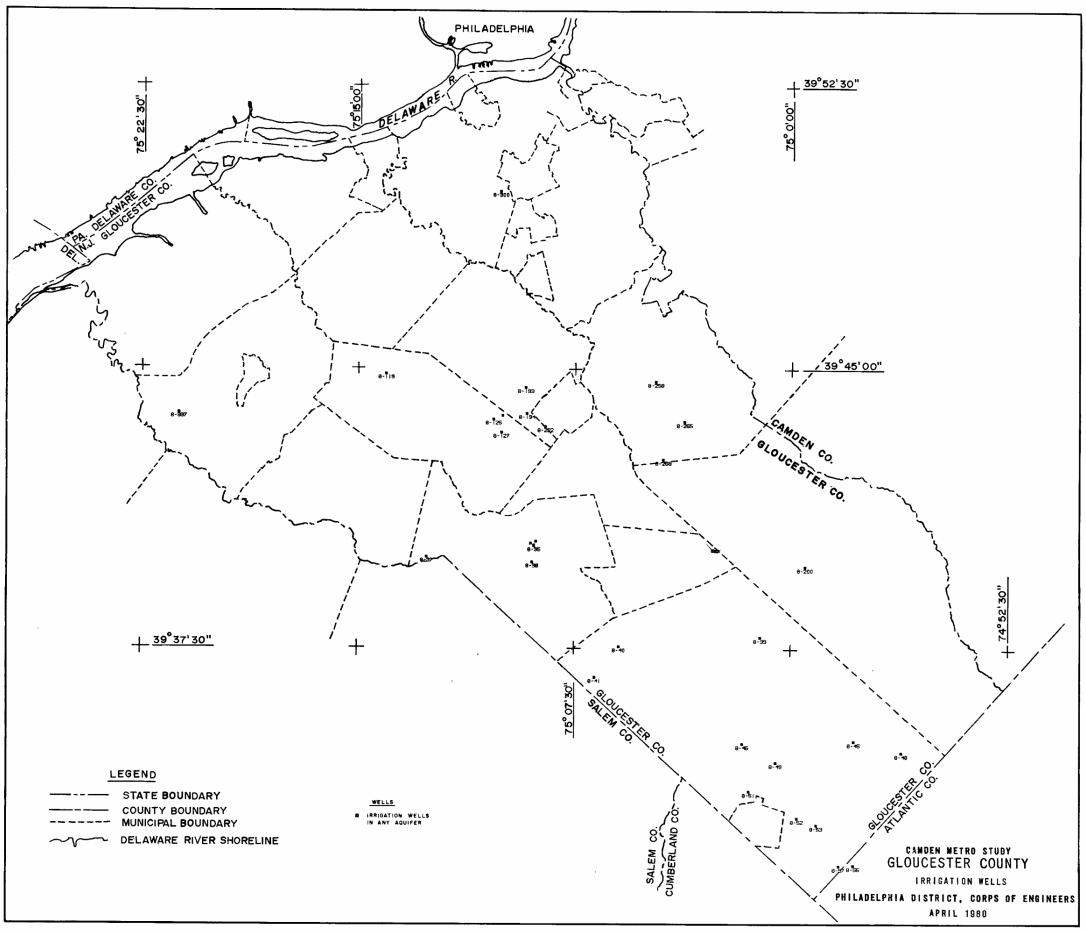
N.J.
BURLINGTON CO.
CAMDEN CO.
CAMDEN CO.
GLOUCESTER CO.
CAMDEN CO.
ATLANTIC CO.
WELLS
IRRIGATION WELLS IN ANY AQUIFER
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORE LINE
SCALE IN MILE
0
2
CAMDEN METRO STUDY
CAMDEN COUNTY
IRRIGATION WELLS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-17


PHILADELPHIA
DELAWARE R.
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DEL.
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DELAWARE CO.
GLOUCESTER CO.
39° 45' 00"
CAMDEN CO.
GLOUCESTER CO.
74° 52' 30"
39° 37' 30"
75° 07' 30"
GLOUCESTER CO.
SALEM CO.
SALEM CO.
CUMBERLAND CO.
GLOUCESTER CO.
ATLANTIC CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
WELLS
IRRIGATION WELLS IN ANY AQUIFER
CAMDEN METRO STUDY
GLOUCESTER COUNTY
IRRIGATION WELLS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-18

SERVICE AREAS

Service area information was collected from the NJDEP and from the Delaware Valley Regional Planning Commission (DVRPC). Both agencies supplied maps (1" = 1 mi. 1976) detailing present service areas. County maps delineating water company service areas were also developed. The service area boundaries are an updated version of those compiled by the NJDEP in August 1976. The result is a fairly reliable mapping of present service areas on which to base other work with projection figures.

The analysis assigns water purveyors to account for the major users in any given area. This is based on the assumption that the major use in the future will be demanded from a municipal water supply system. DVRPC has projected the number of sewered homes to the year 2000 in their "Waste Treatment Management Interim Projections Report." Those projections were extended to the year 2030 to project overall water use figures in the study area. These figures, in conjunction with the service area maps, resolve the problems of assignment of supply to local users. Table 3D-18 is a listing of the major water supply purveyors while Figures 3D-19 through 3D-22 show their spatial distribution.

TABLE 3D-18

WATER SUPPLY PURVEYORS

BURLINGTON COUNTY

COMPANY	MAJOR WATER SOURCE	LATEST PUMPAGE (MGD)	DIVERSION LIMIT (MGD)
Bordentown Water Dept.	G.W. Raritan/Magothy	2.25	3.00
Burlington City Water Dept.	G.W. Infiltration Delaware R.	2.12	5.17
Burlington Twp. Water Dept.	G.W. Raritan/Magothy	1.20	2.70
Columbus Water Co.	G.W. Raritan/Magothy	2.00	3.00
Crosswicks Water Co. (Garden St. Water Co. Hamilton Sq. Div.)	G.W. Raritan/Magothy	0.05	2.80
Evasham Mun. Util. Auth.	G.W. Raritan/Magothy	1.71	2.83
Florence Twp. Water Dept.	G.W. Raritan/Magothy	1.01	2.00
Fort Dix	(MILLITARY SUPPLY)		
Hampton Lakes Water Co.	G.W. Mt. Laurel/Wenonah	0.24	1.00
Lakes Water Co.	G.W. Raritan/Magothy	0.12	0.35
Lake Valley Water Co.	G.W. Mt. Laurel/Wenonah	0.17	0.36
Maple Shade Township Water Dept.	G.W. Raritan/Magothy	1.85	3.10
Medford Water Co.	G.W. Raritan/Magothy	0.15	0.31
Moorestown Township Water Dept.	G.W. Raritan/Magothy	2.14	3.67
Mt. Holly Water Co.	G.W. Raritan/Magothy	2.48	3.10
Mt. Laurel Mun. Util. Auth	G.W. Raritan/Magothy	0.54	3.13
New Jersey Water Co. (Delaware Valley Dist.)	G.W. Raritan/Magothy	6.76	16.12
Pemberton Boro	G.W. Englishtown	0.02	0.35
Pemberton Township Water Dept.	G.W. Raritan/Magothy		0.29
Sunbury Village Water Co.	G.W. Mt. Laurel/Wenonah	0.08	0.20
Taunton Lakes Water Co.	G.W. Mt. Laurel/Wenonah	--	--
Willingboro Mun. Util. Auth.	G.W. Raritan/Magothy	4.43	10.33
Wrightstown Water Co.	G.W. Raritan/Magothy	0.12	0.30
Vincentown	G.W. Mt. Laurel/Wenonah	0.05	0.10

TABLE 3D-18 (Cont'd)

WATER SUPPLY PURVEYORS

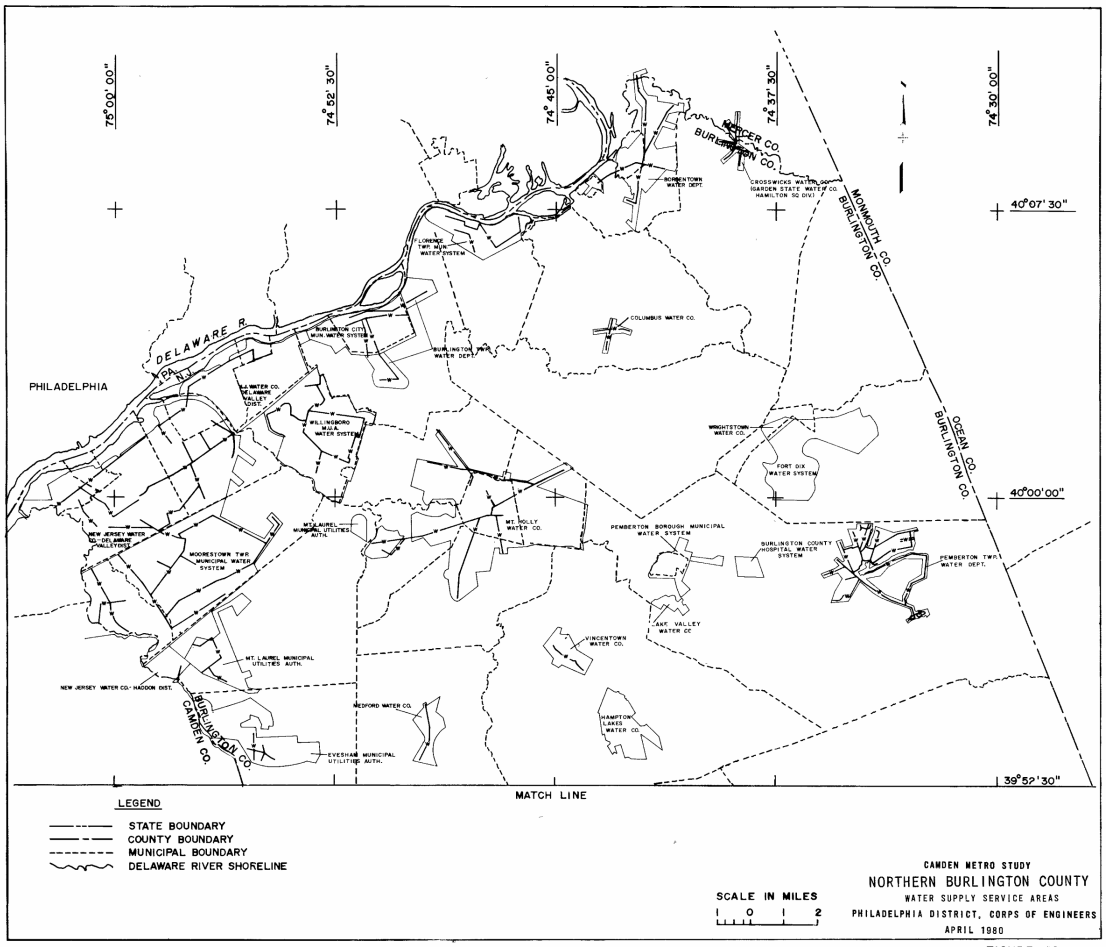
COMPANY	MAJOR WATER SOURCE	LATEST PUMPAGE (MGD)	DIVERSION LIMIT (MGD)
CAMDEN COUNTY			
Bellmawr Water Dept.	G.W. Raritan/Magothy	1.43	2.07
Berlin Water Dept.	G.W. Raritan/Magothy	0.98	1.50
Brooklawn Mun. Util., Auth.	G.W. Raritan/Magothy	0.26	0.52
Camden City Water Co.	G.W. Raritan/Magothy	24.56	44.64
Clementon Water Dept.	G.W. Raritan/Magothy	0.54	1.00
Collingswood Mun. Util. Auth.	G.W. Raritan/Magothy	2.91	5.17
Garden State Water Co. (Blackwood Div.)	G.W. Raritan/Magothy	1.16	2.50
Gloucester City Water Dept.	G.W. Raritan/Magothy	1.99	3.10
Haddonfield Mun. Util. Auth.	G.W. Raritan/Magothy	1.32	3.25
Haddon Twp. Water Dept.	G.W. Raritan/Magothy	2.03	2.07
Ivystone Water Co.	G.W. Cohansey	0.04	0.26
Merchantville-Pennsauken Water Co.	G.W. Raritan/Magothy	7.07	11.50
Mt. Ephraim Water Co. (purchase water	from NJ Water Co. Haddon Dist.)		
NJ Water Co. (Camden District)	G.W. Raritan/Magothy	4.34	6.46
NJ Water Co. (Haddon District)	G.W. Raritan/Magothy	19.33	27.17
Pine Hill Boro Mun. Util. Auth.	G.W. Raritan/Magothy	0.54	0.78
Winslow Water Co.	G.W. Cohansey	0.34	-
GLOUCESTER COUNTY			
Clayton Water Dept.	G.W. Raritan/Magothy	0.46	1.00
Deptford Twp. Mun. Util. Auth.	G.W. Raritan/Magothy	1.87	2.50
East Greenwich Twp. Mun. Util. Auth.	G.W. Raritan/Magothy	0.55	1.00
Edenwood Water Co.	G.W. Raritan/Magothy	0.19	0.50
Glassboro Water Dept.	G.W. Raritan/Magothy	1.46	3.00
Greenwick Twp. Mun. Util. Auth.	G.W. Raritan/Magothy	0.63	1.61
Mantua Water Co.	G.W. Raritan/Magothy	0.09	0.20
Monroe Twp. Mun. Util Auth.	G.W. Cohansey	0.66	1.45

TABLE 3D-18 (Cont'd)

WATER SUPPLY PURVEYORS

GLOUCESTER COUNTY (Cont'd)

COMPANY	MAJOR WATER SOURCE	LATEST PUMPAGE (MGD)	DIVERSION LIMIT (MGD)
National Park Water Dept.	G.W. Raritan/Magothy	0.29	0.78
Newfield Water Dept.	G.W. Cohansey	0.84	1.81
Paulsboro Mun. Util. Auth.	G.W. Raritan/Magothy	1.43	2.07
Pitman Boro. Mun. Util Auth	G.W. Raritan/Magothy	1.46	2.75
Penns Grove Mun. Util Auth. (Bridgeport Div.)	G.W. Raritan/Magothy	0.34	1.00
Pureland	G.W. Raritan/Magothy	-	5.17
Sewell Water Co.	G.W. Raritan/Magothy	0.21	0.41
South Jersey Water Co.	G.W. Raritan/Magothy	0.08	0.18
Swedesboro Mun. Util. Auth.	G.W. Raritan/Magothy	0.33	0.36
Washington Twp. Mun. Util. Auth.	G.W. Raritan/Magothy	1.23	2.88
Wenonah	G.W. Raritan/Magothy	0.16	0.52
West Deptford Twp. Mun. Util. Auth. (incl. Greenfield Water Co.)	G.W. Raritan/Magothy	1.55	4.44
Westville Mun. Util. Auth	G.W. Raritan/Magothy	0.75	0.83
Woodbury Water Dept.	G.W. Raritan/Magothy	1.41	3.62
Woodbury Heights Water Co.	G.W. Raritan/Magothy	-	0.60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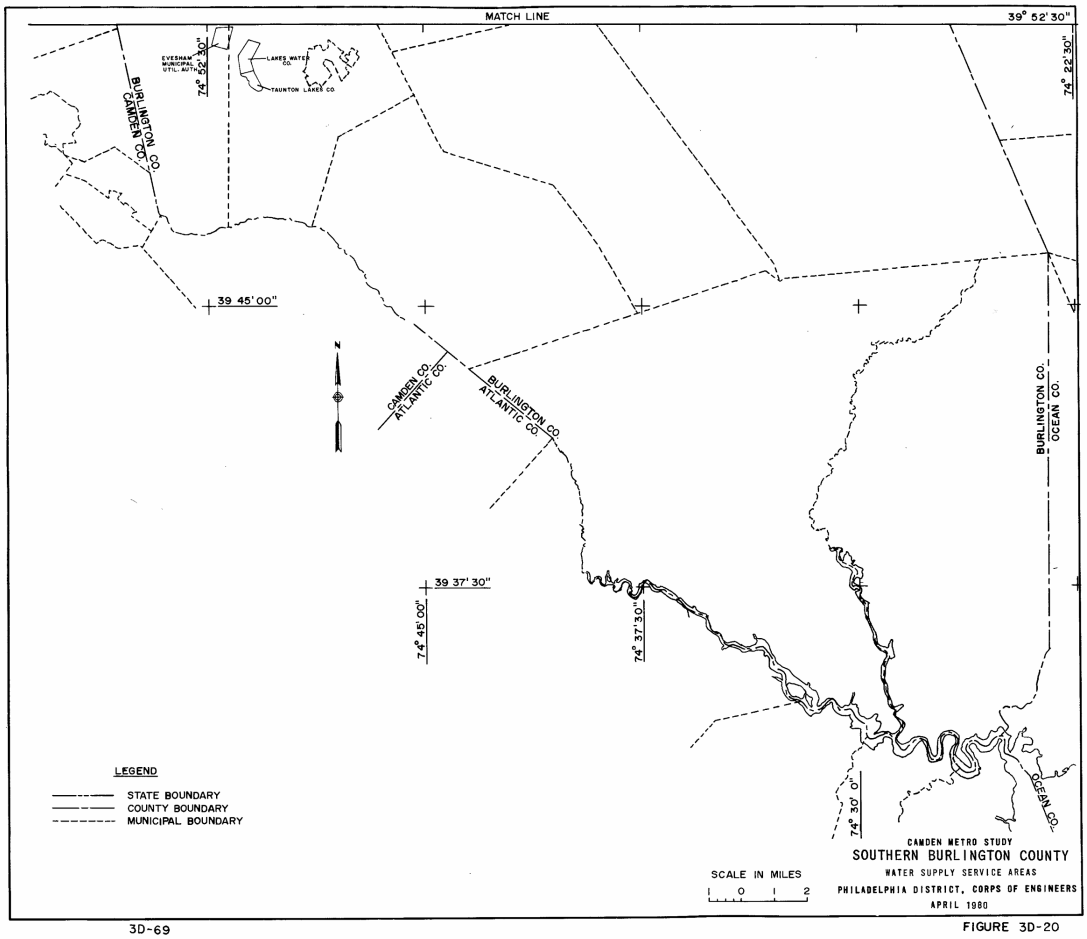
DELAWARE R.
PHILADELPHIA
BURLINGTON CO.
MERCER CO.
MONMOUTH CO.
OCEAN CO.
CAMDEN CO.
BURLINGTON CITY MUN. WATER SYSTEM
BURLINGTON TWP. WATER DEPT.
FLORENCE TWP. MUN. WATER SYSTEM
BORDENTOWN WATER DEPT.
CROSSWICKS WATER CO.
GARDEN STATE WATER CO. HAMILTON SQ. DIV.
COLUMBUS WATER CO.
WILLINGBORO MUA WATER SYSTEM
NEW JERSEY WATER CO.-DELAWARE VALLEY DIST.
MOORESTOWN TWP. MUNICIPAL WATER SYSTEM
MT. LAUREL MUNICIPAL UTILITIES AUTH.
MT. HOLLY WATER CO.
WRIGHTSTOWN WATER CO.
FORT DIX WATER SYSTEM
PEMBERTON BOROUGH MUNICIPAL WATER SYSTEM
BURLINGTON COUNTY HOSPITAL WATER SYSTEM
PEMBERTON TWP. WATER DEPT.
ARP. VALLEY WATER CO.
VINCENTOWN WATER CO.
HAMPTON LAKES WATER CO.
MEDFORD WATER CO.
EVESHAM MUNICIPAL UTILITIES AUTH.
NEW JERSEY WATER CO.-HADDON DIST.
MATCH LINE
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
SCALE IN MILES
0
1
2
CAMDEN METRO STUDY
NORTHERN BURLINGTON COUNTY
WATER SUPPLY SERVICE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE. 3D-19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74° 22' 30"
EVESHAM MUNICIPAL UTIL. AUTH.
LAKES WATER CO.
TAUNTON LAKES CO.
BURLINGTON CO.
CAMDEN CO.
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CAMDEN CO.
ATLANTIC CO.
BURLINGTON CO.
ATLANTIC CO.
BURLINGTON CO.
OCEAN CO.
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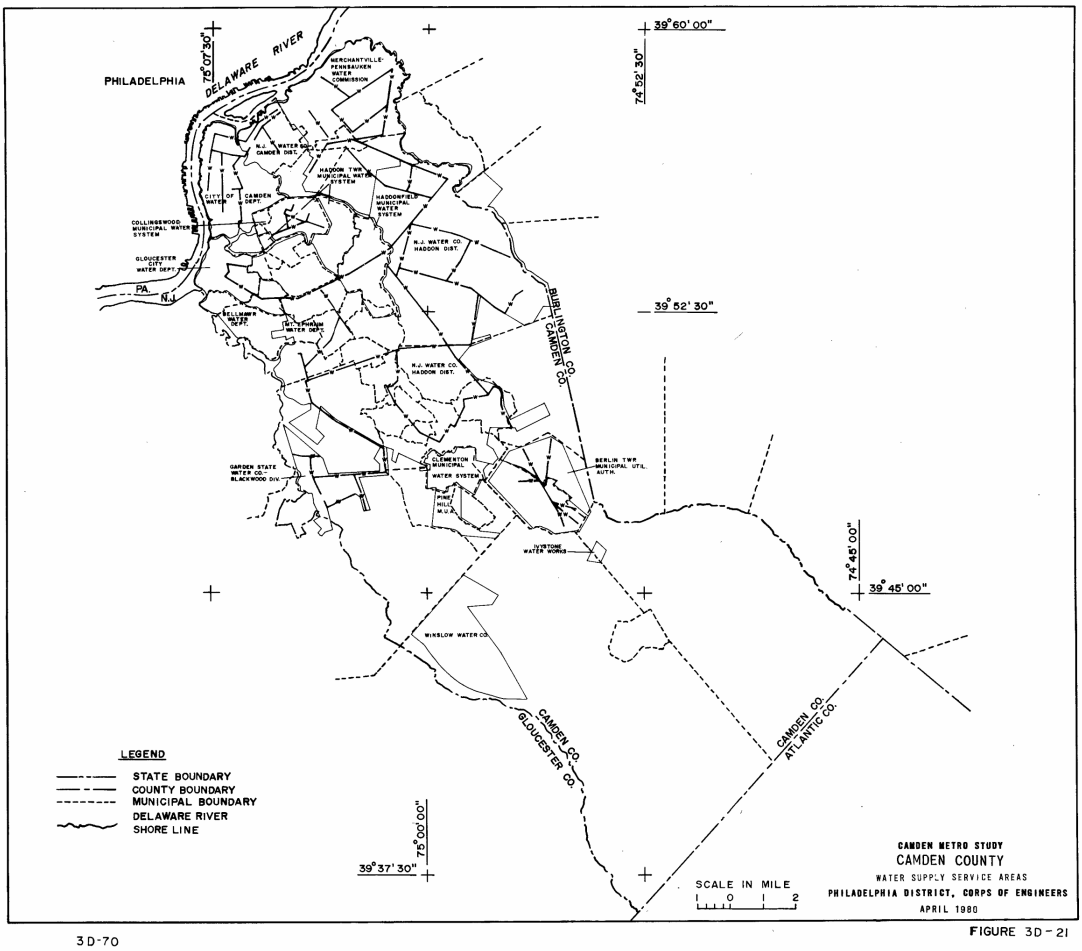
74° 30' 0"
OCEAN CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
SCALE IN MILES
0 1 2
CAMDEN METRO STUDY
SOUTHERN BURLINGTON COUNTY
WATER SUPPLY SERVICE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-20


PHILADELPHIA
DELAWARE RIVER
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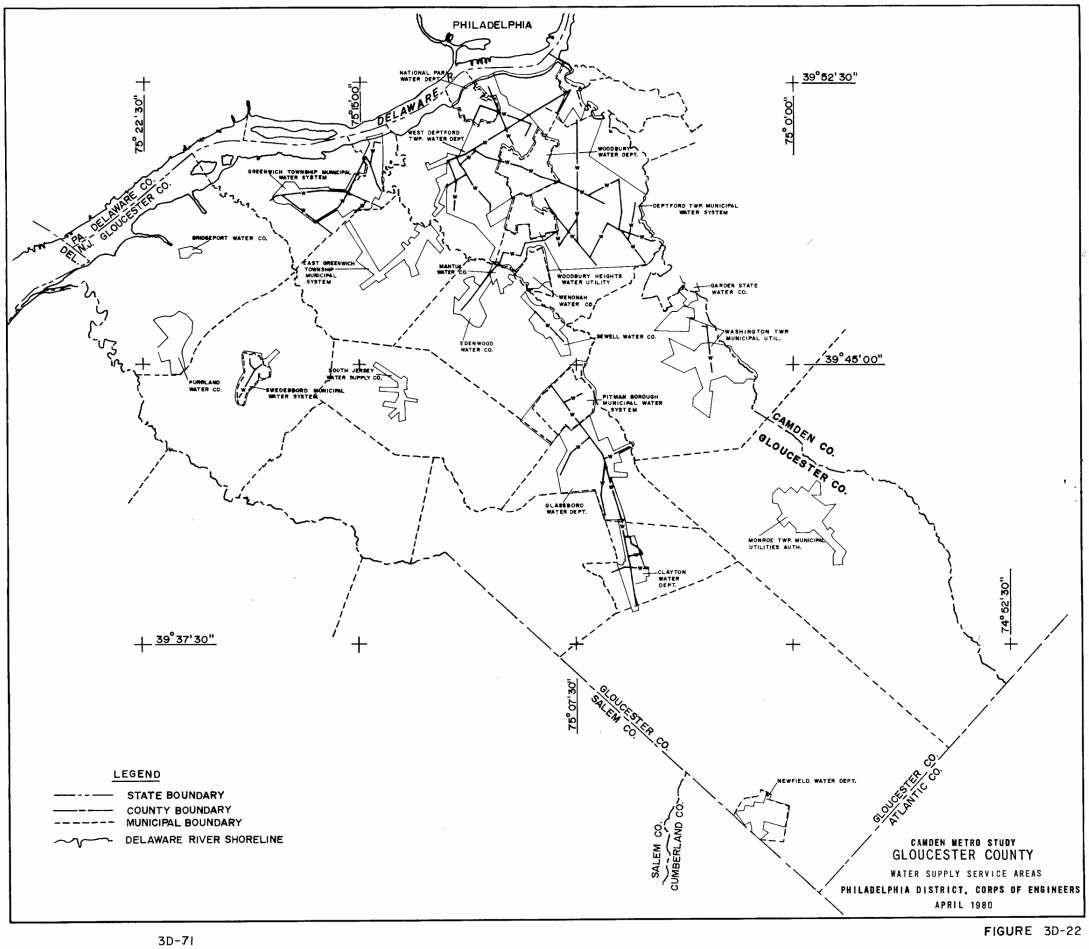
39°60'00"
74°52'30"
39°52'30"
74°45'00"
39°45'00"
75°00'00"
39°37'30"
MERCHANTVILLE-PENNSAUKEN WATER COMMISSION
N.J. WATER CO. CAMDEN DIST.
CITY OF CAMDEN WATER DEPT.
HADDON TWP. MUNICIPAL WATER SYSTEM
HADDONFIELD MUNICIPAL WATER SYSTEM
COLLINGSWOOD MUNICIPAL WATER SYSTEM
GLOUCESTER CITY WATER DEPT.
PA
N.J.
N.J. WATER CO. HADDON DIST.
BELLMAWR WATER DEPT.
RUNNEMEDE WATER DEPT.
BURLINGTON CO. / CAMDEN CO.
GARDEN STATE WATER CO. BLACKWOOD DIV.
CLEMENTON MUNICIPAL WATER SYSTEM
PINE HILL M.U.A.
BERLIN TWP. MUNICIPAL UTIL. AUTH.
KEYSTONE WATER WORKS
WINSLOW WATER CO.
CAMDEN CO. / GLOUCESTER CO.
CAMDEN CO. / ATLANTIC CO.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORE LINE
SCALE IN MILE
0
2
CAMDEN METRO STUDY
CAMDEN COUNTY
WATER SUPPLY SERVICE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-21


PHILADELPHIA
DELAWARE R.
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39° 52' 30"
39° 45' 00"
39° 37' 30"
74° 52' 30"
75° 07' 30"
PA.
DEL.
N.J.
DELAWARE CO.
GLOUCESTER CO.
CAMDEN CO.
GLOUCESTER CO.
GLOUCESTER CO.
SALEM CO.
SALEM CO.
CUMBERLAND CO.
GLOUCESTER CO.
ATLANTIC CO.
NATIONAL PARK WATER DEPT.
WEST DEPTFORD TWP. WATER DEPT.
WOODBURY WATER DEPT.
DEPTFORD TWP. MUNICIPAL WATER SYSTEM
GREENWICH TOWNSHIP MUNICIPAL WATER SYSTEM
BRIDGEPORT WATER CO.
EAST GREENWICH TOWNSHIP MUNICIPAL SYSTEM
MANTUA WATER CO.
WOODBURY HEIGHTS WATER UTILITY
GARDEN STATE WATER CO.
WENONAH WATER CO.
EDENWOOD WATER CO.
BEWELL WATER CO.
WASHINGTON TWP. MUNICIPAL UTIL.
PURVLAND WATER CO.
SWEDESBORO MUNICIPAL WATER SYSTEM
SOUTH JERSEY WATER SUPPLY CO.
PITMAN BOROUGH MUNICIPAL WATER SYSTEM
GLASSBORO WATER DEPT.
MONROE TWP. MUNICIPAL UTILITIES AUTH.
CLAYTON WATER DEPT.
NEWFIELD WATER DEPT.
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
DELAWARE RIVER SHORELINE
CAMDEN METRO STUDY
GLOUCESTER COUNTY
WATER SUPPLY SERVICE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3D-22

SECTION E

WATER SUPPLY NEEDS AND PROJECTIONS

SECTION E

WATER SUPPLY NEEDS AND PROJECTIONS

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SECTION E

WATER SUPPLY NEEDS AND PROJECTIONS

INTRODUCTION

Important elements in the development of plans and programs to satisfy future municipal water needs are projections of future population levels and estimates of future land use and resource trends. The purpose of this section is to document the forecast of future water supply needs based on the extension to the year 2030 of demographic data developed by the Delaware Valley Regional Planning Commission (DVRPC) during preparation of its Year 2000 Regional Development Guide. The extension of these projections beyond the year 2000 provides information suitable for use in long-range planning.

The first part of this section contains a description of the planning process that resulted in the development of a locally accepted projection of population and employment levels for the year 2000 and interim periods. These parameters are projected to the year 2030 for each county and municipality in the study area and were utilized in modelling the future water needs of the tri-county study area.

The second part of this section contains the projections of residential, manufacturing and "other employment sector" land use

requirements to meet the population projections. This second portion forecasts future water use based on the projected growth.

Regional Projections to Year 2030

Description of the Year 2000 Development Guide. The DVRPC recognized citizen involvement as extremely important and incorporated it into all stages of the preparation of the Development Guide through regional citizen advisory committees and open forums. The process investigated a broad range of alternative futures for the region before proceeding to detailed planning activities.

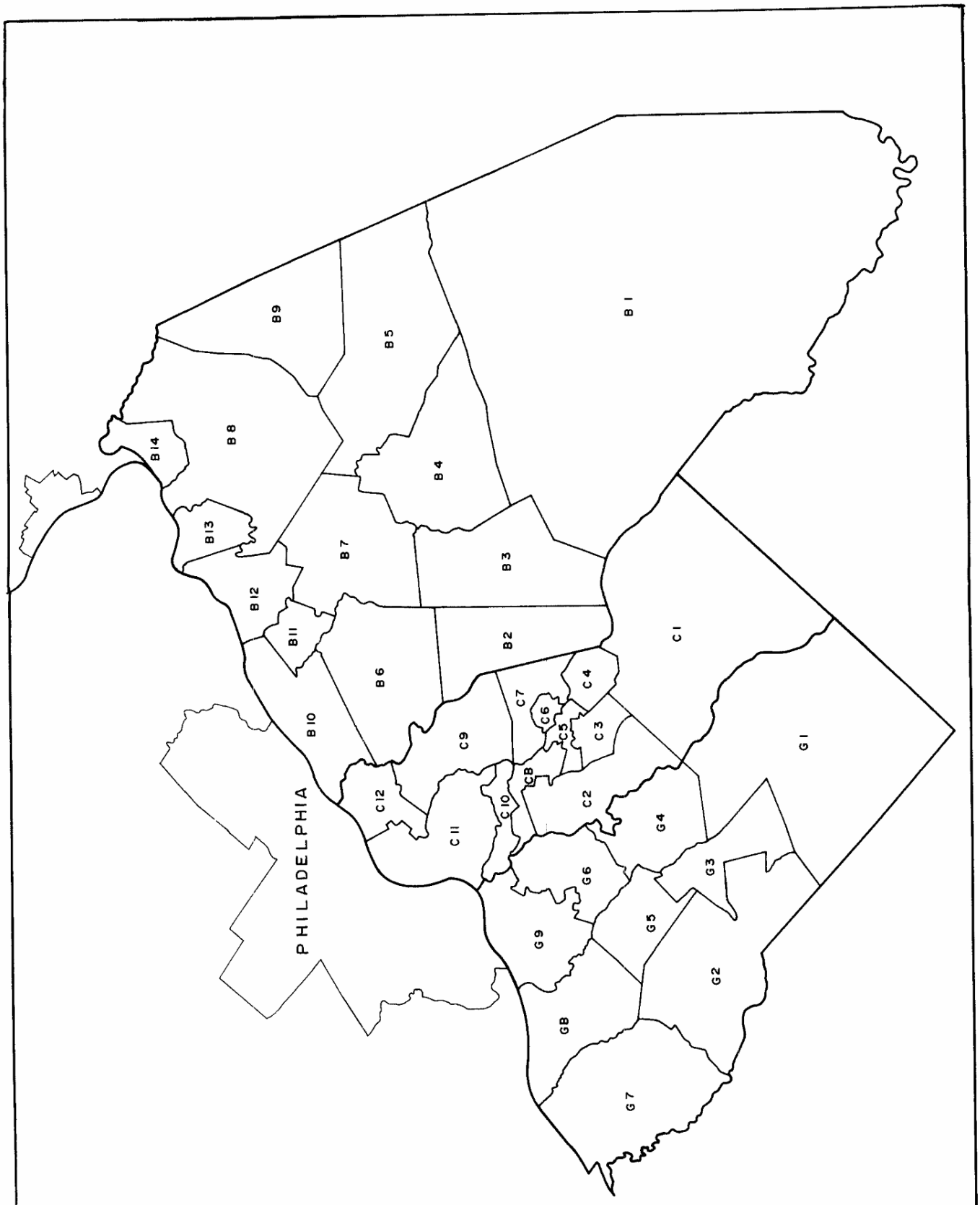
The New Jersey counties preferred a future which suggests growth near the developed areas of the region. Existing public investments would serve many of the needs of new residents although new facilities would be needed in some areas. Rural land lost to development would be minimized.

DVRPC Forecasting Method. In the development of forecasts for the year 2000, demographic trends were used to establish assumptions concerning fertility, death rate, migration, immigration and other characteristics. Population and employment forecasts based on those assumptions were then developed.

These forecasts were compared and characteristics of each were altered to produce a harmonious regional system. A land use forecast was then developed based on those population and employment projections.

Extrapolation of Forecasts to Year 2030. For purposes of analysis with the water demand model, the tri-county study area was divided into 35 areas shown in Figure 3E-1. Table 3E-1 alphabetically lists townships and boroughs referenced to the 35 areas. The division was based on municipal boundaries, water company service areas and growth areas identified in the Year 2000 Development Guide. Forecast values for population, employment and land use were then aggregated for each of the 35 areas. This data was then entered into a computer model which generated the results on a graphics display. Additional data points were visually added until a smooth, curvilinear relationship was achieved. The computer model then generated extrapolated values for the years 2010, 2020 and 2030 and plotted the result.

In general, the values obtained reflected a continuation of the trends developed by DVRPC. These were, in most instances, based on declining growth rates and were limited by such factors as land availablility and maximum densities. Compatibility of results was obtained by considering the effects of adjacent areas on the extrapolation of values. The population, employment and land use values for Burlington County, Camden County and Gloucester County for the years 1970, 2000 and 2030 are shown in Tables 3E-2, 3E-3 and 3E-4 respectively.



CAMDEN METRO STUDY

WATER USE PROJECTION AREAS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3E-1

TABLE 3E-1

TOWNSHIP AND BOROUGH INDEX

Burlington County

Township	Projection Area	Township	Projection Area
Bass River	B-1	Medford Lakes	B-3
Beverly City	B-10	Moorestown	B-6
Bordentown	B-14	Mt. Holly	B-7
Bordentown City	B-14	Mt. Laurel	B-6
Burlington	B-12	New Hanover	B-9
Burlington City	B-12	North Hanover	B-9
Chesterfield	B-8	Palmyra	B-10
Cinnaminson	B-10	Pemberton	B-5
Delanco	B-10	Pemberton Boro	B-5
Delran	B-10	Riverside	B-10
Eastampton	B-7	Riverton	B-10
Edgewater Park	B-10	Shamong	B-1
Evesham	B-2	Southampton	B-4
Fieldsboro	B-14	Springfield	B-8
Florence	B-13	Tabernacle	B-1
Hainesport	B-7	Washington	B-1
Lumberton	B-7	Westampton	B-7
Mansfield	B-8	Willingboro	B-11
Maple Shade	B-6	Woodland	B-1
Medford	B-3	Wrightstown	B-9

Camden County

Township	Projection Area	Township	Projection Area
Audubon	C-11	Laurel Springs	C-8
Audubon Park	C-11	Lawnside	C-10
Barrington	C-11	Lindenwold	C-5
Bellmawr	C-10	Magnolia	C-8
Berlin	C-4	Merchantville	C-12
Berlin Boro	C-4	Mt. Ephram	C-11
Brooklawn	C-10	Oaklyn	C-11
Camden City	C-11	Pennsauken	C-12
Cherry Hill	C-9	Pine Hill	C-3
Chesilhurst	C-1	Pine Valley	C-3
Clementon	C-3	Runnemede	C-8
Collingswood	C-11	Stratford	C-8
Gibbsboro	C-6	Somerdale	C-8
Gloucester	C-2	Tavistock	C-11
Gloucester City	C-11	Voorhees	C-7
Haddon	C-11	Waterford	C-1
Haddonfield	C-11	Winslow	C-1
Hi-Nella	C-8	Woodlynne	C-11

Gloucester County

Township	Projection Area	Township	Projection Area
Clayton	G-3	Newfield	G-1
Deptford	G-6	Paulsboro	G-3
East Greenwich	G-8	Pitman	G-2
Elk	G-2	South Harrison	G-7
Franklin	G-1	Swedesboro	G-7
Glassboro	G-3	Washington	G-4
Greenich	G-8	Wenonah	G-6
Harrison	G-2	West Deptford	G-9
Logan	G-7	Westville	G-9
Mantua	G-5	Woodbury	G-9
Monroe	G-1	Woodbury Heights	G-9
National Park	G-9	Woolwich	G-7

TABLE 3E-2

POPULATION, EMPLOYMENT, AND LAND USE VALUES
BURLINGTON COUNTY, NEW JERSEY

	POPULATION 2/			MANUFACTURING EMPLOYMENT 1/			RESIDENTIAL LAND USE		
Area	1970	2000	2030	1970	2000	2030	1970	2000	2030
B-1	6,941	13,500	15,037	108	69	39	1,494	2,882	3,810
B-2	13,477	40,000	55,990	63	75	75	1,495	4,320	5,757
B-3	13,084	25,000	32,626	982	1,192	1,201	2,278	3,520	3,889
B-4	4,982	7,400	8,865	141	97	67	1,204	1,724	2,084
B-5	17,853	28,700	33,907	126	178	183	2,345	4,508	6,282
B-6	43,262	75,000	97,307	6,250	8,028	8,252	5,128	8,255	9,935
B-7	24,612	37,300	45,094	2,271	3,370	3,690	2,239	3,719	4,696
B-8	8,031	13,400	17,174	157	107	63	1,277	2,054	2,660
B-9	9,858	10,800	11,172	0	65	119	1,274	695	508
B-10	60,673	74,000	79,978	4,765	5,983	6,080	4,825	6,386	7,505
B-11	43,414	45,000	45,585	154	188	190	2,855	3,406	3,900
B-12	22,603	30,300	34,962	3,433	4,732	5,059	1,655	2,744	3,612
B-13	8,560	11,700	13,566	2,642	3,749	4,040	572	1,060	1,482
B-14	12,408	17,700	20,890	1,297	1,582	1,582	937	1,495	1,980
TOTALS	289,758	429,800	512,153	22,389	29,415	30,640	29,578	46,768	58,100

1/ Figures are for employment within the county, rather than the number of employed persons residing in the county.

2/ Difference between above values and those shown in Appendix 1 is attributed similarly to the exclusion of military related data. Also the extrapolation model used to project to 2030 resulted in small variances from those shown in the Year 2000 data.

TABLE 3E-3

POPULATION, EMPLOYMENT, AND LAND USE VALUES
CAMDEN COUNTY, NEW JERSEY

	POPULATION 2/			MANUFACTURING EMPLOYMENT 1/			RESIDENTIAL LAND USE		
Area	1970	2000	2030	1970	2000	2030	1970	2000	2030
C-1	16,076	42,644	58,433	1,705	2,294	2,410	2,010	4,448	5,744
C-2	26,511	74,963	100,712	1,084	1,503	1,605	2,660	6,857	8,644
C-3	9,647	14,469	17,638	141	203	222	1,033	1,532	1,876
C-4	10,689	15,105	17,805	1,164	1,163	1,071	956	1,418	1,690
C-5	12,199	22,208	29,500	67	123	139	802	1,720	2,504
C-6	2,634	4,196	5,151	125	173	182	229	390	500
C-7	6,214	23,458	35,677	95	0	0	766	2,198	2,939
C-8	36,440	50,829	59,874	624	469	340	2,180	2,842	3,275
C-9	64,395	81,806	93,148	6,029	6,464	6,177	5,667	7,737	9,292
C-10	29,623	39,646	44,715	2,521	2,686	2,687	1,715	2,139	2,458
C-11	200,971	213,873	220,361	24,118	23,354	22,801	6,770	7,554	8,154
C-12	40,806	46,443	49,874	9,273	10,653	11,446	2,097	2,399	2,562
TOTALS	456,205	629,640	732,888	46,946	49,085	49,080	26,885	41,234	49,638

1/ Figures are for employment within the county, rather than the number of employed persons residing in the county.

2/ Difference between above values and those shown in Appendix 1 is due to small variances between the extrapolation model and that of the Year 2000 plan.

TABLE 3E-4

POPULATION, EMPLOYMENT, AND LAND USE VALUES
GLOUCESTER COUNTY, NEW JERSEY

	POPULATION 2/			MANUFACTURING EMPLOYMENT 1/			RESIDENTIAL LAND USE		
Area	1970	2000	2030	1970	2000	2030	1970	2000	2030
G-1	24,548	38,141	48,122	1,318	1,751	1,804	4,265	7,647	10,486
G-2	6,594	10,671	13,094	38	43	43	1,703	2,843	3,703
G-3	28,388	36,655	41,355	3,118	3,273	2,962	2,341	3,409	4,245
G-4	15,741	30,000	39,207	638	710	663	2,277	3,464	4,112
G-5	9,643	15,882	19,982	600	662	639	1,315	2,470	3,354
G-6	26,596	37,041	44,203	1,268	1,405	1,329	2,395	3,562	4,399
G-7	5,274	37,680	59,809	711	1,329	1,529	725	3,697	4,317
G-8	17,000	22,286	25,125	3,219	3,704	3,630	1,621	2,814	3,707
G-9	38,857	48,666	54,635	2,514	2,852	2,777	2,969	4,304	5,025
TOTALS	172,641	277,022	345,532	13,424	15,729	15,376	19,611	34,209	43,348

1/ Figures are for employment within the county, rather than the number of persons employed residing in the county.

2/ Difference between the above values and those shown in APPENDIX 1 is due to small variances between the extrapolation model and that of the Year 2000 plan.

It is important to note that the population figures for Burlington County, which were input to the projection model, exclude the military population since no growth was expected in this sector. More information on this exception is presented later in this section.

Analysis of Future Water Needs

Procedure. Future water needs of the tri-county area were defined in sufficient detail so that those needs could be identified as being met by withdrawals from specific wells or well fields.

Extrapolated regional projections were used to guide the forecast of future water use in the tri-county study area. The first step was to define the present water use and relate it to the study area's demographic and economic characteristics. The area's characteristics were then used in a computer simulation to estimate the present water use. This estimate was compared to the available water use records. With this in hand, future demands were determined using a forecast model based on a model used effectively in other metropolitan regions.

The computer system that was used in this analysis is the "Water Supply Municipal and Industrial Needs" model developed for the Office for Water Resources Research, United States Department of the Interior (OWRR). It has been used to forecast water use in Baltimore and Columbia, Maryland, and Baton Rouge, Louisiana. The model is a planning tool for estimating water needs for residential, commercial, institutional, industrial and public sectors of the community. Within these sectors, needs are futher estimated for individual categories.

The use of this method and its input were coordinated with the staff of DVRPC.

Model Development. The system used to analyze the tri-county area is composed of two models. The first estimates present water needs and the second forecasts the needs of the future. The first model disaggregates municipal water demands into the smallest categories of water usage consistent with the availability of useful data. Each category of water usage is separately estimated, either by a mathematical function or a usage coefficient. Mean annual daily needs are estimated for each category. The categories are then aggregated into four sectors of demand and these are, in turn, aggregated into total municipal requirements.

The present needs model is based entirely on data describing the various categories of water users, as well as climatic and other data for the study area. The model takes account of the actual level of activity in each category of water use, making it responsive to changes in the mix of water-using activities which occur as communities grow and mature.

The forecast model incorporates all of the functions of the present needs model in addition to the capability to project parameter values and construct forecasts of water demands.

Three forecasting methods are incorporated in the projections of water use parameters. The methods are: use of a projection made external to the system, projection by extrapolation of historical trends and projections by an internal growth model derived for that purpose.

Projection of values of many of the parameters used by the forecast model are frequently available as part of routine urban planning for cities and metropolitan areas. Such factors as total residential population, total employment, per capita personal income and total manufacturing employment are of vital interest to cities attempting to attract new industry or to rehabilitate old areas. Records of historical values are often readily available and estimates of future values are being constantly revised and updated.

Model development was based on Standard Metropolitan Statistical Areas (SMSA). Since an SMSA is a complete, integrated economic and social unit, the possibility of obtaining useful information for statistical analysis is greatly improved. The marked influence of the Second World War and the immediate post-war period on virtually every parameter was the principal reason for beginning most data collection with 1948. In the case of residential data, it was necessary to use 1940 data, since most parameters are available for decennial census only. Certain growth equations in the forecast model required adjustments to compensate for the characteristics of the tri-county area.

Compared to other sectors of water demand, industrial water requirements were the most diverse in nature and least amenable to estimation. A simple unit use coefficient method was selected for the industrial water requirements computations, using employment within the Standard Industrial Classification category as the water use parameter. This approach works well in the case of those industries

whose municipal water requirements are primarily for sanitary or personal purposes. When large amounts of process water is involved, as in the case of petroleum refineries or food processors, the water use is supplemented by historic information.

Types and Sources of Information Used by the Model. Information used to forecast water needs was collected from Federal, regional and local agencies. Additional information, where applicable, was generated for the study. Demographic data for the base year 1970 and historic trends for the different residential sub-groups came from the Bureau of the Census. Information on industry was provided by the New Jersey Department of Labor and Industry for the period of 1960 to 1976. Insight on industry location came from Labor and Industry and DVRPC. Labor and Industry figures were also used for commercial employment in the wholesale, retail, financial and service sectors. Commercial water use parameters were estimated based on personal surveys and review of local directories. Lists of information used in the forecast model are contained in Tables 3E-5 through 3E-9.

TABLE 3E-5

INFORMATION IDENTIFYING FORECAST AREA

Name of Area
Base Year of Analysis
Lattitude and Longitude of Area
Base Year Population
Bass Year Population Density
Population between ages 20 and 39
Total Employment
Employment in Transportation, Communication & Utilities
Per Capita Income
Employment in Service Industries

TABLE 3E-6

RESIDENTIAL INFORMATION

Number of homes - metered and sewered
(include apts.) metered and septic
self-supplied and sewered
self-supplied and septic
Average Price of Water
Housing Density
Value ranges of housing
Number of homes in each value range

TABLE 3E-7

COMMERCIAL AND INSTITUTIONAL INFORMATION

Hotels and Motels - Square Footage
Barber Shops - Number of Chairs
Beauty Shops - Number of Stations
Restaurants - Seating Capacity
Taverns - Seating Capacity
Hospital and Nursing - Number of Beds
Medical Offices - Square Footage
Elementary Schools - Number of Students
Car Washes - Square Footage
Churches - Membership
Golf and Swim Clubs - Memberships
Office Buildings - Square Footage
Jails & Prisons - Number of Prisoners

TABLE 3E-8

INDUSTRIAL/COMMERCIAL

Food Products
Textile Products
Apparel Products
Lumber Products
Furniture
Paper Products
Printing and Publishing
Chemical Products
Petroleum Refining
Rubber and Plastic Products
Leather Products
Stone, Clay and Glass Products
Primary Metals
Fabricated Metals
Mechanical Machinery
Electrical Machinery
Transportation Equipment
Instruments
Miscellaneous

TABLE 3E-9

HISTORIC INFORMATION IN AREA

Population
Persons per Household
Number of Homes
Value Ranges of Homes
Education Level of Adults
Elementary School Enrollment
Secondary School Enrollment
Employment in Service Industries
Employment in Medical Services
Employment in Industry

In addition to the above information, projections of certain characteristics were used to guide the pattern of growth in the tri-county area. For each projected year, estimates of population, land use, manufacturing employment and sewered homes were extracted from the Year 2000 Future Alternatives Analysis by DVPRC.

Agricultural land use in the tri-county area has declined steadily as farmland has been developed into residential areas. While historic records of irrigation water use reflect transient increases during periods of severe drought, the overall trend in agricultural use is

toward lower average pumpage rates. The adoption of more intensive farming practices on the remaining farmland could lead to an increase in the irrigation use, but the overall effect would probably not lead to agricultural water use exceeding the present amount. For these reasons, agricultural water use was maintained at the present level into the future rather than arbitrarily reducing the values.

Present military activity, centered in Burlington County, is lower than in the past. No firm plans exist for any expansion of activity in the near future, as evidenced by the lack of population growth in the Wrigtstown-New Hanover area shown in the Year 2000 Regional Development Guide. Historic records of water use by the military parallel the reduction in activity. While the population related to military activities was excluded from the tables in this section, the water use was maintained at the present level to reflect the assumption that no change in military activities would occur.

Estimating Present and Future Water Use

The first step in forecasting the tri-county's future water needs was to adequately reproduce the water use for a particular year for which actual data on water use existed. The year 1970 was chosen as the base year for the analysis because information concerning all necessary aspects of water usage was available.

Future water needs in each of the 35 sub-areas described previously and shown in Figure 3E-1 were forecasted on a ten-year interval from 1970 to 2030 for various categories of residential, commercial, industrial and miscellaneous sectors of the community.

The miscellaneous sector included community uses, system losses, agricultural and military uses. These water needs were further associated to the 35 areas based on the projections of future growth described previously. Water needs for the 35 areas for the years 1970, 2000 and 2030 are shown in Tables 3E-10 through 3E-17.

TABLE 3E-10

TOTAL RESIDENTIAL WATER NEED (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.287	0.556	0.65	C-1	0.732	2.448	3.615	G-1	1.458	3.218	4.494
B-2	0.859	3.003	4.665	C-2	1.765	6.620	9.456	G-2	0.343	0.649	0.802
B-3	1.458	2.633	3.266	C-3	0.562	0.988	1.239	G-3	1.997	2.75	3.253
B-4	0.279	0.532	0.635	C-4	0.630	0.990	1.176	G-4	0.988	1.996	2.597
B-5	0.925	2.197	2.639	C-5	0.881	1.971	2.616	G-5	0.465	0.870	1.099
B-6	3.602	7.547	10.086	C-6	0.157	0.223	0.240	G-6	1.487	2.325	2.781
B-7	1.622	2.615	3.380	C-7	0.423	1.667	2.661	G-7	0.325	1.494	2.315
B-8	0.348	0.726	0.952	C-8	2.631	4.637	5.43	G-8	1.071	1.596	1.98
B-9	0.641	0.892	0.900	C-9	4.970	6.655	8.264	G-9	2.873	3.877	4.511
B-10	4.601	6.087	6.846	C-10	2.101	3.114	3.896				
B-11	3.012	3.139	3.187	C-11	14.264	20.252	21.742				
B-12	1.698	2.934	3.415	C-12	2.935	4.206	4.683				
B-13	0.652	1.138	1.344								
B-14	1.016	1.787	2.131								
TOTAL	21.0	35.786	44.096	TOTAL	32.051	53.771	65.018	TOTAL	11.007	18.775	23.832

TABLE 3E-11

SELF-SUPPLIED RESIDENTIAL WATER NEEDS (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.287	0.556	0.650	C-1	0.673	0.720	1.008	G-1	1.002	1.462	1.995
B-2	0.107	0.189	0.276	C-2	0.524	1.499	2.109	G-2	0.278	0.392	0.482
B-3	1.232	2.217	2.739	C-3	0.015	0.012	0.012	G-3	0.091	0.025	0.028
B-4	0.184	0.191	0.229	C-4	0.048	0.019	0.023	G-4	0.193	0.178	0.233
B-5	0.295	0.202	0.241	C-5	0.032	-	-	G-5	0.158	0.119	0.150
B-6	-	-	-	C-6	0.026	0.018	0.018	G-6	0.397	0.114	0.135
B-7	0.144	0.221	0.272	C-7	-	-	-	G-7	0.112	0.517	0.816
B-8	0.261	0.221	0.286	C-8	-	-	-	G-8	0.096	0.111	0.136
B-9	-	-	-	C-9	-	-	-	G-9	0.056	0.031	0.035
B-10	-	-	-	C-10	-	-	-				
B-11	-	-	-	C-11	-	-	-				
B-12	-	-	-	C-12	-	-	-				
B-13	-	-	-								
B-14	-	-	-								
TOTAL	2.510	3.797	4.693	TOTAL	1.318	2.268	3.170	TOTAL	2.383	2.949	4.010

TABLE 3E-12

COMMERCIAL WATER NEEDS (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.031	0.117	0.165	C-1	0.187	0.765	1.171	G-1	0.223	0.541	0.819
B-2	0.338	0.649	0.878	C-2	0.566	1.687	2.518	G-2	0.068	0.257	0.405
B-3	0.186	0.72	1.144	C-3	0.268	0.548	0.791	G-3	0.555	1.053	1.507
B-4	0.050	0.123	0.183	C-4	0.177	0.393	0.593	G-4	0.200	0.559	0.828
B-5	0.257	0.339	0.398	C-5	0.331	1.249	1.971	G-5	0.198	0.640	1.037
B-6	0.900	1.740	2.475	C-6	0.047	0.142	0.229	G-6	0.202	0.451	0.689
B-7	0.593	1.101	1.526	C-7	0.161	0.370	0.503	G-7	0.099	0.679	1.157
B-8	0.533	0.64	0.73	C-8	0.505	0.991	1.410	G-8	0.177	0.297	0.386
B-9	0.133	0.119	0.105	C-9	1.897	3.320	4.676	G-9	0.796	1.606	2.359
B-10	0.996	1.253	1.447	C-10	0.290	0.657	0.969				
B-11	0.524	1.59	2.631	C-11	3.697	4.855	5.950				
B-12	0.506	1.01	1.474	C-12	0.873	1.859	2.831				
B-13	0.111	0.189	0.25								
B-14	0.261	0.495	0.704								
TOTAL	5.389	10.085	14.11	TOTAL	8.999	16.836	23.612	TOTAL	2.518	6.089	9.187

TABLE 3E-13

INDUSTRIAL WATER NEED (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.034	0.022	0.012	C-1	0.757	0.963	1.021	G-1	0.453	1.005	1.134
B-2	0.029	0.034	0.034	C-2	0.408	0.607	0.664	G-2	0.003	0.034	0.034
B-3	0.335	0.399	0.393	C-3	0.003	0.004	0.004	G-3	0.935	0.845	0.741
B-4	0.090	0.076	0.053	C-4	0.402	0.503	0.460	G-4	0.192	0.357	0.420
B-5	0.062	0.063	0.053	C-5	0.008	0.026	0.035	G-5	0.124	0.170	0.168
B-6	1.896	2.891	3.026	C-6	0.091	0.084	0.077	G-6	0.341	0.381	0.362
B-7	0.74	2.135	2.661	C-7	0.079	0.002	0.002	G-7	2.991	5.496	6.195
B-8	0.042	0.039	0.025	C-8	0.236	0.138	0.099	G-8	6.730	7.095	6.215
B-9	0.028	0.051	0.093	C-9	1.667	1.750	1.664	G-9	8.485	9.579	9.340
B-10	1.712	2.226	2.29	C-10	2.243	2.925	2.910				
B-11	0.04	0.045	0.045	C-11	12.211	14.663	12.990				
B-12	2.969	4.032	4.200	C-12	5.843	5.687	5.556				
B-13	1.054	1.952	2.218								
B-14	0.767	1.015	0.99								
TOTAL	9.798	14.98	16.093	TOTAL	23.948	27.352	25.482	TOTAL	20.254	24.962	24.609

TABLE 3E-14

MISCELLANEOUS WATER NEED (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.14	0.271	0.302	C-1	0.355	0.889	1.207	G-1	0.569	0.843	1.043
B-2	0.276	0.810	1.131	C-2	0.533	1.507	2.024	G-2	0.170	0.251	0.300
B-3	0.287	0.527	0.68	C-3	0.194	0.291	0.355	G-3	0.580	0.746	0.840
B-4	0.10	0.149	0.178	C-4	0.215	0.304	0.358	G-4	0.338	0.625	0.810
B-5	0.359	0.577	0.682	C-5	0.245	0.446	0.593	G-5	0.197	0.322	0.405
B-6	0.87	1.508	1.956	C-6	0.053	0.084	0.104	G-6	0.535	0.745	0.888
B-7	1.278	1.533	1.689	C-7	0.125	0.472	0.717	G-7	0.106	0.757	1.202
B-8	0.161	0.269	0.345	C-8	0.776	1.066	1.247	G-8	0.342	0.448	0.505
B-9	4.525	4.573	4.581	C-9	1.294	1.644	1.872	G-9	0.781	0.978	1.098
B-10	1.349	1.616	1.737	C-10	0.595	0.797	0.899				
B-11	0.873	0.905	0.916	C-11	4.099	4.358	4.488				
B-12	0.628	0.783	0.877	C-12	0.820	0.934	1.002				
B-13	0.172	0.235	0.273								
B-14	0.249	0.356	0.420								
TOTAL	11.267	14.112	15.767	TOTAL	9.304	12.792	14.866	TOTAL	3.618	5.715	7.091

TABLE 3E-15

TOTAL WATER NEED (mgd)

Burlington County				Camden County				Gloucester County			
Area	1970	2000	2030	Area	1970	2000	2030	Area	1970	2000	2030
B-1	0.492	0.966	1.13	C-1	2.031	5.065	7.014	G-1	2.703	5.608	7.490
B-2	1.502	4.496	6.708	C-2	3.272	10.421	14.662	G-2	0.584	1.192	1.541
B-3	2.266	4.278	5.482	C-3	1.028	1.831	2.389	G-3	4.066	5.394	6.341
B-4	0.519	0.88	1.049	C-4	1.425	2.191	2.587	G-4	1.718	3.537	4.655
B-5	1.602	3.176	3.771	C-5	1.465	3.693	5.215	G-5	0.983	2.002	2.708
B-6	7.267	13.685	17.542	C-6	0.348	0.533	0.650	G-6	2.564	3.907	4.720
B-7	4.234	7.385	9.256	C-7	0.788	2.510	3.883	G-7	3.522	8.426	10.870
B-8	1.085	1.674	2.052	C-8	4.148	6.832	8.186	G-8	8.319	9.437	9.087
B-9	5.326	5.635	5.679	C-9	9.828	13.369	16.477	G-9	12.936	16.040	17.308
B-10	8.627	11.183	12.32	C-10	5.23	7.494	8.673				
B-11	4.449	5.678	6.779	C-11	34.270	44.129	45.170				
B-12	5.802	8.76	9.966	C-12	10.472	12.685	14.072				
B-13	1.99	3.515	4.085								
B-14	2.293	3.653	4.245								
TOTAL	47.454	74.964	90.064	TOTAL	74.305	110.753	128.978	TOTAL	37.395	55.543	64.720

TABLE 3E-16

TRI-COUNTY AREA
TOTAL GROUNDWATER NEED (mgd)

	1970	2000	2030
Residential			
Burlington	21.000	35.786	44.096
Camden	32.051	53.771	65.018
Gloucester	11.007	18.775	23.382
Total	64.058	108.332	132.946
Commercial			
Burlington	5.389	10.085	14.110
Camden	8.999	16.836	23.612
Gloucester	2.518	6.089	9.187
Total	16.906	33.010	46.909
Industrial			
Burlington	9.798	14.980	16.093
Camden	23.948	27.352	25.482
Gloucester	20.254	24.962	24.609
Total	54.000	67.294	66.184
Miscellaneous			
Burlington	11.267	14.112	15.767
Camden	9.304	12.792	14.866
Gloucester	3.618	5.715	7.091
Total	24.189	32.619	37.724
Total Water Need*	159.153	241.255	283.763

* Differs slightly from summation of individual county water needs due to rounding of values.

TABLE 3E-17

TRI-COUNTY AREA
AGRICULTURAL AND MILITARY WATER NEED (mgd)*

Area	Agricultural	Military
B-2	0.006	
B-3	0.024	
B-7	0.783	
B-9	-	4.356
B-10	0.129	
B-12	0.174	
C-1	0.032	
C-8	0.044	
C-11	0.059	
G-1	0.076	
G-2	0.037	
G-4	0.022	
G-5	0.003	

* Average Annual Daily Water Need; assumed to remain constant in future years; included in miscellaneous water need.

SECTION F

GROUNDWATER ANALYSIS MODEL

SECTION F

GROUNDWATER ANALYSIS MODEL

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SECTION F

GROUNDWATER ANALYSIS MODEL

INTRODUCTION

Since the 1880's, the Raritan-Magothy aquifer (a groundwater reservoir) has been a principal source of water in southern New Jersey. Early in its development history, the aquifer was used sparingly, tapped by shallow dug wells. Since then, the aquifer has yielded ever-increasing quantities for industrial, municipal and agricultural needs. As a consequence, water levels within the aquifer had dropped continuously. Since 1956, the combined effects of increased pumpage and the 1961-1967 drought have caused aquifer drawdown to accelerate. Groundwater quality declined due to spot contamination and salt water intrusion into the aquifer. In 1973, total pumpage from the aquifer within the tri-county area was approximately 136.6 million gallons per day. With the planned industrial and residential growth in mind, residents and planners are concerned that there will be sufficient additional fresh water available to support this expansion. To develop a planning tool to analyze and solve problems associated with increasing groundwater

withdrawals, a finite difference groundwater model was developed by the United States Geological Survey (USGS) and executed by the Waterways Experiment Station of the Corps of Engineers (WES). WES followed an approach designed to answer the following questions:

- What effect will present or increased pumping rates have upon groundwater availability in these counties?
- What effect will present or increased pumping rates have upon groundwater quality in these counties?
- What would be acceptable groundwater pumping rates within these counties?

Discussion

Development of the Model. The aquifer model discussed was adopted for use by the USGS based upon the initial models developed by Konikow (1967). It is a mathematical representation or model of the mechanics of groundwater flow within the aquifer in which basic hydrodynamic equations are solved directly by the computer. As in the case of all mathematical models, there are various limitations to this analysis which will be identified as they appear. The graphic representation of the study area is shown in Figure 3F-1.

Two fundamental relationships are required to describe groundwater flow. These are velocity and hydrostatic pressure (head). The velocity is dependent upon differences in pressure, from one point to another in the aquifer, while the hydrostatic pressure changes with time as the velocity transports fluid from one place to another in the aquifers. Two equations are necessary for this solution.

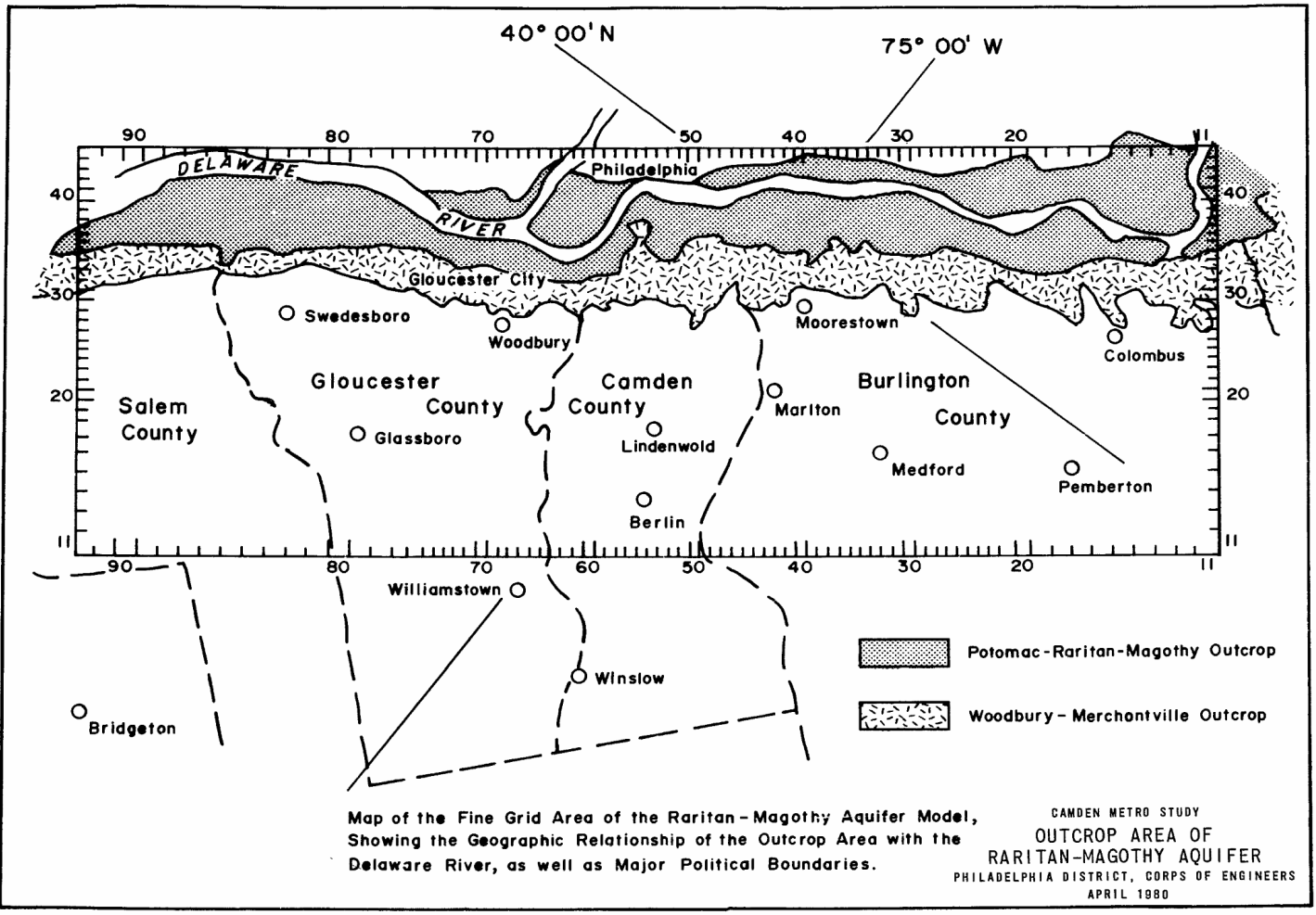


FIGURE 3F-1

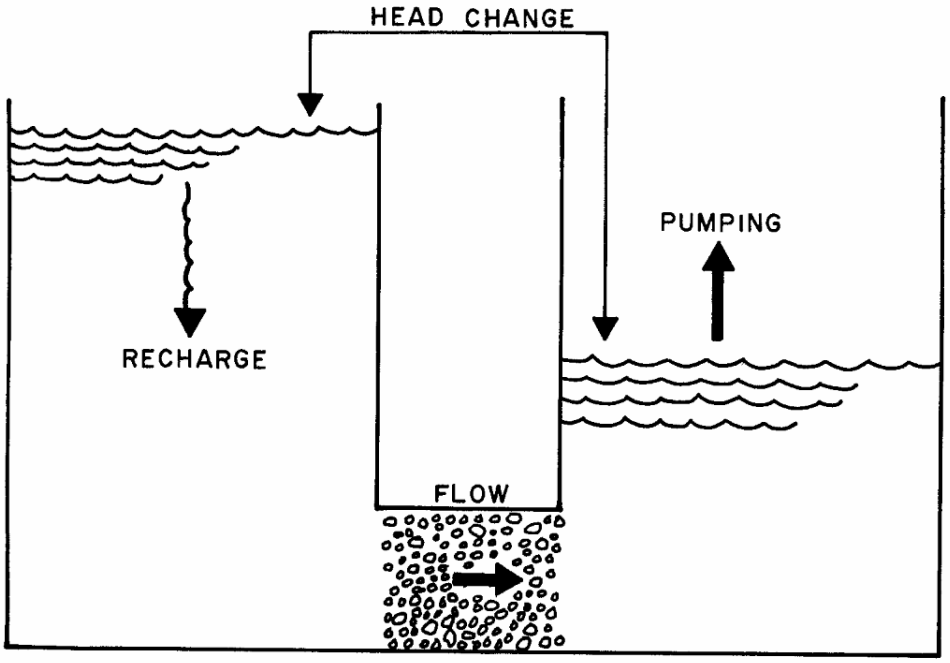
Map of the Fine Grid Area of the Raritan-Magothy Aquifer Model, Showing the Geographic Relationship of the Outcrop Area with the Delaware River, as well as Major Political Boundaries.

CAMDEN METRO STUDY
OUTCROP AREA OF
RARITAN-MAGOTHY AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

For convenience in model formulation and computation, consider a model of an aquifer divided into layers of rectangular grids or nodes of finite volume interconnected by channels. The Raritan-Magothy model divided the aquifer into 4400 elements (44 x 100) of variable grid dimensions ranging from one-half mile per side to over 57 miles per side. In the simplified illustration of nodes coupled together shown on page 3F-5, a change in head (water elevation or pressure) at a node results from the net flow of fluid into the node. Since the node surface area remains constant, the volume change is due to change in head. Compared to surface waters, the porosity (which is less than or equal to one) implies larger head changes for the same net inflow into the node.

In addition to flow of water from one node to another due to differences in head, there may be various natural and/or man-made mechanisms for flow into or out of the node. For example, the aquifer layer which represents the water table or top of the groundwater system is subject to distributed recharge from natural sources, as well as direct stream recharge at specific locations. Recharge flow at each node must be specified and these contribute to increasing head under natural conditions. Similarly, there are natural and induced sinks or losses. Wells utilized for public water supply and other withdrawal purposes act to decrease head at each node affected.

In addition, there are groundwater seepage and discharge to streams. The pumping wells and natural discharges are introduced at



RESISTIVE POROUS MEDIUM
DESCRIBED BY HYDRAULIC
CONDUCTIVITY

SCHEMATIC TO ILLUSTRATE FLOW IN A POROUS MEDIUM

each node by numerical terms. Finally, there is the coupling from one layer in the model to another. Since such flows are driven by vertical pressure differences in the aquifers, they are characterized by terms analogous to the horizontal velocity. It should be emphasized that such terms reflect the anisotropic flow and the velocity. An additional term, specific storage, is roughly the height of the saturated layer [1/]. The change in velocity with time is limited by hydraulic conductivity, a term which combines fluid viscosity with the permeability of the medium. This constantly reflects the role of viscous forces upon fluid flow in porous media.

Upon completion of the model as a computer program, it is then calibrated for use. To calibrate the model, historical values of aquifer stresses are used to drive it and the various input parameters are manipulated at each grid node until the model produces answers which are comparable to past field data. It must be noted that this is a trial and error technique and there is no unique set of input variables which will allow the model to be calibrated.

The quality model, adopted from a code written by Konikow of the USGS, solves the equations for solute transport. The model proceeds by recalling information from the quantity model to calculate

1/ Specific storage in a saturated media is defined as that volume of water tnat a unit volume of aquifer releases from storage under a unit decline in hydraulic head.

velocities at all nodes, and grid boundaries for both X and Y direction. It also calculates dispersion equation coefficients for the X and Y directions as well as the cross product coefficients. The model then inserts four "particles" into each of the grid elements in the 44 x 100 array and assigns a concentration to each particle.

The model next moves the particles in response to the flow regime gradients, determines the new particle locations and calculates the sum of all particles and concentrations within each node of the array. Finally the model actually changes the concentrations of the particles at the nodes and applies the coefficients of dispersion to modify the new concentration in response to hydrodynamic dispersion. This procedure is repeated to the end of the simulation period.

The water quality data for both the aquifer and the recharge water were obtained from all of the available USGS reports, New Jersey State Geological Survey Reports and from the USGS data bank documenting the results of an ongoing program of monitoring the quality of surface waters and wells in the State of New Jersey. It was originally intended to model several dissolved constituents, including chloride, sodium, nitrate, trace metals, etc. However, the data base available for most of these was inadequate.

The most reliable data base, that for the chloride ion, only contained data for about five per cent of the grid elements in the model. It was the only dissolved species considered. This lack of data precluded calibration of the quality model and it was assumed that if the quantity model were calibrated, the quality model would

also be calibrated. It must be pointed out that this assumption was made in order to develop the link between the quantity and quality models and that additional calibration and verification is desirable.

The operation of the model involved changing the pumping rates at specific discharge points (wells) on the grid nodes according to assumed or projected schedules of pumping over specific time periods. The computer solved the equations on a node-by-node basis (iteratively) to produce outputs of changing water levels, quality changes, dewatering and infiltration through each of the individual time steps that correspond to future years of interest.

Specific limitations to the ultimate accuracy of the groundwater model exist and are herein discussed for introductory purposes only. For example, it is important that hydrodynamic concepts such as hydraulic conductivity and specific storage be specified upon each grid node within the model. In practice, specific storage is poorly known but is relatively constant over moderate areas, whereas, hydraulic conductivity varies widely.

Values of hydraulic conductivity and storage, if not available from actual well data, were estimated. In actuality, less than one-tenth of the nodes have field data. The resultant lack of detail available for use in the model does induce uncertainties which can vary considerably from node to node. However, the power of the model lies in its ability to address regional changes in head and quality. It should not be used to describe local (well-to-well) aquifer

characteristics. Figure 3F-2 shows the piezometric surface of the aquifer for the year 1976. Figure 3F-3 shows the distribution of dissolved chloride ion for 1973.

SUMMARIES OF SUB-STUDIES

Sub-Studies I and II

The minimum practical (safe) yield conditions for the aquifer were the first tasks that were initiated upon the development of the physical and chemical groundwater models. Safe yield, a groundwater use term, has been informally defined as that amount of groundwater that may be continuously removed from the aquifer without causing problems. For this study the working definitions for minimum practical (safe) yield were developed to satisfy the following three conditions:

I. That rate of pumping that could be carried out in the aquifer so that drawdowns in the aquifer would not permit recharge from the Delaware River into the aquifer. This must be accomplished using only existing well locations, either by modifying pumpage rates at active pumping sites, or by shutting down wells which were pumping.

II. That rate of pumping that would not accelerate movement of the saltwater interface into the aquifer beyond a defined rate of one mile per 100 years. The "saltwater interface" was operationally defined as the position within the aquifer where the water becomes saltier (higher in chloride ion content) with depth and the chloride

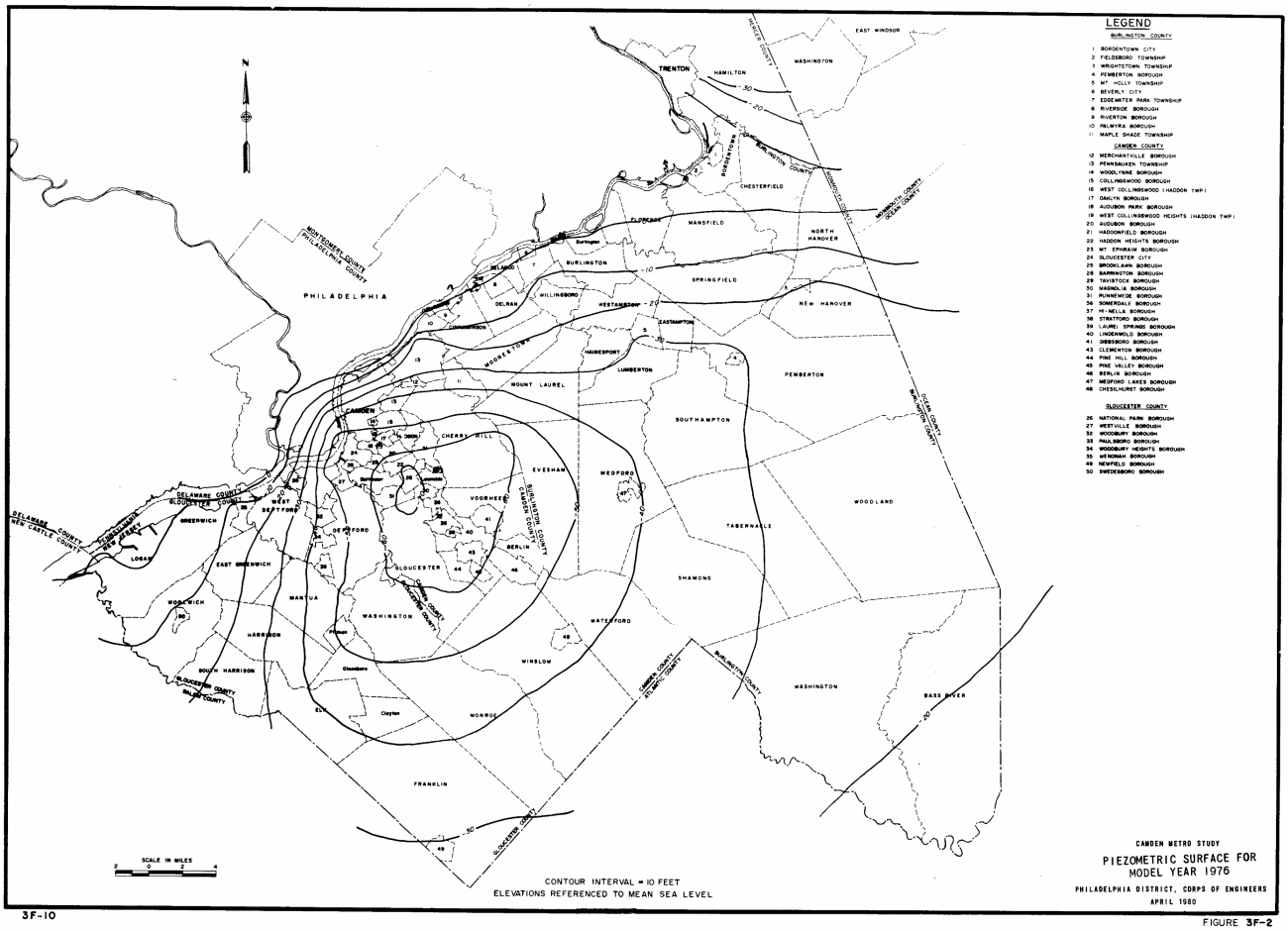
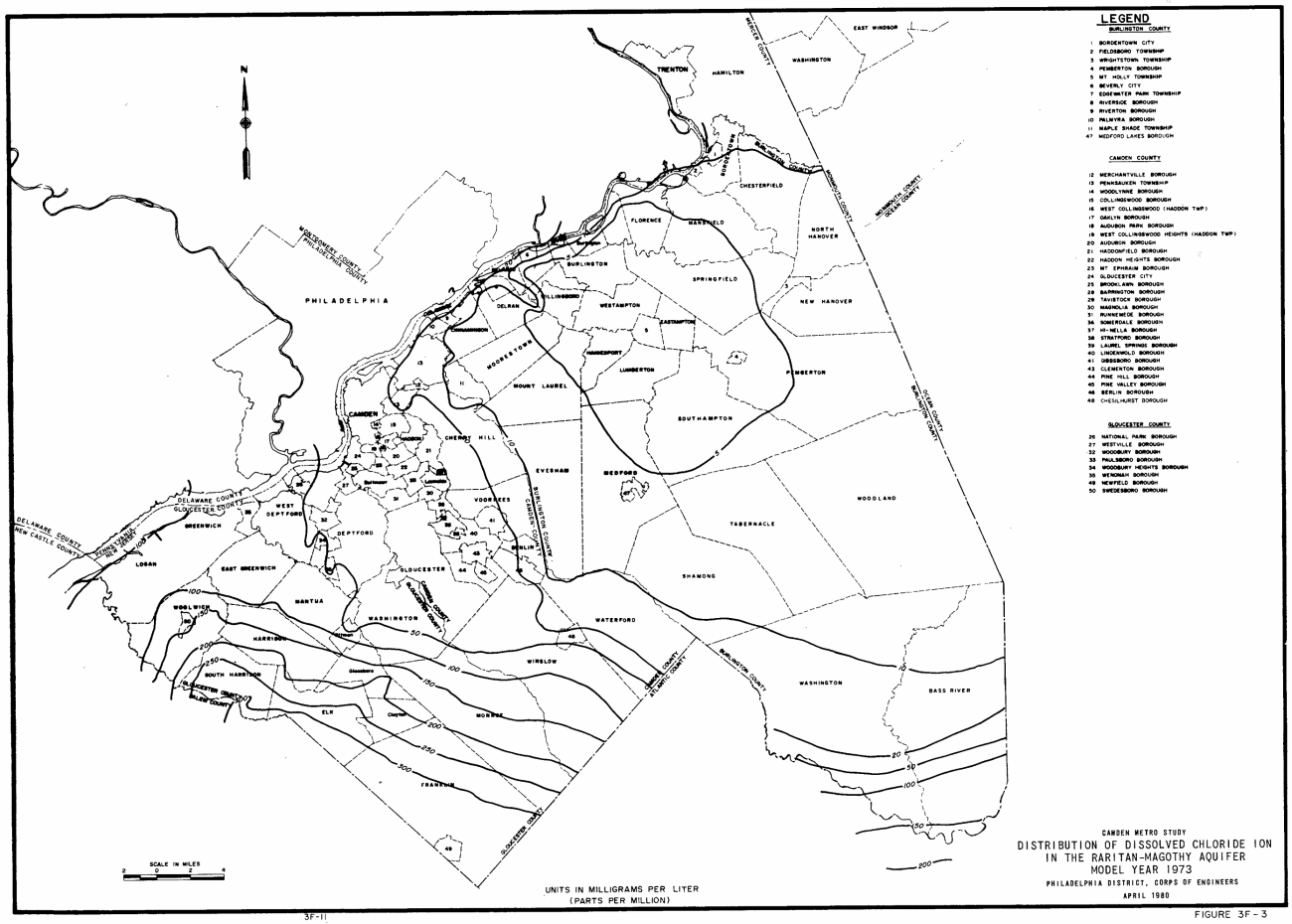

LEGEND
BURLINGTON COUNTY
1 BORDENTOWN CITY
2 FIELDSBORO TOWNSHIP
3 WRIGHTSTOWN TOWNSHIP
4 PEMBERTON BOROUGH
5 MT. HOLLY TOWNSHIP
6 BEVERLY CITY
7 EDGEWATER PARK TOWNSHIP
8 RIVERSIDE BOROUGH
9 RIVERTON BOROUGH
10 PALMYRA BOROUGH
11 MAPLE SHADE TOWNSHIP
CAMDEN COUNTY
12 MERCHANTVILLE BOROUGH
13 PENNSAUKEN TOWNSHIP
14 WOODLYNNE BOROUGH
15 COLLINGSWOOD BOROUGH
16 WEST COLLINGSWOOD (HADDON TWP.)
17 OAKLYN BOROUGH
18 AUDUBON PARK BOROUGH
19 WEST COLLINGSWOOD HEIGHTS (HADDON TWP.)
20 AUDUBON BOROUGH
21 HADDONFIELD BOROUGH
22 HADDON HEIGHTS BOROUGH
23 MT. EPHRAIM BOROUGH
24 GLOUCESTER CITY
25 BROOKLAWN BOROUGH
28 BARRINGTON BOROUGH
29 TAVISTOCK BOROUGH
30 MAGNOLIA BOROUGH
31 RUNNEMEDE BOROUGH
34 SOMERDALE BOROUGH
37 HI-NELLA BOROUGH
38 STRATFORD BOROUGH
39 LAUREL SPRINGS BOROUGH
40 LINDENWOLD BOROUGH
41 DEBSBORO BOROUGH
43 CLEMENTON BOROUGH
44 PINE HILL BOROUGH
45 PINE VALLEY BOROUGH
46 BERLIN BOROUGH
47 MEDFORD LAKES BOROUGH
48 CHESILHURST BOROUGH
GLOUCESTER COUNTY
26 NATIONAL PARK BOROUGH
27 WESTVILLE BOROUGH
32 WOODBURY BOROUGH
33 PAULSBORO BOROUGH
34 WOODBURY HEIGHTS BOROUGH
35 WENONAH BOROUGH
49 NEWFIELD BOROUGH
50 SWEDESBORO BOROUGH
N
PHILADELPHIA
TRENTON
HAMILTON
EAST WINDSOR
WASHINGTON
CHESTERFIELD
MANSFIELD
NORTH HANOVER
SPRINGFIELD
NEW HANOVER
PEMBERTON
SOUTHAMPTON
MEDFORD
WOODLAND
TABERNACLE
SHAMONG
WATERFORD
WINSLOW
WASHINGTON
BASS RIVER
MOUNT LAUREL
CHERRY HILL
VOORHEES
EVESHAM
BERLIN
GLOUCESTER
CAMDEN
DELRAN
WILLINGBORO
BURLINGTON
FLORENCE
BORDENTOWN
DELAWARE COUNTY
GLOUCESTER COUNTY
NEW CASTLE COUNTY
SALEM COUNTY
CAMDEN COUNTY
BURLINGTON COUNTY
OCEAN COUNTY
MONMOUTH COUNTY
MERCER COUNTY
SCALE IN MILES
2 0 2 4
CONTOUR INTERVAL = 10 FEET
ELEVATIONS REFERENCED TO MEAN SEA LEVEL
CAMDEN METRO STUDY
PIEZOMETRIC SURFACE FOR
MODEL YEAR 1976
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3F-2



CAMDEN METRO STUDY

DISTRIBUTION OF DISSOLVED CHLORIDE ION IN THE RARITAN-MAGOTHY AQUIFER MODEL YEAR 1973

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3F-3

ion content at the base of the aquifer exceeds 250 mg/l. The concentration is the Environmental Protection Agency (EPA) standard for drinking water. This condition must also be met by modifying or terminating pumpage at existing well sites.

III. That rate of pumping that would satisfy Conditions I and II while simultaneously allowing the addition of new wells to intercept water that discharges from the aquifer.

Simulation Results. Minimum Practical Yield Condition I was satisfied within a few years by pumping 62.7 cfs (40.5 mgd) from the fine grid area of the aquifer. This involved shutting down or reducing the withdrawal in many wells. Recovery rates of the piezometric surface for the first year of simulation ranged from 4.2 feet/year to 62.5 feet/year and by the year 1980 the rates of recovery had decreased to less than one foot/year. By the year 2000 much of the aquifer had recovered to a head above the static level at the beginning of the simulation in 1956. Water velocities and chloride ion concentrations also decreased significantly after only a few years of simulation. The water budget for Condition I showed that recharge from the Delaware River had completely reversed within the first year and that a greater percentage of the pumpage was supported by infiltration from precipitation and leakage through the confining layer. The water quality and velocity aspects of the Minimum Practical Yield Condition I indicated a general slowing of water migration rates and improvement in aquifer conditions. A comparison between the position of the 50 feet/year isogram and the position of the salt water interface indicated that the salt water interface was moving much more slowly

than one mile per 100 years. This indicated that the Minimum Practical Yield Condition I pumping regime also satisfied the fundamental requirement of Minimum Practical Yield Condition II.

Minimum Practical Yield Condition III was intended to intercept the water that was discharging from the aquifer to the Delaware River in Minimum Practical Yield Condition I. This condition was found to be met by specifically locating 64 new sites pumping an additional 37.6 cfs (24.3 mgd) from the aquifer. Recovery rates for this condition ranged forom 3.6 feet/year to 62.2 feet/year for the first year and declined to less than one foot/year by 1980.

The static level of 1956 had generally been achieved by the year 2030. As in Minimum Practical Yield Condition I the water velocities and chloride on concentrations decreased significantly. The water budget also showed a greater percentage of pumpage being supported by infiltrations from precipitation and leakage through the confining layer. The recharge from the river had reversed but the 64 new wells had held the net discharged to the river down to 1.2 cfs as compared to the Minimum Practical Yield Condition I discharge of 20.4 cfs. The pumpage

on concentrations decreased significantly. The water budget also showed a greater percentage of pumpage being supported by infiltrations from precipitation and leakage through the confining layer. The recharge from the river had reversed but the 64 new wells had held the net discharged to the river down to 1.2 cfs as compared to the Minimum Practical Yield Condition I discharge of 20.4 cfs. The

pumpage regime of Condition III did result in a slight recharge of the aquifer in the upper river reach but the excellent water quality made this desirable anyway. The salt water interface was found to be migrating at a rate less than the one mile/100 years limit and as a result all the requirements for Minimum Practical Yield Condition III were met. This total pumpage of 100.3 cfs (64.8 mgd) was, however, significantly less than the 1973 pumpage. It should be noted that the satisfaction of these conditions was determined by a trial and error process and any number of pumping distributions could satisfy these minimum practical yield conditions.

Sub-Studies III and IV. These studies involved the determination of the maximum quantity of groundwater and corresponding best quality which could be withdrawn from the Raritan-Magothy without realizing permanent damage to the aquifer.

The following conditions of maximum yield were analyzed:

- Projection I - A projection through the year 2030 assuming zero growth from 1973 pumping rates. Both quantity and quality changes were analyzed.

- Projection II - A projection through the year 2030 assuming a one per cent compounded annual growth rate in pumpage applied across the board. Only quantities were analyzed.

- Projection III - A projection through the year 2030 assumming that pumpage growth would be accelerated at the same rate as the population growth rate for quantity and quality.

- Projection IV - A projection through the year 2030 assumming that pumpage growth would reach the present diversion grant limits on a 27-year growth schedule for quantity and quality.

- Projection V - A projection through the year 2030 assuming a two per cent compounded annual growth rate in pumpage applied across-the-board for quantity and quality.

- Projection VI - A projection through the year 2030 assuming a three per cent compounded annual growth rate in pumpage applied across-the-board for quantity only.

Throughout all of these simulations, no regard was given to the capability of the wells to actually pump the quantities assigned.

Simulation Results. A comparison of the hydrologic data from all six projections for the year 1976 was made and it was found that the data were virtually identical, although this was the last year this was the case. For this reason, 1976 was used as the baseline year. Figure 3F-2 illustrates the piezometric surface through most of the aquifer for the year 1976. The most significant features of the piezometric surface are:

- The generally elliptical shape of the depressed head contours.

- The most depressed heads in the aquifer are approximately 75 feet below mean sea level (MSL).

- The region of most severely depressed heads is in the central Camden County in the vicinity of Runnemede, Magnolia and East Barrington.

- The elevated heads in northeastern Burlington County result from a high head in the outcrop belt near Trenton and are held high in the model by a constant head boundary condition outside the fine grid area.

- The zero head contour roughly follows the Delaware River in response to a constant head boundary imposed by flow in the river.

Projection I. Assuming no increase in the 1973 pumping rates, it was found that the aquifer continued to drawdown very slowly in response to the constant pumping. Generally, the aquifer showed relatively constant concentrations of chloride ion, and relatively constant velocities, while the drawdown rate dropped to less than 0.01 feet/year, indicating a virtual steady state condition. The water budget indicated only a slight increase in total recharge to the aquifer from the river induced by heavy pumping along the river. The change in storage remained consistently low, indicating that virtually all of the pumpage was accounted for through recharge, with very little "mining" of water stored in the aquifer. River recharge remained relatively constant throughout the projection, increasing by only about 1.5 per cent over the course of the simulation.

A comparison between the position of the 50 feet/year isogram with the positon of the salt water interface indicated that the position of the salt water interface was moving more rapidly than the desired rate of one mile/100 years.

The maximum drawdown is slightly more than 50 feet and is centered in the Berlin Borough, Lindenwold and Clementon areas of Camden County. The center of this "cone of depression" is located approximately five miles to the southeast of the area of most severly depressed heads.

Although the 1973 pumpage rates are at a relatively steady state, it should be noted that recharge from the Delaware River accounts for about 43 per cent of all pumpage from the fine grid of the aquifer. This condition is considered undesirable.

Projection II. Assuming a one per cent annual growth rate of the 1973 pumping rates, pumping from the fine grid area of the aquifer increased to 391.4 cfs by the year 2030, an increase of 1.76 times the 1973 withdrawal rates. This pumping stress caused a rapid response of the aquifer with drawdown rates ranging from 0.4 to 1.0 feet/year between 1976-1990 and steadily increasing to a range of from 0.7 to 1.7 feet/year by the year 2030. The water budget for this projection indicated that 321 nodes became unsaturated but no nodes were pumped dry. The storage change remained constantly low throughout, indicating that "mining" of water from storage was not necessary to compensate for the increased pumping. This increase in demand was met by a 49 per cent increase in leakage through the confining layer and an increase in recharge from the Delaware River by a factor of 2.4 over the 1973 rate.

Heads dropped drastically with the most severely depressed heads reaching 150 feet below MSL by the year 2030. This pumpage caused a

pronounced deepening and broadening of the "cone of depression" as well as a northwesterly shift in the center of the cone of about four miles from the Projection I drawdown distribution. This pattern indicated that recharge from the river was unable to keep pace with increased pumping stress and that groundwater within the fine grid area was in motion toward the major demand centers in northern Camden County in order to make up the deficit.

Projection III. This projection assumed an increase in the 1973 pumping rate at the same rate as the population growth rate curve. Under this pumping stress the drawdown rate accelerated to over 1.6 feet/year and then tapered off in response to the decreasing rate of pumpage increase. Although chloride ion concentrations remained relatively constant, velocities increased markedly in response to the additional pumpage and heads fell to more than 120 feet below MSL by the year 2030.

The water budget indicated a decrease in the percentage of pumpage supported by infiltration from precipitation and leakage through the confining layer, while the rate of river recharge increased by a factor of 2.1. Although no nodes were pumped dry, 281 nodes were desaturated by the year 2030. The water quality model indicated a general deterioration of quality with a corresponding increase in velocities. The salt water interface was found to be moving more rapidly than the desired rate of one mile/100 years. The maximum drawdown for this projection was slightly more thatn 120 feet and was

centered in the Voorhees and Tavistoc areas of central Camden County. This "cone of depression" was centered in the same area as the most severly depressed heads.

Projection IV. The 1973 pumping rates were augmented to allow pumpage to reach the legal diversion limit by the year 2000. Under this pumping stress, the aquifer continued to drawdown at rates which accelerated to as high as nearly 4.0 feet/year by the year 2000 and then dropped off quickly in response to the cessation of pumping increases. The chloride ion concentrations and the velocities also increased, although the rate of velocity increase tapered off after the year 2000. The heads in tnis projection continued to deteriorate throughout the projection with heads falling to more severely depressed heads than 140 feet below MSL by the end of simulation.

The water budget for this projection showed an increase in pumpage over the 1973 rate by a factor of 1.8 by the year 2000 with pumpage remaining constant thereafter. Under this pumpage the percentage of pumpage supported by precipitation and infiltration again decreased while the percentage supported by recharge from the river increased by a factor of 2.3. Although there were no nodes pumped dry, by the year 2030 there were 343 desaturated nodes. This projection again showed the salt water interface moving more rapidly than the desired maximum rate of one mile/100 years with a corresponding general decline in water quality throughout the area.

Maximum drawdown for this simulation was almost 140 feet and was centered on the Gibbsboro, Lindenwold and Stratford area of Camden County which was also the location of the most severly depressed heads.

Projection V. A two per cent annual increase in the 1973 pumping rates was simulated in this projection with dramatic results. Although the quantity aspects of the simulation were run to the year 2030, the quality computations had to be terminated after the year 2010 due to an instability caused by the excessive stresses resulting from the accelerated pumping. The drawdown rate accelerated to as high as 13.0 feet/year with heads falling to more than 400 feet below MSL in northern Camden County, causing 872 nodes to be desaturated and 39 nodes to be pumped completely dry.

Throughout this simulation water quality declined while velocities climbed. Again the salt water interface was moving at a rate higher than the desired maximum.

The percentage of pumpage supported by precipitation and leakage again declined while the recharge from the river increased by a factor of about 4.8. The maximum drawdown reached 400 feet and was centered in the Haddon Heights and East Barrington area, the same area as the most severely depressed heads.

Projection VI. This projection added a three per cent annual growth rate to the 1973 pumpage. The results of this simulation were similar to Projection V, but more severe. Subjected to this pumpage, the aquifer drawdown reached a rate of more than 14 feet/year causing 1174 nodes to be desaturated and 154 nodes pumped dry. The percentage of

pumpage supported by precipitation and leakage again declined. The percentage of pumpage supported by recharge from the river increased to the point where the recharge rate became limited by transmissivity to a rate of roughly 500 cfs. A pumping rate which forced recharge from the river to exceed 500 cfs resulted in a rapid increase in "mining" of water stored in the aquifer. Total drawdown was unavailable due to a premature termination of the simulation, but by the year 2020, the aquifer had been severely desaturated, with an area of roughly 35 square miles beneath the City of Camden having been pumped completely dry. Approximately 15 square miles of the aquifer in the vicinity of Penns Grove had also been completely dewatered.

Of the various projections, only I and II could be supported by the aquifer without sustaining major changes in quantity and quality. Projections III and IV were realistic since they paralleled real world conditions. In both cases, some damage would be sustained by the aquifer. However, since the damage sustained occurs early in the time simulation and tails off later in the simulation, the model predicts that in both projections the rate of aquifer damage reduces with time. Projection V and VI inflicted so much damage to the aquifer that future increases in pumpage at these rates shold not be sustained for any long period of time.

Sub-Studies V &VI. The optimum future demand analysis was a simultation of the aquifer response to increased pumpage as a result of future groundwater demand from projection areas within the

tri-county area through the year 2030. The projected pumpage demands were assumed to be directly proportional to projected population and industrial growth and were assigned to the nearest 1973 active well or wells within each demand center. Under this projection, the pumpage rate increased to 384.9 cfs (248.8 mgd) by the year 2030. Since the demand analysis addressed essentially only the "fine grid area", the 1973 pumpage for all wells not within this area was increased at the same rate as the tri-county average population growth water curve. Several features were added to the model for this task. These features allowed:

- New pumpage rates to be input at irregular intervals for all nodes.
- Water demand from a well that had been shut down due to poor water quality to be redistributed to the nearest pumping well.

Two projections were made for future demand in accordance with population growth centers. For Projection I, quantity and quality changes were simulated through the year 2030 without regard to deteriorating water quality. For Projection II, quantity and quality changes were simulated through the year 2030 with shut-down of wells that showed quality below the EPA standard for drinking water (maximum allowable chloride ion concentration of 250 mg/l). The pumpage of these shut-down wells was then reassigned to nearby good quality wells.

Simulation Results: Projection I. The drawdown of the aquifer for this projection accelerated to over seven feet/year by the year 2000

and then tapered off in response to the reduced rate of pumpage increases. Water quality decreased and velocities increased with the salt-water interface moving at a much higher rate than the desired maximum. The rate of river recharge for this simulation increased by a factor of almost 2.2. No nodes were pumped dry during this projection, but the number of desaturated nodes rose to 423 by the year 2030. The maximum drawdown for this projection was in excess of 200 feet and was centered in the Gibbsboro and Lindenwold area of central Camden County, which was slightly southeast of the area of the most severely depressed heads.

Projection II. This projection used the same pumpage as Projection I but used two options; one to limit pumpage due to poor water quality, and the other to reassign terminated pumpage to the next nearest active pumping site having acceptable water quality. The results of this projection was essentially the same as Projection I since both used exactly the same pumpage rates and the same fundamental distribution. Another reason for the similarity is that the largest amount of pumpage to be reassigned in any given year was about 30 cfs, or only between five and ten per cent of the total pumpage for each year.

Sub-Studies VII & VIII. These sub-studies address other aquifers and are described in the Plan Formulation Appendix under Water Budget - Other Formations Analysis.

Sub-Study IX. This sub-study involved a preliminary analysis of the impact of artificial recharge as a means of supplementing supply to the Raritan-Magothy. Within the scope of this sub-study the followng four techniques of recharge were identified.

- Ponds to trap runoff and allow it to infiltrate into the aquifer.
- Injection of treated wastewater by the use of injection wells.
- Injection of water pumped from other aquifers.
- Increasing leakage between aquifers by construction of filter galleries between the overlying aquifers and the Raritan-Magothy aquifer.

A limited computer analysis of one possible approach to artificial recharge was run to test the response of the aquifer to an active recharge program. For ease of simulation the injection method of recharge was used. The source of recharge was assumed to be advanced sewage treatment effluents. Injection wells were located in 125 grid elements, 122 within the fine grid area and a constant injection rate of one cfs/well was assumed. The chloride ion concentration of the injected water was assumed to be 120 mg/l. The 1973 pumpage rate was used throughout the simulation along with the option to limit pumpage due to poor water quality. This simulation was terminated at the end of 1976.

This pumpage regime produced a rapid recovery rate of up to 4.5 feet/year in 1973 and by 1976 had slowed to below one foot/year.

Generally heads recovered, velocities decreased and chloride ion concentrations declined. The percentage of pumpage supported by infiltration remained relatively constant while the leakage rate declined by 40 per cent due to the rapidly rising heads throughout the aquifer. Recharge from the river dropped rapidly in response to recovering heads near the river and accounted for less than six per cent of the total pumpage by 1976, as compared to 42.6 per cent in 1973. A comparison of the position of the 50 feet/year isogram with the position of the 150 mg/l isochlor indicated that the salt water interface was moving between 50 and 100 feet/year, a significant improvement over most of the other projections.

This simulation, while initially encouraging, should be run for longer periods using varying recharge and pumping arrays in order to adequately assess quantity and quality changes. These longer simulations would also help assess whether aquifer damage from increasing water demand could be mitigated by recharge.

Wastewater effluents can be designed for groundwater recharge and wastwater renovation via use of wells, causing a potential dual benefit. Based on the local desires effluents with rapid-infiltration basins may be considered to supplement groundwater supplies and benefit the wastewater treatment process.

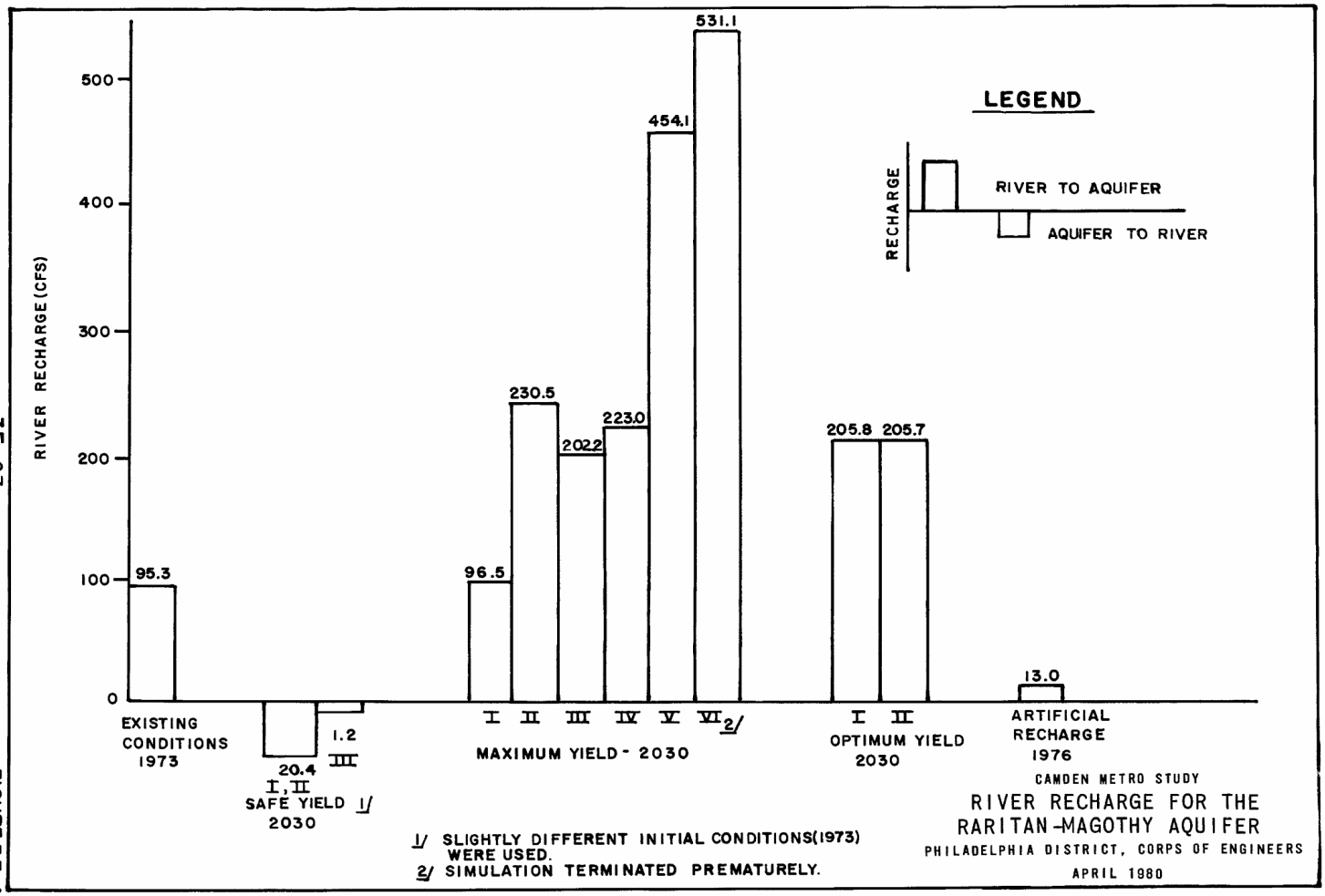
Table 3F-1 is a compilation of important values selected to summarize the response of the Raritan-Magothy aquifer to various pumping distributions. Figures 3F-4, 3F-5 and 3F-6 present this same data in bar graph form.

TABLE 3F-1

RARITAN-MAGOTHY AQUIFER RESPONSE TO VARIOUS PUMPING STRESSES

	Initial Conditions 1973	Safe Yield I & II 2000 1/	Safe Yield III 2000 1/	Maximum Yield I 2030	Maximum Yield II 2030	Maximum Yield III 2030	Maximum Yield IV 2030	Maximum Yield V 2030	Maximum Yield VI 2030 2/	Optimum Future Demand I 2030	Optimum Future Demand II 2030	Artificial Recharge 1976
Total Pumpage (cfs)	223.5	67.0 4/	76.7 5/	223.5	391.4	363.1	400.3	691.0	870.5	384.9	384.9	219.5 3/
Pumpage Supported by Infiltration From Precipitation (%)	17.3	61.6	50.4	17.3	9.8	10.6	9.6	5.6	4.4	10.0	10.0	17.6
Pumpage Supported by Leakage Through Confining Layer (%)	30.8	44.7	37.5	31.0	25.9	26.6	25.6	20.9	17.5	26.9	26.9	18.7
River Recharge (cfs)	95.3	-20.4	-1.2	96.5	230.5	202.2	223.0	454.1	531.1	205.8	205.7	13.0
Pumpage Supported By River Recharge (%)	42.6	-32.4	-1.6	43.2	58.5	55.7	55.7	65.7	61.0	53.5	53.4	5.9
Desaturated Nodes	132	33	35	140	321	281	343	872	1174	423	418	49
Dewatered Nodes	0	0	0	0	0	0	0	39	154	0	0	0

1/ Slightly different initial conditions (1973) were used.
2/ Simulation terminated prematurely.
3/ 4 cfs terminated due to poor water quality.
4/ WES used 62.7 cfs in a later simulation due to discovery of a missassignment of pumpage. A comparison showed little or no impact upon the results.
5/ This value is only fine grid area pumping and does not reflect the additional pumping of 37.6 cfs.



3F-2.7

FIGURE 3F-4

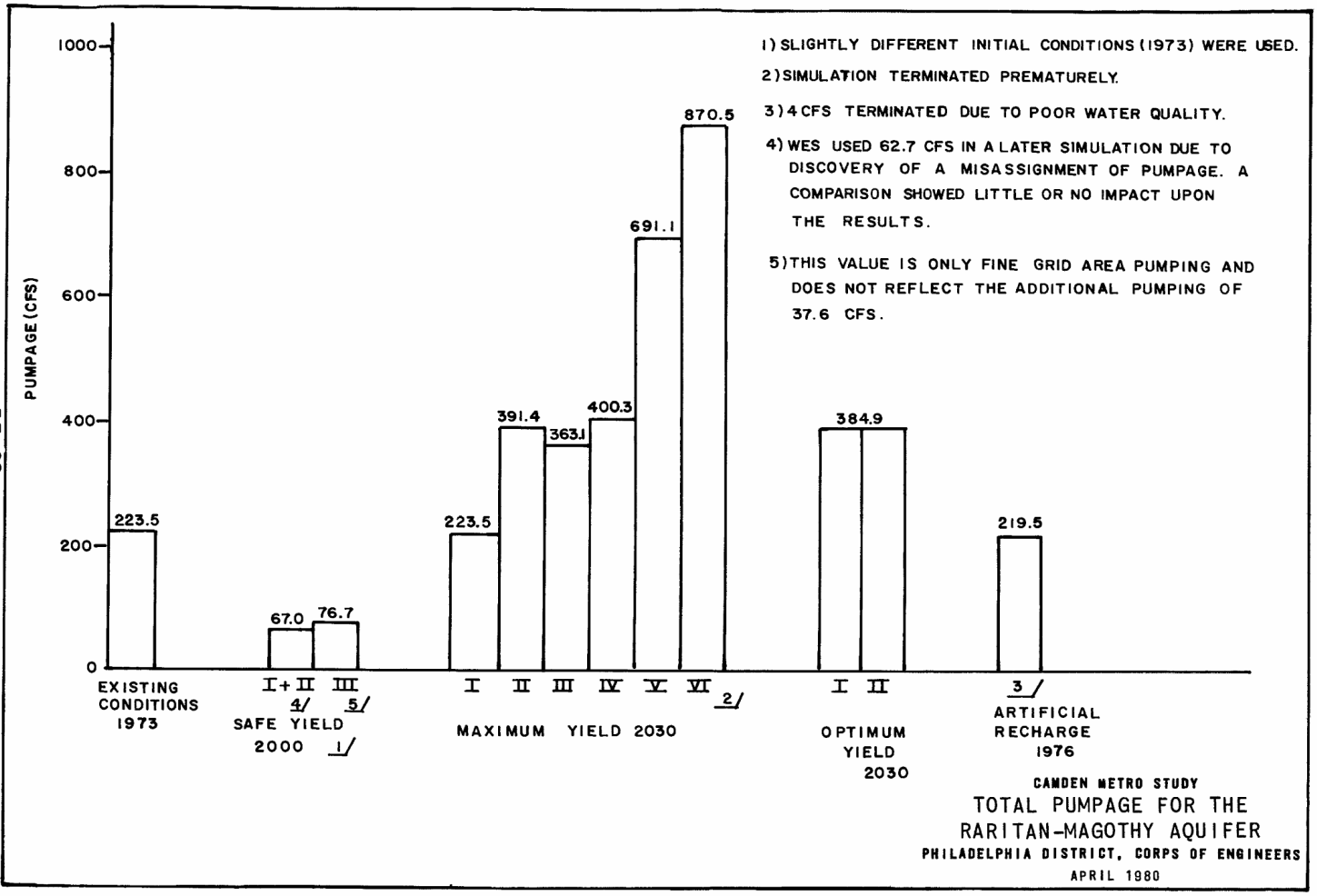
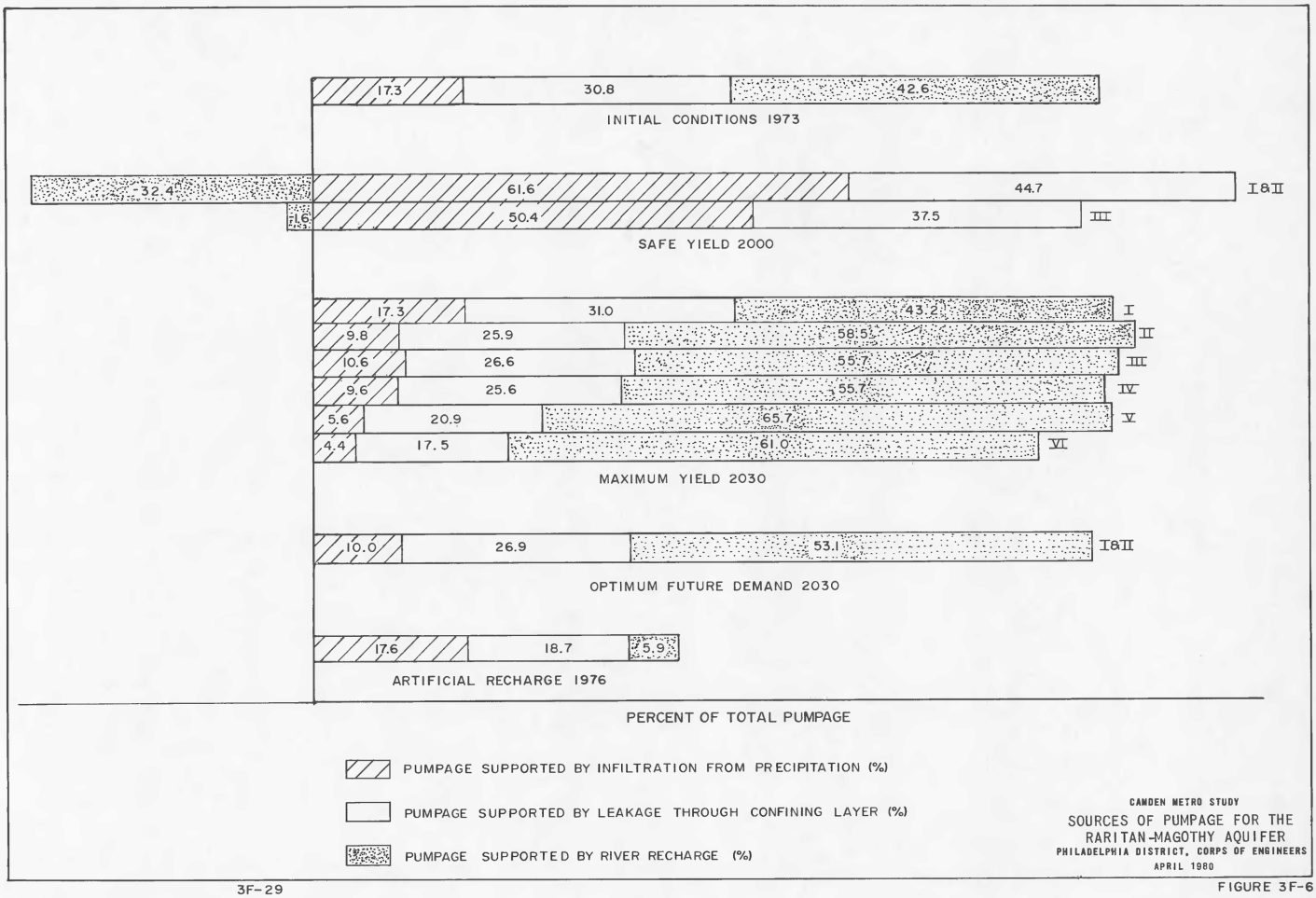

PUMPAGE (CFS)
1000
800
600
400
200
0
223.5
67.0
76.7
223.5
391.4
363.1
400.3
691.1
870.5
384.9
219.5
EXISTING CONDITIONS 1973
I+II 4/
III 5/
SAFE YIELD 2000 1/
I
II
III
IV
V
VI 2/
MAXIMUM YIELD 2030
I
II
OPTIMUM YIELD 2030
3/
ARTIFICIAL RECHARGE 1976
1) SLIGHTLY DIFFERENT INITIAL CONDITIONS (1973) WERE USED.
2) SIMULATION TERMINATED PREMATURELY.
3) 4 CFS TERMINATED DUE TO POOR WATER QUALITY.
4) WES USED 62.7 CFS IN A LATER SIMULATION DUE TO DISCOVERY OF A MISASSIGNMENT OF PUMPAGE. A COMPARISON SHOWED LITTLE OR NO IMPACT UPON THE RESULTS.
5) THIS VALUE IS ONLY FINE GRID AREA PUMPING AND DOES NOT REFLECT THE ADDITIONAL PUMPING OF 37.6 CFS.
CAMDEN METRO STUDY
TOTAL PUMPAGE FOR THE RARITAN-MAGOTHY AQUIFER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3F-5



CAMDEN METRO STUDY

SOURCES OF PUMPAGE FOR THE RARITAN-MAGOTHY AQUIFER

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

APRIL 1980

FIGURE 3F-6

MODEL ANALYSIS RESULTS

The water supply aspect of the Camden Metropolitan Urban Study, through the use of mathematical modelling techniques, analyzed the Raritan-Magothy aquifer under various pumping conditions. One condition, referred to as minimum practical (safe) yield, started by assuming that the aquifer experiences no movement of salt-fresh water interface and no recharge from the Delaware River. To achieve this condition, a number of wells would have to be shut down or have their pumpage reduced. However, the aquifer would soon begin to discharge into the river. This discharge water could be withdrawn by the addition of wells along the river in the tri-county area. The conditions described above do not supply enough water to meet the current demand, but they serve as a reference point and provide a description of the characteristics at the conservative end of the groundwater management program.

The next condition, referred to as maximum yield, described the range of the aquifer characteristics under several management possibilities. These ranged from the current pumpage levels, in which the aquifer is experiencing moderately depressed piezometric heads and a slowly advancing salt-fresh water interface, to extreme pumpage increases where the aquifer displays extremely low heads and, in some cases, dewatered wells.

The third condition, referred to as optimum yield, applied a real-world situation to the aquifer. The input to this condition was a future pumpage demand based on the expected growth of population, industry and commerce which was in accord with Year 2000 projections for the tri-county region. These projections, along with the expected per capita water demand, were extrapolated to the year 2030. In addition, the model was modified to shift wells to other areas when the groundwater quality reached unacceptable levels, as is common practice. The results of this condition show that the aquifer would be damaged in a manner similar to the severe conditions imposed by the high pumpage of the maximum yield condition. This indicated that the future demand pumpages, however reasonable and realistic, would cause the aquifer to sustain damage.

The three yield conditions indicate that the Raritan-Magothy needs careful management in order to remain a source of good quality water for years to come.

SECTION G

RECREATIONAL NEEDS

SECTION G

RECREATIONAL NEEDS

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SECTION G

RECREATIONAL NEEDS

This section includes a discussion of the State (of New Jersey's) Comprehensive Outdoor Recreation Plan (SCORP) and a marina survey conducted as part of this study.

NEW JERSEY STATEWIDE COMPREHENSIVE OUTDOOR RECREATION PLAN (SCORP)

The 1977 SCORP was prepared by the New Jersey Department of Environmental Protection and is the official state document for guiding outdoor recreation activities. The plan represents the culmination of an extensive planning program that encompassed broad citizen participation and active involvement by a wide range of Federal, state and local agencies.

The primary goals of the 1977 SCORP are to provide information on open space and recreation and lead to decisions concerning:

1. Increases in the number, quality and variety of recreational opportunities needed to meet the needs of the people of New Jersey.

2. Protection of an optimum amount of open space for current and future use.

3. Full use of the recreational potential of open space.

4. Enhancement of the state's natural environment.

5. Coordination of recreation and open space planning with the state's other planning programs.

6. Effective and efficient use of Land and Water Conservation funds and State Green Acres funds.

Specifically, the objectives of the 1977 SCORP are:

1. To compile accurate, up-to-date information on the supply and demand for open space, water resources and outdoor recreational facilities in New Jersey.

2. To develop strategies for addressing open space and recreation deficiencies.

3. To define the roles and responsibilities of the private sector and the various levels of government in providing recreational opportunities.

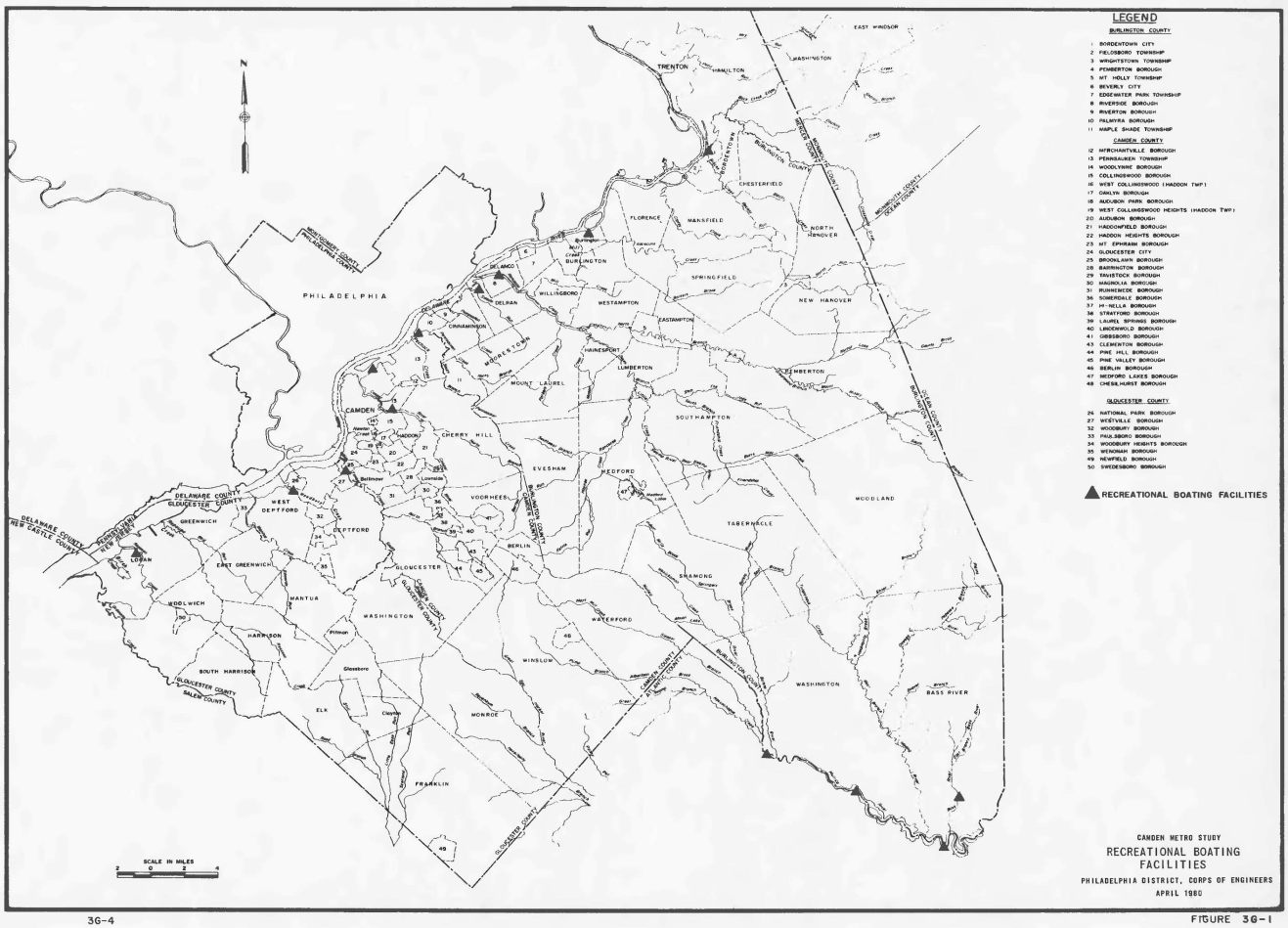
4. To establish policies and priorities for distributing Federal and state recreational development funds and open space acquisition funds and to increase the efficient use of these funds.

The counties were the base unit used in the SCORP in analyzing the state's facility deficits. Factors adding to this decision were county variations in population characteristics, development patterns, the natural resources available for recreational use and the opportunity to provide useful information to a level of government which is active in the planning and development of recreation facilities. Since the method used for distributing the demand considered both the resource opportunities in the counties and the

desire of people to participate in certain activities within close proximity of their homes, the facility deficits in one county cannot be used to offset surpluses in neighboring counties. For planning purposes it has been assumed that the State of New Jersey has the resources needed to provide facilities which will meet existing and projected recreation demands. However, it is recognized that county demand for many activities will not be met within each county. Therefore, the residents of one county will frequently have to travel to another county in order to satisfy their demands for such activities as swimming, boating, fishing, hunting and camping.

MARINA INVENTORY

In order to quantify the need for recreational boating facilities, a field inventory of existing facilities was undertaken by this office. The inventory consisted of field interviews with the owners of over 35 marinas. The marinas were grouped into areas of concentrated boating facilities as shown on Figure 3G-1. The results of the inventory, including type of facility, number of boats, depths and services offered is shown on Table 3G-1.



CAMDEN METRO STUDY
RECREATIONAL BOATING FACILITIES
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
APRIL 1980

FIGURE 3G-1

TABLE 3G-1

SUMMARY OF FIELD INVENTORY
BURLINGTON COUNTY

FACILITY NAME	TYPE	# OF BERTHS	PERMANENTLY BASED CRAFT					DEPTH AT FACILITY (MLW)	SERVICES OFFERED			
			OUTBOARD 1/	IN-BOARD 2/	CRUISER 2/	SAILBOAT	OTHER		FUEL	REPAIRS	LAUNCH RAMP	WINTER STORAGE
CROSSWICKS CREEK												
Bordentown Yacht Club	Private	30	0/10		2/18			2'	X			
Bordentown City Park	Public	--						2'			X	
Yapewzi Yacht Club	Private	29	0/10		6/0	11		2'				
RANCOCAS CREEK												
Big "D" Valley Marina	Public	--						2'	X	X	X	X
Bridgeboro Marina	Public	50		50/0				7'	X	X	X	X
Dan's Boat Yard	Public	50		15/5	5/5	10		14'	X	X	X	X
Eble's Marina Inc.	Public	58		29/0	29/0			5'	X		X	X
Art's Rancocas Marina	Public	80	25/0		0/10			7'			X	X
MULLICA RIVER												
Charu Marina	Public	292	0/58		88/146			6'	X	X		X
Allen's Dock	Public	70	0/20		0/20			10'	X			X
*Chestnut Neck Boat Yard	Public	90	0/60		0/15			5'	X	X	X	X
Cavileer's Boat Rental	Public	8	2/0					1'			X	
Pacemaker Corporation	Private	--						6'		X		
*Sweetwater Casino Boat Yard	Public	43	0/2		17/9			5'	X			
*Mullica River Marina	Public	40										
Mullica River Boat Basin	Private	--					3/	2'	X		X	X
							3/	3.5'	X	X	X	X
ASSISCUNK CREEK												
Curtin Marina Inc.	Public	120		42/42	24/0	12		11'	X	X	X	X
DELAWARE RIVER												
Riverton Yacht Club	Private	70				70		9'				X
Riverside Marina	Public	200		30/170				8'	X	X		X
P. Evanson Boat Co.	Public	70				70		7.5'		X		X
Plum Point Marina Inc.	Public	40	0/12	0/4	24/0			7'	X	X	X	X
Castle Harbor Marina	Private	135			0/60	20		7.5'		X	X	X
Dredge Harbor Yacht Basin	Public	200	0/40	50/0	0/110			11'	X	X		

1/ Under 16'/Over 16'
2/ Under 25'/Over 25'
3/ Canoe Rental
* Atlantic County Facility

TABLE 3G-1 (Cont'd)
SUMMARY OF FIELD INVENTORY
CAMDEN COUNTY

FACILITY NAME	TYPE	# OF BERTHS	PERMANENTLY BASED CRAFT OUTBOARD 1/	IN-BOARD 2/	CRUISER	SAILBOAT	OTHER	DEPTH AT FACILITY (MLW)	SERVICES OFFERED FUEL	REPAIRS	LAUNCH RAMP	WINTER STORAGE
COOPER RIVER												
Cooper River Yacht Club	Private	60				350		5'			X	
BIG TIMBER CREEK												
Boat Doctor	Public	30	15/0	0/15				19'		X		X
Joe's Marina	Public	14	10/0		3/1			12'	X		X	
Blue Anchor Power Boat Assoc.	Private	15	2/0	0/13				10'				
DELAWARE RIVER												
Farragut Sportsman's Assoc.	Private	30	0/15		0/15			14'	X		X	X
					GLOUCESTER COUNTY							
RACCOON CREEK												
Bridgeport Boat Club	Public	17	3/0		0/13		3/	2.5'	X	X	X	X
Gibbstown Boating Club	Private	10			5/5			2.5'			X	
Sweedesboro Boat Club	Private	--						2.5'			X	
WOODBURY CREEK												
National Park Boat Club	Private	10	4/0		2/2			5'			X	
BIG TIMBER CREEK												
Harry's Boat Yard	Public	2	2/0					16'		X		
Westville Power Boat Assoc.	Private	15	5/0		0/10			18'				X
Glenview Marina	Public	14			4/5			2'				X
Merk's Marina	Public	8	0/4		0/4			2'				X
Al's Boat Service	Public	10			0/10			20'		X	X	X

1/ Under 16'/Over 16'
2/ Under 25'/Over 25'
3/ 33' Charter Boat

CAMDEN METROPOLITAN URBAN STUDY

APPENDIX 4

INSTITUTIONAL ARRANGEMENTS AND ANALYSIS

SECTION A • FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT INSTITUTIONAL ARRANGEMENTS

SECTION B • WATER SUPPLY INSTITUTIONAL ARRANGEMENTS

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT

SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT

INSTITUTIONAL ARRANGEMENTS

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SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT INSTITUTIONAL ARRANGEMENTS

FEDERAL FLOOD CONTROL ORGANIZATIONS

Federal Emergency Management Agency

Flood Insurance and Hazard Mitigation Office: National Flood Insurance Program. This agency, which until recently was known as the Federal Insurance Administration, Region II, is composed of a small staff, most of whom are professionals.

Regulations and procedures for the Flood Insurance Program are described in the Federal Register of 26 October 1976. The regulations cover the following topics:

- Definitions of terms
- Eligibility requirements; i.e., actions that must be taken by a community to become eligible and to remain eligible for the program
- Establishment of priorities
- Criteria for local and state flood plain management regulations
- Planning considerations for flood-prone areas
- Insurance coverage and premium rates
- Sale of insurance and adjustment of claims
- Insurance maps; i.e., flood hazard boundary maps and flood insurance rate maps

- Community right to appeal flood elevation determinations
- Procedure for map correction
- Exemption of state-owned properties under self-insurance plan

Beyond the Federal/state relationship described in the regulations, the Federal Emergency Management Agency has a contract with the State of New Jersey which allows the state to contract for services with consultants in the name of the FEMA. At the time, this agreement was unique, but other similiar contracts are anticipated. The main feature of the agreement with New Jersey is the ability for the state to contract with consultants. The agreement also stipulates that any extra work required by the state in mapping the flood fringe (defined as the areas inundated by a flood having a discharge equal to 125 per cent of the 100-year discharge) will be carried out by the state. On the other hand, the FEMA agrees to pay the cost of the 1" = 200' scale mapping which the State of New Jersey desires.

Department of Housing and Urban Development

Federal Disaster Assistance Administration. The Federal Disaster Assistance Administration (FDAA) is currently undergoing a reorganization change in which it will become part of (FEMA). The responsibility of this agency is to provide Federal disaster assistance under the provisions of the Disaster Relief Act of 1974, Public Law 93-288. This law authorized FDAA

to coordinate the activities of Federal agencies and direct any Federal agency to utilize its available personnel, supplies, facilities and other resources in providing disaster assistance.

Federal disaster assistance is intended to supplement but not be a substitute for that afforded by the states and their political sub-divisions and by private relief organizations. When a governor believes that Federal assistance is necessary to supplement the efforts and available resources of the state and local government, he may request that the President declare a major disaster or make an emergency determination in order to implement the 1974 Disaster Relief Act.

The FDAA distributes a handbook which covers the criteria for determining eligibility plus policies and procedures related to Damage Survey Reports and inspections of completed work. Although it has been prepared primarily for use by Federal and state inspectors, in the event of an emergency or major disaster, local agencies involved may also find the information helpful.

Department of the Army

Corps of Engineers. The Corps of Engineers, in cooperation with other Federal and local agencies, is authorized to engage in the preparation of a series of long-range comprehensive plans for the development of the river basins of the nation. These framework plans inventory and determine the programs and projects required for the optimum utilization and protection of the nation's water resources. The major topics included in

these studies are: navigational improvement, flood control, major drainage basins, irrigation, hydroelectric power, water supply, water quality control, outdoor recreation, and fish and wildlife conservation and enhancement.

Comprehensive river basin studies when undertaken within urban areas, such as the Camden Metropolitan Urban Study, are conducted under the Corps' Urban Studies Program. Through this program, the Corps endeavors to provide a range of urban water resources plans that are compatible with the overall plans of the region under study. These plans are formulated to provide an integrated approach to the management of the water resources of each region.

In addition to comprehensive and urban studies, the Corps performs project feasibility studies. Some of these studies are known as survey investigations and recommend the authorization of specific plans to solve water resource problems. Others are conducted under the Small Flood Control Project Authority which provides funds for the Corps to construct small projects for flood control not specifically authorized by Congress.

Flood Plain Information Reports have been prepared by the Corps to promote the wise use of flood plain land. More recently, the Corps is taking part in the National Flood Insurance Program by providing detailed rate maps and floodway and hazard boundary maps.

The Corps also participates in flood emergency operations and disaster assistance under P.L. 84-99 whenever and wherever required as a supplement to individual and local community efforts.

Department of Agriculture

Soil Conservation Service. The Soil Conservation Service, located in Somerset, New Jersey, directs field operations and provides technical assistance to individuals or groups of farmers, landowners and operators in the development, application and maintenance of soil and water conservation plans through local Soil Conservation Districts in each county. A district is led by a five-member civilian group and advised by a district conservationist who is employed by the Soil Conservation Service, USDA. The five-member groups are typically composed of people who represent the following occupations: farmers, craftsmen, engineers and recreation facility owners. The district, assisted by the conservationist, develops and carries out soil and water conservation programs, and advises contractors, local environmental commissions and school boards on development and land use activities. The specific programs which the SCS administers include P.L. 83-566, Small Watershed Flood Prevention Act; P.L. 46, the Soil Conservation Act; and the Resource Conservation and Development Program under which the South Jersey area, including the tri-county area, has recently been approved.

The Soil Conservation Districts have two primary sources of funds: the permit fees for soil erosion and sediment control and the sale of seedling trees. In addition, they occasionally receive funds from the county and the state.

Department of Commerce

National Weather Service. The National Weather Service (NWS) is part of the Commerce Department's National Oceanic and Atmospheric Administration (NOAA). The Philadelphia NWS office is responsible for the entire State of New Jersey.

The NWS issues forecasts and warnings of weather on an hourly basis. They monitor and report upon river and flood conditions that can affect the safety, welfare and general economy of the entire populace. The NWS also conducts necessary research, including analyses and studies of hydrological data for broad application to water resources planning, design and operational problems.

Acquiring basic weather data enables the NWS to construct interpretative reports. The general public is informed for forecasts by radio, television, press, telephone and telegraph. Routine coordination of information for operational purposes is conducted by local NWS offices of Federal and state agencies concerned with disaster relief, water control and management.

Because of its responsibility to provide nationwide forecasts and warning services, the NWS is interested in comprehensive water and related land planning studies and project reports, including future plans and their anticipated implementation. The application of weather data analysis to future project planning has become increasingly widespread.

Department of the Interior

Geological Survey, Water Resources Division. The Unites States Geological Survey office, located in Trenton, covers the entire State of New Jersey. Its objectives, in general terms, are to determine the source, quality, quantity, movement and availability of both surface and ground waters. The work includes investigations of floods and droughts, their magnitude, frequency and relation to climatic and physiographic factors. The USGS evaluates the available waters in river basins and groundwater aquifers, and makes comparisons to the water requirements for industrial, domestic and agricultural purposes. This agency also gathers data on the chemical and physical properties of water and studies the relationship between climate, topography, vegetation, soil and water supply.

The USGS maintains a central catalog of information on water data and provides technical assistance in the fields of hydrology and groundwater to other Federal agencies. One

example of this assistance is the USGS's contribution to the Corps' Camden Metropolitan Urban Study: performing a computer modeling analysis of groundwater withdrawals.

The USGS cooperates with the New Jersey Department of Environmental Protection on many water resources investigations and these efforts are published in the State of New Jersey's Water Resources Circulars or the Geological Survey's Special Reports. A list of publications is available from the USGS office.

REGIONAL FLOOD CONTROL INSTITUTIONS

Delaware River Basin Commission

The DRBC, an interstate-Federal agency established by the Delaware River Basin Compact (P.L. 87-328; New Jersey Laws of 1961, Chapter 13), maintains a continuous planning effort in the field of water resources throughout the basin, which includes a large portion of the area covered by the Camden Metrpolitan Urban Study. The planning program covers surface and ground supply, water quality management, flood-loss reduction, recreation, fish and wildlife management, hydroelectric power generation and watershed management (including erosion control). Section 13.1 of the Compact requires that the DRBC develop and adopt a Comprehensive Plan for the immediate and long-range development and use of the water resources of the

basin. The Commission adopted its initial Comprehensive Plan in 1962, and this plan has been modified frequently to include new projects facilities, policies and standards.

Article II of the compact requires that the planning of all projects related to powers delegated to the DRBC be undertaken in consultation with the Commission. No public project affecting the water resources of the basin can be constructed or operated unless it shall have been first included by the DRBC in its Comprehensive Plan.

The DRBC's Comprehensive Plan is, therefore, an essential basis for planning new water-related developments in any portion of the Delaware River basin, including those portions in Burlington, Camden and Gloucester counties.

In November 1976, the DRBC amended the Comprehensive Plan to include an article on flood plain regulations. These regulations specify various regulated or prohibited uses of land and address the technical aspects of flood flow computations.

To resolve the confusion created by the use of various hydrologic methods by state and Federal agencies, the DRBC formed a Hydrologic Coordinating Committee in 1976. The committee is concerned with facilitating the exchange of hydrologic information among the several state and Federal agencies, as well as requiring these agencies' calculations to be consistent and compatible.

Delaware Valley Regional Planning Commission

The Commission is the official Federal A-95 clearinghouse and planning agency for the Phialdelphia-Trenton metropolitan area. Specifically, DVRPC's area of responsibility includes the nine member counties of Bucks, Chester, Delaware, Montgomery and Philadelphia in Pennsylvania and Burlington, Camden, Gloucester and Mercer in New Jersey. One of its major functions is to develop comprehensive regional plans for land use, highway, mass transit, water supply, water pollution control (such as the current Section 208 study) and open space. Further, it develops capital programs for each of these functional areas.

As part of its plan implementation activity, DVRPC serves as the regional information center for the area. The agency also acts to coordinate intergovernmental cooperation through its membership and numerous public forums. Its various planning functions are formulated and reviewed by regional representatives; these technical experts comprise the Technical Advisory Committees. Their recommendations are further reviewed by the Planning Coordinating Committee before being presented to the board. Two recent major studies at DVRPC affecting water resources were the Year 2000 Plan, which predicted the growth of the entire nine-county region, and the tri-county Section 208 Study, which produced a waste management plan for Burlington, Camden and Gloucester counties.

STATE FLOOD CONTROL ORGANIZATION

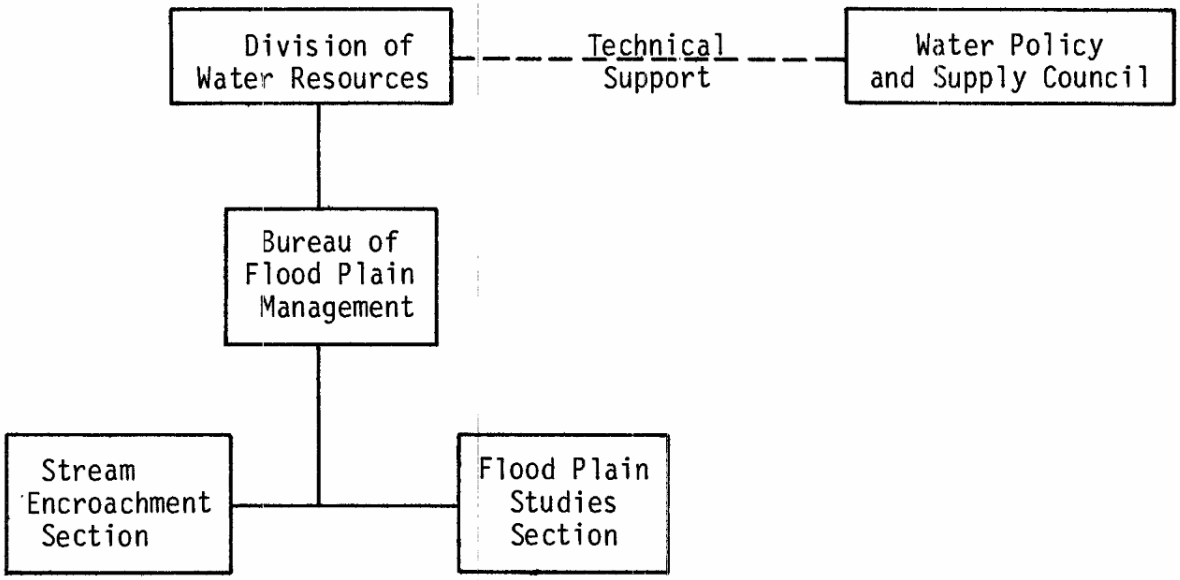
A chart showing the inter-relationships of those state agencies dealing with flood control is depicted on page 4A-12.

New Jersey Laws

1929 Stream Encroachment Act (NJSA 58: 1-26). The 1929 Stream Encroachment Law is New Jersey's most powerful tool for regulating the construction and maintenance of structures within streams. The law requires any public authority or private person desiring to build or repair a structure within the natural high-water mark of any stream to notify the state and to comply with any conditions the state may prescribe. The state's primary interest is to "safeguard the public against danger from the waters impounded or affected by such structure." The law also grants power to the state to direct any person to remove or repair a structure in any stream. In addition, the law sets a schedule of fines to be levied against violators.

The law is generally carried out by sections in the Bureau of Flood Plain Management. The applications for permits to contruct or alter structures in streams are received, reviewed, and either granted or denied by the Stream Encroachment Section. Violators of the law are reported to the Stream Encroachment Section which then investigates and prosecutes as appropriate.

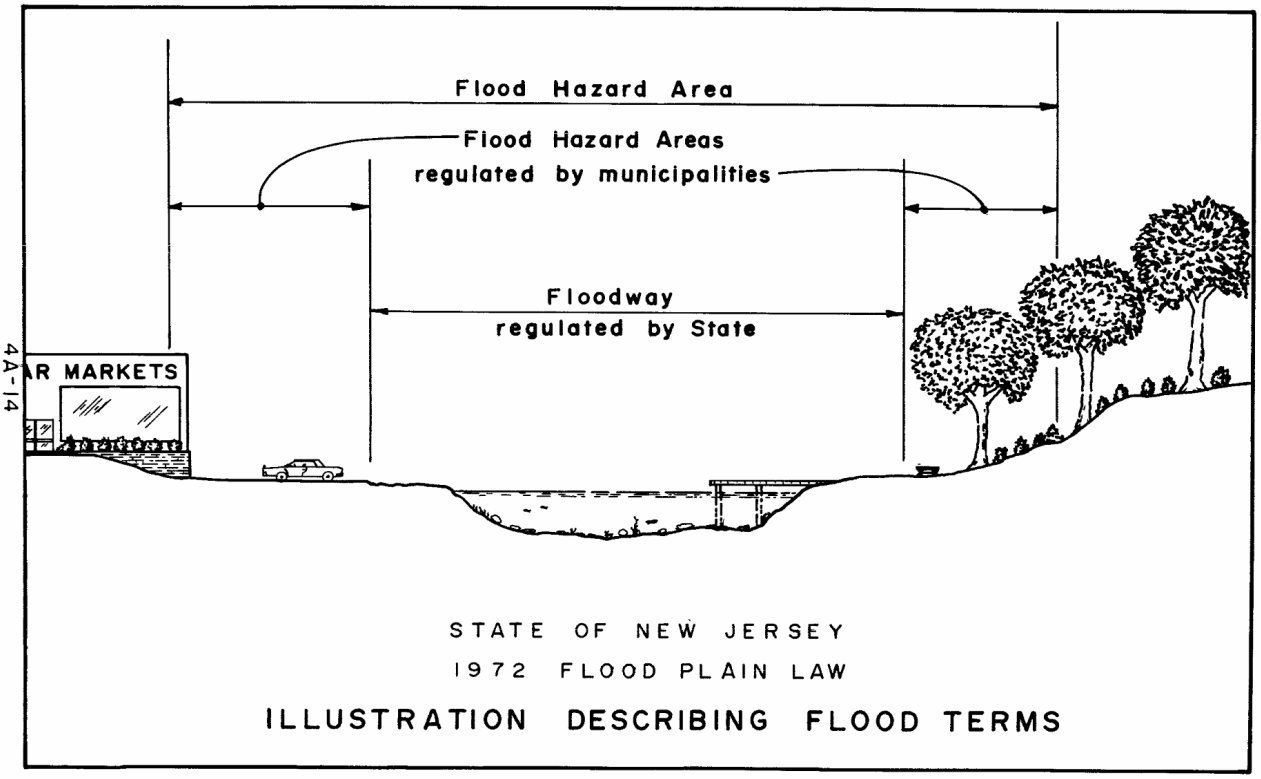
NEW JERSEY
FLOOD INSURANCE AND
FLOOD PLAIN REGULATION ORGANIZATION



1972 Flood Plain Act (NJSA 58: 16A-50). The Flood Plains Act gives the State of New Jersey and local municipalities more responsibility and power to control land use in flood hazard areas. For example, the state has responsibility to: 1) delineate flood plains, 2) mark in the field any flood hazard area, 3) adopt regulations to control the use of land in a delineated floodway, 4) provide standards for municipalities to use as a guide to land use in flood fringes and 5) levy fines and penalties on any person who violates a provision of this act. The municipalities are now responsible for adopting and enforcing rules concerning the development and use of land in flood fringe areas.

The regulations under this law are to be applied only to "delineated" streams. The concept of a delineated stream and the process by which a stream is so characterized is described in the section on the Water Policy and the Supply Council.

In carrying out the provisions of this law, the state places responsibility on the staff of the Bureau of Flood Plain Management. Items No. 1 and 2, (above), pertaining to delineation of flood plains and the field marking of flood hazard areas, are performed by the Flood Plain Studies Section. Refer to page 4A-14 for an illustration of the flood terms discussed above. The state's third area of responsibility -- regulations to control the use of land -- is a program which is administered by the Stream Encroachment Section. Enforcement of



STATE OF NEW JERSEY

1972 FLOOD PLAIN LAW

ILLUSTRATION DESCRIBING FLOOD TERMS

regulations is broken into three groups: prohibited land uses, regulated land uses and unregulated or fully permitted uses.

Of the three groups of regulated uses, two were adopted for adminstrative purposes in April 1975. They are the regulations pertaining to prohibited uses and unregulated uses. In effect, this action made few changes to development regulations in New Jersey, since the 1929 Stream Encroachment Law is also in effect. However, the third portion of the regulation -- regulated uses -- will bring more land use under state control. The Stream Encroachment Section will participate in the preparation of these regulations.

The state's fourth responsibility under the 1972 law is to prepare guidelines for flood fringe regulations which the municipalities will employ in passing their own ordinances. The 1972 law gives the municipalities the responsibility to regulate the use of the flood fringe areas, i.e. the area within the flood hazard area which is not actually in the floodway.

The fifth area of responsibility -- to levy fines and penalties -- will be carried out in conjunction with the state's forthcoming land use regulations.

Department of Environmental Protection Act of 1970 (P.L. 1970 c.33, NJSA 13: ID-1) and Supplement: An Act Concerning the Application for Construction Permits to the Department of Environmental Protection (P.L. 1975, c.232). The provisions of

these laws permit the establishment of rules and regulations to provide good administration of the various DEP permit programs, including the 1929 Stream Encroachment Act. In particular, the law led to a set of rules and regulations, signed by the Commissioner, which expedite the permit process, assure adequate public notice, continue effective administration of other laws, revise certain procedures involving the Water Policy and Supply Council, and establish a fee schedule. The rules also bring together five different permit programs which are administered by various divisions in DEP for the purpose of better administrative control and public notice. For example, the five permit programs are all jointly represented in the "DEP Weekly Bulletin", which gives the status of any permit application filed or acted upon under the five programs. It also serves to notify the public of any council meetings or public hearings to be held in the near future.

New Jersey Department of Environmental Protection

Water Policy and Supply Council. The Water Policy and Supply Council is a unique regulatory body having quasi-judicial, quasi-legislative and quasi-executive powers. It is made up of 11 appointed members who serve part-time at no compensation. The members represent a variety of career backgrounds: businessmen (the most common), mayors, professors and farmers. The council engages in activities related to water supply, flood control policy and decision-making. The Council is supported by technical services provided by various state agencies and

departments. For engineering services such as hydrology, hydraulics, groundwater data, surface water supplied and water quality information, the council turns to the Department of Environmental Protection's Division of Water Resources. There are at least six major functions of the council which are described below.

Concerning the Flood Insurance Program, the council has authority to set policy and criteria in technical and non-technical matters. For example, in recent years the council has passed various resolutions altering or clarifying the Department of Housing and Urban Development (HUD) standards for detailed rate studies. In one such action, the council stated that the floodway should be "designed to carry the waters of the 100-year flood without increasing the water surface elevation of the 100-year flood more than two-tenths of one foot (0.2 ft.) at any point." HUD criteria in this matter allows a one-foot increase. In other actions, the council declared that all flood discharges should be computed using the Stankowski method (the NJDEP reviews these computations and allows other methods as appropriate); that all stream discharge computations, for insurance or encroachment, shall be based on a 100-year recurrence interval; and that the whole flood hazard area shall have a design flood discharge 25 per cent greater than that used for defining the actual floodway limits.

In addition, the council requires more detailed base maps for flood hazard area mapping than the Federal Insurance Administration (FIA) requires.

In the area of stream encroachment, the council works under two laws. The 1929 Stream Encroachment Law, NJSA 58: 1-26, gives DEP the responsibility to require permits for any construction in any stream in New Jersey. The actual review and permit grant or denial is performed in the Stream Encroachment Section in the Division of Water Resources. The council acts as an appellate board to hear the cases of applicants who feel the need of a hearing.

Under the second law, the 1972 Flood Plain Act, NJSA 58: 16A-50, the council establishes the aforementioned flood insurance criteria and promulgates regulations to be observed by developers in delineated streams.

Concerning the concept of delineating a stream or flood hazard area, the council plays a role in a six-step process. The council's function is to review the flood map and then conduct public hearings. Following the hearings, the maps are approved by the commissioner, advertised in the New Jersey Register, altered in response to comments if appropriate, and then processed as a final delineation.

In the area of water supply, a major function of the council is to grant water diversion rights to water purveyors and self-supplied users who are desirous of withdrawing water from

wells and surface sources. In this area the council has original jurisdiction, i.e., it makes the original decision to grant or deny the rights.

In the area of water use and water quality the council makes judgement on consumptive vs. non-consumptive use permits. "Consumptive" means the actual use or consumption of water, which returns less water to the stream than was removed, as well as the act of returning water whose quality is lower than that of the withdrawn water.

The council has spent the greatest amount of time on encroachment matters, with water supply and water quality matters second in volume of work.

Division of Water Resources

Bureau of Flood Plain Management: Flood Plain Studies Section. This section has responsibility to perform the various studies required in the Flood Insurance Program. Under Federal funding, this agency prepares detailed rate maps which qualify a municipality to join the regular insurance program. The Flood Plain Studies Section has grouped the various municipalities into project areas according to geographic criteria and proximity. A typical project area would be made up of a group of eight to ten municipalities located on the same stream or in the same watershed. The section then arranged these project areas into a priority list. The criteria used in preparing the priority list relied on density of population and intensity of damage in recent floods as recommended by HUD. As back-up data,

the staff relied on flood damage records from Hurricane Doria in 1971, a disaster in 1973 and the thunderstorm floods of 1975. As a result of this work, the municpalities along the Raritan, Passaic and Rahway rivers in northern New Jersey were listed as high priority. This priority listing was performed by the staff of DEP's Flood Plain Studies Section and recommended to HUD. The municipalities of the tri-county area are listed as of lesser priority.

When the project areas were assembled, the section invited the various Federal agencies capable of preparing detailed rate maps to select any project areas with which they were already familiar. The Corps of Engineers, both Philadelphia and New York Districts, the Geologic Survey and the Soil Conservation Service are the most active Federal agencies. After these agencies made their selections, the Flood Plain Studies Section laid plans to study the remaining project areas. Generally, all these are actually performed by consulting engineers hired by DEP since HUD allows the NJDEP to contract engineering services and to administer the contracts.

In work performed by the various Federal agencies, the NJDEP allows the agency to use its own in-house hydrologic method. In the contract work, NJDEP usually requires its consulting engineers to first try the Stankowski methods of hydrologic analysis. However, the NJDEP allows other methods if they produce better results. A second requirement of DEP is that the

mapping be done at a scale of 1" = 200' H and 1"=5'V. This requirement is more strict than HUD's criteria which employs the "best available" maps, usually quadrangle sheets, with scales of 1"=2,000'H and 1"=20'V. An exception is work done for HUD by other Federal agencies, such as the Corps or SCS, which will still use quadrangle sheets since this is considered an inter-agency agreement. Work done by consulting engineers employs the 1"=200' mapping, either existing or newly-produced. HUD, at the Washington level, has agreed to pay the cost of DEP's more strict mapping requirements, but under certain circumstances the state, county, or municipality will also contribute.

Recently HUD has sought to cut costs by declaring that certain municipalities can be converted from emergency insurance without detailed rate maps. This condition will apply to municipalities whose watersheds are less than one square mile or who expect no development in the flood hazard area for five years. In these cases the Flood Plain Studies Section will go to the field and update the municipality's flood hazard map. The section predicts that many rural areas will be converted to regular insurance by this method.

The Flood Plain Studies Section also particpates in studies to delineate streams for development regulations under New Jersey's 1972 Flood Plain Act (NJSA 58: 16A-50). The section prepares flood hazard area maps and forwards them to DEP's Water Policy and Supply Council for hearings and other administrative procedures prior to the decision for the final delineation.

The combination of Federal and state programs, with different purposes, criteria and stream profiles, requires three maps to adequately display all the flood data.

First, the Detailed Rate Map shows hazard zones for insurance premium purposes. The degree of flood hazard for each zone is designated using letters and numbers. These maps employ a 100-year flood as the basic criteria.

Second, the Floodway and Hazard Boundary Map is provided to the municipality as a forerunner of the Detailed Rate Map. It shows flood-prone areas in order to encourage the municipality to begin land use regulations, and to enter the flood insurance program. The map always shows the 100-year floodway and sometimes a 500-year flood hazard boundary.

The third map, the New Jersey Flood Hazard Area Map, is associated with New Jersey's Flood Plain Act of 1972. This map is produced to provide a basis for New Jersey's flood hazard area delineations. It shows which area is floodway and which is flood fringe within the flood hazard area. It will be used by the state and the municipality in regulating land use within the flood hazard area under the 1972 act. The New Jersey Flood Hazard Area Map and the HUD Floodway and Hazard Boundary Maps agree in the description of the 100-year floodway; however, the New Jersey map also shows the flood fringe which is based on a flood 25 per cent greater than the 100-year flood. The additional 25 per cent flow generally produces a difference in

elevation of about one foot in the flood fringe to be regulated by the municipality. NJDEP contracts with consulting firms have required the three types of maps and DEP has also requested any Federal agencies who participate in flood mapping to provide the three maps.

Under the 1972 Flood Plain Act, the Flood Plain Studies Section also currently contributes to the flood fringe guidelines which each municipality will use to draft their own flood fringe ordinance. In the future, the section will contribute to the rules for regulated uses of delineated flood plains, as prescribed by the 1972 Flood Plain Act.

Division of Water Resources

Bureau of Flood Plain Management: Stream Encroachment Section. The Stream Encroachment Section of NJDEP is responsible for carrying out the 1929 Stream Encroachment Act (NJSA 58: 1-26). This responsibility requires two functions: 1) the review and approval of applications for permits for stream encroachment, and 2) the investigation and processing of violations. Of the two functions, the review and approval of permit applications generates the greater workload.

The stream encroachment permit program operated by DEP begins by educating the applicant to the requirements of the law and to the review and approval process. The Stream Encroachment Section has prepared and currently distributes a permit application package to any developer who requests it. The package contains three items: 1) a copy of DEP's 90-day construction permit regulations; 2) a revision

to the regulations which adjusts the fee schedule; and 3) an application form for permits for stream encroachment. The applicant completes the form and sends it to the section. The application is then recorded and the process of review (which should be completed within 90 days according to New Jersey regulations) is begun.

After any necessary investigations are carried out, the section will grant or deny the permit. In many cases, the section requires the developer to make certain modifications to the plan in order to grant a permit. If a developer is denied a permit, he can appeal the decision to the Water Policy and Supply Council. In mist cases the council upholds the section's decision. If the developer wishes, he may then take his appeal to the New Jersey courts.

The second important function of the Stream Encroachment Section is the investigation and processing of violations. A typical violations case is initiated by a person outside the state government who reports the situation. All violations handled by this section involve persons who intend to build something. A few problems involve persons owning land fills; however, these cases are ordinarily handled by the Solid Waste Managment Bureau. After the Stream Encroachment Section is notified of a violation, it sends a questionnaire to the reporting person to obtain the address and date of the violation. Following this, the section sends an inspector to

the site to verify and document the case. The inspector visits almost every site, and occasionally revisits a site depending on the action of the violator. In many cases, the violation is brought about by ignorance on the part of the violator. Often the situation is resolved by the violator submitting a proper application or by correcting the error in the construction plans.

If no settlement is reached by this stage, the section will refer the case to the Attorney General's office. The Attorney General's first function is to take the violator before the Water Policy and Supply Council. If the violator is charged and fined but refuses to comply, the Attorney General then takes the case to the New Jersey court. In addition, as mentioned in the Water Policy and Supply Council portion, the violator may appeal to the New Jersey court if he feels he has been treated unfairly. The greatest number of cases are located in the northern New Jersey area while the Burlington-Camden-Gloucester area makes just a modest contribution to the volume of cases. The Stream Encroachment Section coordinates with the Bureau of Solid Waste Management of land fill expansion and with the monitoring, surveillance, and enforcement Elements on matters of land fill leaching problems.

COUNTY FLOOD CONTROL INSTITUTIONS

Introduction

County planning boards were established by the New Jersey

County and Regional Planning Enabling Act, Sections RS 40:27-1 to 40:27-11. This law was originally passed in 1935 and revised in 1968. Under this law, each county is permitted to create a planning board to prepare a master plan for the physical development of the county. Also under this law, counties may prepare capital improvement programs, official maps and require local governments to submit subdivision plans. Each county then passed resolutions to require developers to submit plans to the county planning board for review and approval. In this review process, the counties' main interest is to avoid traffic congestion and to minimize roadway drainage that affects the county road system. Each of the three counties has published a booklet for the benefit of developers explaining state requirements and their own particular requirements, procedures and construction details.

State Enabling Law - County and Regional Planning Enabling Act NJSA 40:27-1 to 40: 27-11

The County Planning Law is New Jersey's current enabling legislation to grant power and responsiblility to the various counties for land use control. The law's first provision enables the boards of freeholders to appoint a planning board and employ a staff, commonly called a department, to carry out the various investigations, mapping, reviews and coordination activities. The functions performed by the planning boards are divided into two main categories: master plan mapping and land development reviews.

The master plan mapping is to be done by the planning board which is empowered to employ experts as required. The law requires the planning board to hold public hearings on the master plan and to keep close contact with the municipalities throughout the planning and post-planning period. The law also describes the proper relationship between the planning board and the freeholders regarding overriding decisions and appeals.

Land development reviews, the second and more voluminous planning board function, are described in the section on county planning organizations. The law gives the planning boards responsibility to review all site plans or subdivisions which affect the drainage facilities or traffic along county highways. It also describes the application process, time limits, required coordination, appropriate construction details, performance and maintenance guarantees, appeals and the proper coordination between municpalities and counties in order to work together efficiently.

Burlington County Planning Board and Department

The Burlington County Planning Board has nine members and a department staff. About one-third of the manpower of the department is devoted to site plan and subdivision review work. This involves data gathering and making preliminary recommendations which are passed to the Land Development Review Committee. This committee is composed of six voting members: a county freeholder, the county engineer, the planning director, the chairman and two other members of the planning board. The committee consults the

planning board's lawyer as necessary and reviews and approves (or disapproves) all subdivisions and site plans abutting county roads. Subdivisions and site plans come before the Planning Board only on appeal, and then only when they have been reviewed again by the committee.

Although the county was reviewing subdivisions for several years before the 1968 revision of the state's County Planning Law, the review process was formalized in 1970, and was strengthened by a new county resolution dated June 1975. Four examples of improvements to the review system are shown below:

- One resolution and review process now covers both site plans and subdivisions.
- The 1975 resolutions employ the Soil Conservation District's standards on erosion and sedimentation control mentioned earlier in this appendix.
- The new resolution provides better design criteria for roadway drainage and traffic control.
- The current (1975) resolution gives the developer better directions and aid in obtaining the other permits which he may require.

Burlington County has published in a 158-page manual entitled Land Development Review Resolution which explains all the requirements of the 1975 law, especially the submission and review process. It also indicates county requirements for drainage and traffic control and provides tables, graphs and detailed sketches to aid the engineer. The county planning

department, in concert with the engineer's department, has performed flood plain management studies but no longer engages in this work. However, the planning department can request such studies under the 1960 Federal Flood Control Act. The county can also aid the municipalities by recommending flood control policies and practices. In the past, the county planning board has actively circulated model flood plain ordinances for local adoption.

Camden County Planning Board and Department

Camden County has a nine-member planning board and planning department. Approximately 25 per cent of the department manpower is devoted to land development reviews. Camden County review procedures and related criteria are carried out under a county resolution adopted in July 1970. The county published a 60-page manual entitled Sub Division Review and Site Plan Review: Procedures, Engineering and Planning Standards, which explains the review system and the various engineering requirements.

Environmental Agency. The Camden County review process is enhanced by the County Environmental Agency which prepares environmental assessments of land development and aids the local municipality in its own land development review. The agency is a county office which Camden County established to protect and improve the environmental quality of life. The Environmental Agency's funding comes from the county and is supplemented by state grants for specific jobs. The agency has five main functions:

- It provides technical input to other county offices on environmental matters. This is the type of service the agency provides in the land development review process.
- The agency serves as liason between various levels of government in environmental matters.
- It provides educational and advisory programs on ecology and sound land use policies for the municipalities.
- It initiates research on the natural features of the county and their proper use.
- Finally, the agency is empowered to acquire and manage real or personal property for environmental reasons.

Gloucester County Planning Board and Department

The Gloucester County Planning Department is considered an arm of the Board of Freeholders, not of the Planning Board. About 40 per cent of the manpower is engaged in land development review. This review is assisted by four professionals from the engineering department. The four engineering staff members: county engineering, assistant county engineer drainage engineer, and traffic engineer, are also assisted by various non-professionals as required. The county planning organization published two manuals in 1971, Site Plan Review and Subdivision Review. The two manuals present the procedures, details and design standards which a developer is required to follow in his submissions.

As a service to the municipalities, the county, in 1976, conducted a Soils Interpretation Mapping Program which mapped

and described all areas based on soil types. Under this program the whole county was mapped at a scale of 1"=400'. Among other purposes, these maps will be the interim basis for a flood zoning program in the county whereby the county planning staff will promote municipal flood plain zoning regulation, since the county has no zoning power of its own. To carry out this program, the county held workshops at the municpalities and then the municpalities were able to enact their own zoning regulations using the maps as a guide. Since the correlation of soil types to flood-prone areas is not 100 per cent, the maps are seen as having an interim value. Accordingly, they will be used until the state completes its flood mapping program.

CITY, TOWNSHIP AND BOROUGH FLOOD CONTROL INSTITUTIONS

Municipal Land Use Law, 1976, (NJSA 40:55D-1 to 40:55D-92)

The Municipal Land Use Law of 1976 is the most recent state law related to municipal control of land development. It reorganizes, consolidates and strengthens various enabling statutes concerned with municipal land control activities. In so doing, the 1976 law repealed and replaced many previous statutes including the Municipal Planning Act, the Official Map and Building Permit Act, the Municipal Zoning Enabling Act and the Municipal Planned Unit Development Act. The 1976 law places greater emphasis on flood control as this quote from the act

demonstrates: "it is the intent and purpose of this act to secure safety from fire, flood, panic and other natural and man-made disasters."

The 1976 law is a broad document which provides enabling legislation for the following municipal organizations or functions: municipal planning boards, master planning, capital improvement planning, official mapping, subdivision and site plan reviews and appeals, zoning laws and boards of adjustment, and combined planning efforts by two or more municipalities.

In the matter of a municipal planning board, the law provides for the creation of a planning board by the municipal governing body. It also directs the board's membership composition, its activities, responsibilities, and relationship to the municipal environmental commission and other organizations. The board's activities are expanded to deal more closely with zoning activities and land development reviews.

Regarding subdivision and site plan reviews, the law enables and requires the municipality to pass ordinances which establish the local requirements and procedures. The state law requires, among other items, provision in the municipal ordinances which "ensure adequate water supply, drainage, shade trees, sewage facilities, and other utilities necessary for essential services to residents and occupants."

In the article on zoning, the state law recommends that the municipal ordinance include a provision which will "designate and regulate the areas subject to flooding (1) pursuant to the

New Jersey 1972 Flood Plains Act or 2) as otherwise necessary in the absence of appropriate flood hazard area designations..."

City of Camden

Planning Board. The Planning Board is a nine-member body appointed by the Mayor to oversee the preparation and revision of a Master Plan and to serve as an appellate board for persons who may be refused some land use revision by the Bureau of Planning. In the past, the board had a minor role in planning and development in the city, but the board's role was strengthened in 1977 when the city passed an ordinance in response to the New Jersey Municipal Land Use Law (NJSA 40: 55D-1).

Division of Planning. The Division of Planning is composed of two bureaus. They are:

- Bureau of Planning. the Bureau of Planning serves as a staff to the planning board, as state law enables, and the chief of the bureau is a member of the board. The city's 1977 land use ordinance brought site plans under the control of the Bureau of Planning and stengthened the city's control over conservation and land use, as did the revised Comprehensive Plan which was approved in 1977. To carry out these duties, the bureau has prepared rules, regulations and guidelines to aid the developer in meeting the subdivision review requirements. The bureau's flood control powers are limited, since they can only advise a subdivider that flood-proofing is necessary if the location is in a flood plain.

• Bureau of Intergovernmental Relations. Among this bureau's diverse roles are three which pertain to flood control and development control. The bureau serves as liason between the city, the Corps' Camden Metropolitan Study and DVRPC's Section 208 Study. It also serves as a staff for the Environmental Commission which reviews environmental assessment reports for proposed development by the city. (See the paragraph on the Environmental Commission, in this report.) In addition, the bureau analyzes the location of the proposed development to determine if it falls in a flood hazard area according to the Federal Flood Hazard Area Maps. In case a development does fall in a flood hazard area, the bureau's only action is to recommend that the builder use flood-proofing. However, enforcement of the building code by the building inspector will ensure that the development is constructed using flood-proofing. (See the paragraph on the Building Bureau.)

In addition to above-mentioned flood-related functions, the bureau serves as a staff to the Mayor's Citizen Advisory Commission, aids the other city departments in obtaining grants, loans, etc., monitors Federal and state registers for rules and regulations pertaining to city projects and performs other duties at the request of the mayor.

Environmental Commission. The Environmental Commission's responsibility is to review and assess the city's own plans for community development and redevelopment. The purpose of this

redevelopment. The purpose of this review is to determine if the plans for development are in accordance with Federal and state environmental guidelines. This group determines what action the city should take to insure the clearance of the project through Federal and state reviews. The commission has direct access to the mayor and exerts much incluence over the environmental aspects of city projects.

The body, which was formed in 1975, is composed of seven members who are all technically qualified to review reports.

Zoning Board of Adjustment and Building Bureau. The Zoning Board is a seven member body which hears appeals from land owners seeking adjustments and variances to the zoning map.

Staff support for the Zoning Board is provided by the Building Bureau of the Division of Public Works. The Building Bureau, led by the building inspector, has responsibility to enforce any flood control regulations or flood zoning laws which may be passed by the city governing body. For example, the city has switched from the 1972 New Jersey Buidling Code to the 1975 Building Officials and Code Administrator's (BOCA) Building Code. This new code, which will be used statewide and which includes many more flood-proofing provisions, will be enforced by the Building Bureau.

Other Municipalities in the Tri-County Area

In addition to the City of Camden, there are exactly 100 other municipalities in Burlington, Camden and Gloucester counties. In the spring of 1977, each municipality passed legislation to revise procedures and to strengthen the various boards and commissions. Most local governments now have a planning board, a zoning board of adjustment, an environmental commission, and all have a building inspector. All local governments now have a building code, and most have zoning ordinances, planned unit development laws, subdivision ordinances and master plans. In addition to these boards and commissions mandated by law, a few municipalities employ a full-time planner or staff of planners, and, in a few cases, two or more local governments combine together to discuss development topics common to all parties.

Municipalities in Burlington County. The Burlington County Board of Freeholders publishes a directory of municipal officials and the Planning Board maintains files on the membership of the municipal planning boards environmental commissions, and zoning boards of adjustment. The county also keeps a file of the various municipal zoning ordinances and subdivision regulations. Each year, in order to keep abreast of changes in municipal officials and ordinances, the county contacts each municipality and updates the directory and files.

Municipalities in Camden County. The Camden County Planning Department publishes a directory of municipal officials and members of the municipal planning boards, environmental commissions and zoning boards. In addition, the county keeps a file of the various municipal zoning laws and subdivision regulations. Like the other counties, each year Camden County will update the directory and files on the various municipalities.

Municipalities in Gloucester County. The Gloucester County Planning Department keeps files on the membership of the municipal governing bodies, planning boards, environmental commissions, zoning boards, zoning and sub-division ordinances, master plans, building codes and planned unit development ordinances. These items are listed in an informal, unpublished inventory which can be updated each year as is done in the other counties.

PLANNING FOR EMERGENCIES

This section addresses the role played by emergency service agencies in flood preparedness and relief. During 1979 and 1980, the various agencies involved in emergencies are being combined and reorganized. The title "Civil Defense" is gradually being replaced by one emphasizing emergency management or service.

When a flood or other type of disaster strikes, the municipality has the inherent responsibility to initiate responsive action, and if the situation is serious, to begin coordinating with the county and neighboring municipalities. There have been local floods in the three-county area in 1962, 1964, 1968, 1971 and 1979. In addition, many neighboring counties, such as Mercer, Monmouth, Ocean, Atlantic, Cape May and Cumberland, have been declared flood disaster areas in 1975 or 1976.

Description of State Emergency Organization

In New Jersey, the Bureau of Emergency Services has the responsibility to coordinate all emergency activities as mandated by state statute, Chapter 438. The Bureau of Emergency Services is under the authority of the state police which, in turn, is one division of the Department of Law and Public Safety whose chief officer is the attorney general. The recent reorganization, converting Civil Defense to Emergency Services under the state police, was accomplished by the governor's Executive Order. Further organizational refinements are anticipated under the attorney general's authority.

Description of Existing County Emergency Organizations

In New Jersey, the executive officer or governing body of each county and municipality is mandated by state law to establish and execute disaster preparedness and emergency services which are required to protect property and save lives

in emergency situations. The local government's responsibilities include providing advanced planning (both permanent solutions and contingency plans), developing operational readiness, and establising recovery assistance.

Burlington County. In Burlington County, emergency services are managed by a small staff that also administers the Department of Public Safety, the Police Academy and the Forensic Laboratory. The emergency services staff operates a communications center which links all county fire and emergency units and some police departments. An emergency operations center was also opened. The Public Safety building has a 200-seat auditorium and eight classrooms. The alternate emergency operations center is in Edgewater Park. As state and Federal laws require, the county has prepared a warning system, an emergency plan and a notification system. Advance planning and coordination is carried on with the state, neighboring counties and the municipal emergency officials.

Camden County. The Camden County emergency organization has both a permanent and temporary staff (the latter serve as necessary). The emergency operations center is located in the Lakeland Hospital Area and the county communications center is in Lindenwold. The alternate emergency center is in the Bellmawr Boro Hall.

The county holds planning and training sessions for auxiliary police, regular and auxiliary firemen, county fire police, radiological monitors and shelter managers. The planning and training includes various emergency situations such as fires, riots, hospital disasters, explosions, natural disasters, radiological accidents, plane crashes, forest fires, petroleum depot problems and hazardous material spills.

Gloucester County. The Gloucester County emergency agency is primarily a volunteer organization headed by a paid coordinator. The county has a communication center in the court house in Woodbury and an emergency operations center at the same location. If this facility is incapacitated, operations will shift to the City of Woodbury Police Department. The county practices pleasure craft rescues and holds disaster drills with the municipalities several times a year. It also holds information meetings to update the public on services offered and new equipment.

SECTION B

WATER SUPPLY

SECTION B

WATER SUPPLY INSTITUTIONAL ARRANGEMENTS

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SECTION B

WATER SUPPLY INSTITUTIONAL ARRANGEMENTS

INTRODUCTION

The purpose of this section is to provide an inventory of institutions which deal with the quantity of water available for treatment, distribution and consumption in the tri-county area. Because a main concern of this study is the quantity of good quality groundwater, this work is closely allied to DVRPC's P.L. 92-500, Section 208 planning efforts to control non-point sources of pollution.

FEDERAL WATER SUPPLY ORGANIZATIONS

Department of the Army, Corps of Engineers

Nationally, the Corps of Engineers has had a more active role in water supply since the passage of the Water Supply Act of 1958. That act authorized modification of Corps Reservoirs for municipal and industrial water supply use, for such storage if economically justified and represents the least costly alternative.

In 1965, Congress authorized the Corps to conduct a water supply study for the northeastern United States, commonly called NEWS (Northeastern Water Supply Study). That study was prepared by the North Atlantic Division office in New York. The NEWS report listed 26 Urban Metropolitan Areas from Maine to Virginia. Encompassing the Delaware Valley was the Trenton-Philadelphia-Wilmington area, which included the western one-third of Burlington County and the western one-half of Camden and Gloucester counties. This portion of the tri-county area was evaluated for future requirements. The News report recommended a regulatory program along with a better system of test and observation wells. In addition, studies such as the Camden Metropolitan Urban Study address the water supply needs of specific areas as directed by Congress.

Environmental Protection Agency

Safe Drinking Water Act. The Safe Drinking Water Act, P.L. 93-523, was signed by the President on December 16, 1974. It provides for national standards for drinking water to protect the public health, but emphasizes the importance of Federal-state cooperation and encourages states to assume primary enforcement responsibility for public water systems.

The Act gave the Environmental Protection Agency the power to set regulations for drinking water quality, defined state responsibilities, and set standards for inspections and record-keeping. In December 1975, the EPA published regulations governing drinking water quality, including maximum contaminant

levels, monitoring, reporting, public notification and record-keeping. This regulation defined the interim primary drinking water standards to regulate those characteristics which are considered health hazards. The law provides that the EPA set forth secondary drinking water standards to regulate water characteristics which are regarded as aesthetic such as turbidity, taste, color and odor. In January 1976, the EPA published regulations regarding grants to states, the states' role, variances, exemptions and Federal actions should the states fail to enforce the drinking water standards.

One important point made by the EPA regulations is to define which water systems are subject to the law. A public water system is one which has at least 15 service connections or regularly serves 25 individuals daily at least 60 days out of the year. The public water systems are then divided into two groups: community and non-community. A community water system means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. The distinction between community and non-community is that the former serves as the principal year round water supply for the users, while the latter supplies its users for a short term or on an occasional basis. Major suppliers and mobile home parks are examples of public community suppliers, while stores, schools and restaurants are examples of public non-community suppliers.

Water Supply Branch, Region II. The Water Supply Branch of EPA performs two major functions related to water quality. The first function is to implement the Federal Safe Drinking Water Act. In this activity, the Water Supply Branch has the primary responsibility to enforce the act; however, it works closely with the Department of Environmental Protection's Bureau of Potable Water, Water Supply Master Plan and Bureau of Water Resources Planning and Management. The second function is to ensure that any water supply planning efforts in Region II cover the health aspects of water quality. The Safe Drinking Water Act provisions covering underground injections also apply to land fill leaching and it is through this authority that the EPA takes an active role in groundwater quality.

Department of the Interior

Geological Survey, Water Resources Division. The Geological Survey is the foremost data-gathering agency in the field of water resources. Its objectives, in general terms, are to determine the source quality, quantity, distribution, movement and availability of both surface and groundwaters. The USGS achieves these objectives by collecting, evaluating and interpreting data and by developing predictions using mathematical models. The staff develops approximately 30 per cent of their effort to water quality monitors, 30 per cent to groundwater hydrology and 40 per cent to surface water

hydrology. The USGS objectives do not include regulating or setting standards for water quality and withdrawals. The USGS maintains a central catalog of information on water data and provides technical assistance in the fields of hydrology and groundwater to other Federal agencies. One example of this assistance is USGS' contribution to the Corps' Camden Metropolitan Urban Study: the development of a computer program which mathematically models the Raritan-Magothy aquifer. The USGS transferred the program to the Corps' Waterways Experiment Station for the analysis phase.

The USGS cooperates with the New Jersey Department of Environmental Protection on many water resources investigations and these efforts are published in the State of New Jersey's Water Resources Circulars or the Geological Survey's Special Reports. A list of publications is available from the Geological Survey office.

REGIONAL WATER SUPPLY INSTITUTIONS

Delaware River Basin Commission

The DRBC, a Federal-state compact commission established by the Delaware River Basin Compact (P.L. 87-328; New Jersey Laws of 1961, Chapter 13, and other state laws), maintains a continuous planning effort in the field of water resources throughout the basin, which includes a large portion of the area covered by Camden Metropolitan Urban Study. The planning

program covers surface and groundwater supply, water quality management, hydroelectric power generation and watershed management (including erosion control).

Section 13.1 of the compact requires that the DRBC develop and adopt a Comprehensive Plan for the immediate and long-range development and use of the water resources of the basin. The commission adopted its initial Comprehensive Plan in 1962, and this plan has been modified frequently to include new projects, facilities, policies and standards.

Article II of the compact requires that the planning of all projects related to powers delegated to the commission be undertaken in consultation with the commission. No public project affecting the water resources of the basin can be constructed or operated unless it is first included by the commission in its Comprehensive Plan. The DRBC jurisdiction includes all water supply wells with an ability to pump 100,000 gallons per day. The New Jersey Department of Environmental Protection first reviews applications for diversion grants. If the application is approved, the Department of Environmental Protection will forward the application to the Basin Commission for approval. If the Department of Environmental Protection encounters difficulty with the application, they will summon the DRBC and conduct a joint review to avoid duplication.

Since 1977, the DRBC has acted in cases where a well have overdrawn the aquifer and safe yield has been exceeded. This interest and activity was aroused during the drought of

1976-1977. The DRBC can hold adversary hearings to determine what, if any, action is injurious and to determine a remedy. The hearing is conducted by a hearing officer who is appointed by the DRBC because of his ability, experience and interest in water resources and diversion laws. For example, such a person may be a full-time judge from the court system or a professor in water resources planning. The hearing officer accepts and reviews the testimony and then makes a recommendation to the DRBC. The commission will consider the recommendation and act on the case. The commission's possible actions include restrictions to pumping, orders to cease pumping, fees and fines. If the adversary wishes, he may appeal the DRBC's decision through the court system. In New Jersey where the Water Policy and Supply Council functions regularly, the DRBC and the council could conduct a joint hearing in a well overdraft case.

The DRBC is conducting a Level B study of the Delaware which includes water supply topics.

Delaware Valley Regional Planning Commission

The Planning Commission has recently completed a comprehensive water quality management planning program which was funded by the U. S. Environmental Protection Agency. The study, commonly called Section 208 planning, considered the quality of tri-county area groundwater. The draft of the Section 208 report treated groundwater quality in three aspects: assessment, standards and recommendations for monitoring and sampling.

The groundwater quality assessment is composed of four parts. The plan first presents a physical description of the major aquifers. It then describes the most serious non-point sources of pollution: landfills, industrial lagoons, septic tanks, urban runoff and industrial storage areas. The plan then reports on groundwater samples and briefly summarizes the situation in the vicinity of each major category of non-point source. Finally, the plan ranks the site-specific sources showing the relative importance of each source as a contributor to the pollution of different aquifers.

In the second aspect, water quality standards, the 208 Plan describes the recent standards published by the U.S. Environmental Protection Agency and the New Jersey Department of Environmental Protection. The plan describes water quality tests performed by the National Academy of Sciences.

The third aspect gives recommendations for groundwater monitoring divided into three sub-programs, each accompanied by a cost estimate. The land surface monitoring sub-program includes inventory and surveillance of pollution sources and precipitation studies. The second sub-program focuses on the vadose zone -- the unsaturated subsurface soil. The last subprogram, groundwater monitoring, samples the water through existing wells and includes a data management program.

After the Governor's certification and the U. S. Environmental Protection Agency's approval, this plan for the improvement of both surface and groundwater quality will guide all water quality management in the future.

STATE WATER SUPPLY ORGANIZATION (SEE PAGE 4B-10)

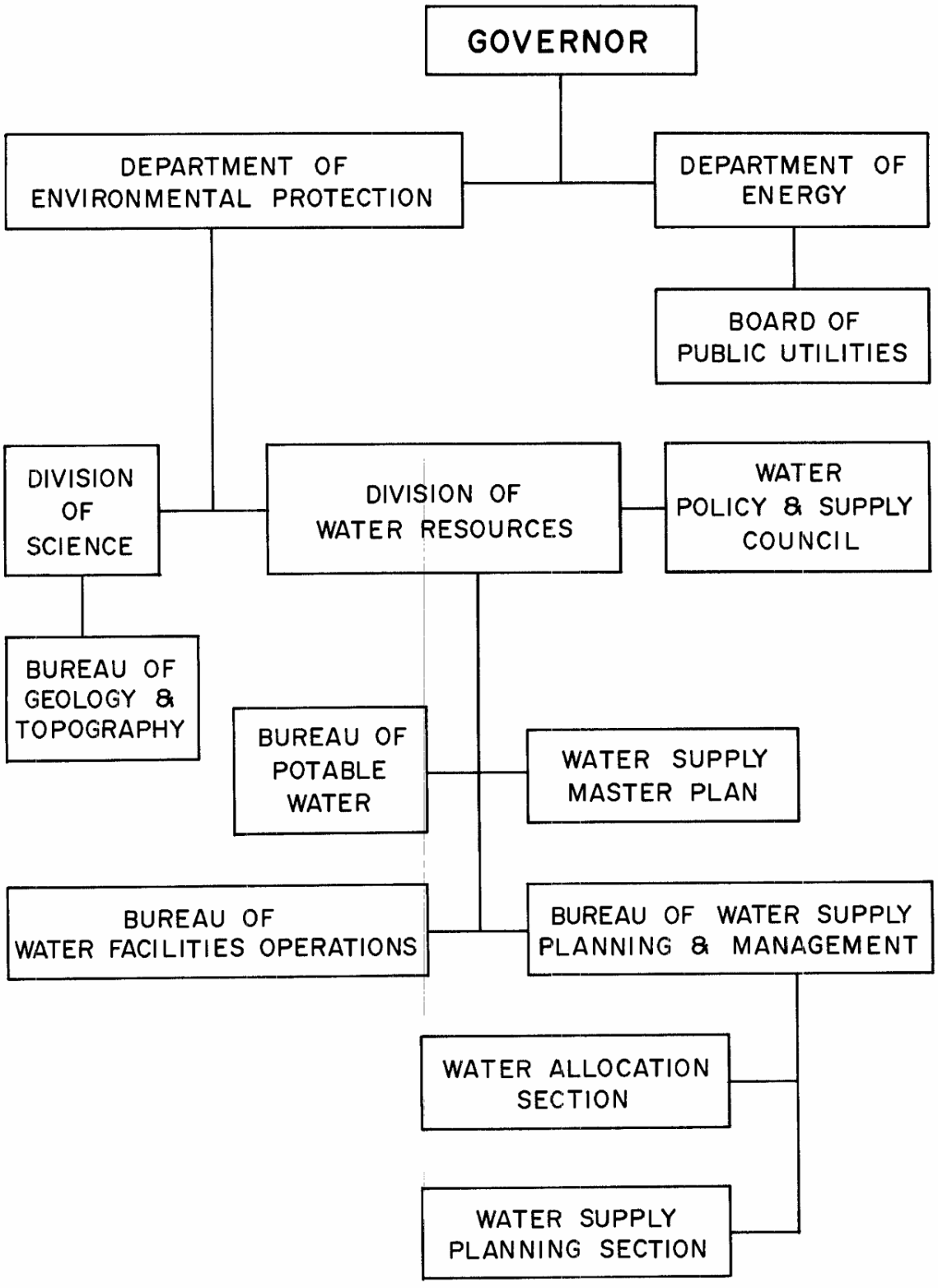
New Jersey Laws

New Jersey Safe Drinking Water Act of 1974 (NJSA 58: 12a-1). The New Jersey Safe Drinking Water Act was enacted in response to the Federal law which mandated states to take responsibility for regulating drinking water quality. The Act gave the Bureau of Potable Water in the Department of Environmental Protection the responsibility to regulate public-community and public non-community water supplies. The Bureau's first task was to set primary and secondary standards which are at least as stringent as the national standards. The primary standards, which regulate water characteristics related to health hazards, are already in effect. The secondary standards, which regulate water characteristics considered to be more of an aesthetic problem, will be promulgated in 1979.

In addition to establishing standards, the law gives the Bureau the responsibility to inspect all the public-community and public-non-community water supplies. The law defines these suppliers accoding to the Federal EPA definitions.

Realty Improvement Act of 1954: "Chapter 199". Chapter 199 mandates the local Boards of Health throughouth the state to review designs and inspect and test all new wells and distribution systems. The strict guidelines on septic tanks and other fixtures were prepared by the Bureau of Potable Water in DEP. Currently each of the three counties has a program to review, test and inspect new wells and these programs are described later in this report.

NEW JERSEY WATER SUPPLY ORGANIZATION



The counties often act for the municipalities because of Public Law 1976, Chapter 329, which provides for municipal boards of health to contract with the county health department or provides for a county board of health to supercede a municipal board of health.

New Jersey Department of Environmental Protection

Water Policy and Supply Council. The Water Policy and Supply Council is a unique regulatory body having quasi-judicial and quasi-legislative powers. It is made up of 11 appointed members who serve part-time at no compensation. The members present a variety of career backgrounds: businessmen, mayors, a college professor in environmental quality and farmers. The council engages in policy and decision-making for water supply and flood control.

In the area of water supply, a major function of the council is to grant water diversion rights to water purveyors and self-supplied users who wish to withdraw water from wells and surface sources. These applicants prepare plans of their diversion schemes and submit these proposals to the council and the DEP staff. The council, acting as a quasi-judicial body, holds hearings on the proposal and allows adversaries to voice their objections. The Council makes a decision to grant or deny the application. Its rules permit a hearing to proceed even if only one council member is present. After the council has

acted, the decision by a quorum of five members must be approved by the commissioner of DEP. If the applicant or the adversary objects to the council's ruling, he can go to court for redress.

The council is supported by technical services provided by various state agencies and departments. For engineering services such as hydrology and hydraulics, groundwater data, surface water supplies, and water quality information, the council turns to DEP's Division of Water Resources. The relation between the council and DEP has three aspects. During the hearing proceedings DEP acts to aid council members by asking technical questions, and giving advice and recommendations. On other matters, when the DEP has planned and promoted a particular water supply project through the Division of Water Resources' Bureau of Water Supply Planning and Management, the DEP will appear before the council as a friend of the court in the water supply development by other organizations or as an applicant/advocate of a state water supply project.

In small project applications to the council, such as irrigation wells for diversion, the DEP staff makes recommendations to the council, which renders a decision on the project.

The council's time is consumed by other business, such as stream encroachment applications and hearings. The council's

activities and problems are described in a report published by the New Jersey County and Municipal Government Study Commission in 1975, entitled Water Supply Management in New Jersey. This report is available through the DEP.

Office of the Commissioner, Division of Science: Bureau of Geology. The Bureau of Geology receives permit applications from anyone who wishes to drill a well. This includes private well owners as well as public or privately-owned water purveyors. The bureau reviews the application, issues permits, coordinates the new well with USGS data and finally files and maintains the data as part of the state's geologic record. The bureau also does mapping and analysis work and publishes the results in cooperation with the USGS. The Bureau of Geology maintains liaison with the Division of Water Resources, especially the Bureau of Water Pollution Control, and also tests and issues licenses to new drillers and annually re-licenses experienced drillers.

Division of Water Resources: State Water Supply Master Plan. The Water Supply Master Plan study provides public officials with up-to-date data and recommendations so they may address the many major water supply issues. The Master Plan was initiated by the Governor, funded by the legislature, and conducted by the Department of Environmental Protection. The study addresses several issues, among them: drought standards to be used for designing and operating reservoirs, analysis and evaluation of

various water supply development projects, an analysis of the state's water supply needs, and institutional studies to clarify the management of the state's water supply program. The study will be conducted by the state but the work will be performed by consultants. The state will also operate a public participation program, and will coordinate this planning effort with other water resources studies in New Jersey, New York, and Pennsylvania.

Division of Water Resources: Bureau of Potable Water. The Bureau of Potable Water is responsible for the quality of water distributed in New Jersey. The bureau sets standards and conducts testing, inspection, project reviews and permit programs.

The Safe Drinking Water Act of 1974 has brought about several changes to the bureau's program activities as was previously described.

The act has also altered the bureau's inspection activities. Prior to the law's passage, the bureau inspected the quality of water delivered by approximately 560 large public water purveyors. Since the law took effect, the state's inspection, monitoring and surveillance responsibilities have grown prodigiously. The state is now responsible for public non-community supplies, formerly "semi-public", and requires each well owner to have the water tested by an approved lab four times per year and to keep the results on file. The public non-community suppliers include motels, camps, hotels,

restaurants, service stations, schools, shopping centers and others. When this group is added to the public community, the estimated number of suppliers requiring inspection rises from 700 (prior to when the law took effect) to 6,000 - 7,000.

The Bureau of Potable Water also inspects new well construction and samples the water before permitting the supplier to begin distribution. The staff of the bureau also spends considerable time reviewing plans for water supply projects, issuing permits to begin construction, and inspecting the construction and connections.

The bureau's activities continue with a data collection effort along with the Federal Environmental Protection Agency to compile data on carcinogens in drinking water. The bureau conducts seminars on water supply topics for public education from time to time. Finally, the bureau maintains liaison with the other bureaus in the Division of Water Resources, the State Health Department, the county and local health boards and the general public.

Division of Water Resources: Bureau of Water Supply Planning and Management. This bureau consists of the following two sections:

- Water Allocation Section. The Water Allocation Section activities fall into two main categories: support to the Water Policy and Supply Council and record gathering and management. In support of the council, the section sits with council members during hearings, asks technical questions of the applicant, and

gives advice to the council as required. If the council approves an applicant's request to withdraw water, the Commissioner of the Department of Environmental Protection concurs and the decision is not appealed to the courts, the applicant may proceed to construct the facility. Then the section must inspect the facility to verify that the work was performed as approved and then report its findings to the council.

The Water Allocation Section's record-gathering activity involves collecting quarterly reports from each water supplier who withdraws surface or groundwater or who buys or sells bulk quantities of water for distribution. In general, these reports show the total water diverted from surface and ground sources, the net waters delivered to the franchised area, the number of connections and the estimated population served. All the reports are filed by purveyor name.

- Water Supply Planning Section. In general, this section has the responsibility of planning for the state's long-range water supply needs. The section's surface water activities include planning reservoir systems which may be developed by the state or a major water purveyor, acting as a consultant to the water source developer both before and during the Water Policy and Supply Council's hearings, and performing engineering duties for the division's water facilities operations element which operates the state-owned Delaware and Raritan Canal and the Spruce Run and Round Valley reservoirs in Hunterdon County.

The section's groundwater investigation activities have been delegated to the U.S. Geological Survey through a contractual agreement since 1921. In 1958, state water bond funds were made available to USGS to do a ten-year intensive investigative program. Since that time, additional state funds have been provided to continue the earlier work and this effort has produced several surveys and studies in the three-county area, including the model of the Raritan-Magothy aquifer now in use by the Corps' Waterways Experiment Station.

The section also engaged the legislature's County and Municipal Government Study Commission and this joint effort was culminated in 1975 with the completion of a report entitled "Water Supply Management in New Jersey." That report led to the initiation of the State Water Supply Master Plan Study. The section prepared the Program Design Document for the master plan study and the request for proposal to solicit consulting firms to do the study. The section participated in the selection of the designated consulting firms and continues to play a supportive role in the master planning process.

The section also provides budget data and schedules for the state capital spending program in water supply construction.

Department of Energy

Board of Public Utilities. The New Jersey Public Utility Commission has broad powers to regulate various utilities in the state. There are three commissioners, each appointed to a six-year term. The staff is responsible for regulating rates

and quality of service for water, electric, gas, movers, trash haulers, rail, cable television and common carriers.

Water supply represents less than one-quarter of the total staff effort. The PUC staff maintains liaison with the Water Supply Master Plan and also deals with the Bureau of Potable Water on complaint issues. In its routine record gathering and regulatory activities, the PUC concentrates on privately-owned water supply companies. Specifically, the PUC has the multiple responsibility to see that the water companies provide adequate service, to set rates for the companies, to keep proper records and direct the supplier on what records must be kept, to insure that the supplier's operation and new construction are in accordance with current standards and investigate citizen's complaints about service. The PUC's record-keeping responsibilities require private suppliers to report various data in April of each year. Among the information the suppliers provide is financial and engineering data, sources of supply, peak demands, number of feet of main of each size, number of customers and number of hydrants. The full report from each supplier ranges from 70 to 80 pages. The PUC also requires municipal suppliers and water supply authorities to provide a brief report each year to show the number of customers, rates, sources and related data.

Another of the PUC's responsibilities is to see that the water companies provide adequate service and to investigate citizen's complaints. When the PUC receives a complaint, a

staff investigator will phone and then visit the supplier. If the company fails to correct a problem, the PUC issues a "show cause" order. If there is no solution, the PUC can go to the state attorney general, who can appoint a receiver to take over the company.

The PUC's rate-setting responsibility is carried out mainly by the Rate and Audit Divisions. It is also possible for the PUC's Audit Division to discover a financial problem in the operation of a water supplier, especially one of the small companies. This could lead to a suggestion by the PUC to the supplier that a rate increase request may be proper to continue providing adequate services at the current standard.

COUNTY WATER SUPPLY INSTITUTIONS

County Health Agencies

General. The three county health departments are each involved in regulating water supplies through review processes and periodic testing. This section will describe these activities in general and the following sections will point out particular characteristics of each county.

Under the Realty Improvement Act, Chapter 199, each county reviews and approves new public non-community and private wells. Before applying to the county, the applicant must obtain a permit from the Bureau of Geology. If the proposed well is over 70 gpm, the applicant must also obtain diversion rights from the Water Policy and Supply Council. Another stipulation requires that the wells be drilled only by licensed drillers.

After the state's requirements are satisfied, the applicant then furnishes the county with a map of the location, data on neighboring sewers, septic tanks and wells, proof of a licensed driller, and the state-assigned well number. After county approval, the applicant must also obtain a local building permit. During construction, the county inspects the well to verify the location and check on the installation technique.

When the well is installed and hooked up to the building plumbing, the county takes a sample to certify the water for use. This is generally a bacteriological test; however, chemical analyses are occasionally needed due to location of neighboring facilities. After a private well is certified, the county will not conduct any more perodic tests.

When public non-community wells are certified and operating, they are subject to quarterly inspections under the 1974 New Jersey Safe Drinking Water Act. This responsibility to test rests with the DEP; however, the counties have each adopted testing programs to verify water quality. These county tests are usually performed on a one or two-year cycle. The tests are judged against the primary and secondary drinking water standards promulgated under the 1974 Act.

The county health departments each respond to complaints by persons on private or public water supply systems. In such cases, the county will send an inspector who takes a sample of the water and promptly sends it to the county or state lab for analysis. The most common complaints are due to tastes and odors caused by the iron content and acidic property of the

water. Another complaint commonly heard is brought on by tastes or odors in the water at the end of a distribution line. This can be cured by the county requesting the supplier to flush the lines.

The county has no jurisdiction over public-community suppliers. The state takes the responsibility for reviewing, granting rights and testing these purveyors while the county gives aid to the state in complaint cases. Finally, the county requires no records on quantities withdrawn whether by private owner or public purveyor.

Burlington County Health Department. The Burlington County Health Department spends about 30 per cent of staff time on water supply activities. They have maintained a well review and certification program for over six years and report a continuous rise in the number of applications from the owners of public non-community and private wells. In 1976 there were about 700 applications, in 1977 there were 1,049 wells and the county estimates that even more applications were made in 1978.

The county carries out a sampling and inspection program for the public non-community wells, formerly known as semi-public. At least once a year, the county samples the potable water in each school, restaurant, etc. and checks the owner's file for the results of the tests required quarterly. In 1977, the county took 2,131 samples.

The county maintains a laboratory which performs bacteriological analyses. It is also capable of performing the

various chemical analyses and is expected to receive EPA certification soon.

In responding to complaints, the county has found the most common problem to be turbidity, sediment and iron in the water. Other complaints have resulted in a survey and monitoring program in Mt. Laurel and two other locations to assess the nitrates on the water systems. This problem is attributable to the on-site septic systems in the vicinity.

Camden County Board of Health. The staff of the Camden County Board of Health if composed of 40 to 50 employees, half of whom are licensed inspectors. About 15 per cent of staff time is spent reviewing and certifying new wells (over 600 per year), performing periodic testing of existing wells and responding to complaints. The review and certification program encompasses every municipality except Cherry Hill Township, which has its own board of health staff.

The periodic testing of public non-community sources is partially carried out by the county and partially by the approved laboratories. For example, the county takes two samples per year and the approved lab, acting for the owner, takes two other samples.

Camden County's response to complaints is facilitated by two testing conveniences: the use of kits for field-testing water and the county bacteriological lab in Winslow Township. When there is a need for chemical testing, the county sends the samples to the state lab. The most common complaint concerns the iron and highly acidic nature of the local groundwater.

Gloucester County Health Department. The Gloucester County Health Department, with a staff of ten to fifteen employees, devotes approximately 25 per cent of its effort to the three phases of water supply activities. The first phase, review and certification of new wells, was initiated after allowing some time for the many unlicensed drillers in the county to obtain the proper state credentials. That initial period was one of adjustment and teaching for the county staff and well drilling establishment.

The county performs tests on schools twice a year and on restaurants once a year, while requiring the restaurants to have an approved lab conduct three tests per year. The county also tests about 200 migrant farm labor camp wells each year.

In its third phase of water supply activities--response to complaints--the county reports the most common problems to be iron and acid (as in the neighboring counties). Another complaint is the stale taste and odor experienced by homeowners who are at the end of a distribution line. As was mentioned earlier, this situation can be corrected by occasional flushing of the lines, which the county requests the water supplier to perform.

Public Water Supplier

Mount Holly Water Company (a typical public supplier). The Mount Holly Water Company operates five wells and they maintain one observation well. The company has three storage tanks whose

total capacity is 2,500,000 gallons. The company also operates two treatment plants: one treats 1,500 gallons per minute and the other 2,250 gpm. The company's total withdrawal rights are between 4.5 and 5.0 million gallons per day (mgd).

The company is owned by the Elizabethtown Water Company and its withdrawal is metered at the well-head. Each service hook-up is metered to record consumption for billing. Each year ten per cent to 12 per cent of the water is unaccounted for and represents main breaks, leaks and firefighting.

The company, like every supplier in the state, must file periodic reports to various agencies. To the State Water Policy and Supply Council and the Federal Environmental Protection Agency, they send monthly and quarterly reports. The State Public Utility Commission receives quarterly and annual reports. The State Health Department requires copies of the daily log, and occasionally the company answers requests by various surveyors and study groups. The data supplied in these reports gives a picture of every aspect of the water supply business. A sample of the topics reported includes the population served, the number of meters, repairs, land use of each user, sample and test results, and quantity withdrawn. Some water companies (not Mount Holly) have records of bulk sales to neighboring municipalities or to large industrial users.

The Mount Holly Water Company has no interconnections with neighboring companies, although they have maintained contact

with the Willingboro Municipal Utilities Authority. The two have discussed interconnections but have performed no preliminary planning or estimating.

Back-Up Systems and Interconnections. In the event of pump breakdowns, water main breaks, or extreme demands due to firefighting, the water supplier will have a need for a back-up system. One answer is an interconnection with a neighboring water supplier. In cases where an interconnection is necessary, the Water Policy and Supply Council has the authority to order it. Aware of the expense involved, the council has suggested interconnections more often than it has ordered them.

Most municipally-owned or authority-owned water suppliers do not come under the Public Utilities Commission and a rate increase to fund an interconnection is not subject to the commission's approval. Privately-owned water suppliers are under the PUC and must take the cost of interconnections out of their profits.

Water suppliers who are miles from another supplier find the cost of interconnection prohibitive. Suppliers close to or abutting another supplier can install a temporary interconnection using large diameter hoses in less than a day. Neither situation indicates a desire to build a permanent interconnection.

In the tri-county area elevated storage tanks serve as a good back-up system, able to deliver water for a limited period of time in case of pump failure or extreme demands. Elevated

tanks also serve to moderate the peaks and valleys of daily and seasonal demands. This method is the best alternative to interconnections.

MUNICIPAL WATER SUPPLY INSTITUTIONS

Cherry Hill Township Health Department

Cherry Hill is the only municipality in Camden County with a health department. The other 36 municipalities contract with the county for health services. Since greater than 95 per cent of the township population is served by the New Jersey Water Company or the Merchantville-Pennsauken Water Company, the health department's inspection program is minimal. Only ten per cent of staff time is devoted to water supply, primarily for inspection of a few new private wells, response to complaints about odors or colors in the water, and tests of wells used by seasonal farm laborers.

SOLE SOURCE OF WATER SUPPLY

The Safe Drinking Water Act, P.L. 93-523, includes a provision to aid in preventing aquifer contamination. The law gives the EPA the power to determine that if an aquifer, which is sole or principal drinking water source for an area, was contaminated, it would create a significant hazard to public

health. The act calls for this determination to be published in the Federal Register. After publication of such a notice, no federal money may assist any project which the EPA determines may contaminate the aquifer through the recharge zone to create a significant hazard to public health.

Two areas in the nation have been designated to date. One is the San Antonio, Texas, area where the Edwards Underground Reservoir is the sole source of water supply for over one million people. The other area is the Spokane Valley Rathdum Prairie Aquifer in Idaho and Washington State which supplies water to approximately 338,000 people.

There are several advantages of sole source designation. It points out the value of the aquifer and its vulnerability to contamination by requiring a review of any Federally-financed project. This, in turn, will encourage the local governments to look more closely at the various development plans for their area.

The main problem associated with sole source designation is the opposition expressed by community members. Persons with interests in multi-unit housing developments, highways, and sewage collection, treatment, and disposal facilities often voice opposition. These activities are often supported by Federal funds which could be reduced. However, the activity can have some influence on the aquifer by generating a runoff which could contaminate the groundwater. In addition, operators of land fills, bulk storage facilities, and pipelines, while not

usually Federally-financed, often oppose state or local government restrictions, A third form of opposition can come from state or local officials who may feel that this designation takes some power or responsibility away from the state government. However, Section 1424 (e) of the Safe Drinking Water Act does not make designation contingent on state or local regulations, even though these regulations may require review of such projects. Opposition is also voiced by persons who see many reviews as a duplication of efforts.

The process by which an aquifer is designated is relatively simple. The EPA's administrator or regional administrator can initiate the process or it can be started by a petition from a local entity to the regional administrator. The petition must include several identifying and descriptive components. There should be a statement of why contamination of the aquifer would result in a significant health hazard, a full description of the aquifer, including its boundaries, recharge areas, and source of the recharge. The petition should also include data on the area for which the aquifer is considered a sole source, the population, alternate sources of water, recharge, projects which might contaminate the aquifer, and the public water systems utilizing water from the aquifer. The petition is reviewed by the regional administrator who can also hold a public hearing if there is a significant public interest. When the review is complete, the regional administrator forwards the petition along

with a recommendation to the administrator for his determination. The final determination is published in the Federal Register and includes a description of the aquifer and its recharge zones.

After an aquifer has been determined a sole source, the review of a project can be initiated by the administrator, the regional administrator, or by petition. The regional administrator has the responsibility for carrying out the project review and any related activities such as public hearings, requests for environmental impact statements, exploring alternative schemes, and recommendations to the administrator.

Currently, local groups in the tri-county area, such as the Sierra Club and the Environmental Defense Fund, supported by many county and local officials, have studied the sole source concept and submitted a petition to Region II of the EPA. Public hearings to gather comments from local officials and residents were held in May 1979.

CAMDEN METROPOLITAN URBAN STUDY

APPENDIX 5

IMPACT ASSESSMENT

SECTION A • FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT
SECTION B • WATER SUPPLY
SECTION C • WATER-BASED RECREATION

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT

INSTITUTIONAL ARRANGEMENTS

SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT

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SECTION A

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT

In the tri-county area, as well as throughout southern New Jersey, flooding is primarily a dispersed local problem. Few floods are widespread; most damage centers cover only a few acres. Flood control measures, such as dams for regional solutions or levees and floodwalls for local protection, are not feasible. Consequently, the study area must employ alternative tools to minimize the impact of potential flooding.

RETENTION/DETENTION BASINS

In order to reduce the increase in peak stream flow caused by urbanization, two similar physical systems can be used as part of a local program of flood control. Recharge basins deter stormwater from entering a stream and permit gradual seepage of this water into the groundwater table. Detention basins temporarily hold back the rainwater until streams can handle the increased flow without flooding. Generally, neither is designed to reduce the flooding below preconstruction levels. Their goal is to prevent potential increases

in flooding as a result of urbanization. A discussion of the impact of basins is provided in the Plan Formulation Appendix and will not be repeated here.

FOREGOING DEVELOPMENT IN HYDROLOGICALLY SENSITIVE AREAS

Locating all vulnerable structures outside the flood plain will not directly modify the environment or change existing conditions. Development in the flood plain would simply be transposed to an alternate site.

Tables 5A-1 through 5A-4 summarize the environmental impacts caused both by the construction of basins and by foregoing development in sensitive areas.

TABLE 5A-1
PHYSICAL-CHEMICAL CHARACTERISTICS

	EARTH			WATER				ATMOSPHERE				PROCESSES		
	CONST. MATERIALS	SOILS	LANDFORMS	SURFACE, QUALITY	SURFACE, QUANTITY	GROUND, QUALITY	GROUND, QUANTITY	AIR QUALITY	CLIMATE, MICRO	CLIMATE, MACRO	FLOODING	EROSION	SEDIMENTATION	DRAINAGE
FLOOD CONTROL														
I RECHARGE/DETENTION BASINS	0	0	M	0	-	0	+	0	M	0	+	+	M	0
II FOREGOING DEVELOPMENT IN HYDROLOGICALLY SENSITIVE AREAS	0	0	0	0	0	0	-	0	0	0	+	0	0	0
WATER SUPPLY														
IA RARITAN-MAGOTHY/SOLE SOURCE	0	0	0	0	-	-	-	0	0	0	0	0	0	0
B RARITAN-MAGOTHY/EXISTING RATE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C RARITAN-MAGOTHY/REDUCED RATE	0	0	0	0	+	+	+	0	0	0	0	0	0	0
II DELAWARE RIVER/SUPPLEMENTARY	0	-	0	0	-	0	0	0	0	0	0	0	0	0
III OTHER AQUIFERS/SUPPLEMENTARY	0	0	0	0	0	-	-	0	0	0	0	0	0	0
IV CONSERVATION	0	0	0	+	+	+	0	0	0	0	0	0	0	0
V PRESERVATION & ENHANCEMENT OF NATURAL RECHARGE	-	0	0	0	0	0	+	0	0	0	0	0	0	0
VI ARTIFICIAL RECHARGE	0	0	0	0	-	0	++	0	0	0	0	-	-	0
RECREATION														
I BOAT LAUNCHING	0	0	0	-	0	0	0	0	0	0	0	0	-	0

0 No Change
- Minor Negative Result
= Major Negative Result
+ Minor Positive Result
++ Major Positive Result
M Mixed Impact

TABLE 5A-2
LAND USE

	URBAN							RURAL				MANAGEMENT AREAS		
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	OPEN SPACE	TRANSPORTATION	RECREATION	CROP LAND	PRIME LAND	FOREST	PASTURE	PARKS	FOREST	OPEN SPACE	OUTDOOR REC
FLOOD CONTROL														
I RECHARGE/DETENTION BASINS	-	-	-	M	0	+	-	0	-	M	0	0	0	0
II FOREGOING DEVELOPMENT IN HYDROLOGICALLY SENSITIVE AREAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WATER SUPPLY														
IA RARITAN-MAGOTHY/SOLE SOURCE	-	-	-	-	0	0	-	-	0	-	0	0	-	0
B RARITAN-MAGOTHY/EXISTING RATE	0	0	0	0	0	0	-	-	-	0	0	0	0	0
C RARITAN-MAGOTHY/REDUCED RATE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II DELAWARE RIVER/SUPPLEMENTARY	0	-	-	-	-	0	-	0	-	-	0	0	-	0
III OTHER AQUIFERS/SUPPLEMENTARY	0	0	-	0	0	0	-	0	-	-	0	0	0	0
IV CONSERVATION	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V PRESERVATION & ENHANCEMENT OF NATURAL RECHARGE	0	0	0	+	0	+	0	0	0	0	0	0	0	0
VI ARTIFICIAL RECHARGE	0	0	0	-	0	0	0	0	0	0	0	0	0	0
RECREATION														
I BOAT LAUNCHING	0	0	0	M	0	++	0	0	0	0	+	0	0	+

NOTE: Refer to Table 5A-1 for explanation of the symbols.

TABLE 5A-3
BIOLOGICAL CONDITIONS

	FLORA								FAUNA				
	LAND COVER	VIRGIN STANDS	CLIMAX COMM.	CROPS	MICROFLORA	AQUATIC PLANTS	BIRDS	TERRESTRIAL SPECIES	FISH & SHELLFISH	BENTHOS	INSECTS	MICROFAUNA	MIGRATION
FLOOD CONTROL													
I RECHARGE/DETENTION BASINS	-	0	-	-	0	0	0	-	-	-	-	-	0
II FOREGOING DEVELOPMENT IN HYDROLOGICALLY SENSITIVE AREAS	0	0	0	0	0	0	0	0	0	0	0	0	0
WATER SUPPLY													
IA RARITAN-MAGOTHY/SOLE SOURCE	-	0	0	0	0	-	0	-	0	0	0	0	0
B RARITAN-MAGOTHY/EXISTING RATE	0	0	0	0	0	0	0	0	0	0	0	0	0
C RARITAN-MAGOTHY/REDUCED RATE	0	0	0	0	0	+	0	0	0	0	0	0	0
II DELAWARE RIVER/SUPPLEMENTARY	-	-	0	-	0	-	0	-	-	-	0	0	-
IIIA OTHER AQUIFERS/SOLE SOURCE	-	0	0	0	0	0	0	-	0	0	0	0	0
IIIB OTHER AQUIFERS/SUPPLEMENTARY	0	0	0	0	0	0	0	-	0	0	0	0	0
IV CONSERVATION	0	0	0	0	0	0	0	+	+	0	0	0	0
V PRESERVATION & ENHANCEMENT OF NATURAL RECHARGE	+	0	0	0	0	0	0	0	0	0	0	0	0
VI ARTIFICIAL RECHARGE	0	0	-	0	0	0	0	-	0	-	0	-	0
RECREATION													
I BOAT LAUNCHING	-	0	0	0	0	0	0	-	0	-	0	0	0

NOTE: Refer to Table 5A-1 for explanation of the symbols.

TABLE 5A-4
HUMAN RESOURCES

	CULTURAL				SOCIO-ECONOMICS			
	ARCHAEOLOGIAL	HISTORICAL	SCENIC VIEWS	RECREATION	HEALTH/SAFETY	LIVING STANDARD	TAX BASE	TAX EXPENDITURES
FLOOD CONTROL								
I RECHARGE/DETENTION BASINS	0	0	0	+	+	+	0	-
II FOREGOING DEVELOPMENT IN HYDROLOGICALLY SENSITIVE AREAS	0	0	0	0	0	0	0	0
WATER SUPPLY								
IA RARITAN-MAGOTHY/SOLE SOURCE	0	0	0	0	-	0	0	-
B RARITAN-MAGOTHY/EXISTING RATE	0	0	0	0	0	0	0	0
C RARITAN-MAGOTHY/REDUCED RATE	0	0	0	0	+	0	0	0
II DELAWARE RIVER/SUPPLEMENTARY	-	-	-	0	0	0	0	-
III OTHER AQUIFERS/SUPPLEMENTARY	0	0	0	0	0	0	0	-
IV CONSERVATION	0	0	0	0	0	M	0	+
V PRESERVATION & ENHANCEMENT OF NATURAL RECHARGE	0	0	+	+	+	0	-	-
VI ARTIFICIAL RECHARGE	0	0	0	0	+	0	0	=
RECREATION								
I BOAT LAUNCHING	0	0	M	+	0	0	0	0

NOTE: Refer to Table 5A-1 for explanation of the symbols.

SECTION B

WATER SUPPLY

INSTITUTIONAL ARRANGEMENTS

SECTION B

WATER SUPPLY

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SECTION B

WATER SUPPLY

Nearly all of the present tri-county water demand is satisfied by groundwater. Since the primary source of groundwater is the Raritan-Magothy Formation, the first portion of this analysis focuses on that aquifer. In addition, utilizing the Delaware River and other groundwater formations as sole or supplemental sources was considered. Finally, artificial recharge and conservation, preservation and enhancement of natural recharge areas were analyzed.

RARITAN-MAGOTHY AQUIFER

Use as a Sole Source

Using only the Raritan-Magothy aquifer to provide all of the projected water demand will result in accelerated drawdown of the aquifer. With projected growth centers for future water demand coinciding with the area of current drawdown depressions, considerable damage to the aquifer could result. Drawdown will eventually result in the abandonment of existing wells as the amount of water capable of being withdrawn is reduced. The need for new wells with lateral pipelines to join existing distribution systems will mainly cause

economic effects and, to a lesser extent, terrestrial habitat effects and open space loss.

Projections of demand through the year 2030 indicate even further reliance on Delaware River recharge to supply the aquifer if it continues to be the sole source of supply for the study area. Withdrawn water could then be characterized as river water filtered through ground sediment mixed with infiltrating surface water. While the effects of utilizing poor quality river water are not completely known, the impact on public health would be negative.

Under this scheme, water quality would also decrease because of the increase of chloride that would come with accelerated movement of the salt/fresh water interface.

Terrestrial habitat loss and ground cover removal will occur because the amount of new constrtuction will require utilization of undeveloped residential, commercial and industrtial land, open space and cropland for well sites and pipelines.

Another impact to the biological community will be a reduction in soil moisture content in the recharge area immediately adjacent to large draw wells. Plants depending on a higher water table, principally those located along streambanks or bordering wetlands, will be gradually replaced by upland species.

Continued dependence on the Raritan-Magothy aquifer will transfer the area's water supply problems to future generations. In the interim, the situation will worsen with increasing production costs from redrilling, relocating and distributing the diminishing water supply. As a result, consumers will pay more for a product of

decreasing quality and the need to develop new supplies to meet the additional future demands will still exist.

Use at Existing Rate

Limiting withdrawal to present levels would require some supplemental water supply development. The Raritan-Magothy aquifer will continue to drawdown very slowly in response to the constant pumping regime as opposed to the more rapid pace when well withdrawal is first undertaken. In terms of head distribution, the aquifer had attained nearly a steady state condition, allowing for withdrawal from present wells at present rates. The source of water to the Raritan-Magothy remained almost constant with only a slight increase in total recharge to the aquifer from the Delaware River, induced by heavy pumpage along the river. The amount of storage change remained consistently low throughout the projection, indicating that nearly all the pumping was replaced through recharge and not from aquifer reserves.

Water quality, especially the number of chloride ions, shows little change except for some improvement in low chloride concentration areas. Overall the salt water migration rates slowed and aquifer conditions improved slightly.

It is reasonable to assume that continued pumping at present rates

will not seriously disrupt the ability of this aquifer to yield present quantities indefinitely. However, Delaware River recharge would be a main source of aquifer water.

New wells will require utilization of present open space and forest land, both for well sites and pipeline right-of-ways.

Use at Decreased Rates

The minimum practical yield scenario limits withdrawal to stringent qualifying conditions. With a goal to return the aquifer to prepumpage conditions, there would be no Delaware River recharge and a reduced movement of saline water into the aquifer. Less than half the present pumpage would be allowed, requiring a sizable amount of supplemental supply.

A computer analysis indicated that the aquifer would respond quite rapidly to reduced pumping stress. The amount of storage in the aquifer would increase substantially during the first four years and at a lesser rate thereafter. The present recharge of water from the Delaware River to the aquifer would be reversed completely. Wells positioned to intercept the majority of water flowing toward the river would account for much of the water withdrawn under this option. Concentrations of dissolved chlorine ions decreased markedly in the first few years of reduced withdrawal and then levelled off, reversing a trend which had already caused some well use to be eliminated because of poor water quality. A recession in the salt-water

interface near Swedesboro also occurred. Biological effects would result from a slight increase in surface runoff as the water table rises. Wetland plant types would shift into bordering low-lying upland sites.

DELAWARE RIVER WITHDRAWALS

Use as a Sole Source

The Level B study indicated that sufficient Delaware River water would not be available year-round to meet both the needs of the study area and the maintenance of a 3000 cfs level at Trenton, NJ. If most of the study area demand were transferred to the Delaware River, water quality conditions during the river's low flow periods--late summer thru mid-fall--would decline to the extent that downstream water users would be denied continuous water of acceptable quality. Since this option is not feasible, no further discussion is warranted.

Use as a Supplementary Source

Withdrawal of a limited quantity of water from the Delaware River is only possible during periods of higher river flows. This water could be utilized to supplement groundwater withdrawal and to minimize the further adverse effects of aquifer overpumpage. Extensive treatment of withdrawn water would probably be necessary to prepare it for potable use.

The salinity characteristics of the Delaware River in the segment bordering Camden and Gloucester counties makes both withdrawals in the upstream reaches and a major pipeline transferring water to the tri-county demand centers necessary. Although most of the pipeline would probably be located on undeveloped land, some commercial and industrial land would also be needed.

Vegetation in the right-of-way is always removed and access to the water lines requires that trees with their destructive roots be kept under control. Herbaceous species will rapidly re-establish themselves on the open ground after pipeline construction, forming a stabilizing ground cover. The area would develop a vegetative community that could support most of the former inhabitants. The degree of impact on birds and mammals will depend on the duration of construction and the availability of temporary refuge. Utilization of existing rights-of-way, either power lines or highways, would reduce both the need for new climax forest removal, and the impact on the main terrestrial habitat. Some disruption of fields and pastures is likely.

Stream crossing by the pipeline system will probably occur. Besides destruction of aquatic species and habitat in the pipeline right-of-way during excavation, trenching will suspend fine materials at and around the construction site. Siltation will alter the habitat around the trench. Its effect will be greatest in the area nearest the cut and will decrease as distance from the cut increases. Turbidity in the waters of the construction area will decrease light

penetration which will reduce photosynthesis activity. Since fish are capable of migrating from the area during construction, they should not be affected. Recovery of the area will take one to three years, during which benthic organisms will resettle and transients will reappear. The new community will be less diverse in age and size because its members will have started growing at about the same time.

Adverse impacts on adjacent property owners should be limited to temporary increases in noise and dust plus aesthetic disruption. Where highway rights-of-way are used as pipeline routes or highways need to be crossed, there will be a disruption of traffic patterns. The effect on archaeological and historical resources will have to be determined through surveys.

The river segment downstream of the withdrawal point would have a significant reduction in downstream flow. The remaining freshwater flow would travel toward the bay at a reduced rate, during which the capacity of the river to assimilate wastewater would be reduced accordingly. This would mean either a reduction in water quality or a need to improve the waste treatment of plants discharging in this river segment.

OTHER AQUIFERS

Increased utilization of other aquifers to supply some study area water needs is possible. The Cohansey, a water table aquifer, will be discussed first, followed by the Englishtown and Mount Laurel-Wenonah formations which are confined aquifers.

The Cohansey is predominantly a water table aquifer. Its water quality is subject to easy and rapid contamination from pollution sources, both point and non-point, and is usually controlled by local conditions at the surface. Water quality in the Cohansey is generally good due in large part to the sparsely populated, rural nature of most of its outcrop area.

Potential exists for water quality deterioration of the aquifer from poor land surface management. Locally, high concentrations of nitrates are found, probably from leaching nitrate fertilizers in agricultural areas of the outcrop belt. A systematic program of monitoring groundwater quality and the establishment of stringent guidelines on the locations and methods of solid and liquid waste disposal for the entire outcrop belt would be needed, as well as guidelines for proper use of fertilizers and pesticides in the outcrop areas.

Increased pumpage rates could affect the advance of the salt water intrusion line and alter the study area's water supply. Such secondary effects would need to be analyzed further.

Utilization of the Cohansey will require placement of additional wells with associated pipeline construction. Although the effects of well placement on wildlife will be minor, depending on the number, length and location of transport pipelines, their impact on the biologic community could be severe.

Plant and animal species dependent on moist soil will be affected by the large withdrawals. Lowering the water table will cause a

gradual movement to upland habitat.

Tapping the Cohansey will aid the three counties in meeting their drinking water needs. This option could be phased in slowly as the need develops. Sufficient potential exists for contamination of the Cohansey as development of the tri-county area continues.

The effects of surface activities on the Englishtown and Mount Laurel-Wenonah aquifers are not as direct or as immediate as on the Raritan-Magothy or Cohansey because of the confining soil layers which exist. However, the effect on water transfer rates between adjacent aquifers would be raised by pumpage. Since much of any confined aquifer's available water comes from seepage through overlying layers, pumpage from one aquifer could affect those aquifers above and below it. Detailed studies would be necessary to determine how this would affect withdrawals from each aquifer.

The use of the Cohansey, Englishtown, and Mount Laurel-Wenonah aquifers would require construction of new well withdrawal systems. The degree of terrestrial habitat loss that would result will depend on the amount of water to be removed and the amount of pipelines needed to transport water to new demand centers. With the predicted demand center being located near existing high water use areas, new pipelines can share right-of-ways and minimize impacts to natural habitat. Heavy use of areas zoned for industry can be expected.

CONSERVATION

Measures can be taken to reduce water supply demand. Review of past attempts has shown that water conservation plans using more efficient plumbing, metering and other similiar devices have varied from ineffective to moderately successful. As experience in such procedures continues and additional mechanisms are introduced, the probability and degree of success is likely to increase.

Conservation helps to decrease further utilization of the Raritan-Magothy aquifer or use of another source of water. The chief benefits will result from eliminating some additional withdrawal, treatment and transmission facilities. Habitat alteration and its effect on wildlife will not be as severe. The quantity and quality of ground and surface water will also increase in comparison to any non-conservation scheme.

Increased concentrations in wastewater as a result of conservation will mean more efficient sewage treatment, with cleaner streams and improved aquatic habitat.

PRESERVATION AND ENHANCEMENT OF NATURAL RECHARGE

The aquifer recharge areas in the three counties have been identified as having special resource value. Changing the recharge

rates in those areas would most affect the amount of water available to the Raritan-Magothy aquifer. Development of these areas could, if not properly managed, degrade the quality of water undergoing infiltration. Preservation of these sites at existing levels of development is possible and desirable. Further development in these areas could be impeded and remedial action taken to ensure that existing development and industrial activities do not degrade the quality of waters undergoing infiltration.

Failure to take this action would result in a deterioration of existing water system quality and quantity and increase the demand for additional wells or alternate methods of water supply.

Preservation of recharge areas will promote open space and recreation on the urban fringe where development is now occurring. Elimination of these sites from development pressures will, however, place adjacent sites in a position to be developed, since the demand for development will not change. As a result, it is anticipated that no major net change in biological conditions will result.

ARTIFICIAL RECHARGE

Injection of treated water from sewage treatment facilities is a possible water supply alternative. The injections well site itself will require exclusion of other land uses. Non-intensive concurrent use of pipeline right-of-ways for cropland or open space is expected. Appropriate landscaping can minimize aesthetic disruption.

The effects of pipeline construction on terrestrial ecosystems are centered around the removal of vegetation and the disturbance of soils. The severity of the construction impacts depends on the season, the types of vegetation encountered, the construction practices employed and the nature and timing of vegetative restoration. Damage to terrestrial ecosystems can be minimized but not eliminated by avoiding critical habitat areas including wetlands, by scheduling construction for low-rainfall periods to reduce sedimentation and by starting restoration as soon as possible after construction begins. Terrestrial species will, nevertheless, be temporarily deprived of some habitat, especially where existing right-of-way can not be utilized.

SECTION C

WATER-BASED RECREATION

SECTION C

WATER-BASED RECREATION

An inventory of existing boat launching facilities and marinas was performed and used to determine capacities, present usage and demand. Future demand was determined in conjunction with the state's efforts in the preparation of the new State Comprehensive Outdoor Recreation Plan.

Construction of additional marine facilities would cause various environmental impacts. There would be a localized modification of sedimentation patterns in the waterways and a slight degredation of water quality by motor craft. Construction of docks, ramps and access channels would involve modification of the waterway bottom and required upland sites to deposit dredged sediments. Recreation potential would be improved but roads, parking areas and concurrent facilities would eliminate vegetative habitat and the species located there.

CAMDEN METROPOLITAN URBAN STUDY

PUBLIC INVOLVEMENT PROGRAM

APPENDIX 6

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

APPENDIX 6

PUBLIC INVOLVEMENT PROGRAM

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APPENDIX 6

PUBLIC INVOLVEMENT PROGRAM

INTRODUCTION

This appendix describes the public involvement program of the Camden Metropolitan Urban Study. The program was used to disseminate information to interested participants and to channel their response to those responsible for the conduct of the study.

OBJECTIVES

- To inform and involve all individuals, groups and organizations whose interests are likely to be affected by the planning process.
- To foster a climate of confidence among individuals and groups so that all views will be heard and considered and conflict will be identified and resolved whenever possible.
- To establish a continuous flexible feedback system which can be modified in response to new needs as they are identified.

- To develop a means for monitoring the effectiveness of the public involvement strategy to ensure that all relevant viewpoints are being considered.

STAGE I PUBLIC INVOLVEMENT EFFORTS

During Stage I planning, a Steering Committee made up of Federal, state, regional and local representatives was established to provide policy guidance and technical review of the Plan of Study. (POS). An average of 30 representatives participated in the 11 Steering Committee meetings which were held during the development of the POS.

During March 1974, the Corps of Engineers sponsored three public meetings to initiate public participation in the development of the POS. Several weeks in advance of these meetings, an information brochure was mailed to residents in the study area. The brochure described the overall purpose of the study and outlined the water resource problems and issues which had been identified by the Steering Committee. The brochure requested attendees at the meetings to provide assistance to the study effort by outlining what they considered to be the major water resource problems and issues. An evening meeting was held in each of the three counties. Views expressed at those meetings were incorporated into the POS.

JOINT PUBLIC INVOLVEMENT PROGRAM

In 1975, the Delaware Valley Regional Planning Commission (DVRPC) received a grant from the Environmental Protection Agency (EPA) to conduct area-wide waste treatment planning under Section 208 of Public Law 92-500 in the New Jersey counties of Camden, Burlington and Gloucester. The study was conducted between June 1975 and December 1977. Because of similarities in the Camden Metropolitan Urban Study and the Tri-County 208 study, as well as because of the desire of the local citizenry to have a concise, coordinated program, the Corps of Engineers and DVRPC created an integrated public involvement program. Citizen meetings were conducted jointly and technical data was made available in a united and consistent manner.

In December 1975, DVRPC initiated its public involvement program for the Section 208 Study. That program was expanded in April 1976 to serve the joint needs of both studies. The program included holding four levels of citizen meetings and producing and distributing joint news letters.

ORIGINAL COMMITTEE STRUCTURE

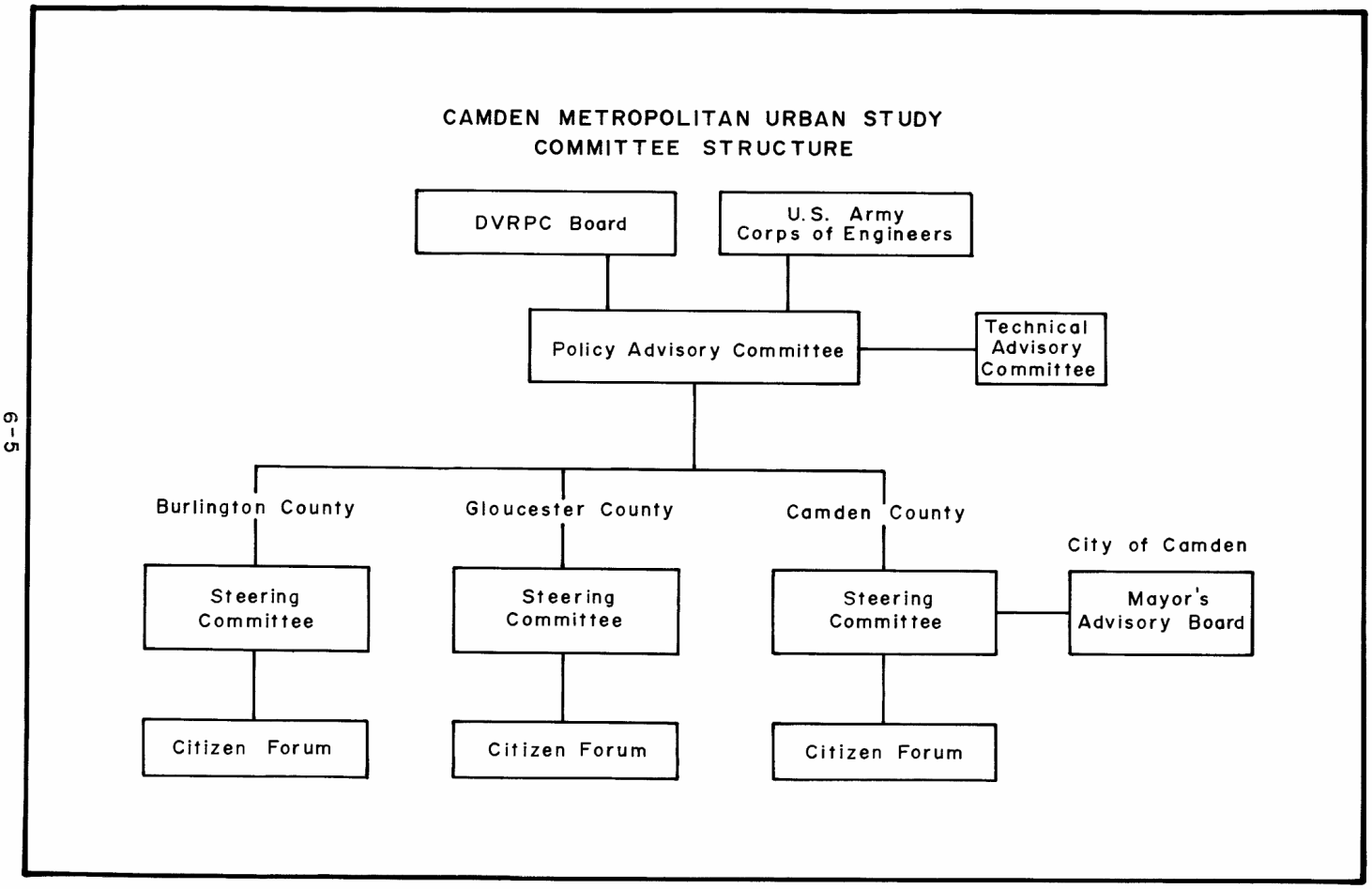
The committee structure consisted of two local committees in each of the three counties in the study area and two regional committees to

provide overall guidance on technical issues and policy. The county committees were known as Citizens' Forums (CF) and Steering Committees (SC). The regional committees were designated the Technical Advisory Committee (TAC) and the Policy Advisory Committee (PAC). The committee structure as proposed is shown on page 6-5.

The membership of these committees was flexible and a committee seat was available for any citizen or municipal official expressing an interest. Major committee meetings were publicized and all sessions were open to the public.

Citizens' Forum

Each county's Citizens' Forum provided an opportunity for individuals and county representatives to meet with Corps of Engineers personnel and obtain an explanation of various study aspects. These meetings centered on presentations and questions which generated discussion among the committee members. Due to the nature of these committees, the membership was constantly changing with different individuals attending each of the meetings. This resulted in topics frequently being repeated at different meetings. In order for the forums to act as a vehicle for relaying comments and suggestions to the county SC, six of the permanent delegates to each county CF were elected to membership on each county SC. Each county CF met approximately quarterly. The meetings were advertised far in advance and generally were attended by as many as 125 persons, including members of the SC, TAC, and PAC.


CAMDEN METROPOLITAN URBAN STUDY
COMMITTEE STRUCTURE
DVRPC Board
U.S. Army Corps of Engineers
Policy Advisory Committee
Technical Advisory Committee
Burlington County
Gloucester County
Camden County
City of Camden
Steering Committee
Steering Committee
Steering Committee
Mayor's Advisory Board
Citizen Forum
Citizen Forum
Citizen Forum

Steering Committees

The Steering Committees (SC) met bi-monthly in each county with the intention of considering policy issues from the county and sub-county perspective. Each SC included the following members:

Freeholder Delegates	2
Municipal Officials	6
Municipal Discharges	6
Industry	6
Citizen Forum Delegetes	6
Agricultural Delegates	6
County & Major City Technical Staffs	6
Total	38

One of the municipal delegates in Camden County was from the City of Camden. The municipal dischargers included county and regional sewage authorities. Industry representatives were identified with the assistance of county planning boards.

As originally conceived, the SC was to be the vehicle by which concerns and comments regarding various study issues were to be made known to the PAC. The original functions of the county steering committees included:

- Identifying county water resources problems and establishing priorities for resolving them.
- Advising the PAC on the relative importance of water resources goals in relation to other county objectives.
- Coordinating the water resources study effort with on-going county planning activities.
- Advising the PAC on the appropriate timing, rate and location of future development in the county and its implications of water resources planning.
- Reviewing the alternative water resources plans.

Technical Advisory Committee

The Technical Advisory Committee (TAC) was composed of technically-oriented persons from Federal, state, and local government and from business. Representatives of the CF's and SC's also held membership. This committee was charged with the responsibility of converting hard technical issues into understandable policies for the PAC to address. For example, working papers (reports on specific study tasks) were cleared through the TAC before being presented to the PAC.

Policy Advisory Comittee

The Policy Advisory Committee (PAC) was composed of elected officials and department heads from all three counties. It examined water resources issues and recommended direction for the study effort. All three previously mentioned committees had representatives on the PAC. In the early months, the PAC heard Corps' presentations on the preparation of the working papers and the organization of the activities. The PAC set policy for the main work effort of the study. For example, upon the recommendations of TAC, it chose the Rancocas Creek, Cooper River, and Mantua Creek watersheds for the urbanization analyses conducted under the flood control portion of the Corps' study.

Supplementary Meetings

The citizen involvement structure of committees and meetings was supplemented by meetings between representatives of the Corps and

county officials. Corps personnel visited each planning board on an "as needed" basis to make presentations and obtain advice and recommendations. Heads of related agencies such as engineering departments and environmental agencies were also contacted. This policy of direct contact was particularly helpful in the development and review of working paper drafts prior to their formal presentation to the committees.

Although the City of Camden is within the limits of Camden County, the city had special interests and concerns of its own. Therefore, whenever county meetings were organized, the city was visited separately. The public involvement structure thus actually adddressed the needs and concerns of four rather than three interests. This proved particularly successful during the analysis of a floodwarning system along the Delaware River in the City of Camden.

REVISED COMMITTEE STRUCTURE

As originally conceived, the SC was to be the vehicle by which concerns and comments regarding various study issues were to be made known to the PAC. However, as the study progressed, it became obvious that the SC's were not functioning in the intended manner.

Concerns over policy issues were being directed to both the TAC and PAC by county representatives as well as by members of the CF's and SC's. It became advisable to hold joint meetings of the CF and SC in each county. This practice was initiated by mid 1977.

At the same time, it became apparent that the same people were attending and representing their agencies at all levels of the public involvement program. Accordingly, joint PAC-TAC meetings as well as joint CF-SC meetings were also held whenever practicable.

TECHNICAL TOPICS DISCUSSED IN THE PUBLIC INVOLVEMENT EFFORT

Flood Control and Flood Plain Management

The results of the damage survey were presented to the committees. The various structural and non-structural flood damage reduction measures evaluated, including those for the ten top damage centers and the flood warning system were also presented.

Based on committee guidance, the Cooper River, Rancocas Creek and Mantua Creek watersheds were selected for further study.

Hydrologic studies were conducted to determine the effects that future development would have on flooding problems in these three watersheds. The methodology, assumptions and procedures used in conducting the hydrologic studies as well as the findings, were presented to the committees.

An analysis was made of several institutions related directly and indirectly to flood control and flood plain management. This included a study of the use of recharge basins and detention basins to retain stormwater and minimize flood damages. A slide presentation detailing the types, functions and importance of stormwater basins was presented to all committees.

Water Supply

The forecast of future growth patterns to the year 2030, based on the extension of demographic data developed by the DVRPC for its Year 2000 Regional Development Guide, was presented to the committees. The extension of those projections beyond the year 2000 was considered suitable for use in long-range water needs planning.

The committees were presented with the forecast of future water needs on a ten year interval from 1970 to 2030 for various categories of residential, commercial, industrial and miscellaneous sectors of the community.

As the Raritan-Magothy model analysis tasks were developed by WES, the committees were given presentations outlying the model studies. One of the first tasks to be completed, the analysis of natural recharge areas, including an evaluation of the regional potential for recharge of the Raritan-Magothy Aquifer, and the identification of natural recharge areas. As a result of committee discussions, additional work was performed on the assessment of recharge sites. This additional work was designed to clarify the method of analysis and define its reliability and limitations. Presentations on the minimum practical yield and maximum yield analysis were also made.

Recreation and Fish and Wildlife

An inventory of existing boat launching facilities and marinas was undertaken with the cooperation and support of each county in the study area, which prepared a letter of introduction to the operators

of marinas to explain the purpose of the inventory and elicit their support and cooperation. The survey results were then presented to the committee.

A report detailing existing fish and wildlife resources in the study area was also presented to all committees.

Newsletter

During the contract period with DVRPC, the Corps and DVRPC jointly produced "Hydrologic", a newsletter with a circulation of between 2,000 and 3,000 copies. The list below presents titles of typical articles published during the study.

- GENERAL

COE Coordinates Water Study with DVRPC 208 Program Flexibility: Key to COE Urban Studies Program
Institutional Survey Vital Part of SNJWRS
DRBC Begins Update of River Basin Plan
Sludge Disposal Alternatives Studied
SNJWRS Schedule Released
Our Final SNJWRS Report is Ready

- FLOOD CONTROL

Corps to Study Flooding
COE Releases Flood Damages Report
Flood Proofing Protects Homes, Businesses
Flood Insurance Explained (two-part article)
Flood Warning System Could Reduce Losses
DRBC Committee Studies Flood Prediction Methods
COE Flood Control Analysis Listed
Delaware River Basin Subject of COE Flood Control Study
New Program to Improve Accuracy of Predicting Flooding Conditions
Urbanization Modelling Results Announced

- WATER SUPPLY

SNJWRS to Develop Program for Water Supply Management
Water Supply Model: Goal of SNJWRS
You Can Help Conserve Water
Raritan-Magothy Withdrawals Exceed Safe-Yield Capacity
Study of Water Needs Progressing
Future Water Needs to Increase Corps Finds
Corps Takes Close Look at Groundwater Recharge
Tri-County Water Supply Assessed
Our Water: Where It Comes From, Why We're Running Out
What Happens If We Don't Change Course?
Would Conservation Make a Difference?
Supplementing the Raritan-Magothy: Corps Water Models Predict Future Needs

- RECREATION

Fish, Wildlife Resources to be Inventoried
Boating Facility Inventory Completed
Urban Recreation Needs Revealed
A Word About Recreation Navigation

CAMDEN METROPOLITAN URBAN STUDY

APPENDIX 7

WATER QUALITY MANAGEMENT; TRI-COUNTY 208 STUDY

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

APPENDIX 7

WATER QUALITY MANAGEMENT

TRI-COUNTY 208 STUDY

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APPENDIX 7

WATER QUALITY MANAGEMENT TRI-COUNTY 208 STUDY

INTRODUCTION

A comprehensive water quality management planning program for Burlington, Camden and Gloucester counties, commonly referred to as Section 208 planning, began in 1975. Funded by the United States Environmental Protection Agency (EPA), its objective is the development of an area-wide management plan to protect surface water and groundwater from pollution. The technical measures to control pollution and the management procedures and institutional, financial and regulatory arrangements necessary to carry them out are included.

The planning process began with inventories of information concerning water quality goals, environmental and demographic characteristics, water quality, existing water pollution sources, control facilities, programs and agencies. The second step included estimation of future population and employment, selection of land use goals and an analysis of existing water quality. These results

provided the basis for identification of present and potential water quality problems and determination of water pollution control needs.

A variety of technical alternatives and institutional and management possibilities were examined with emphasis on the control of non-point pollutant sources, such as urban and agricultural stormwater runoff. These alternatives were screened, with the assistance of the citizens and officials who participated in Section 208's advisory committee and county forums to produce a shortened list of the most promising alternatives. An overview of the planning process is given in the following paragraphs.

PLANNING FRAMEWORK

The water quality management plan applies to Burlington, Camden and Gloucester counties. It responds to Federal goals and objectives as defined by law and to local goals and objectives as determined through discussions among study participants.

The water quality management plan, like all functional planning, must employ the same set of assumptions about the future. These assumptions stress moderate growth rates with new growth in and around existing urban and suburban centers. For the purpose of water quality planning, the population of the tri-county area is projected to increase from about 950,000 in 1970 to about 1.4 million in the year 2000.

WATER QUALITY PROBLEM ASSESSMENT

Historical water quality data for tri-county area streams has been analyzed along with data obtained through a sampling program designed to bridge important gaps in the historical data. This data shows that phosphorous and fecal coliform water quality standards are often violated. Extreme daily dissolved oxygen variations occurred at eight of 27 stations sampled, suggesting the presence of excessive nutrients. Bottom deposits were sampled at 63 stations on the Crosswicks Creek, Pennsauken Creek, Big Timber Creek and Great Egg Harbor River. This data suggests that the effects of the few deposits which exist are not a major problem.

A sampling program to test for the effects of site-specific non-point sources, such as landfills and septic tank concentrations, showed that these effects are similar in magnitude to background loads, making a distinction impractical. Stormwater monitoring stations, established at five locations in the study area and at four other locations in New Jersey, provided information regarding the duration and magnitude of standards violations for various substances with respect to flow. Biochemical oxygen demand and nitrates in some cases had elevated levels during storm conditions. Calculations of phosphorous loadings, as well as sampling results, indicate that most impoundments in the tri-county area are potentially eutrophic. This information will be useful in designing flood prevention facilities which have high water quality benefits.

The most probable sources of severe water quality violations have been identified in 86 segments of 11 major watersheds. The watersheds have been mapped, showing discharging point sources and potential non-point sources. Despite significant non-point source effects, point sources are the primary cause of observed water quality problems in the Crosswicks, Blacks, Assiscunk, Rancocas, Pennsauken, Great Egg Harbor, Cooper, Newton, Mantua, Raccoon and Big Timber watersheds. Although it is rather difficult to definitively rank non-point sources, agricultural and urban non-point source impacts can be observed in the tri-county area.

Historical groundwater quality data was analyzed during the study and a sampling program was designed to obtain field evidence of the effects of these sources on groundwater quality. Historical data show that iron and manganese often exceeded public water supply standards.

A sampling program to test for the effects of potential pollution sources on groundwater showed elevated levels of dissolved solids, heavy metals and hydrocarbons from landfills, lagoons and storage areas. Industrial waste and stored materials caused more acute elevations. Nitrates were the primary contaminant found below septic tanks and hog feedlot areas.

Sampling did not show significant quality impacts from infiltration of Delaware River water on wells located at the river front. However, more samplings are required to verify this conclusion.

A ranking of potential groundwater pollution sources suggests that landfills, industrial lagoons and industrial storage areas are the three most serious potential sources. About 80 per cent of the sources lie over aquifers which are used for water supply, most over the Raritan-Magothy and the Kirkwood-Cohansey aquifers.

Water quality standard revisions have been recommended by the Section 208 Study to NJDEP and DRBC for their consideration. Important recommendations included the support of antidegradation standards for the Mullica River, upper reaches of Rancocas Creek and all tri-county groundwater, future consideration to upgrade standards for the Great Egg Harbor River and the immediate adoption by NJDEP of water quality criteria for all groundwater in the study area.

NON-POINT SOURCE CONTROLS

Under the Section 208 plan, the county planning departments are recommended to provide area-wide stormwater planning, coordination and technical assistance services. Watershed advisory committees are to be used to achieve inter-agency coordination and the DVRPC, SCD and other agencies should provide staff assistance as needed. State,regional and county agencies should cooperate in developing and adopting design and maintenance standards, model ordinances for detention basins and other on-site Best Management Practices (BMP). DVRPC and county planning departments have leading roles in these activities. Under the Section 208 plan, the municipalities are

recommended to continue and improve the use of development controls for drainage, consistent with area-wide standards and with increased county agency participation in site plan review. County reviews are to incorporate any delegated state review functions from the Stream Encroachment Permit Program.

Under the Section 208 plan, the state, regional and county agencies are recommended to cooperate in developing or refining guidelines for management of natural features (stream corridors in non-agricultural areas in particular). These agencies, with the assistance of DVRPC and the county planning departments, should also cooperate in developing criteria for stormwater effluent characteristics on a watershed basis for urban areas.

The Section 208 plan calls for state, regional, county and city agencies to cooperate in developing criteria for combined sewer overflow characteristics with the specific aim of meeting in-stream standards in the vicinity of Camden and Gloucester. DEP will require combined sewer faciltites management for National Pollutant Discharge Elimination System (NPDES) permits covering discharges from combined sewer service areas in those two counties. Any other combined sewered areas should be included when identified.

The Section 208 plan calls for the DOT and the DEP to cooperate in recommending road de-icing chemical application and storage standards, with county agency comment and assistance in disseminating information to the municipalities.

State and Federal agencies (USDA and NJDOA with EPA and DEP assistance) are asked to cooperate in incorporating established usage practices into product labelling, while the Cooperative Extension

Service is requested to develop and conduct expanded lawn fertilizer information programs through county offices and retail stores.

The Soil Conservation Districts review and certify, with the assistance of the State Soil Conservation Committee as needed, sediment control plans for all construction activity (excluding individual single homes) that results in land disturbances exceeding 5,000 square feet. The Soil Conservation Districts, the Soil Conservation Service and the Cooperative Extension Service work together to deliver programmed technical and financial assistance services to farmers. Both activities are supported in the Tri-County Plan.

The county agencies (solid waste agency, planning department or health department) and the DEP Solid Waste Administration cooperate in performing programmed planning services for solid waste management in coordination with 208 management agencies and programs (DEP Division of Water Resources, DVRPC and DRBC).

The DEP Division of Water Resources, in coordination with the DEP Solid Waste Administration, develops and refines standards for location, design and operation of land disposal facilities (landfills and lagoons), incorporating groundwater protection needs; and strengthens criteria for remedial controls use at polluting facilities. The DEP Solid Waste Administration and county agencies cooperate in improving administration of landfill regulations, including registration permit reviews; and inspections (i.e. well samples) and related enforcement activities, while incorporating groundwater protection concerns. The Section 208 coordinating

agencies (DEP Division of Water Resources, DVRPC and DRBC) can provide technical assistance and area-wide monitoring support.

DEP's Division of Water Resources and the county agencies cooperate in establishing routine administration of lagoon regulations, including renewable permits, inspection (i.e. well samples) and related enforcement activities. The Section 208 coordinating agencies (DVRPC, DRBC) can provide technical assistance as needed.

Under the Section 208 plan, land disposal facility operators are required to incorporate standards for new waste disposal and implement feasible remedial measures for polluting facilities as necessary. The NJDEP will intervene as needed to ensure timely implementation.

NJDEP develops and adopts standards for siting, design and operation of major hazardous and toxic materials (HTM) storage facilities and pipelines. NJDEP, with county health department assistance and in cooperation with existing DRBC, EPA, U.S. DOT, PUC and local land use programs, implements a comprehensive regulatory program (including spill controls) for HTM storage facilities and pipelines.

Under the Section 208 plan, DEP develops, updates and maintains on-site sewage disposal (septic tank) standards, incorporating siting and density criteria, with county health department input and comment. Homeowners have responsibility for facility maintenance and, if needed, replacement. The Section 201 agencies will extend public sewerage as needed. The state and local enforcement officials will continue to expand enforcement activities against illegal waste disposal, incorporating increased penalties.

The Section 208 study will set water quality management priorities and define a monitoring and surveillance program for surface and groundwater to determine causes and effects. A four-part surface water program is recommended for the tri-county area to eliminate gaps in the existing data base, so that the effectiveness of non-point source controls in achieving water quality goals may be determined.

A three-part groundwater monitoring and sampling program is also recommended. The primary objectives are to better identify problem areas, improve the understanding of the local groundwater system and to measure the relative benefits of management practices.

These programs, as recommended, would cost over one-half million dollars per year. It may be assumed that only selected portions of this program will be started in the first year of continuing planning. The total cost of all approved measures to control and monitor non-point sources exceeds $25 million over the next 20 years.

POINT SOURCE CONTROLS

Water quality planning must exercise control over the Section 201 direct discharges in the tri-county study area. Initially, however, the Section 208 plan will incorporate the proposals of the 11 facility planning areas being drafted in the tri-county area when these plans are consistent with the Section 208 plan.

Extensions or improvements to sewered areas are anticipated to serve 90 per cent of the population by the year 2000 compared to the

1970 figure of 82 per cent. Estimated capital expenditures for these improvements are in excess of $660 million.

The Camden County Municipal Utilities Authority, Gloucester County Sewer Authority, Mount Holly Sewer Authority, Pemberton Township Municipal Utilities Authorities and Florence Township should be designated to continue their current responsibilitis for treatment and conveyance for their areas. Ongoing Section 201 facility plans will delineate designated management agencies responsible for treatment, conveyance and collection in their respective areas. The Section 208 point source plan will incorporate these decisions when the Section 201 plan is certified. However, in the course of these Section 201 studies in Burlington and Gloucester counties, this plan recommends that more centralized management of responsibilities for treatment and conveyance be pursued. Additionally, all ongoing studies should consider the cost-effectiveness of consolidating responsibilities for collection systems with those agencies in charge of treatment and conveyance.

A single agency responsible for treatment of wastewater for communities in the Pinelands should be pursued. This recommendation is made on the basis of similar future needs in these communities for decentralized sewage treatment systems serving clusters of homes, and the economics of scale associated with consolidated management approaches.

The NJDEP should develop a statewide plan for sludge disposal. In taking responsibility for licensing dischargers from EPA, NJDEP

should develop an expanded program of monitoring and surveillance. Based upon new data and policies, NJDEP should revise wasteload allocations for point source dischargers throughout the study area.

MANAGEMENT OF WATER QUALITY

The recommended continuing planning process provides for the establishment of the Water Quality Management Policy Board. DVRPC is the recommended continuing planning agency. A commitment must be obtained from each management agency to assume its designated responsibilities.

PUBLIC PARTICIPATION

Most local participation in the Section 208 study came through the Policy Advisory Committee (PAC). PAC was assisted by the Technical Advisory Committee, county steering committees and citizens forums. In addition to committee meetings, DVRPC mounted a newsletter program to stimulate citizen interest.

The public participation program made contributions to the selection of various study items for special emphasis, to population projections and to the selection of the elements presented in the final plan.