CA - Manasquan

Dec. 13, 1984

Final Report: Manasquan Reservoir System, Water Demand and Conjunctive Use

Report by Metcalf + Eddy, Inc.

Pg. 86

CA002556Z

DT-24 - end.
3/19/85 - EDS.

FINAL REPORT
MANASQUAN RESERVOIR SYSTEM
WATER DEMAND AND CONJUNCTIVE USE

DECEMBER 13, 1984

MANASQUAN
RESERVOIR SYSTEM

NEW JERSEY
WATER SUPPLY AUTHORITY

Metcalf & Eddy, Inc.
Woodward-Clyde Consultants
New Jersey First, Inc.
Holt & Ross, Inc.
Arthur Young & Company

FINAL REPORT
MANASQUAN RESERVOIR SYSTEM
WATER DEMAND AND CONJUNCTIVE USE

DECEMBER 13, 1984

LIST OF FIGURES

GENERAL

The objective of this task is to develop and evaluate alternatives for the conjunctive (combined) use of the surface water to be supplied by the Manasquan Reservoir System (MRS) and the existing "overdrafted" groundwater supplies. This entailed evaluating several alternatives for the distribution of water from the MRS to communities in the study area.

The major steps performed under this task were the:

- o Development of Population and Water Demand Projections
- o Establishment of Demand Centers
- o Development of Conjunctive Use Plan Alternatives
- o Evaluation of Conjunctive Use Plan Alternatives

Projections

The projected population growth in combination with the increasing per capita consumption of water will increase the present study area water usage of 69 (mgd) million gallons per day to 95 mgd in the year 2000 and 117 mgd by 2020. This increasing demand will place an even greater burden on the already overdrafted groundwater supplies unless the Manasquan Reservoir System is developed.

Demand Centers

Demand centers were established prior to the development of conjunctive use plan alternatives. These demand centers grouped communities based on the following criteria: location, political boundaries, water purveyor service areas, water supply interconnections, existing groundwater conditions and other water supply possibilities. The makeup of the demand centers is shown in Table ES-1.

Development of Alternatives

Three conjunctive use plan alternatives were developed. These alternatives differ in the number of demand centers included within the MRS service area. The main consideration in the development of these alternatives was the preservation of the groundwater resource. Water needs and proximity to reservoir or intake areas, which impact the economic feasibility, were also considered in the development of the conjunctive use plans. The demand centers included under each alternative are shown in Table ES-2.

Evaluation of Alternatives

Based on the evaluation of alternatives it is recommended that conjunctive use plan Alternative B be implemented. Under this alternative all of the communities/water purveyors included in demand centers 1 through 5 will be serviced by the MRS. Alternative B is significantly less expensive than Alternative A. It is also only slightly more expensive than Alternative C and offers several major advantages as described below.

As indicated in Table 3-7, Jackson Township is a large rural cummunity, which is only partially served by a water purveyor, and may not be included within the critical area. In addition, it appears that Manalapan and Marlboro may be serviced by an alternative water supply project. For these reasons the

TABLE ES-1. DEMAND CENTERS

Demand Center	Constituents
1. Monmouth Coastal	Brielle Manasquan Sea Girt Spring Lake Spring Lake Heights Belmar South Belmar Avon
2. Host	Wall Aldrich Water Co. (Howell) Parkway Water Co. (Howell) Adelphia Water Co. (Howell) Farmingdale
3. Monmouth Consolidated	Monmouth Consolidated Water Co. Allenhurst Red Bank Highlands Atlantic Highlands West Keansburg Water Co. Union Beach Keansburg MUA Keyport Aberdeen Township Aberdeen Township MUA Matawan
4. Ocean Coastal	Point Pleasant Point Pleasant Beach New Jersey Water Co. - Ocean County District Brick Township MUA New Jersey Water Co. - Lakewood District Lakewood Twp. MUA
5. Freehold Boro & Freehold Twp.	Freehold Boro Freehold Twp.
6. Marlboro & Manalapan	Manalapan Marlboro Township MUA Gordons Corner Water Co. Englishtown
7. Jackson Township	Jackson Township MUA

TABLE ES-2. CONJUNCTIVE USE PLAN ALTERNATIVES

Demand Centers	Conjunctive Use Plan A	B	C
1. Monmouth Coastal	x	x	x
2. Host	x	x	x
3. Monmouth Consolidated	x	x	x
4. Ocean Coastal	x	x	x
5. Freehold Boro & Twp.	x	x	
6. Marlboro & Manalapan	x		
7. Jackson Twp.	x		

additional cost to construct a water transmission system for Alternative A cannot be justified.

However, no alternative water supply has been developed for Freehold Borough or Township and both of these communities are projected to be included within the critical area. In addition the demand for water under Alternative B is sufficient to utilize the full safe yield of the MRS in the initial year of operation. This will ensure that the usage of the overdrafted groundwater supplies is minimized. For these reasons the slightly higher cost of Alternative B, as compared to Alternative C is justified.

CHAPTER 1

INTRODUCTION

OBJECTIVE

The objective of this task is to develop and evaluate alternatives for the conjunctive use of the surface water to be supplied by the MRS and the existing overdrafted groundwater supplies. Conjunctive use is defined as the concurrent use of two or more water sources for water supply. The evaluation of conjunctive use plan alternatives includes apportionment of water from the proposed MRS and a determination of economic feasibility.

APPROACH

The four major steps performed under this task were the:

- Development of Population and Water Demand Projections
- Establishment of Demand Centers
- Development of Conjunctive Use Plan Alternatives
- Evaluation of Conjunctive Use Plan Alternatives

A brief description of each step follows:

The first step was to determine the water demands for each of the communities in the study area. Population projections used in this study were based on projections made by the New Jersey Department of Environmental Protection (NJDEP) and the New Jersey Department of Labor and Industry. These population projections were then multiplied by a projected per capita usage to determine water demands for each community. An interim report on "Population and Water Demand Projections" was prepared and distributed in May, 1984. This report, which describes the methodology and results of the population and water demand projections is included in Appendix A.

Subsequent to their review of that report, the Water Needs task force of the Manasquan Reservoir Citizens Adivsory Board issued their own report, which is included in Appendix B. They summarized their findings as follows:

- o The year 2000 population projections adopted by the NJDEP are too low.
- o The MRS should be presented not as a vast store of water for intensive new development but as a supplement to the supplies used for current needs which will allow for better water management.
- o The startup of the reservoir system should be tied to a scale-back or revocation of groundwater diversion rights as part of a conjunctive use program.
- o Water conservation should be an integral part of the water management plan for the area.

The second step was to establish demand centers. These demand centers grouped communities based on the following criteria: location, political boundaries, water purveyor service areas, water supply interconnections, existing groundwater conditions, and other water supply possibilities.

The third step was the development of conjunctive use plan alternatives. Each of the alternatives developed included a different grouping of demand centers. Once the conjunctive use plan alternatives were set, the water from the MRS was apportioned to each of the demand centers based on need.

The fourth and final step was the evaluation of conjunctive use plan alternatives. As part of this step, the water transmission lines needed to distribute MRS water were sized and construction cost estimates were prepared. Recommendations on conjunctive use plan alternatives were then made, based on the major criteria of preservation of groundwater resources and economic feasibility.

Detailed descriptions of how the demand centers were established, and the conjunctive use plan alternatives developed and evaluated are included in the following chapters of the report.

CHAPTER 2

DEMAND CENTERS

GENERAL

A demand center is several communities which have been grouped together based on the criteria discussed later in this chapter. The demand centers were the basis for the development of conjunctive use plan alternatives and were used in determining the size of the transmission lines needed to distribute the MRS water.

The potential service area for the MRS consists of 60 communities presently serviced by 40 water purveyors. These communities were grouped into seven (7) demand centers. The constituents of each demand center are included in Table 2-1 and shown on Figure 2-1.

As can be seen on Figure 2-1 some of the communities included in the study area were not included in any of the demand centers. Colts Neck, Upper Freehold and Millstone Township were not included in any of the demand centers because of their rural nature and the likelihood that water service by a municipal or private purveyor will not be available. Roosevelt and Allentown were also not included because of their small demands and distances from the intake and reservoir areas.

CRITERIA

The following criteria were used to establish the seven (7) demand centers:

TABLE 2-1. DEMAND CENTERS

Demand Center	Constituents
1. Monmouth Coastal	Brielle Manasquan Sea Girt Spring Lake Spring Lake Heights Belmar South Belmar Avon
2. Host	Wall Aldrich Water Co. (Howell) Parkway Water Co. (Howell) Adelphia Water Co. (Howell) Farmingdale
3. Monmouth Consolidated	Monmouth Consolidated Water Co. Allenhurst Red Bank Highlands Atlantic Highlands West Keansburg Water Co. Union Beach Keansburg MUA Keyport Aberdeen Township Aberdeen Township MUA Matawan
4. Ocean Coastal	Point Pleasant Point Pleasant Beach New Jersey Water Co. - Ocean County District Brick Township MUA New Jersey Water Co. - Lakewood District Lakewood Twp. MUA
5. Freehold Boro & Freehold Twp.	Freehold Boro Freehold Twp.
6. Marlboro & Manalapan	Manalapan Marlboro Township MUA Gordons Corner Water Co. Englishtown
7. Jackson Township	Jackson Township MUA

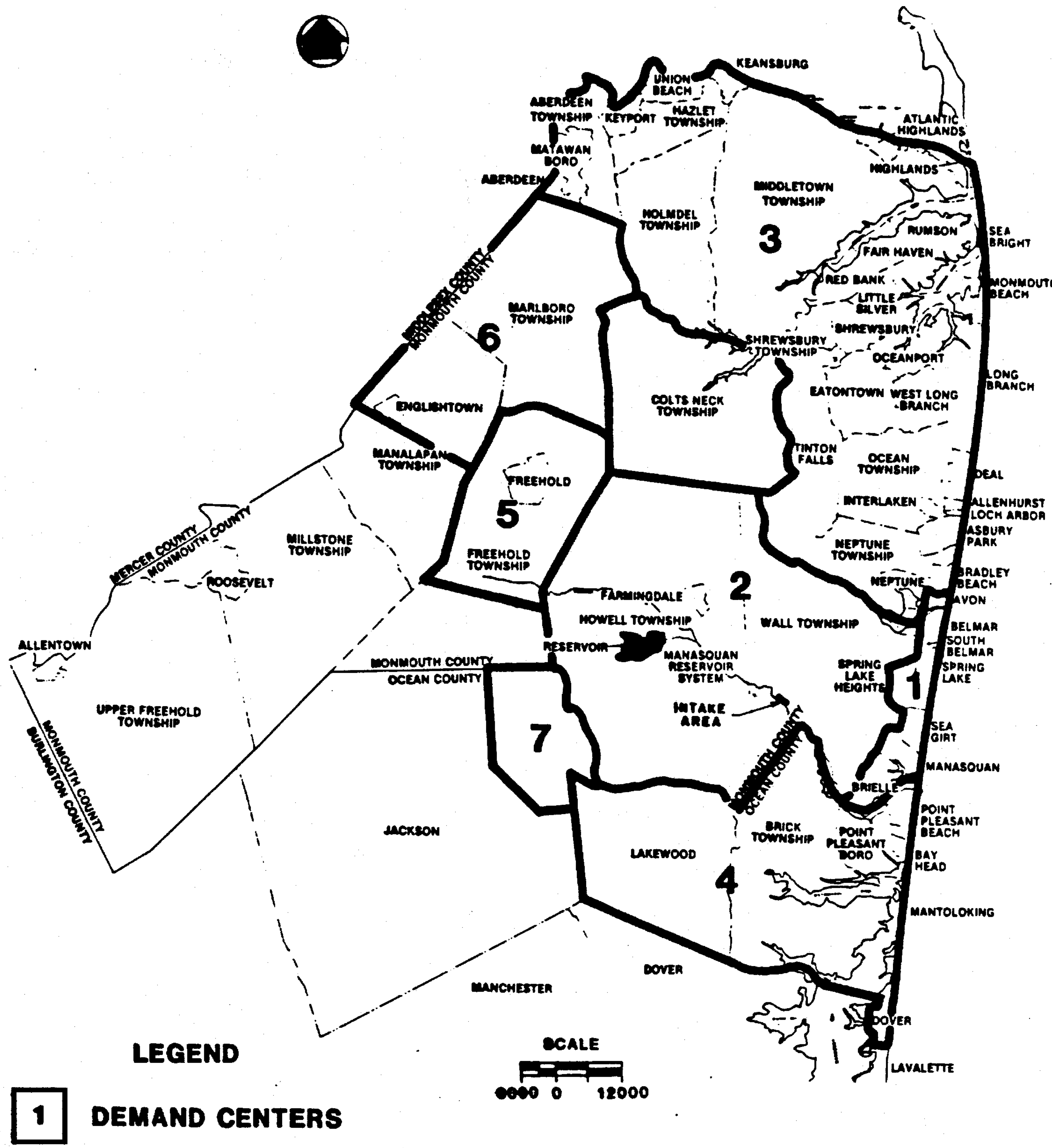


FIGURE 2-1 DEMAND CENTERS

- Location
- Political boundaries.
- Water purveyor service areas
- Interconnections
- Existing groundwater conditions
- Other water supply possibilities

Location

The demand centers were used to determine the point of delivery and size of MRS water distribution pipelines. For this reason it was necessary that all communities within a demand center be located adjacent to one another.

Political Boundaries

The demand centers were established so that no community would be split into more than one demand center. County boundaries were also used to establish demand centers. For example, demand centers 4 and 7 include only Ocean County communities and demand centers 1, 2, 3, 5 and 6 include only Monmouth County communities.

Water Purveyor Service Areas

The existing water purveyors will be responsible for distributing MRS water to their customers. Therefore, communities served by a common water purveyor were included in the same demand center. For example, all of the communities serviced by Monmouth Consolidated Water Company are included in demand center 3.

Interconnections

An interconnection is a pipeline between two adjacent water distribution systems, which allows water to flow from one system to the other. Existing and potential interconnections will be an integral part of the distribution system of MRS water, because it is not economically feasible to build new transmission pipelines from the MRS to each community being served.

Existing Groundwater Conditions

The NJDEP is presently evaluating the condition of groundwater supplies throughout the state. Based on preliminary information, it appears that most or all of the potential MRS service area will be designated a "critical area", because of the declining groundwater levels. However, even within this "critical area" some areas have more severe problems than others. To the extent possible, areas with similar severity of groundwater problems were included in the same demand center.

Other Water Supply Possibilities

At the present time, a water supply study for the South River Basin is being prepared. Some of the communities in the potential MRS service area such as Marlboro, Manalapan and Freehold Township and Borough are also included in the South River Basin study. Communities which are included in both study areas were grouped separately from those that are not.

CHAPTER 3

CONJUNCTIVE USE

DEFINITION

Conjunctive use is defined as the concurrent use of two or more water sources for water supply. In the context of this study, it refers to the combined use of the existing groundwater supplies and surface water from the MRS. Both the MRS and groundwater sources have limited supply capabilities. The implementation of a conjunctive use plan will help to relieve the "overstressed" aquifers of the region and increase the potential supply of surface water from the MRS.

BASIS FOR MRS USAGE

At one time, groundwater supplies were sufficient to meet the water supply needs of the study area. However, as evidenced by the declining groundwater levels over the last 30 years, this natural resource has been greatly depleted. The declining groundwater level is the result of large scale groundwater pumping, which exceeds the natural recharge capability of the aquifer. Since the late 1950's, the rate of groundwater level decline has accelerated. In 1960, when approximately 18 mgd of groundwater were being used within the study area, the groundwater levels were already subsiding. Today groundwater usage has increased to approximately 45 mgd and, as a result, groundwater levels are now subsiding at an accelerated rate.

The NJDEP has recognized that groundwater supplies are being overdrafted in this as well as other areas of the state. In response to this problem, they have proposed new Water Supply Management regulations. These regulations allow the NJDEP to designate areas with overstressed groundwater supplies as "critical areas". Within designated "critical areas" the NJDEP will have the power to reduce groundwater usage by modifying the existing diversion permits.

The NJDEP is presently in the process of determining where "critical areas" will be designated. Based on preliminary discussions, it appears that most if not all of the communities in the potential MRS service area will be included within a "critical area". This will mean that present groundwater diversions will most likely be reduced. However, the percentage by which groundwater diversion permits will be reduced will not be known until the NJDEP's work is completed.

In order to answer the question, "How much must groundwater usage be reduced?", the NJDEP is presently evaluating the aquifers through the use of analytical modeling and evaluation of data obtained by the United States Geological Survey. Through this effort the NJDEP will be able to determine the quantity of natural recharge and thus the dependable yield of each of the aquifers. If groundwater usage equals natural recharge, the groundwater would be in equilibrium and the groundwater levels would remain constant. In order to replenish or recharge an aquifer to its natural level, the groundwater usage would have to be less than the natural recharge for a sufficient period of time.

Once the natural recharge rate of the aquifers is determined, the NJDEP would, through the power granted it in the Water Supply Management regulations, reduce present groundwater diversions to some amount less than the natural recharge.

The reduction in groundwater usage would have to be made up through water conservation measures and the use of new water supplies. Based on findings of previous studies, it appears that the proposed MRS water supply project is the only viable alternative for many of the communities in Monmouth and northeastern Ocean counties.

DEVELOPMENT OF ALTERNATIVES

Service Area

Three conjunctive use plan alternatives were developed. These alternatives differ in the number of demand centers which are included in the service area. The make up of each of the conjunctive use plan alternatives is shown in Table 3-1 and illustrated on Figures 3-1, 3-2, and 3-3. As can be seen on the Figures, the service area becomes progressively smaller from Alternatives A through C.

Under all alternatives, MRS water would be distributed to present water purveyors who would be responsible for distributing the water to their customers. Therefore only the areas serviced by water purveyors would be able to receive MRS water. For example, portions of Howell and Wall Township not serviced by water purveyors would not be able to receive MRS water until the local water lines were extended.

TABLE 3-1. CONJUNCTIVE USE PLAN ALTERNATIVES

Demand Centers	Conjunctive Use Plan A	B	C
1. Monmouth Coastal	x	x	x
2. Host	x	x	x
3. Monmouth Consolidated	x	x	x
4. Ocean Coastal	x	x	x
5. Freehold Boro & Twp.	x	x	
6. Marlboro & Manalapan	x		
7. Jackson Twp.	x		

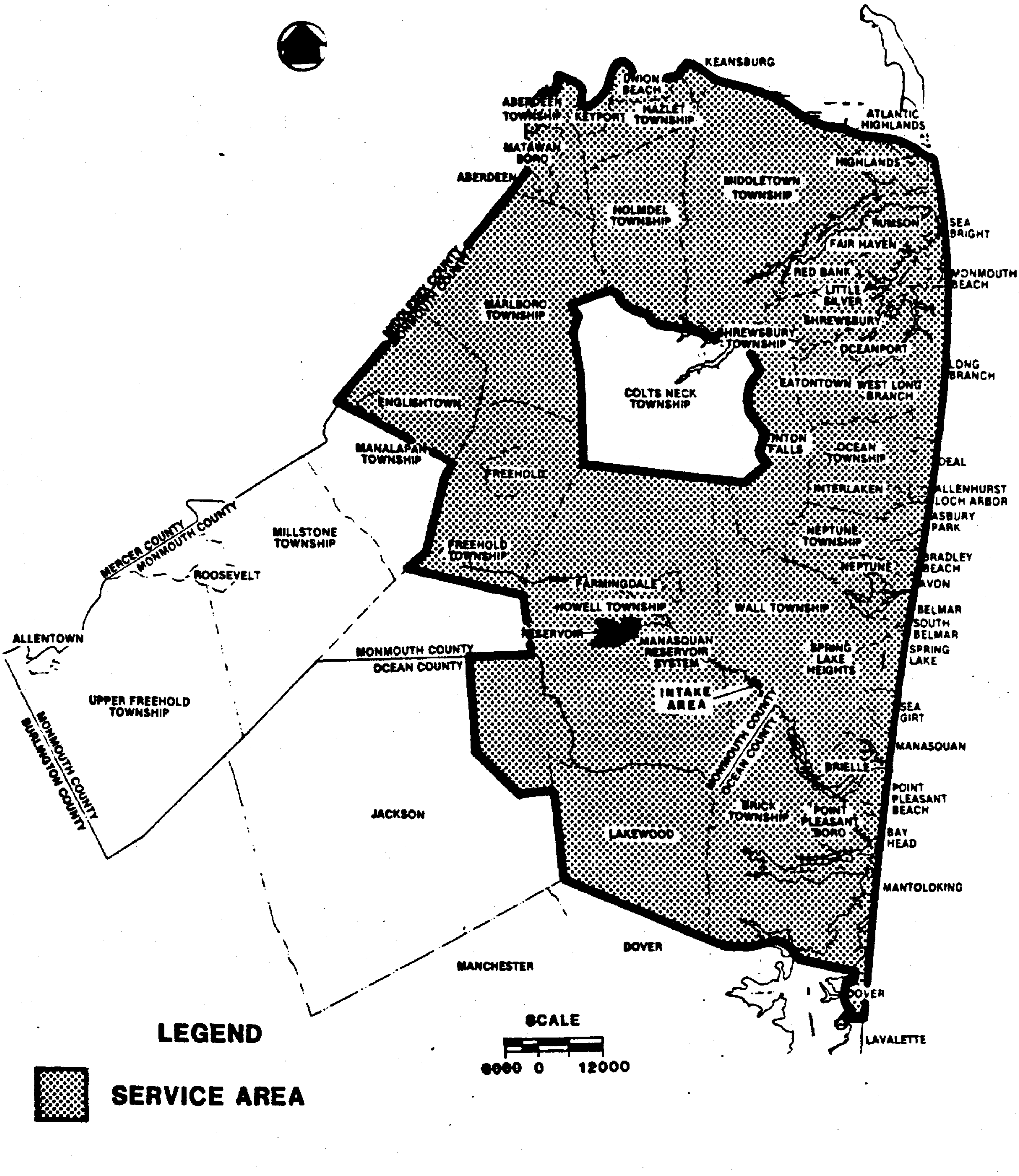


FIGURE 3-1 CONJUNCTIVE USE PLAN ALTERNATIVE A

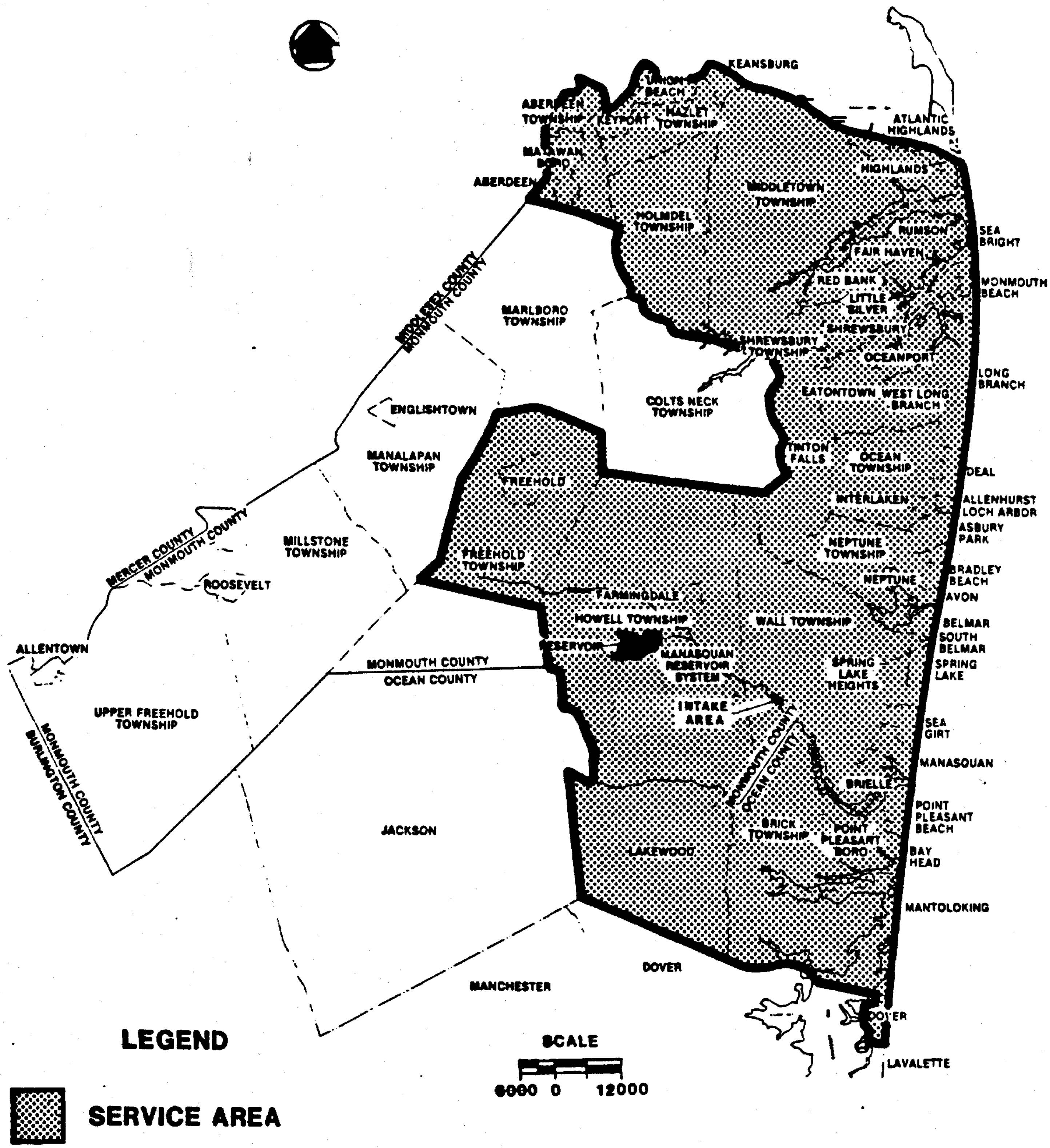
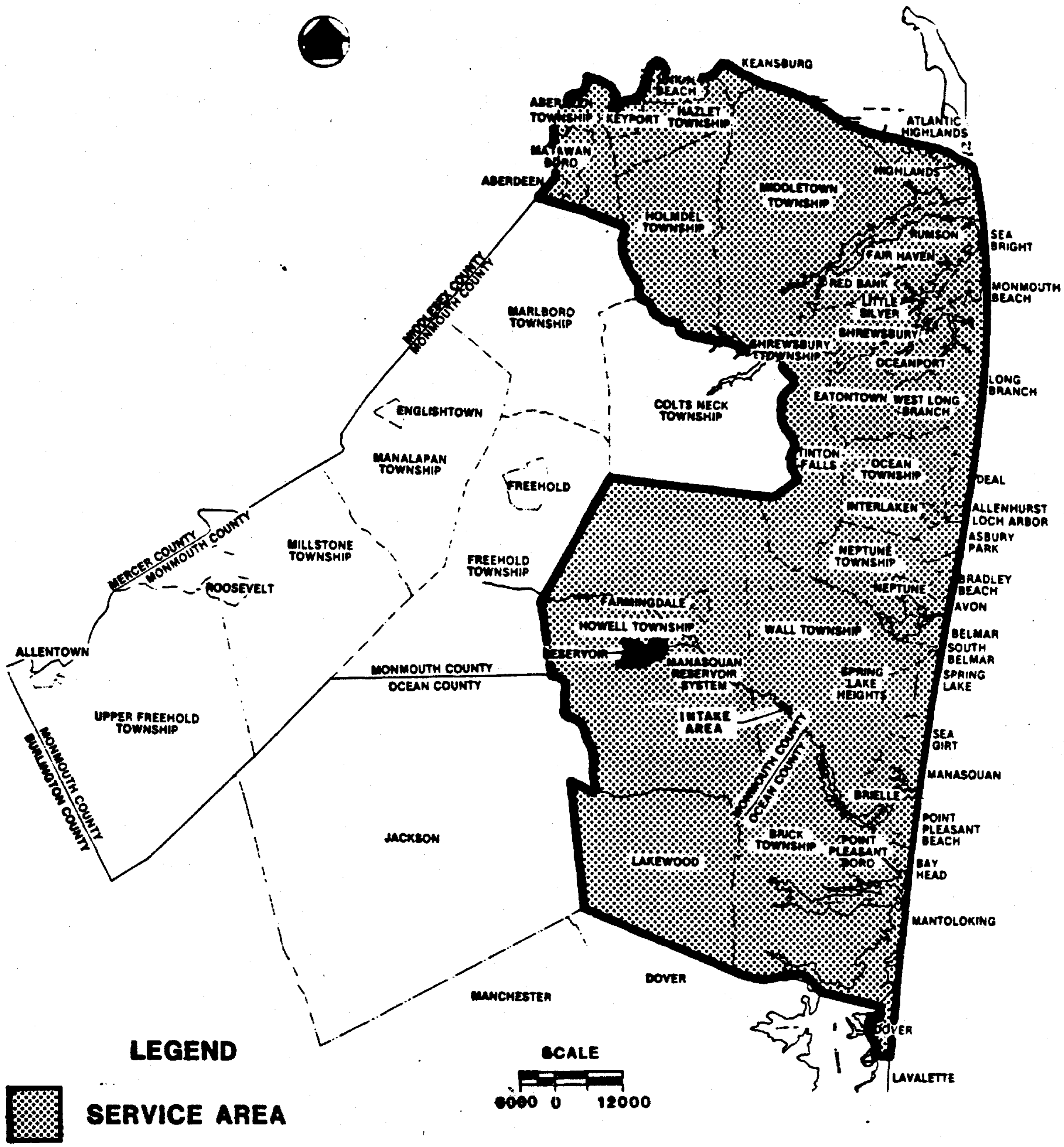


FIGURE 3-2 CONJUNCTIVE USE PLAN ALTERNATIVE B



LEGEND

SERVICE AREA

FIGURE 3-3 CONJUNCTIVE USE PLAN ALTERNATIVE C

The main consideration in developing the conjunctive use plan alternatives was the preservation of the groundwater supplies within the "critical area". Demand centers with the most severe groundwater depletions were given highest priority in the development of the conjunctive use plan alternatives.

Additional items considered in the development of the conjunctive use plan alternatives were the water needs of the communities and their proximity to the MRS project. Both of these items are related to economic feasibility. For instance, it would not be economically feasible to construct a pipeline to distribute water to an area which had a small need for the water and was located far from the MRS reservoir or intake area. This was the case with Allentown and Roosevelt.

Water Apportionment

The recommendation of the project team as stated in the "Institutional Arrangements" report was that the apportionment of water from the MRS should be the responsibility of the NJDEP, with input from local groups.

Before this apportionment can be done, the NJDEP must delineate the "critical areas". Once the "critical area" and the percentage by which groundwater usage must be reduced have been determined, the NJDEP will be able to apportion the MRS water. These decisions are not expected to be made until mid to late 1985.

However, in order to evaluate the economic feasibility of the conjunctive use plan alternatives, it was necessary to know how the water from the MRS will be apportioned. For this reason several assumptions were made and a hypothetical (assumed) flow apportionment was developed. Several discussions were held with the NJDEP to develop an understanding of how the apportionment might be done.

The apportionment of water from the MRS to each demand center was based on need as follows:

MRS Apportionment = Demand - Assumed Future Diversion Permit

The demand is the projected water usage. The demand figures used were revised from those presented in the interim report on "Population and Water Demand Projections" to include the large industrial users who get their water from their own wells.

The assumed future diversion permit is the amount of groundwater withdrawal which will be permitted after the NJDEP delineates "critical areas" and reduces groundwater diversions. As previously mentioned the extent to which existing groundwater diversions will be reduced is not yet known. For the purposes of developing the "hypothetical" apportionment it has been assumed that the present groundwater usage would be reduced by 50 percent. The present and assumed future diversion permit quantities are shown in Table 3-2.

TABLE 3-2. PRESENT/ASSUMED FUTURE DIVERSION PERMIT QUANTITIES (MGD)

	Demand Center 1	2	3	4	5	6	7	Total
Present Diversion Permits								
Groundwater	10.01	6.50	27.51	24.14	9.18	10.10	4.30	91.74
Surface Water	0.00	0.00	33.22	0.00	0.00	0.00	0.00	33.22
Subtotal	10.01	6.50	60.73	24.14	9.18	10.10	4.30	124.96
Present Water Usage								
Average								
Groundwater	3.80	2.87	14.11	12.26	4.87	4.64	1.32	43.87
Surface Water	0.00	0.00	27.47	0.00	0.00	0.00	0.00	27.47
Subtotal	3.80	2.87	41.58	12.26	4.87	4.64	1.32	71.34
Maximum Month								
Groundwater	5.66	4.08	19.65	17.41	6.40	7.77	1.90	62.87
Surface Water	0.00	0.00	33.22	0.00	0.00	0.00	0.00	33.22
Subtotal	5.66	4.08	52.87	17.41	6.40	7.77	1.90	96.09
Assumed Future Diversion Permits								
Groundwater(1)	1.90	1.44	7.05	6.13	2.43	2.32	0.66	21.93
Surface Water	0.00	0.00	25.10(2)	0.00	0.00	0.00	0.00	25.10
Subtotal	1.90	1.44	32.15	6.13	2.43	2.32	0.66	47.03

(1) Assumed future groundwater diversion permit quantities were projected to be 50 percent of the present groundwater usage.

(2) The "safe yield" of the surface water supply of the Monmouth Consolidated Water Company was obtained from the New Jersey Statewide Water Supply Master Plan.

When the need for water exceeded the safe yield of 30 mgd from the MRS, the MRS apportionment equation was revised as follows:

$$\text{MRS APPORTIONMENT} = \frac{\text{Demand Center Demand} - \text{Demand Center Assumed Future Diversion Permit}}{\text{Total Demand} - \text{Total Assumed Future Diversion Permit}} \times 3$$

This equation apportions water from the MRS so that each demand center receives the same percentage of their water needs.

The "hypothetical" apportionment of water from the MRS for each of the conjunctive use plan alternatives is shown in Tables 3-3, 3-4, and 3-5. These apportionments are based on utilizing the safe yield of 30 mgd for the average month and the maximum month demand.

As shown in the tables, the safe yield of 30 mgd from the MRS is used in the initial year of operation (1990) for Alternatives A and B and shortly thereafter in Alternative C. This means that even after the MRS is completed there will be a need for an additional source of water and/or water conservation measures. The additional quantities of water needed are shown in the tables under the heading "Alternative Source".

One of the alternatives for additional water supply is a conjunctive use program which allows an amount of water greater than the safe yield of the MRS to be used. This is possible because of the groundwater supply facilities that exist in the region. This concept referred to as "expandable conjunctive use" is described in the project teams report on "Institutional Arangements".

TABLE 3-3. CONJUNCTIVE USE PLAN ALTERNATIVE A
(MGD)

Source/Demand	Demand Center 1	2	3	4	5	6	7	Total
Year 1990								
Existing Sources								
Average (1)	1.90	1.44	32.15(2)	6.13	2.43	2.32	0.66	47.03
Maximum Month (1)	2.83	2.04	40.63(3)	8.70	3.20	3.89	0.95	62.24
Manasquan Reservoir System								
Average	1.87	2.18	11.78	7.39	2.52	2.68	1.58	30.00
Maximum Month	1.87	2.18	11.68	7.39	2.52	2.68	1.58	30.00
Alternate Sources								
Average	0.48	0.55	3.01	1.89	0.65	0.69	0.40	7.67
Maximum Month	1.82	1.79	9.83	6.12	1.77	3.33	1.46	26.12
Demand								
Average	4.25	4.17	46.94	15.41	5.60	5.69	2.64	84.70
Maximum Month	6.52	6.01	62.24	22.21	7.49	9.90	3.99	118.36
Year 2000								
Existing Sources								
Average(1)	1.90	1.44	32.15(2)	6.13	2.43	2.32	0.66	47.03
Maximum Month(1)	2.83	2.04	40.63(3)	8.70	3.20	3.89	0.95	62.24
Manasquan Reservoir System								
Average	1.87	2.18	11.78	7.39	2.52	2.68	1.58	30.00
Maximum Month	1.87	2.18	11.78	7.39	2.52	2.68	1.58	30.00
Alternate Sources								
Average	0.78	1.79	8.04	4.24	1.45	1.70	2.18	20.18
Maximum Month	2.26	3.63	16.48	9.49	2.83	5.10	4.14	43.93
Demand								
Average	4.55	5.41	51.97	17.76	6.40	6.70	4.42	97.21
Maximum Month	6.96	7.85	68.89	25.58	8.55	11.67	6.67	136.17
Year 2020								
Existing Sources								
Average(1)	1.90	1.44	32.15(2)	6.13	2.43	2.32	0.66	47.03
Maximum Month(1)	2.83	2.04	40.63(3)	8.70	3.20	3.89	0.95	62.24
Manasquan Reservoir System								
Average	1.87	2.18	11.78	7.39	2.52	2.68	1.58	30.00
Maximum Month	1.87	2.18	11.78	7.39	2.52	2.68	1.58	30.00
Alternate Sources								
Average	1.20	3.98	15.79	8.52	2.83	3.40	6.02	41.74
Maximum Month	2.89	6.86	26.27	15.65	4.68	8.08	9.94	74.37
Demand								
Average	4.97	7.60	59.72	22.04	7.78	8.40	8.26	118.77
Maximum Month	7.59	11.08	78.68	31.74	10.40	14.65	12.47	166.61

(1)These quantities are based on assumed future diversion permit quantities shown in Table 3-2.
(2)Includes 25.10 mgd of surface water (Monmouth Consolidated).
(3)Includes 30.80 mgd of surface water (Monmouth Consolidated).

TABLE 3-4. CONJUNCTIVE USE PLAN ALTERNATIVE B
(MGD)

Source/Demand	Demand Center 1	2	3	4	5	Total
Year 1990						
Existing Sources						
Average (1)	1.90	1.44	32.15(2)	6.13	2.43	44.05
Maximum Month(1)	2.83	2.04	40.63(3)	8.70	3.20	57.40
Manasquan Reservoir System						
Average	2.18	2.53	13.73	8.62	2.94	30.00
Maximum Month	2.18	2.53	13.73	8.62	2.94	30.00
Alternate Sources						
Average	0.17	0.20	1.06	0.66	0.23	2.32
Maximum Month	1.51	1.44	7.88	4.89	1.35	17.07
Demand						
Average	4.25	4.17	46.94	15.41	5.60	76.37
Maximum Month	6.52	6.01	62.24	22.21	7.49	104.47
Year 2000						
Existing Sources						
Average(1)	1.90	1.44	32.15(2)	6.13	2.43	44.05
Maximum Month(1)	2.83	2.04	40.63(3)	8.70	3.20	57.40
Manasquan Reservoir System						
Average	2.18	2.53	13.73	8.62	2.94	30.00
Maximum Month	2.18	2.53	13.73	8.62	2.94	30.00
Alternative Sources						
Average	0.47	1.44	6.09	3.01	1.03	12.04
Maximum Month	1.95	3.28	14.53	8.26	2.41	30.43
Demand						
Average	4.55	5.41	51.97	17.76	6.40	86.09
Maximum Month	6.96	7.85	68.89	25.58	8.55	117.83
Year 2020						
Existing Sources						
Average(1)	1.90	1.44	32.15(2)	6.13	2.43	44.05
Maximum Month(1)	2.83	2.04	40.63(3)	8.70	3.20	57.40
Manasquan Reservoir System						
Average	2.18	2.53	13.73	8.62	2.94	30.00
Maximum Month	2.18	2.53	13.73	8.62	2.94	30.00
Alternative Sources						
Average	0.89	3.63	13.84	7.29	2.41	28.06
Maximum Month	2.58	6.51	24.32	14.42	4.26	52.09
Demand						
Average	4.97	7.60	59.72	22.04	7.78	102.11
Maximum Month	7.59	11.08	78.68	31.74	10.40	139.49

(1)These quantities are based on assumed future diversion permit quantities shown in Table 3-2.
(2)Includes 25.10 mgd of surface water (Monmouth Consolidated).
(3)Includes 30.80 mgd of surface water (Monmouth Consolidated).

TABLE 3-5. CONJUNCTIVE USE PLANT ALTERNATIVE C
(MGD)

Source/Demand	Demand Center 1	2	3	4	Total
Year 1990					
Existing Sources					
Average	1.90	1.44	32.15(2)	6.13	41.62
Maximum Month	2.83	2.04	40.63(3)	8.70	54.20
Manasquan Reservoir System					
Average	2.35	2.73	14.79	9.28	29.15
Maximum Month	2.35	2.73	14.79	9.28	29.15
Alternative Sources					
Average	0.00	0.00	0.00	0.00	0.00
Maximum Month	1.34	1.24	6.82	4.23	13.63
Demand					
Average	4.25	4.17	46.94	15.41	70.77
Maximum Month	6.52	6.01	62.24	22.21	96.98
Year 2000					
Existing Sources					
Average	1.90	1.44	32.15(2)	6.13	41.62
Maximum Month	2.83	2.04	40.63(3)	8.70	54.20
Manasquan Reservoir System					
Average	2.35	2.88	15.48	9.29	30.00
Maximum Month	2.35	2.88	15.48	9.29	30.00
Alternative Sources					
Average	0.30	1.09	4.34	2.34	8.07
Maximum Month	1.78	2.93	12.78	7.59	25.08
Demand					
Average	4.55	5.41	51.97	17.76	79.69
Maximum Month	6.96	7.85	68.89	25.58	109.28
Year 2020					
Existing Sources					
Average	1.90	1.44	32.15(2)	6.13	41.62
Maximum Month	2.83	2.04	40.63(3)	8.70	54.20
Manasquan Reservoir System					
Average	2.35	2.88	15.48	9.29	30.00
Maximum Month	2.35	2.88	15.48	9.29	30.00
Alternative Sources					
Average	0.72	3.28	12.09	6.62	22.71
Maximum Month	2.41	6.16	22.57	13.75	44.88
Demand					
Average	4.97	7.60	59.72	22.04	94.33
Maximum Month	7.59	11.08	78.68	31.74	129.09

(1)These quantities are based on assumed future diversion permit quantities shown in Table 3-2.
(2)Includes 25.10 mgd of surface water (Monmouth Consolidated).
(3)Includes 30.80 mgd of surface water (Monmouth Consolidated).

EVALUATION OF ALTERNATIVES

Water Transmission Line Sizing

The initial step in the evaluation of conjunctive use plan alternatives was the sizing of the transmission system required to deliver water from the MRS to the communities served. In order to complete a preliminary design of the transmission systems for each of the conjunctive use plan alternatives, the following items were established:

- o Destinations for water distribution
- o Pressure requirements at these destinations
- o Design flow rates to be delivered to each destination point

A map of Monmouth County water supply facilities prepared by the Monmouth County Planning Board was used to establish distribution system destinations and delivery pressures for demand centers in Monmouth County. Similar information was obtained from individual Ocean County purveyors in the study area. Design flow rates were based on an apportionment of the potential expanded conjunctive use supply of 45 mgd of MRS water. In some cases it was necessary to subdivide demand centers to size transmission systems.

Two criteria were used for sizing distribution system lines. The primary criterion was to keep the line velocities at design flow, between 4 and 6 feet per second. This "rule-of-thumb" was tested on several distribution lines and was shown to result in the most economical line size, with the exception of long lines of smaller diameters. These lines were sized for slightly lower velocities. The secondary criterion was to keep the total dynamic head of all distribution system pump stations below 400 feet to avoid limiting pump selections and to avoid the use of multi-stage pumps.

A preliminary layout of water transmission lines is shown on Figure 3-4 for each of the conjunctive use plan alternatives.

Costs

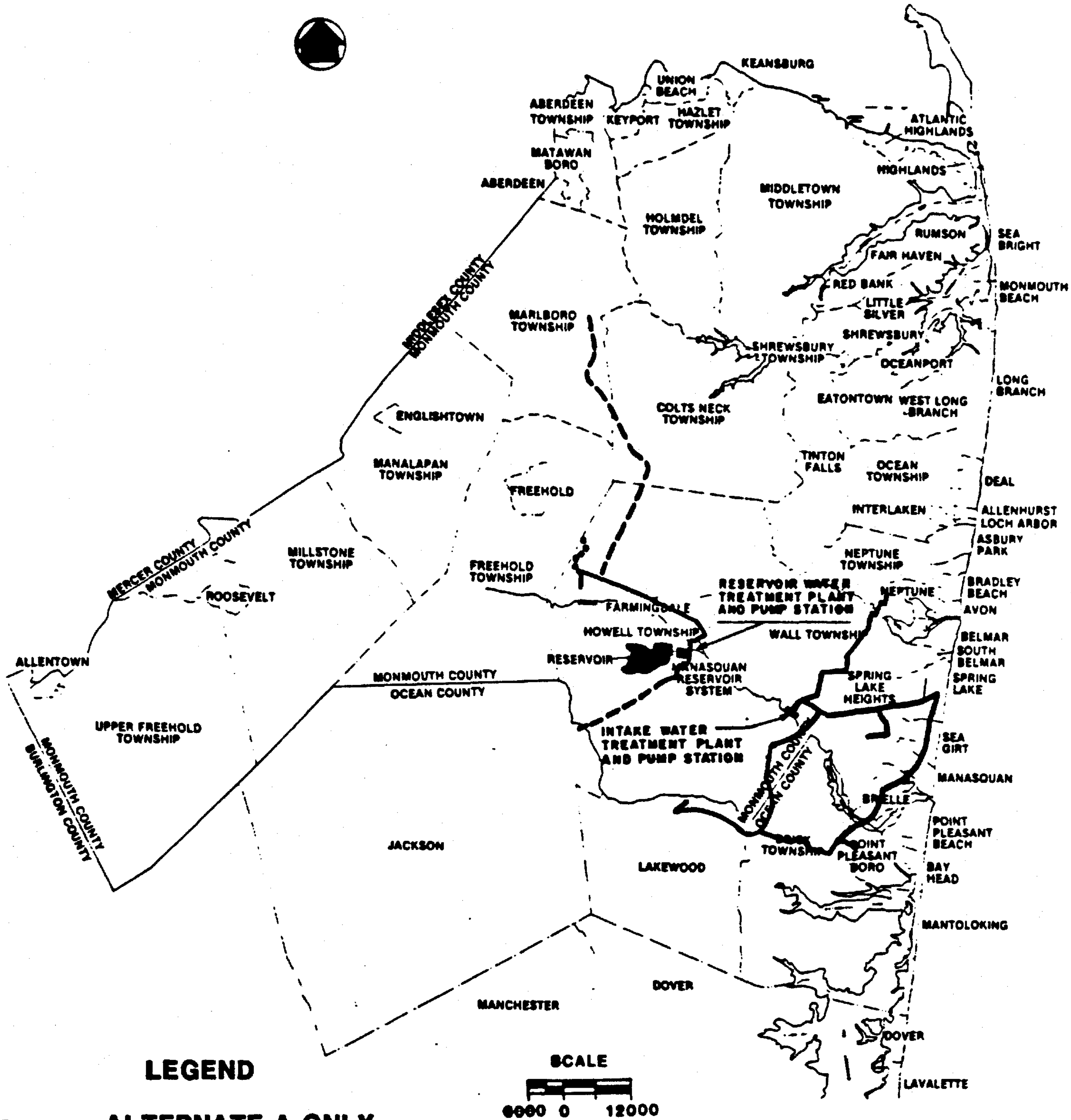
Construction costs for pipelines and pump stations were obtained from cost curves generated from actual construction costs of past projects. Costs from these curves were adjusted to present dollars.

Annual operation and maintenance costs consisted of power (electricity), labor and materials. Power costs were developed based on the full utilization of the 30 mgd safe yield of the MRS. A unit cost for electricity of $0.10/kw-hr was used. Labor and materials costs for operation and maintenance were estimated at one (1) percent of the construction cost for pump stations and one half (0.5) of a percent of construction costs for transmission pipelines.

Costs are summarized for each of the conjunctive use plan alternatives in Table 3-6.

TABLE 3-6. TRANSMISSION COSTS

Alternative	Construction Cost	Annual O&M
A	29,575,000	1,476,000
B	23,788,000	1,307,000
C	22,486,000	1,299,000



LEGEND

- - - - - ALTERNATE A ONLY

.... ALTERNATE A&B ONLY

——— ALTERNATE A,B,&C

FIGURE 3-4 WATER TRANSMISSION SYSTEM ALTERNATIVES

Comparison of Alternatives

Each of the conjunctive use plan alternatives has advantages and disadvantages compared to the other alternatives. A summary of these advantages and disadvantages is included in Table 3.7.

TABLE 3-7. COMPARISON OF ALTERNATIVES

Conjunctive Use Plan Alternative	Advantages	Disadvantages
A	*Highest demand for water. *Immediate use of safe yield (30 mgd). *Largest reduction of groundwater usage. *Serves largest number of communities.	*Transmission system is significantly more expensive than other alternatives. *Manalapan and Marlboro are part of South River study and may have alternative source of supply. *Jackson may not be in "critical area". *Jackson is large rural community which is only partially served by a water purveyor. Future water needs may not coincide with serviced area.
B	*Higher demand for water than Alternative C. *Immediate use of safe yield (30 mgd) in initial year. *Transmission system is significantly less expensive than Alternative A.	*Transmission system is slightly more expensive than Alternative C. *Freehold may have an alternative source of water.
C	*Least expensive transmission system.	*Serves least number of communities. *Safe yield (30 mgd) is not used in initial year.

CHAPTER 4

RECOMMENDATIONS

GENERAL

Based on the evaluation of alternatives it is recommended that conjunctive use plan Alternative B be implemented. This alternative is significantly less expensive than Alternative A. It is also only slightly more expensive than Alternative C and offers several major advantages as described below.

As indicated in Table 3-7, Jackson Township is a large rural community, which is only partially served by a water purveyor, and may not be included within the critical area. In addition, it appears that Manalapan and Marlboro may be serviced by an alternative water supply project. For these reasons the additional cost to construct a water transmission system for Alternative A cannot be justified.

However, no alternative water supply has been developed for Freehold Borough or Township, and both of these communities are projected to be included within the critical area. In addition the demand for water under Alternative B is sufficient to utilize the full safe yield of the MRS in the initial year of operation. This will ensure that the usage of the overdrafted groundwater supplies is minimized. For these reasons the slightly higher cost of Alternative B, as compared to Alternative C, is justified.

SERVICE AREA

The water purveyors/communities which are recommended to be served by the MRS under conjunctive use plan Alternative B are shown in Table 4-1. As shown on the preliminary layout of the MRS water transmission system (Figure 4-1), many of the water purveyors which are recommended for MRS service must receive their apportionment through the Monmouth Consolidated Water Company system. These water purveyors have been delineated in Table 4-1. This situation is necessary because it is not economically feasible to construct MRS distribution lines into these area.

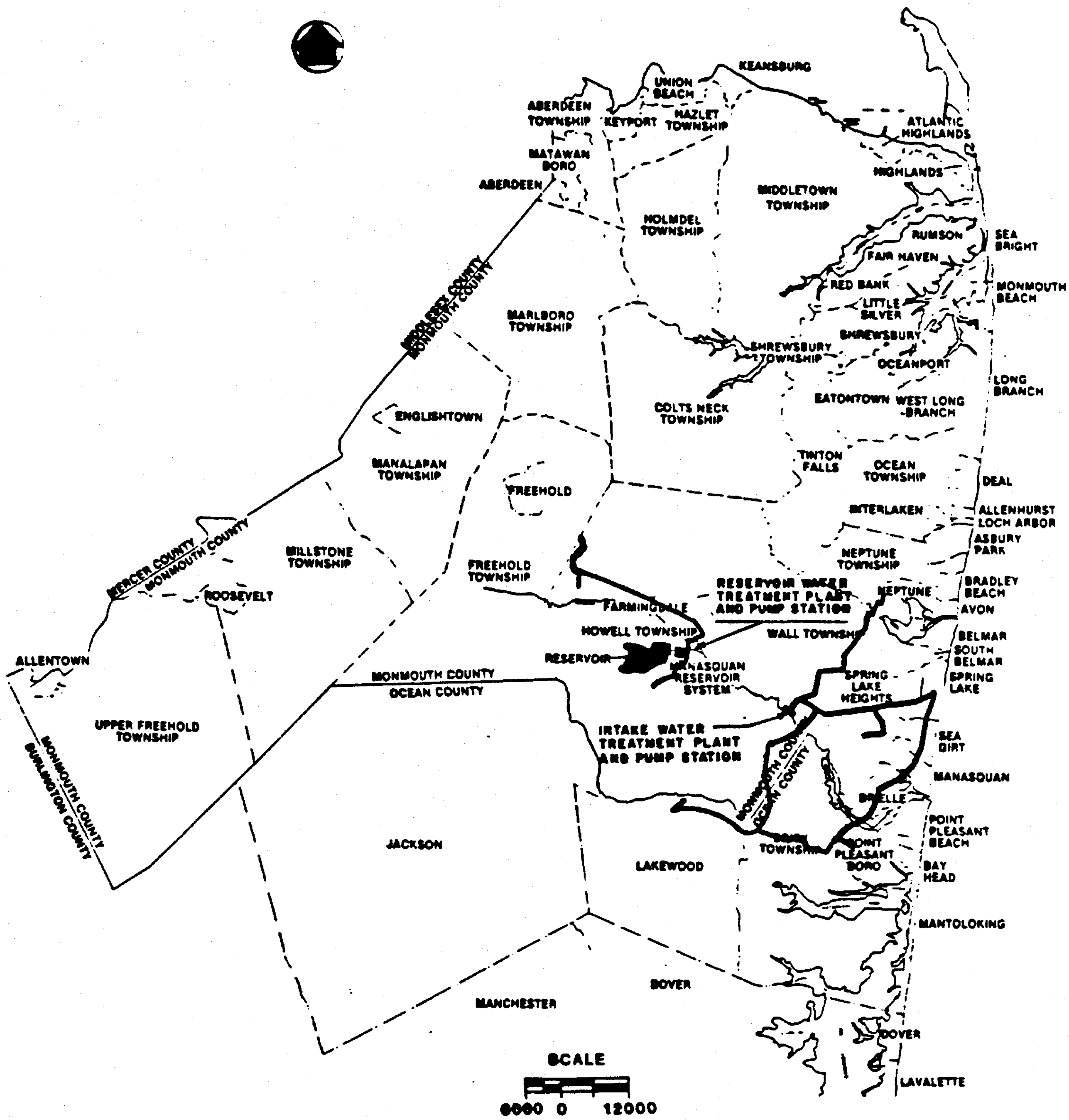


FIGURE 4-1 WATER TRANSMISSION SYSTEM

APPENDIX A.

MANASQUAN RESERVOIR SYSTEM
WATER DEMAND AND CONJUNCTIVE WATER USE
INTERIM REPORT ON
POPULATION AND WATER DEMAND PROJECTIONS

MAY 7, 1984

MANASQUAN RESERVOIR SYSTEM

NEW JERSEY
WATER SUPPLY AUTHORITY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

At one time, groundwater supplies were sufficient to meet the water supply needs of the study area. However, as evidenced by the declining groundwater levels over the last 30 years, this precious water supply has been greatly depleted. The declining groundwater level is the result of groundwater pumping, which exceeds the natural recharge of the aquifer. Since the late 1950's, the rate of groundwater level decline has accelerated. In 1960, when approximately 18 MGD of groundwater were being used within the study area, the groundwater levels were already subsiding. At the present time groundwater usage has increased to approximately 45 MGD, and consequently groundwater levels continue to subside at an accelerated rate.

The water demands projected for the next three decades will place an even greater burden on the already "overdrafted" groundwater supplies unless a new source of water is developed. In order to avoid the potentially catastrophic effect of a total depletion of the groundwater aquifer or of salt water intrusion into the aquifer near coastal areas, the Manasquan Reservoir System has been proposed. This system would provide the residents of Monmouth County and coastal communities in the northern part of Ocean County with a dependable supply of high quality drinking water. In addition to providing a dependable supply of high quality drinking water, it would prolong the life of the areas overstressed groundwater resources.

POPULATION PROJECTIONS

Water demand projections will be made for the years 2000 and 2020. Before demand projections can be developed, projections of populations for these years must be made.

Previous population projections for Monmouth and Ocean counties have been developed by several sources, including the New Jersey Department of Labor (NJDL), New Jersey Department of Environmental Protection (NJDEP), Monmouth County Planning Board, Ocean County and Rutgers University. These projections are summarized in Table 1 for Monmouth County and Table 2 for Ocean County.

Conditions which were imposed on this study were that the year 2000 NJDEP planning policy numbers were to be used for that year and that previously made projections be used in developing the year 2020 population projections. As can be seen in Tables 1 and 2, the only projections which extend to the year 2020 were those developed by the NJDL in 1975. Therefore, those projections will be used as the basis for the year 2020 projections developed in this study.

The NJDL 1975 series which most closely represents NJDEP policy numbers, in the year 2000 for each county was used to project county-wide population to the year 2020. The NJDL projections for 2020 were adjusted by the same percentage difference as between the NJDEP policy number for 2000 and the NJDL number for 2000. The NJDL Series II projection was used for Monmouth County and the Series IV projection was used for Ocean County. Results of the population projections recommended for use in this

TABLE 1. SUMMARY OF POPULATION PROJECTIONS FOR MONMOUTH COUNTY

Agency	1980	1985	1990	1995	2000	2010	2020
Census	503,173	-	-	-	-	-	-
NJDEP Policy	-	-	-	-	588,200	-	-
NJDL Model 1 (1983)	-	515,700	534,400	560,500	588,200	-	-
Model 2 (1983)	-	525,100	546,400	566,000	580,800	-	-
NJDL Series I (1975)	478,505	494,050	504,385	514,715	525,050	545,715	566,380
Series II (1975)	503,345	522,880	542,415	561,950	581,485	620,555	659,625
Series III (1975)	509,555	534,635	559,730	584,815	609,905	660,085	710,260
Series IV (1975)	544,000	592,160	640,320	689,300	738,290	859,085	979,880
Environmental Impact Analysis -							
Low (1977)	-	530,150	563,300	584,900	606,300	-	-
High (1977)	-	577,350	613,700	637,100	661,000	-	-
Monmouth County Planning Board (1974)	-	675,000	-	-	890,000	-	-

TABLE 2. SUMMARY OF POPULATION PROJECTIONS FOR OCEAN COUNTY

Agency	1980	1985	1990	1995	2000	2010	2020
Census	346,038	-	-	-	-	-	-
NJDEP Policy	-	-	-	-	526,500	-	-
NJDL Model 1 (1983)	-	370,100	393,500	420,200	447,300	-	-
Model 2 (1983)	-	407,800	470,200	536,700	605,700	-	-
Average	-	388,950	431,850	478,450	526,500	-	-
NJDL Regression (1978)	330,500	362,200	389,900	409,500	429,000	-	-
Migration 65-70 (1978)	351,600	431,600	511,400	590,100	695,500	-	-
Migration 70-77 (1978)	360,000	459,500	560,100	660,200	765,600	-	-
"Preferred" (1978)	351,600	417,600	480,300	519,900	555,400	-	-
NJDL Series I (1975)	214,125	215,495	216,915	218,335	219,750	222,585	225,420
Series II (1975)	333,840	347,220	360,600	373,980	387,360	414,120	440,880
Series III (1975)	333,840	350,620	367,395	384,175	400,960	434,520	468,075
Series IV (1975)	289,860	326,000	370,140	414,270	458,400	540,195	621,990
Ocean County 208 - Low (1978)	355,200	419,400	471,100	518,700	560,400	-	-
- High (1978)	365,600	440,100	510,300	581,300	646,000	-	-

study are shown graphically on Figures 1 and 2 along with the NJDL 1975 series population projections and the US Census figures for the period 1920 to 1980.

As shown on Figure 1, the population of Monmouth County began to increase rapidly in the 1940's and continued to grow at a very rapid rate through 1970. The population continued to increase at a significant rate between 1970 and 1980, though less rapidly than in the previous thirty years. The increase in population from 1980 to 2020 is projected to be at the same rate as in the 1970 to 1980 period.

The population of Ocean County began to increase rapidly in the 1950's, as shown in Figure 2, and has continued to increase at a very rapid rate through 1980. In fact, according to the 1980 US Census, Ocean County is the fastest growing county in New Jersey. Growth in Ocean County is projected to continue at a rapid rate through the year 2020.

The study area includes all of Monmouth County and Brick, Jackson, Lakewood, Point Pleasant Beach, Bayhead, Mantoloking, and a portion of Dover Township in Ocean County. The study area was established based on proximity to project and use of the same underground water supplies. In addition, water service by municipal or private purveyors is not expected to be available in Colts Neck, Upper Freehold, and Millstone Townships and will be available to limited areas in Howell, Freehold, Jackson, and Lakewood Townships. Areas not serviced by water purveyors will continue to be dependent on private wells. The total projected population of both counties, the estimated study area population and the estimated population served by water purveyors within the study area are shown on Figure 3 and summarized in Table 3.

TABLE 3. POPULATION PROJECTIONS FOR MANASQUAN RESERVOIR SYSTEM

	1980 Population	Projected Populations 2000	2020
Monmouth County			
Total	503,173	588,200	667,241
Study Area	503,173	588,200	667,241
Serviced Study Area	470,140	553,986	632,394
Ocean County			
Total	346,038	526,500	714,392
Study Area	144,301	198,927	255,801
Servied Study Area	125,838	178,731	235,605
Total Study Area	647,474	787,127	923,042
Total Serviced Study Area	595,978	732,717	867,999

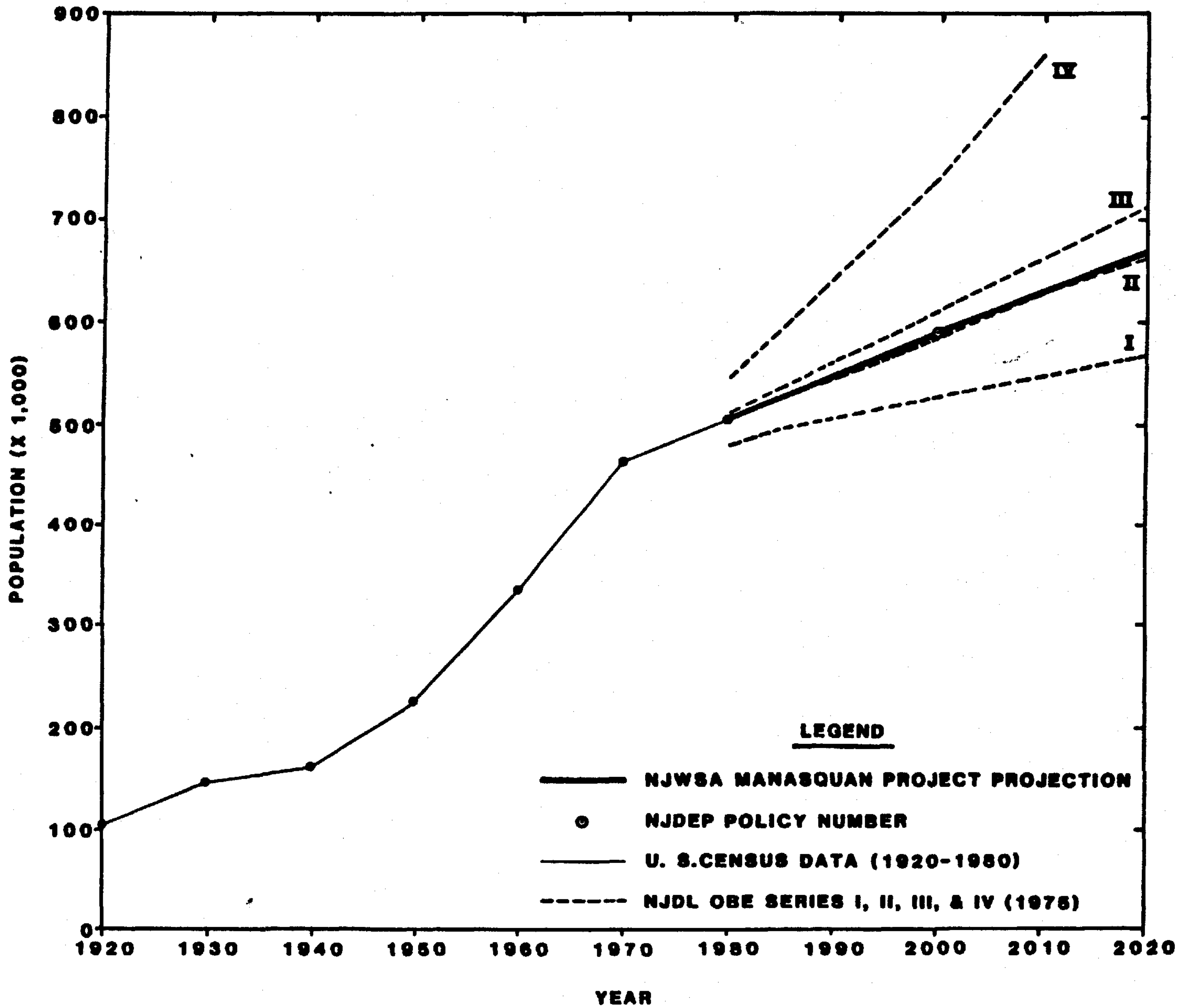


FIGURE 1 MONMOUTH COUNTY POPULATION PROJECTIONS

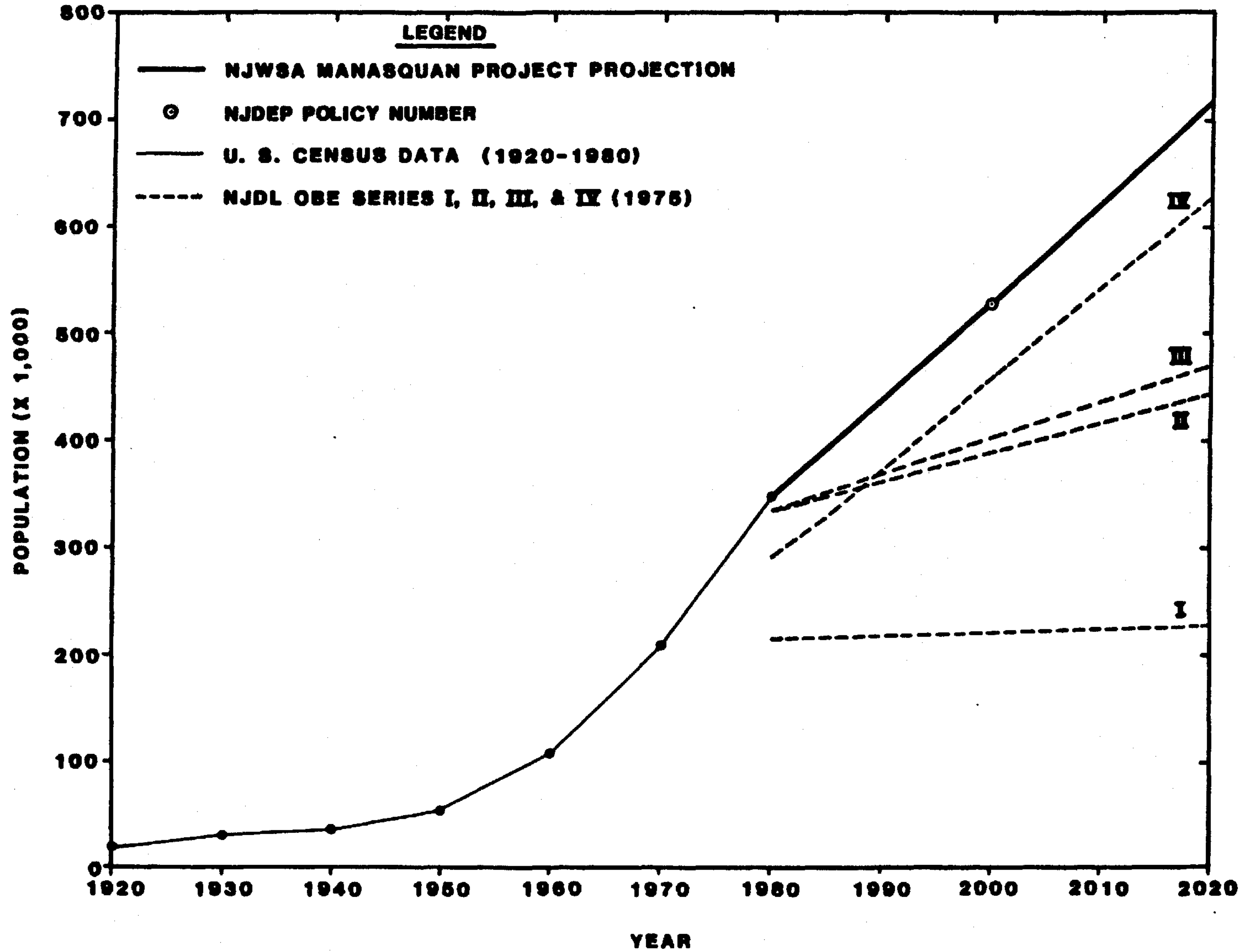


FIGURE 2 OCEAN COUNTY POPULATION PROJECTIONS

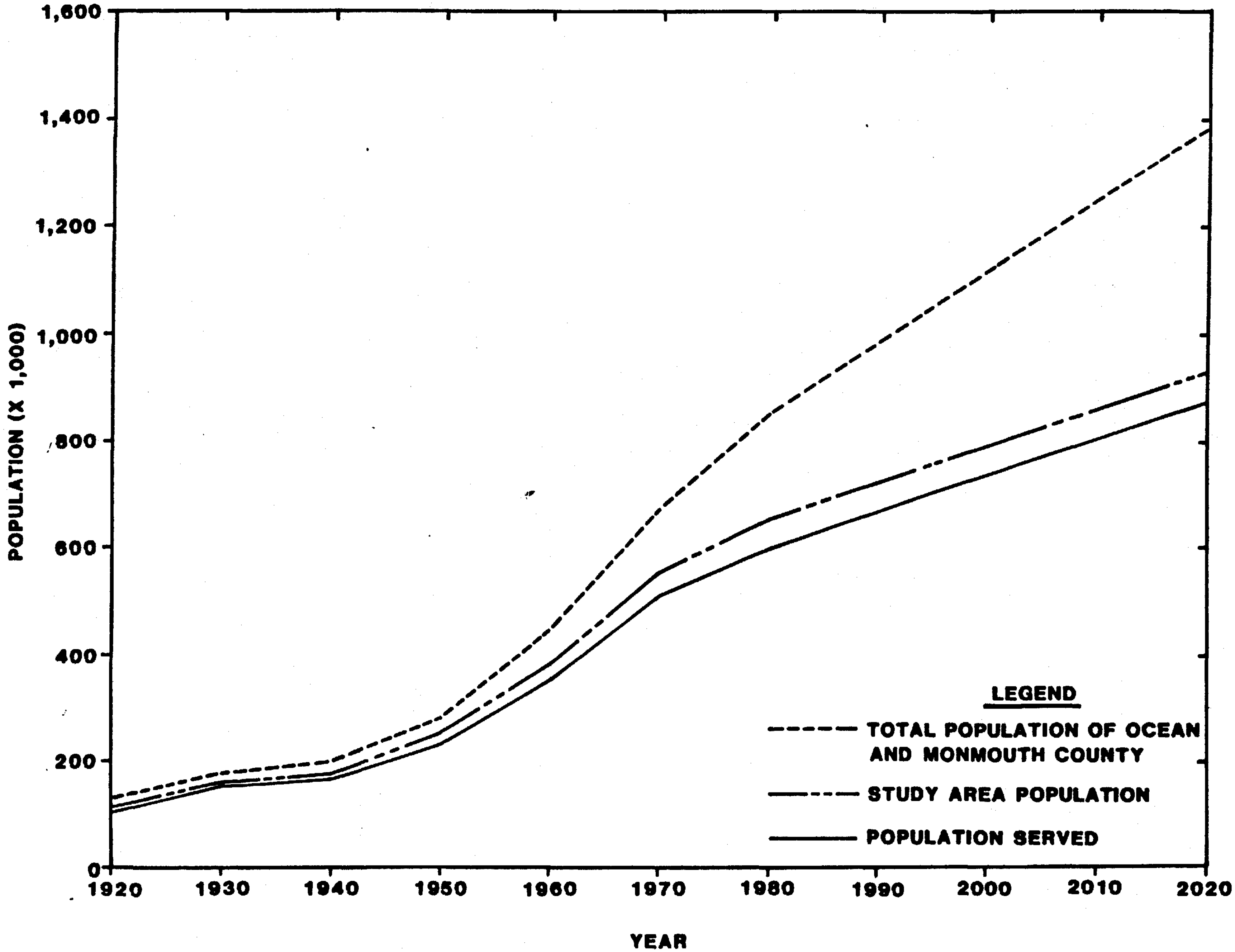


FIGURE 3 STUDY AREA POPULATION

WATER DEMANDS

INTRODUCTION

Water demand projections will be made for the years 2000 and 2020 for each community in the Study Area. Annual average water demand projections will be determined on the basis of the projected population to be served by water purveyors and the representative per capita water usage rate. Projections for maximum month and winter-average demands will be determined by multiplying the annual average water demand by an appropriate factor. These factors will be determined for each community based on existing water use (diversion) records.

PRESENT DEMANDS

Before future water demand projections can be made, it is useful to understand the past and present water use patterns. The Diversion Records which are submitted by every water purveyor to the NJDEP are very useful in developing an understanding of the water use patterns of each community. These records indicate the amount of water diverted (used) on a monthly and yearly basis and the population served.

The 1982 average daily per capita water usage rates were calculated for each community by dividing the average daily water usage by the number of permanent residents served. These per capita rates, which are shown in Table 4, include residential, commercial, and industrial usage as well as system losses. Based on the per capita usage rate, the communities were classified

TABLE 4. AVERAGE DAILY PER CAPITA WATER USAGE (1982)

Municipality/Purveyor	Annual Average Per Capita Usage Rate, gcd	Usage Rate Classification			
		Low	Medium	High	Very High
Matawan Borough/Aberdeen	94	X			
Keyport	116		X		
Keansburg	118		X		
Union Beach	115		X		
West Keansburg W.C.	110		X		
Allenhurst	153			X	
Atlantic Highlands	120		X		
Avon-By-The-Sea	110		X		
Highlands	110		X		
Red Bank	139			X	
Monmouth Consolidated W.C.	120		X		
Belmar W.D.	110		X		
Brielle	127		X		
Manasquan	131		X		
Sea Girt	105		X		
Spring Lake	125		X		
Spring Lake Heights	107		X		
Wall	78	X			
Englishtown	85	X			
Farmingdale	157			X	
Freehold Borough	138			X	
Freehold Township	127		X		
Howell	90	X			
Manalapan/Marlboro	116		X		
Roosevelt	118		X		
Allentown	108		X		
Lakewood	105		X		
Jackson	94	X			
Brick	85	X			
Point Pleasant	112		X		
Point Pleasant Beach	152			X	
NJWC-Ocean County District	246				X
	TOTAL	6	20	5	1

into very high, high, medium, and low usage groups. These groups and rates will be used as a basis for projecting future water demands. The average usage rates for each group were as follows:

Group	Rate
Very High	246 gcd
High	148 gcd
Medium	116 gcd
Low	88 gcd

The high usage rates in Point Pleasant Beach, Allenhurst, and the NJWC(New Jersey Water Company)-Ocean County District are caused by the usage of water by the large number of temporary residents in the summer time. These temporary residents are not included in the population figures used to determine the per capita rates. The high usage rates in Red Bank, Farmingdale, and Freehold Borough are due to the higher than average commercial and industrial usage in these communities.

The Diversion Record data was also used to calculate the maximum-month/annual-average and winter average/annual average factors.

FACTORS AFFECTING PER CAPITA WATER USE

Per capita water consumption not only varies significantly between different areas of the country, but also between different communities in a relatively homogeneous region. For instance, water consumption by different systems in California ranges between 250 and 400 gallons per capita per day (gcd). By comparison, water consumption by communities in the northeast exceeds 150 gcd only where there is significant commercial or industrial water consumption or when there is significant leakage from the water supply mains.

In a study conducted by Metcalf & Eddy based on 1977 water use data, records showed that the average annual water use in the Ridgewood, New Jersey, system was about 104 gcd. The system served four municipalities with the following per capita consumptions:

- Ridgewood - 112 gcd
- Glen Rock - 105 gcd
- Midland Park - 81 gcd
- Wyckoff - 97 gcd

Records of the Westchester Joint Water Works (WJWW) system in Westchester County, New York, were reviewed for comparison purposes in the same study. That system serves consumers in several municipalities in an area very similar in residential development to Ridgewood. Average use for the WJWW system was 184 gcd in 1977. However, the equivalent of 50 gcd was attributed to unaccounted-for-water uses such as for parks and fire hydrants, municipal buildings, and losses through leakage. When corrected for such unaccounted consumption, the use in Ridgewood was calculated to be 98 gcd and in the WJWW system to be 135 gcd. While there is more commercial development in the WJWW area, it would not account for the 37 gcd difference in consumption.

The foregoing illustrates that there can be significant differences in water consumption between communities which are similar in their stage of development and between systems within the same geographical area. The reasons for these differences are due to particular circumstances and system features that do impact on the per capita water consumption. It is the combination of these influences, specific to a particular area, that will determine total water use. The principal direct and indirect influences on per capita water consumption are discussed below by category.

<u>Direct Influences</u>

The direct influences on water consumption are those under the control of the consumer and consist of those uses that are subject to individual choices. These water use options include the use of interior appliances such as dishwashers, clotheswashers, etc., and outside uses such as lawn watering, swimming pools, etc. There are no available studies or data about such uses in the Monmouth County, Ocean County or nearby areas. However, studies have been conducted elsewhere that do show the variables that may impact on the direct or controllable water use portion.

<u>Water Use Devices/Increasing Affluence</u>. In the post-World War II period the greatest increase in per capita consumption occurred because of both availability and the proliferation of water using devices. Not only were clotheswashing and dishwashing machines available, but people had the money to buy them. Increasing affluence also led to the multiple-bath house. In time, yesterday's luxuries

The foregoing illustrates that there can be significant differences in water consumption between communities which are similar in their stage of development and between systems within the same geographical area. The reasons for these differences are due to particular circumstances and system features that do impact on the per capita water consumption. It is the combination of these influences, specific to a particular area, that will determine total water use. The principal direct and indirect influences on per capita water consumption are discussed below by category.

Direct Influences

The direct influences on water consumption are those under the control of the consumer and consist of those uses that are subject to individual choices. These water use options include the use of interior appliances such as dishwashers, clotheswashers, etc., and outside uses such as lawn watering, swimming pools, etc. There are no available studies or data about such uses in the Monmouth County, Ocean County or nearby areas. However, studies have been conducted elsewhere that do show the variables that may impact on the direct or controllable water use portion.

Water Use Devices/Increasing Affluence. In the post-World War II period the greatest increase in per capita consumption occurred because of both availability and the proliferation of water using devices. Not only were clotheswashing and dishwashing machines available, but people had the money to buy them. Increasing affluence also led to the multiple-bath house. In time, yesterday's luxuries have become today's necessities so that the house with one bath and without washing machines is now the exception. There is no question that more water will be used as more ways to use water become available. Average per capita use of residential water-using devices has been estimated by Metcalf & Eddy in other studies to be as follows:

Device	Use gcd
Water Closet	25
Lavatory	3
Shower	12
Bath Tub	8
Kitchen Sink	7
Clothes Washing Machine	9
Automatic Dishwasher	2

It is noted that either the bathtub or the shower would be used, so the total of 66 gcd for all uses is not pertinent. The above numbers are average values for an individual member of an average size family of approximately 3. In any case, it would be safe to say that the average residential per capita use should be approximately 60 gcd where all of the above water using devices are available.

Family Unit Efficiency/Lot Size. A study conducted by the Boston area Metropolitan District Commission (MDC), showed how total water use will vary according to the size of the house lot and to the family size. Using data presented in that report, per capita use in the average Milton, Massachusetts, household is as follows:

Number in Household	Water Use - gcd Small Lot	Water Use - gcd Large Lot
1	140	185
2	90	112
3	73	92
4	67	80
5	60	74
6	57	68

This data illustrates that while each individual may use about the same amount of water for personal use, there is a definite inefficiency in water usage for appliances and lawn watering, for smaller families. It is interesting to note that lot size has an even more significant impact on per capita use. This difference in use can be attributed to greater availability of water using devices in the larger houses and that these houses are typically located on the larger lots, which have larger lawn and garden areas that must be watered. In general, the difference in water use on the basis of family and lot size is related to a difference in affluence.

Type of Housing. There are no definitive and readily available data on the influence of the type of housing on water use. Theoretically, multiple housing units should impact the influence factor where there may be less lawn area per resident to water. Trends in zoning laws and the concept of multiple dwellings, however, have indicated little efficiency to be gained with multiple dwelling developments. Usually, significant open space is required, which negates the lawn and garden efficiency factor. Many multiple developments are condominiums or cooperatives where the residents are the owners. In these situations, there probably will be little difference in water use for the same size family living in a single or multiple dwelling unit.

Indirect Influences

Indirect influences are influences over which the individual has no control. Those are related, for the most part, to characteristics of the water system and to the community use of water as discussed below.

Water Pressure. Except for the water closet and the bath tub that involve batch amounts, water use for most other commonly used water devices in a typical residence will be affected by system pressure. That is to say, water flow through a faucet, shower head or hose valve will be greater at higher pressures than at lower pressures for the same hydraulic opening provided in the flow path. It is true that regulation of flow is possible by throttling the faucet or by regulating the control valve. Tests show, however, that the consumer becomes accustomed to the system and is generally not too conscious of the flow rate of water. Per capita use will be higher where system pressure is higher, all other influences being equal.

System Leakage/Municipal Use. Many of the older water systems in the country lose a significant amount of water through leakage. In addition, there may be a significant use of water that is not metered, for community uses such as street washing, public buildings, municipal swimming pools, parks and fighting fires. The total of leakage and other such unmetered water uses is usually grouped in the general classification of unaccounted-for-water use. As mentioned before, such unaccounted use amounted to the equivalent of almost 50 gcd for the Westchester Joint Water Works system in 1977. This corresponds to 27 percent of the water supplied to the system.

Commercial and Industrial Use. Using the same two communities for illustration purposes, we found that with similar residential service areas there was a significant difference in 1977 in per capita water use between the Ridgewood, New Jersey, and Westchester Joint Water Works systems. As mentioned, the difference of 98 gcd and 135 gcd, respectively, may be attributed to the significantly greater commercial development in the Westchester service area. This development consists, for the most part, of office parks. There is no doubt that commercial development impacts significantly on a community's water consumption. It not only serves to keep the resident population within the local water use area, but it also attracts outsiders on a transient basis who are not counted in the calculation of per capita consumption.

Weather Impact. In communities where lawn watering is a significant part of the water use, it has been found that weather has a profound influence. Water use rises dramatically with dry spells extending more than a few days. In the analysis of water use for Ridgewood a significant difference was found in per capita use between years with relatively dry summers and those years when summer rainfall was higher than normal.

Conservation

Rising population coupled with drought-related shortages in many areas has prompted the need to conserve water. In the past 20 years there have been many studies conducted to determine the best means of reducing per capita water use. One of the better known of these studies was conducted by Metcalf & Eddy for the Santa Clara Water Company in California. The discussions that follow are based primarily on information contained in that report for that study, "Water Savings, May 1976".

Conservation means to reduce the use of water may be classified into two general groupings, structural and non-structural. The structural conservation includes those measures not under the direct control of the individual consumer, such as water pressure. Non-structural measures are those where the consumer is encouraged to reduce the use of water.

Water Saving Devices. The average per capita use of the more common water-using devices has been discussed before. In response to the need to save water, several water saving measures have been incorporated into these water-using devices or appliances. The more practical applications are as follows:

Device	Saving - gcd
Water Closet	7.5
Lavatory Faucet Aerator	0.5
Kitchen Faucet Aerator	0.5
Shower Head	7.5
Washing Machine (Reduced Load Cycle)	2.0

The water closet flow reduction may be considered to be completely structural. Each batch flush is reduced in volume. There is some element of choice, however, with all of the other flow reduction measures. The user may choose to increase the time of flow from the flow-reduced faucets and shower heads. While it is available, the consumer may not select the reduced volume of water for the reduced clothing load in the washing machine. In any case, installation of the water saving devices will effect some reduction of the per capita water use.

The New Jersey as well as other state building codes now require the use of water-saving plumbing fixtures in new construction. In time this will have a significant impact in reducing per capita water usage in the growing communities of Monmouth and Ocean Counties.

The water-saving water closet has almost become the industry standard. The use of this fixture alone may reduce per capita use by about 10 percent. There will always be an element of choice, however, with the other water saving measures. For example, shower heads can be changed and faucet aerators removed.

Pressure Reduction. Reduction of pressure in portions or all of a distribution system is a structural measure for water use reduction. With reduced pressure, all continuous flow devices will yield reduced flow of water in the full open position or for similar throttled positions. Hydraulic analyses of certain high pressure sections of the Ridgewood, New Jersey, system showed that reducing system pressures to 50 psi (pounds per square inch) could effect a reduction in water use of up to 12 percent. However, it is emphasized that consumer choice or habits could probably negate the benefits of reduced pressure. The consumer may operate a sprinkler, for instance, for a longer period to accomplish a lawn soaking equivalent to what was possible in a shorter period at higher system water pressure. In any case, like the water-saving devices, reduction of system pressure will accomplish some reduction of water use.

Reduced pressure will effect immediate and positive reduction in water loss where system leakage is prevalent.

Water Rate Charges. Historically, water prices have been determined based on the need to raise revenue rather than to control consumer consumption. Water has always been provided to consumers at low cost, with rates typically declining for large quantity use.

Water, like any other commodity, should be subject to the laws of economics; specifically the law of demand, which states that the quantity of an item demanded is an inverse function of its price. Studies have shown that if the price of water is increased, the demand will fall, and alternatively, that if the price is reduced, the demand will increase. Many studies are currently being conducted to determine the degree of sensitivity between changes in water prices and their effects on water consumption, for the purpose of evaluating the effectiveness of adjusting water prices to conserve the public water supply by all sectors of users. Such evaluation of effectiveness can only be meaningful with studies covering an extended period of time.

It has been found that the public in many instances will react to immediate changes in price, but will eventually accept the change and revert to original habits. Data collected in the Washington, D.C. metropolitan area showed that price increases had only a temporary effect on reducing water consumption. This area study indicated that a sizable price increase is needed to effect a small reduction in water use.

Voluntary Conservation. There has been pronounced success in past instances with publicity campaigns to encourage the public's cooperation in the reduction of water use, particularly in emergency periods of severe drought conditions. New York City was able to reduce average daily consumption by 12 percent in the 1963-65 drought period. Pinellas County, Florida, achieved a 30 percent reduction from projected demand during the 1973 drought. In the New York City situation it was found that the most significant reductions in water use was the response of the public. Requests to industrial and commercial users were found to be relatively ineffective. However, less than two years after the end of the drought, the public's water use habits returned to normal. Since that time, with little change in population, water use in the City has increased by over 20 percent; almost 50 percent over the low consumption in the drought period.

A disadvantage of the voluntary reduction measure is the impact on water costs. Many water system costs are not production rate related. When water use declines in a system the fixed charges must be supported by revenues. In the recent northern New Jersey drought periods, many water suppliers found it necessary to raise base rates for metered customers to compensate for the lower consumption. The consumer found that there was little cost benefit to be gained by reducing the use of water.

It can therefore be concluded from this and the New York City experience that the extensive public education campaign and water use restrictions imposed during the drought may not be effectively applied on a long-term basis to effect permanent reduction in consumption.

FUTURE DEMANDS

Actual future water demands will be the result of the population growth and the per capita water consumption. The population projections for the serviced study area were summarized in Table 3 for the years 2000 and 2020. Combinations of the factors which influence water consumption will play a part in establishing the future per capita water use in the area.

In 1982 the average per capita water consumption within the study area was 114 gcd. Table 5 summarizes the principal influences on per capita use of water that should be considered in projecting trends. For the study area the influences for increasing water consumption are greater than those for decreasing consumption. Rising costs of water may result in a reduction in water use. In general, however, the cost of water is likely to be relatively low compared to that for other utilities. Consequently, the influence of water cost on water consumption may be negligible in the long term. Only the installation of water-saving plumbing fixtures or system pressure reduction would have a definite, positive impact on reducing per capita use. It would not be prudent, however, to base an estimate of future water consumption on the hope that voluntary conservation or public awareness of the need to conserve water will stabilize or even reduce water usage over an extended period of time. On the other hand, it is reasonable to expect that the new state building code requiring the installation of water-saving plumbing fixtures in all new construction and in major rennovations, will have a positive impact on reducing per capita use.

A plot of the historical data and three projections of per capita water usage for Monmouth County have been plotted on Figure 4. As the figure shows, the historical per capita use rate has varied considerably from year to year. However, the

TABLE 5

INFLUENCES ON PER CAPITA WATER USE

<u>Per Capita Use Increase</u>

Increased Affluence - Proliferation of Water Use Devices

Decreased Family Size

Increased Commercial and Industrial Development

Uncorrected System Leakage

<u>Per Capita Use Decrease</u>

Water Saving Devices - Required by Code

Pressure Reduction

Increased Water Costs

Short Term - Voluntary Conservation

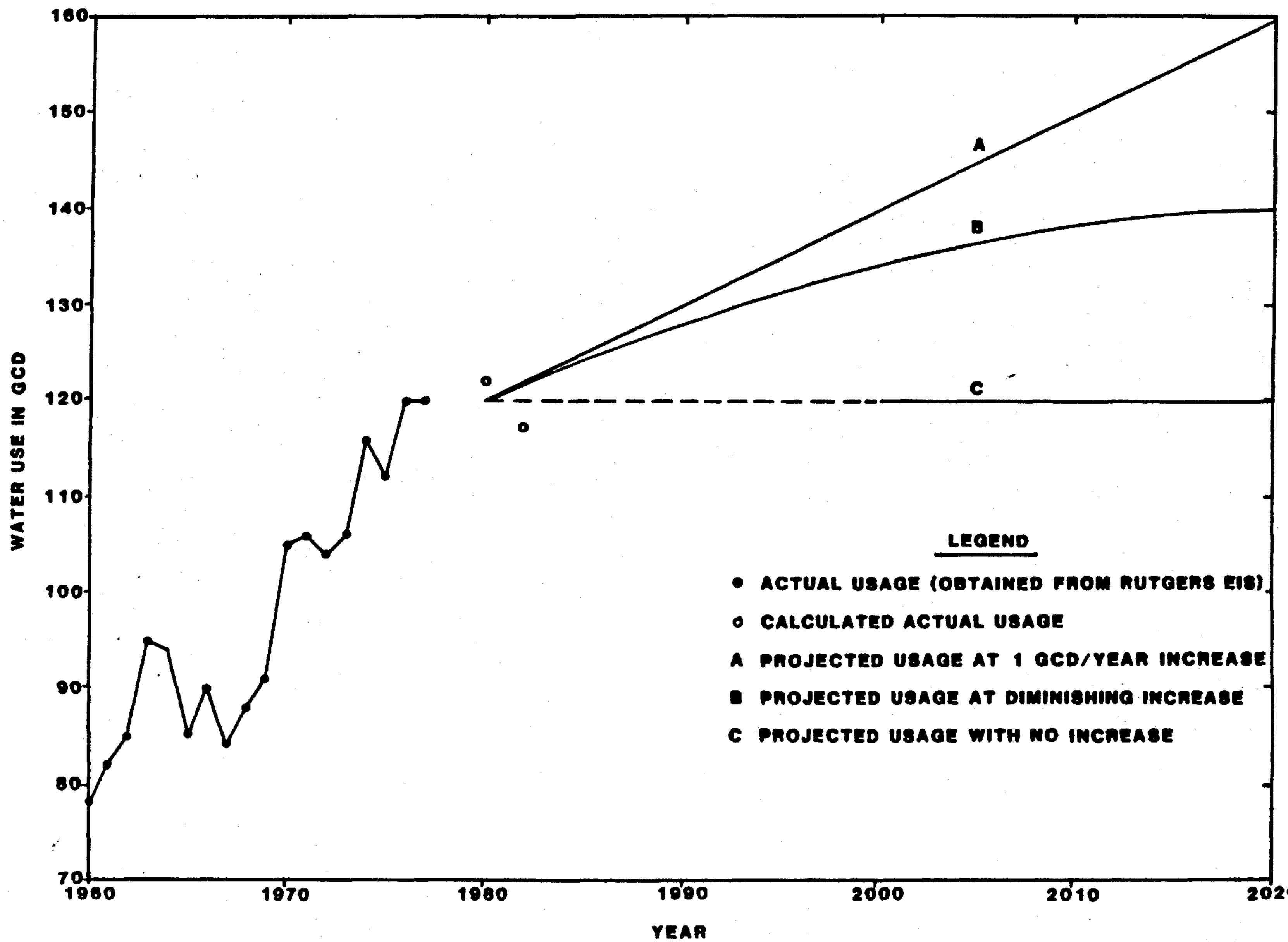


FIGURE 4 HISTORICAL AND PROJECTED PER CAPITA WATER USE MONMOUTH COUNTY

overall trend over the past 20 years has been a steady increase in per capita water use. The two most important influences which have caused this increase are increased affluence (which results in a proliferation of water using devices), and the decreased family size of the resident population.

The three projections of future per capita water usage, denoted as Curves A,B,C, on Figure 4, represent three possible scenarios for future water usage. Curve A represents a continued increase at the rate of 1 gcd per year increase through the year 2020 as projected by previous studies, including the Rutgers Manasquan Project Environmental Impact Statement. Curve B represents a continually moderating rate of increase from the present to the year 2020, when the annual rate of increase approaches zero. Curve C represents a complete leveling off in per capita use rate at the current rate of approximately 120 gcd, at some indeterminant time in the future.

It is unlikely that water usage will continue to increase at 1 gcd per year unless new devices for using more water are invented or unless there is a higher increase in commercial/ industrial development than anticipated. It is also unlikely that per capita water usage will stabilize immediately in Monmouth and Ocean counties as Curve C predicts. Both of these counties are projected to increase substantially in population, which should generate some commercial and industrial growth which will increase the per capita usage.

The actual future per capita water usage will probably fall somewhere between Curves A and C. It is therefore recommended that Curve B be used to project future water demands for the study area. Curve B gives recognition to the historical trend of increasing per capita water usage as well as the fact that in the future, water conservation measures will probably offset any increases caused by the other influences tending to increase per capita usage.

Demands

Estimates of future annual average water demands were calculated by multiplying the projected population served by the projected annual average per capita usage rates presented below. The per capita consumption rate was adjusted for each usage group based on the increase in per capita usage projected by Curve B:

Group	Rate (gcd) 2000	Rate (gcd) 2020
Very High	264	270
High	166	172
Medium	134	140
Low	106	112

Maximum month and winter averages were calculated by multiplying the annual average usage by the appropriate factor (maximum month/annual average or winter average/annual average). These factors were developed using the 1980-1983 water purveyor diversion records. The ratios vary for each water purveyor. The annual average, winter average, and maximum month water demands are given for each community/water purveyor in

Table 6. Figure 5 shows the total water demands projected for the service area.

Figure 6 compares the total water demands projected for the study area with the available surface water diversions. As can be seen, even after the completion of the Manasquan Reservoir System there will be a significant demand which must be met by a combination of groundwater use and other new sources.

TABLE 6. WATER DEMANDS

Municipality/ Purveyor	Present (1982) Usage mgd			Year 2000 Usage mgd			Year 2020 Usage mgd		
	Ann. Ave.	Max. Mo.	Winter Ave.	Ann. Ave.	Max. Mo.	Winter Ave.	Ann. Ave.	Max. Mo.	Winter Ave.
Matawan & Aberdeen	2.51	3.29	2.36	3.48	4.56	3.19	4.36	5.71	3.99
Keyport	0.87	0.95	0.82	1.02	1.20	0.95	1.08	1.27	1.01
Keansburg	1.26	1.56	1.19	1.46	1.90	1.35	1.56	2.03	1.44
Union Beach	0.73	0.85	0.72	0.87	1.00	0.84	0.93	1.07	0.90
W. Keansburg W.C.	3.27	4.58	2.76	4.32	6.09	3.58	4.87	6.87	4.04
Allenhurst	0.14	0.19	0.13	0.16	0.24	0.14	0.18	0.27	0.16
Atlantic Highlands	0.60	0.73	0.56	0.75	0.90	0.71	0.86	1.03	0.81
Avon	0.26	0.40	0.22	0.30	0.47	0.24	0.31	0.48	0.23
Highlands	0.57	0.73	0.53	0.67	0.84	0.61	0.70	0.88	0.64
Red Bank	1.68	1.93	1.62	2.06	2.41	1.97	2.20	2.57	2.11
Mon. Consolidated W.C.	29.11	36.28	25.96	36.34	47.97	31.62	42.35	55.90	36.84
Belmar W.D.	0.92	1.41	0.76	1.12	1.72	0.89	1.18	1.82	0.94
Brielle	0.52	0.73	0.46	0.59	0.88	0.47	0.66	0.98	0.52
Manasquan	0.70	1.06	0.59	0.72	1.12	0.58	0.76	1.19	0.61
Sea Girt	0.28	0.42	0.23	0.36	0.58	0.29	0.38	0.61	0.30
Spring Lake	0.53	0.85	0.41	0.60	1.03	0.44	0.66	1.13	0.49
Spring Lake Heights	0.59	0.79	0.52	0.86	1.16	0.74	1.02	1.38	0.87
Wall	1.54	2.15	1.36	2.83	3.88	2.47	3.76	5.15	3.29
Englishtown	0.08	0.10	0.08	0.11	0.13	0.11	0.12	0.14	0.11
Farmingdale	0.22	0.27	0.20	0.27	0.34	0.25	0.32	0.40	0.30
Freehold Boro	1.40	1.50	1.37	1.88	2.16	1.80	2.14	2.46	2.05

TABLE 6. (continued)

Municipality/ Purveyor	Present (1982) Usage mgd			Year 2000 Usage mgd			Year 2020 Usage mgd		
	Ann. Ave.	Max. Mo.	Winter Ave.	Ann. Ave.	Max. Mo.	Winter Ave.	Ann. Ave.	Max. Mo.	Winter Ave.
Freehold Twp.	1.85	2.51	1.60	2.90	4.00	2.42	4.02	5.55	3.35
Howell	1.11	1.66	0.91	2.31	3.63	1.81	3.52	5.53	2.76
Manalapan & Marlboro	4.35	7.36	3.17	6.38	11.23	4.43	8.07	14.20	5.60
Allentown	0.22	0.26	0.22	0.31	0.37	0.30	0.37	0.44	0.36
Roosevelt	0.10	0.13	0.09	0.10	0.13	0.09	0.11	0.14	0.10
Monmouth Co. TOTAL	55.41	72.69	48.84	72.77	99.94	62.29	86.49	119.20	73.84
Lakewood	3.59	4.84	3.14	5.99	8.51	5.07	7.98	11.33	6.75
Jackson	1.32	1.90	1.07	4.42	6.67	3.31	8.26	12.47	6.19
Brick	4.47	6.14	4.42	6.23	8.41	5.84	7.40	9.99	6.93
Point Pleasant	2.02	2.56	1.87	2.77	3.55	2.48	3.32	4.25	2.97
Point Pleasant Beach	0.84	1.26	0.71	1.06	1.66	0.84	1.27	1.99	1.01
NJWC-Ocean	1.34	2.61	0.91	1.71	3.45	1.14	2.07	4.18	1.38
Ocean County TOTAL	13.58	19.31	12.12	22.18	32.25	18.68	30.30	44.21	25.23
STUDY AREA TOTAL	68.99	92.00	60.96	94.95	132.19	80.97	116.79	163.41	99.07

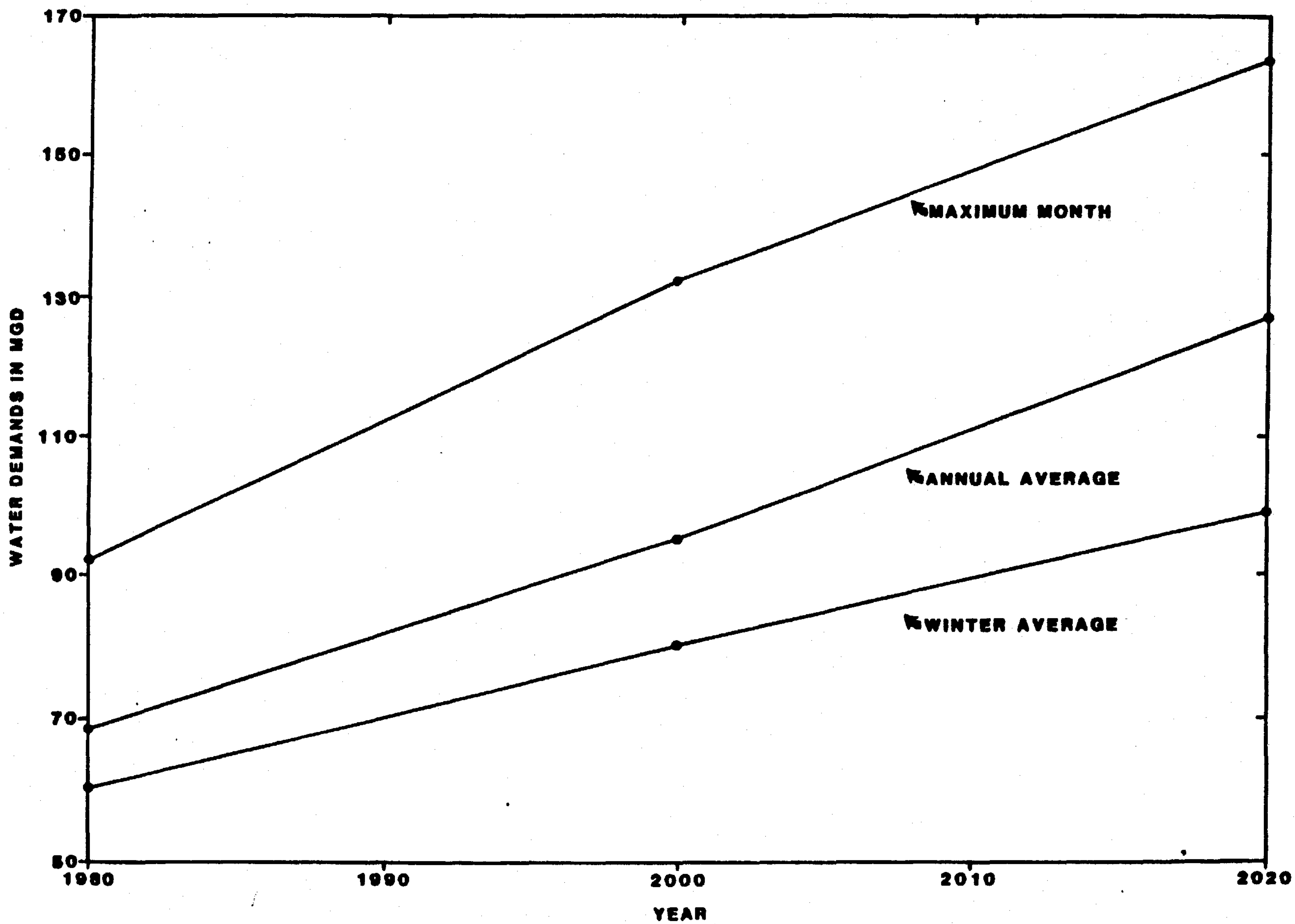


FIGURE 5 WATER DEMAMDS

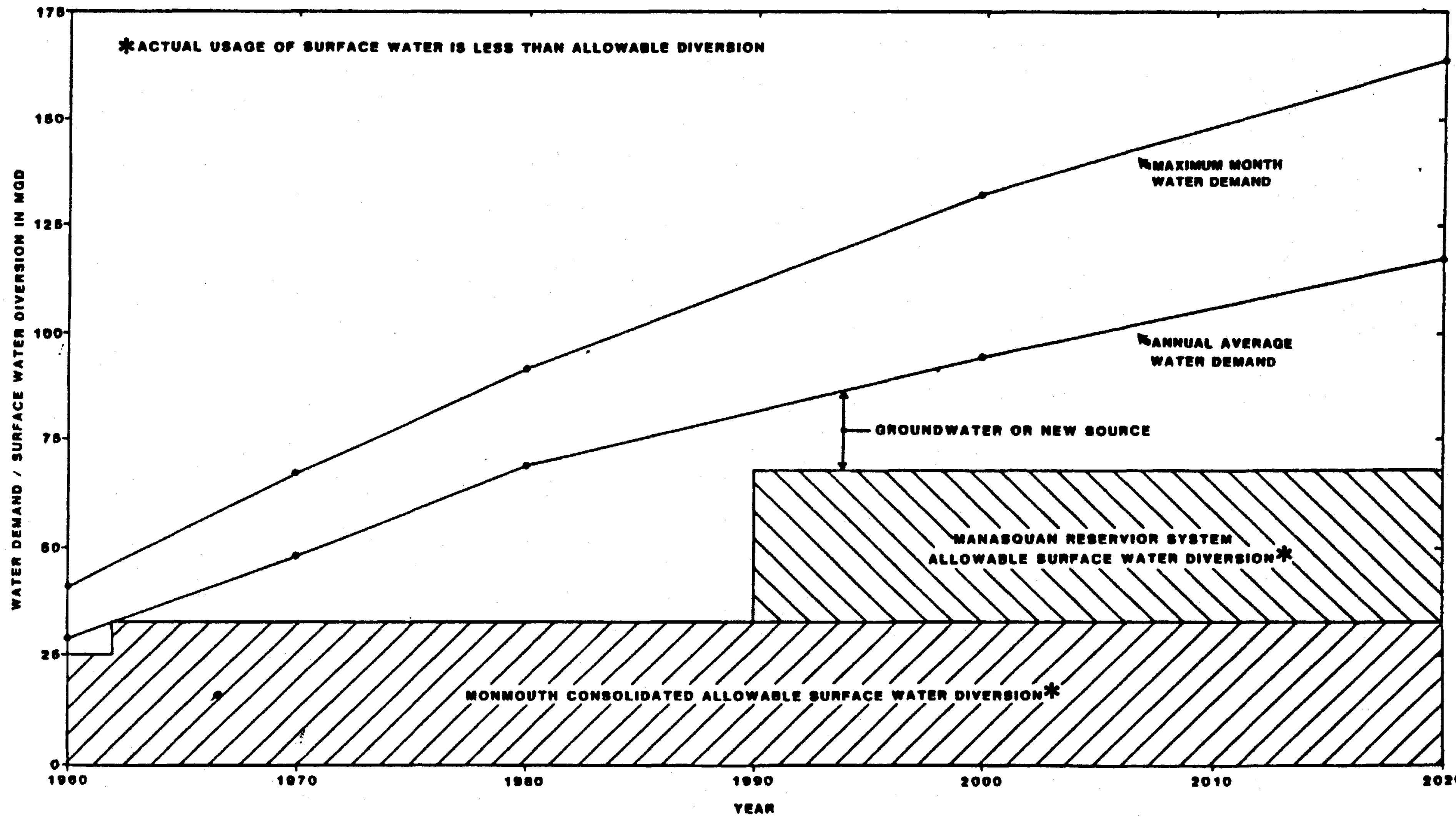


FIGURE 6 WATER DEMANDS AND SURFACE WATER DIVERSIONS

APPENDIX B.

REPORT OF THE WATER NEEDS GROUP TO
THE MANASQUAN RESERVOIR SYSTEM CITIZENS ADVISORY BOARD

- July 18, 1984 -

On June 26, 1984, the Water Supply Group of the Manasquan Reservoir Citizens Advisory Board met with Tom Baxter and John Kantorek of Metcalf and Eddy, Inc. to discuss the Consultant's report entitled "Water Demand and Conjunctive Use: Interim Report on Population and Water Demand Projections" (May 7, 1984). A previous meeting on the report was held June 7, 1984 without the Consultant. The highlights and results of the two meetings are summarized below:*

1. The year-2000 population projections adopted by the New Jersey Department of Environmental Protection for Monmouth and Ocean Counties are considered by the two county planning boards to be too low. (See Table 3, attached.)

2. The Consultant was questioned closely on the assumption that per capita water use will continue to increase, as it has in the past. While the per capita use line employed by the consultant (Figure 4, attached) in developing demand projections shows a steady (though decelerating) increase in the rate of water use, the Consultant points out that the increase is much less than that predicted previously in the Manasquan Reservoir EIS prepared by the Rutgers team.

   The trend line used by the Consultant does take into account decreases in water use resulting from the water-saving requirements of the State building code and other water-saving steps, but it is also based on the assumption that the influences leading to greater water use in the future will outweigh those leading to decreases.

   The rates on the trend line could be low if there is a higher rate of commercial and industrial development than anticipated. The Interim Report does not present a methodology for isolating and forecasting this growth but, instead, multiplies the projected population by the projected per capita water use, which reflects both residential and non-residential water use.

   It should be noted that the Monmouth Consolidated Water Company is assuming no future increase in the current per capita use of 69.4 gpcd for its residential customers. According to the New Jersey Division of Water Resources, 50 gpcd is more than sufficient to maintain the necessary standard of living.

3. The Group feels strongly that the Reservoir should be presented not as vast store of water for intensive new development but as a supplement to the supplies used for current needs which will allow for better water

---

* Some of the technical information was generated by Monmouth County Planning Board staff at the conclusion of the second meeting.

management. The Interim Report makes it clear that, even with the construction of the reservoir, the purveyors in the Manasquan service area will soon be pumping groundwater at a rate approximating that of the early 1960's, when the area's groundwater levels were subsiding at an accelerating rate. It is apparent that our groundwaters have already been overextended by the existing population and that the Reservoir is needed to relieve the burden on our aquifers. (See Figure 6.)

The protection of our aquifers and construction of the reservoir should be treated as one project. The start-up of the reservoir system should be tied to the scale-back or revocation of groundwater diversion rights as part of a conjunctive use program.

The Water Supply Group recommends the development of effective growth management plans and land use controls which would help provide a basis for the allocation of the Manasquan surface water to the individual purveyors. The Group also recommends the phasing in of a mandatory and comprehensive water conservation program in order to extend the useful life of the reservoir system. Without conservation, the State would be forced to impose severe restrictions on new growth.

Both the New Jersey Statewide Water Supply Master Plan (April, 1982) and Monmouth County 208 Water Quality Management Plan (Addendum pp. 24-26, 30-32; August, 1979) call for water conservation programs. The NJSWSMP declares that the State "must take the initiative to educate the citizens of New Jersey on how they can individually and collectively benefit from water conservation programs. When any governmental unit begins its conservation planning, it must first determine what the goals of the conservation program are and whether these goals can be met through supply management, demand management, or a combination thereof."

Supply management programs include system rehabilitation, source protection, and metering. Demand management programs include the use of structural devices such as tap flow restrictors and changes in behavioral patterns.

As one of the components of a comprehensive conservation strategy, the Plan also urges an "evaluation of innovative water use/wastewater disposal practices in all consumer categories" and the promotion of "public acceptance of the same where feasible."

The savings that are possible through water conservation in the home are rather dramatic. For example, the shower (30%) and toilet (40%) account for some 70% of household water consumption. The amount used for toilet flushing can be reduced by some 40-57% using "water closet dams" in conventional toilets and 95% by using newer designs. One of the latest shower heads cuts consumption by 62-72% while still providing a satisfying spray. Water conservation reduces energy as well as wastewater treatment costs; about 50% of the hot water consumed in the home is used in the shower.*

* Sources available upon request.

Large savings are also possible in the workplace. Gillette and Polaroid have reduced their water use by as much as 70% in some plants.

Figure 6, which is an excellent aid to understanding the relationship between supply and demand in the Manasquan service area, has been amended to illustrate the impact of a hypothetical phased conservation program on the gap that exists between supply and demand when the conditions of aquifer recharge are restored. (See also Table A.) The program involves an immediate (1980) savings of 10% which increases to 25% in the year 2000 and 40% in the year 2020. While the Consultant's per capita use trend line does assume some savings resulting from the new State construction code, no figures on the savings are specified in the Interim Report.

If conservation is relied on to "stretch" the water supply to meet the needs of new growth under conditions of normal rainfall care, should be taken not to exceed the supply's carrying capacity, i.e., the point at which no further conservation would be practical during a prolonged drought. This "breaking point" would constitute the true limit to growth in the bi-county area.

In summary, the Water Supply Group recommends that the members of the Citizens Advisory Board give careful consideration to the appropriateness of the population and per capita use projections which form the basis for the Consultant's demand projections; the need for growth management plans and land use controls to guide development and allocation decisions; the impact of the proposed reductions in groundwater withdrawals on the overall water supply; and the relationship of convation to conjunctive use and future growth.

DWM
7/84

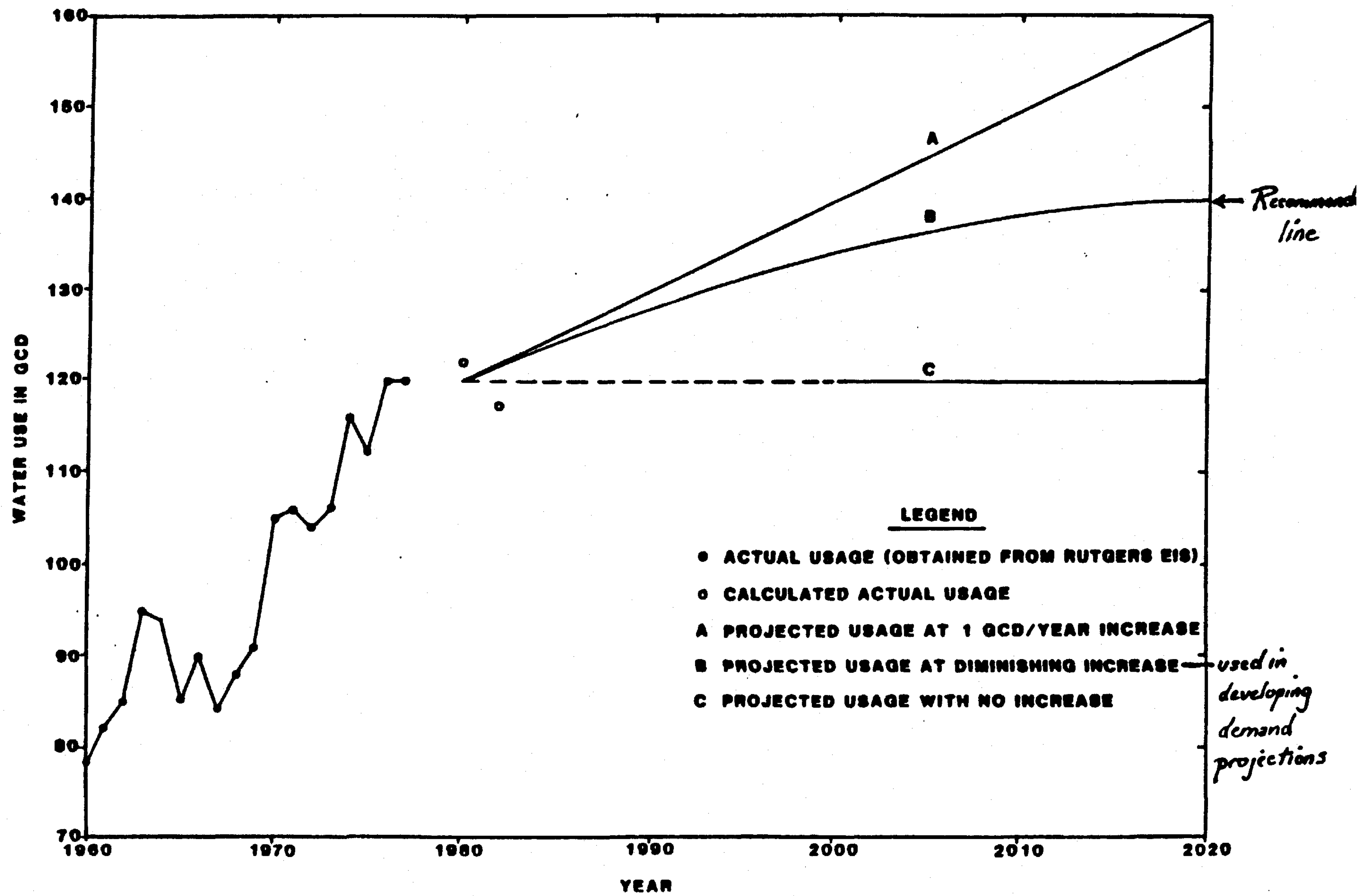


FIGURE 4 HISTORICAL AND PROJECTED PER CAPITA WATER USE MONMOUTH COUNTY

TABLE 3. POPULATION PROJECTIONS FOR MANASQUAN RESERVOIR SYSTEM

	1980 Population		Projected Populations 2000		2020
Monmouth County					
Total	503,173		588,200		667,241
Study Area	503,173		588,200		667,241
Serviced Study Area	470,140	→ 17.8%	553,986	→ 14.2%	632,394
Ocean County					
Total	346,038		526,500		714,392
Study Area	144,301		198,927		255,801
Servied Study Area	125,838	→ 42.0%	178,731	→ 31.8%	235,605
Total Study Area	647,474		787,127		923,042
Total Serviced Study Area	595,978	→ 22.9%	732,717	→ 18.5%	867,999

SOURCE: Metcalf and Eddy, Inc. (May. 1984).

[1]Monmouth County Planning Board (1984 est.): 626,200.
Jersey Central Power and Light (1984 est.): 588,264 (excludes Allentown and some 5% of Upper Freehold land area).
[2]Ocean County Areawide Water Quality Management Plan (1978 est.): 560,400.
[3]Ocean County Planning Board: 211,279 (assumes Dover Township portion of barrier island remains constant).

Table A.

MONMOUTH-OCEAN WATER DEMANDS: 1980-2000

- For Serviced Study Area -

Year	Population[1]	Per Capita Usage[2] (gpcd)	Annual Average Demand (mgd)
1980	595,978	114 / 102.6 (10%)	67.9 / 61.1 (10%)
2000	732,717	130 / 97.5 (25%)	95 / 71.3 (25%)
2020	867.999	135 / 81 (40%)	117 / 70.2 (40%)

69 = without conservation
62.1 (10%) = with 10% conservation

[1] 1980 Census and adopted NJDEP projections.

[2] Annual Average Demand divided by Population.

[3] Metcalf and Eddy, Inc. (May, 1984): Figure 6 and pp. 1-2.

MCPB 7/84

Table B

MONMOUTH-OCEAN WATER WITHDRAWALS: 1960-1983

-For Serviced Study Area-

	1960	1970	1980	1982 ("Present")	2000 (Projection)	2020 (Projection)
Groundwater (mgd)	18	--	39.9	45	26.8	48.8
Surface (mgd)	11	--	28.0[1]	24	68.2[2]	68.2[2]
Total (mgd)	29	45	67.9	69	95	117

SOURCE: Metcalf and Eddy, Inc. (May, 1984): Figure 6 and pp. 1-2. Unless noted otherwise.

1 Monmouth Counsolidated Water Company. Personal communication (July, 1984).

2 Existing Monmouth Consolidated surface water diversion rights and 35 mgd from Manasquan Reservoir.

MCPB 7/84

SOURCE: Metcalf and Eddy (May, 1984). See also Table B.

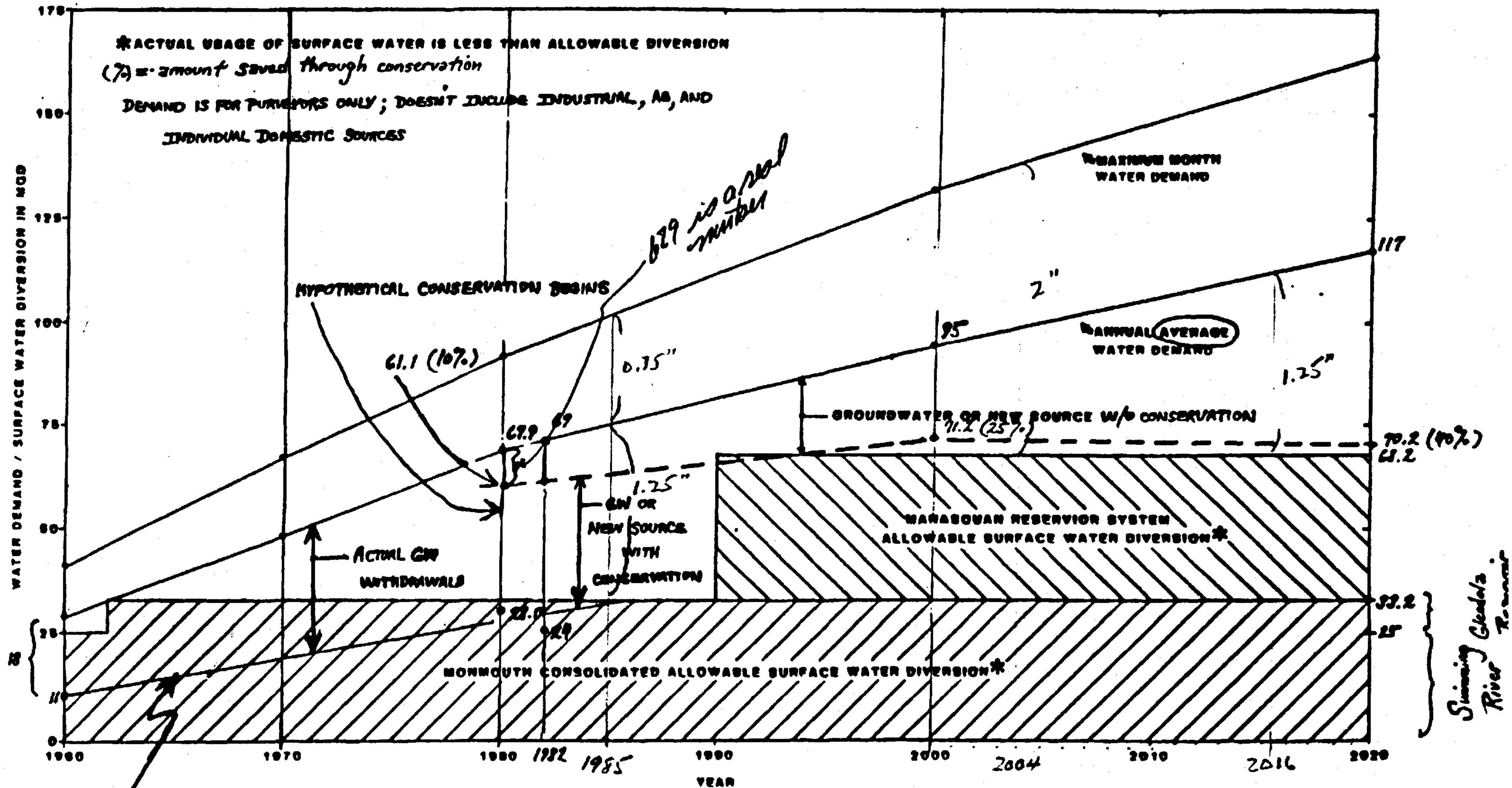


FIGURE 6 WATER DEMANDS AND SURFACE WATER DIVERSIONS