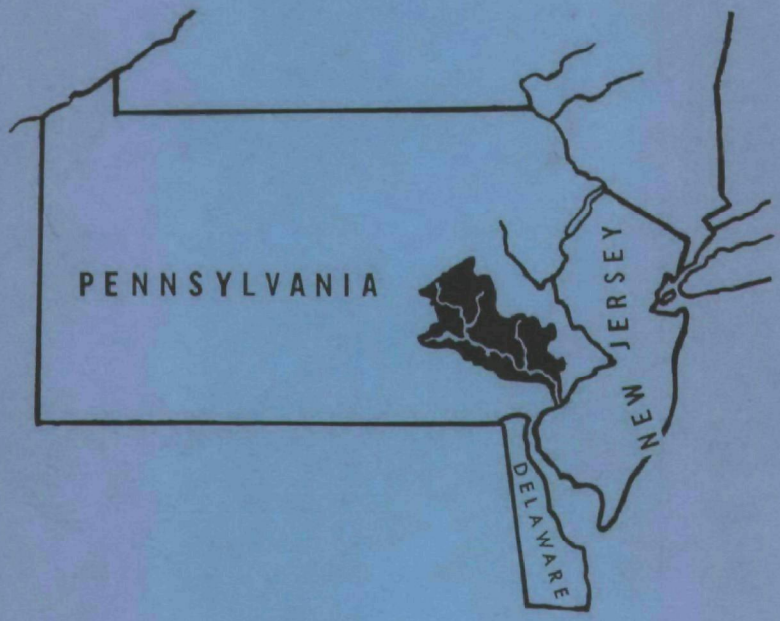
WATER SUPPLY AND WATER QUALITY CONTROL STUDY BLUE MARSH RESERVOIR

SCHUYLKILL RIVER BASIN PENNSYLVANIA



U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
BOSTON, MASSACHUSETTS 02203
June 1968

WATER SUPPLY AND WATER QUALITY CONTROL STUDY
BLUE MARSH RESERVOIR
SCHUYLKILL RIVER BASIN
PENNSYLVANIA

Abstract

A study has been made which discloses a present and future need (to the year 2020) for storage in the proposed reservoir for municipal and industrial water supplies. There is also an immediate need for storage for flow regulation to control water quality. These conclusions are based on hydrologic, economic and demographic analyses. Future needs are based on projected population and industrial growth.

IN COOPERATION WITH THE
U.S. DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT
PHILADELPHIA, PENNSYLVANIA

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Northeast Regional Office
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I. INTRODUCTION

Request and Authority

This study was initiated at the request of the District Engineer, Corps of Engineers, Philadelphia, Pennsylvania, by letter dated October 15, 1964. The letter requested . . . "A review and updating of the recommendations for the development of water supply and flow regulation for quality control for the Blue Marsh Project," located in the Schuylkill River Basin.

Authority to conduct this study is provided in the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et. seq.), and in a Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to Title III of P.L. 500, 85th Congress as amended by P.L. 87-88. Responsibility for this study was transferred to the Department of the Interior as of May 10, 1966, by Reorganization Plan Number 2 of 1966.

Purpose and Scope

The purpose of this study is to determine the need for and value of storage of water in the proposed Blue Marsh Reservoir for municipal and industrial water supply and for water quality control. This reservoir is proposed by the Corps of Engineers for multi-purpose development.

The area considered in this study encompasses portions of Berks, Montgomery, Chester, Bucks, Delaware, and Philadelphia counties, in southeastern Pennsylvania.

Project needs and benefits have been evaluated for the period 1970 to 2020.

Acknowledgements

Information and cooperation provided by the following agencies are gratefully recognized:

U. S. Army Engineer District, Philadelphia, Pa.

U. S. Geological Survey

Delaware River Basin Commission

Pennsylvania Department of Health

Philadelphia Suburban Water Company

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Findings

1. The U.S. Army, Corps of Engineers, is considering construction of a project known as the Blue Marsh Reservoir, on Tulpehocken Creek. This creek is tributary to the Schuylkill River upstream from Reading, Pennsylvania.

2. The Schuylkill River, which flows through southeastern Pennsylvania, is a major tributary of the Delaware River which it joins at the City of Philadelphia.

3. The study area consists of six counties (Berks, Bucks, Montgomery, Chester, Delaware and Philadelphia) lying mostly within the Schuylkill River Basin.

4. The study area is characterized by rolling hills, below Reading, which taper off to tidal marshes at the confluence of the Schuylkill with the Delaware.

5. In 1965, approximately 1.7 million persons lived in the study area with the population density varying from approximately 200,000 people in and around Reading to over one million people in the Norristown-Philadelphia area.

6. The most significant water users in the study area are the people and industries centered in and around the cities of Reading, Pottstown, Norristown and Philadelphia. In 1965, the combined peak daily use for these four urban areas was 487 million gallons per day (MGD).

7. For 1965, estimates of adequately treated waste produced within the study area account for discharges of approximately 38,000 pounds of biochemical oxygen demand. Municipal waste from the urban areas of Reading, Pottstown and Norristown account for 32,000 pounds of this estimate, while the remaining 6,000 pounds are attributable to industrial wastes.

8. The manufacturing categories primarily responsible for industrial waste discharges are: Food and Kindred Products, Paper and Allied Products, Chemicals and Allied Products, Petroleum and Allied Products, Rubber Products, and Primary Metals.

9. The Schuylkill River is used extensively for industrial and municipal water supply. All municipal supplies must receive filtration and chlorination before use.

10. Maintenance of the sport fishery in the Schuylkill River required frequent restocking by the Pennsylvania Department of Fisheries.

11. Water quality in the Schuylkill River is marginal. Observations have revealed dissolved oxygen values less than 4 mg/l, waste concentrations as high as 8 mg/l of biochemical oxygen demand, and concentrations of organic chemicals exceeding recommended limits of Public Health Service "Drinking Water Standards".

Conclusions

1. In the year 2020 approximately 2.9 million people will be using the waters of the Schuylkill Basin for water supply, and approximately 1.9 million people will be using these waters for the dilution and assimilation of treated wastes.

2. Projections to the year 2020 indicate that storage will be necessary to insure 241 MGD for municipal and industrial water supplies in the Norristown region of the study area.

3. During a once-in-50 drought occurrence, a draft on storage* of approximately 3,200,000 acre feet will be needed by the year 2020, to sustain acceptable water quality in the Schuylkill River.

4. The augmentation capacity of the Schuylkill Basin is not sufficient to maintain quality control through stream flow regulation. Therefore, quality control practices such as advanced waste treatment, in addition to stream flow regulation will be necessary.

5. The minimum annual value of municipal and industrial water supply storage in the Blue Marsh Reservoir is estimated at $370,000. This value is based on the assumption that a single purpose reservoir would be the most efficient means of providing the water needed should

* A draft on storage is the sum of the incremental excesses of needed releases over inflows during a drought period.

the Federal project not be built. The cost of this single purpose alternative, therefore, is used as a measure of the minimum value of the storage provided by the Federal reservoir. Calculation of the cost is based on amortization over a 100 year period at a Federal interest rate of 3-1/8 percent. Included in the annual cost are expenditures for operation and maintenance.

6. The minimum annual value of storage releases, that will provide a portion of the quality control needed, is estimated at $321,000. This assumes that storage releases for water supply purposes, which also produce quality control benefits, will be provided.

7. The benefits derived from water quality control in the Schuylkill River above Fairmount Dam will be in the form of:

a) An improved quality in the raw water used for municipal and industrial water supplies.

b) Increased opportunities for recreational activity.

c) Enhancement of a desirable fish population.

d) Prevention of obnoxious septic and near septic conditions.

d) Improvement in the aesthetic qualities of the River.

III. PROJECT DESCRIPTION

Location and Pertinent Data

Blue Marsh Reservoir on Tulpehocken Creek is one of several major projects in the Corps of Engineers' Delaware River Basin plan authorized for Federal construction, to conserve and control the waters of the Delaware River and its tributary streams. The Reservoir will be formed by an earthfill, rock-covered dam across the valley of Tulpehocken Creek about 1 ½ miles upstream from the mouth of Plum Creek and about 6 miles northwest of Reading, Pa. (See Figure 1). The drainage area above this site totals 175 square miles. The Dam which will be 1,100 feet long and 90 feet high will provide a total reservoir storage capacity of 50,000 acre feet. Current apportionment of this storage assigns 3,000 a.f. to sediment deposition, 14,600 a.f. to water supply and recreation, and 32,400 a.f. to flood control.

Streamflow

Since December 1950, the U.S. Geological Survey has maintained a streamflow gaging station on Tulpehocken Creek, 3 miles downstream from the Blue Marsh dam site. The flow record provided by this station shows average daily streamflows in Tulpehocken Creek to be equal to or greater than 88 cfs ninety percent of the time, 72 cfs ninety-five percent of the time, and 60 cfs ninety-eight percent of the time. Average annual flow at the gaging station is 300 cfs. Assuming streamflow to be proportional to drainage area, the average annual flow at the dam site is estimated at 250 cfs. The drainage area serving the U.S.G.S. gage is 211 square miles.

Water Quality

The water quality of Tulpehocken Creek is generally good with a few exceptions. Analyses performed by the U. S. Geological Survey and the Pennsylvania Dept. of Health, presented in Table I show high nitrate and hardness concentrations (about 10 mg/l and 175 mg/l respectively). Additional analyses by the FWPCA have indicated phosphorus concentration in excess of 0.10 mg/l and total coliforms greater than 1000/100 ml.

The primary source of nitrates would appear to be agricultural and the major source of phosphorus, domestic sewage. Except for small forested areas most of the Tulpehocken drainage basin is farm land. The concentration of nitrogen and phosphorus found is in the range to support optimum growth of planktonic algae.

The sources of hardness are limestone and dolomite beds which underlay the headwaters of Tulpehocken Creek. The creek water above Reading, Pa., is considered as "very hard" according to U. S. Public Health Service "Drinking Water Standards". Water treatment may be necessary for industrial use to prevent scale in boilers, water heaters, and pipes.

Watershed bacterial counts generally exceed Pennsylvania State Dept. of Health standards for recreational use. The sources are municipal waste water and agricultural runoff. A study should be conducted to determine if more effective effluent chlorination of the sewage treatment plants in the basin, coupled with a reduction in the bacterial count that occurs with reservoir storage, would

result in a bacterial density within the recreation standard (1000/100ml). Also, a means for control of agricultural pollution should be sought.

Ground waters which recharge the headwaters of Tulpehocken Creek (Jackson Township, Lebanon County) are now contaminated with arsenic compounds originating from the property of production of pharmaceuticals by the Whitmoyer Laboratory. The Pennsylvania Dept. of Health and the Delaware River Basin Commission have approved a permit for controlled ground water decontamination of the area. Whitmoyer Laboratories has informed the DRBC that the contamination will be removed from the ground water and streams to within acceptable limits before the construction of Blue Marsh Dam.

The Pennsylvania Dept. of Health has sampled the Tulpehocken Creek near Reading quarterly. Analyses over the past five years show the dissolved oxygen to be never less than 8 mg/l. The BOD range for the same period is about 1-5 mg/l.

Water quality in the Schuylkill River is marginal. Those parameters which have exceeded limits specified by U. S. Public Health Service "Drinking Water Standards" or "Water Quality Criteria" for aquatic life, recreation, municipal or industrial use are: aluminum, copper, iron, manganese, sulfate, phosphate, nitrate, dissolved oxygen, biochemical oxygen demand, pH, hardness, dissolved solids, coliforms, ABS, and stream temperature.

Acid mine drainage affects the chemical quality of the main stem Schuylkill River throughout to the confluence with the Delaware River (Table 2). However, below Berne alkaline water from tributaries (the

major ones are Tulpehocken and Maiden Creeks) dilutes and neutralizes the acidic Schuylkill River. As a result the normal pH range at Pottstown is 6.5 to 8.0 in contrast to levels below 5 at Berne. The U. S. Geological Survey, prior to the 1965 water year, has reported pH values as low as 3.8 at Pottstown, Pa. A concerted mine drainage abatement program is needed to alleviate the acid condition in the Schuylkill River. Residual hardness and sulfates, comprising most of the dissolved solids concentration, affect water use throughout the length of the Schuylkill River.

The effect of dilution from tributary water is reflected in a reduction of dissolved-solids content. The dissolved-solids content exceeded 400 mg/l at Berne, Pa., 250 mg/l at Pottstown, and 210 mg/l at Philadelphia, Pa., less than 50% of the time. Please note that average dissolved-solids concentrations, shown in Table 2, are higher than these values because the 1965 water year flows are lower than average.

Dissolved oxygen problems occur in the vicinity of metropolitan areas, particularly near Reading, Pottstown, and Norristown. Pennsylvania Dept. of Health analyses reveal summer dissolved oxygen lows of about 7.0 mg/l near Reading, 5.0 mg/l near Pottstown, and 4.0 mg/l near Norristown. The BOD concentration ranges are Reading 1-9 mg/l, Pottstown 1-7 mg/l, and Norristown 2-8 mg/l.

TABLE I

WATER QUALITY - TULPEHOCKEN CREEK (NEAR READING)

(Concentrations in mg/l Except Where Noted)

Constituent	U.S.G.S.Analysis* Oct. 63 - July 65		Pa. Dept. of Health** 1962 - 1967	
	Average	Range	Average	Range
Mean Discharge	109 cfs	53-375 cfs	186.0 cfs	36 - 689 cfs
Dissolved Solids	215.2	174-251	250.7	180 - 308
Hardness	174.4	136-199	154.0	40 - 208 (1)
Alkalinity	169.8	124-196	123.4	75 - 150
Iron	0.00	-	0.3	0.1 - 1.0
Manganese	(2)	(2)	(3)	(3)
Sulfate	29.7	27- 33	41.1	19 - 185
Chloride	12.3	8.6- 18	12.7	7 - 18
Fluoride	0.05	0.00-0.10	no analysis performed	
Nitrate	9.6	7.8-12.0	no analysis performed	
pH (4)	7.6	7.1-8.2	7.8	6.4 - 8.9
Color	4	2-9	17.5	5 - 45
Conductivity	no analysis performed		331.7	300 - 380 micromhos
Temperature	no record made		12.7°C	1 - 24.4°C
Dissolved Oxygen	no analysis performed		11.3	8.2 - 14.4
BOD	no analysis performed		2.9	1.2 - 4.9

* Seven sample average
** Twenty-two sample average

(1) Second lowest value - 120
(2) Two samples contained 0.01 mg/l
(3) One sample contained 0.1 mg/l
(4) Laboratory determinations

TABLE 2

WATER QUALITY - SCHUYLKILL RIVER

(Concentrations in mg/l Except Where Noted)

Constituent	Berne, Pa.		Pottstown, Pa.		Philadelphia, Pa.	
	Average	Range	Average	Range	Average	Range
Mean Discharge	443 cfs	79-1860 cfs	638 cfs	407-868 cfs	1310 cfs	95-5400 cfs
Dissolved Solids	460	193-824	334	217-452	299	207-474
Hardness	277	109-499	182	129-235	170	120-278
Alkalinity	0.5	0-2	74	51-96	76	40-110
Aluminum	1.3	0.4-4.2	-	-	-	-
Copper*	0.06	0.00-0.36	0.06	0.00-0.28	0.05	0.00-0.22
Iron	0.01	0.00-0.02	0.02	0.00-0.03	0.01	0.00-0.02
Manganese	3.6	1.4-7.2	0.00	-	0.08	0.00-0.36
Sulfate	294	115-552	125	75-176	112	64-213
Chloride	10.3	6.5-16	42	19-66	29	18-48
Fluoride	0.1	0.0-0.2	0.2	0.2-0.3	0.3	0.2-0.6
Nitrate	8.8	3.9-14	16	12-21	11	6.9-16
ABS*	0.04	0.00-0.15	0.22	0.05-0.55	0.22	0.00-0.62
pH	4.3	3.8-4.7	7.3	6.8-7.8	7.1	6.8-7.8
Color	4	2-5	11	10-13	7	3-12
Temperature	55°F	32-88°F	-	-	62°F	36-84°F
Dissolved Oxygen*	10.1	8.4-13.4	9.2	5.0-14.2	8.6	4.0-14.0
BOD*	1.9	0.4-5.6	2.7	0.9-5.9	3.4	1.6-7.6

*Pennsylvania Dept. of Health Samples 1962-1967, 20 samples.
All other parameters U. S. Geological Survey October 1964-September 1965
Monthly samples for Berne and Philadelphia. Pottstown, biannual

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area, which is in southeastern Pennsylvania, consists of four sub-areas or regions that might feasibly require and subsequently use the Blue Marsh Reservoir to satisfy immediate and future water supply needs. These sub-areas center around the cities of Reading, Pottstown, Norristown and Philadelphia (see Figure 1). With the exception of a portion of the Norristown sub-area, all are within the Schuylkill River drainage basin. Only the communities served by the Philadelphia Suburban Water Company are outside the basin.

An additional sub-area requires special reference. The Chester sub-area, comprised of the communities served by the Chester Water Authority, is immediately adjacent to the most southeasterly portion of the Norristown sub-area, and was considered in detail in the "Tocks Island Reservoir, Water Quality Control Study".[1]

Tulpehocken Creek, on which the Blue Marsh Project is located, joins the Schuylkill River at the City of Reading. The Schuylkill then flows through all of the sub-areas, except Chester, for approximately 70 miles and unites with the Delaware Estuary at the City of Philadelphia. It is the Schuylkill River which is the object of water quality control consideration in this study. The Delaware Estuary and the lower few miles of the Schuylkill below

Fairmount Dam are the object of the FWPCA Delaware Estuary Comprehensive Study and, therefore, are not included in the detailed work of this Blue Marsh Study.

The preceding sub-areas constitute the entire study area for the Blue Marsh Project and are situated totally within the Commonwealth of Pennsylvania. The counties involved are Berks, Bucks, Montgomery, Chester, Delaware, and Philadelphia.

Topography and Geography

The study area is characterized by rolling hills in the vicinity of Reading, which taper off to tidal marsh lands at the confluence of the Schuylkill and Delaware Rivers. The Schuylkill River is the study area's principal waterway, and along its banks are located the most densely populated urban areas. The River is not commercially navigable but its six dams and pools create conditions suitable for pleasure boats and recreation. Principal tributaries to the Schuylkill are Maiden Creek and Tulpehocken Creek just above Reading; Manatawney Creek at Pottstown; French Creek, Perkiomen Creek and Pickering Creek just above Norristown and Wissahickon Creek just above Philadelphia. Beyond the urban and suburban communities that line the River, there is still much open land well adapted to agriculture and intensely farmed.

Climate

The average annual temperature of 50°F. and mean annual precipitation of 44 inches are characteristic of the study area's continental climate. Temperatures range from a summer average of 71°F. to a winter average of 30°F. and the rainfall which produces an average annual runoff of 21 inches, occurs rather uniformly throughout the year. This pattern of rainfall is ideal for agriculture.

Principal Communities and Industries

The study area has been segmented into four metropolitan sub-areas containing many smaller communities but focusing on one larger center community. These four sub-areas center around the cities of Reading, Pottstown, Norristown, and Philadelphia. There is significant industrial development in each of these sub-areas and the industries most directly connected with water uses and waste discharges fall under six general categories. These categories are Chemicals, Paper, Petroleum, Primary Metals, Food and Rubber.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

Sufficient streamflows in the Schuylkill River have been reported for a number of years and have thus made possible a statistical analysis of the record for each of 3 gaging stations. The stations, maintained by the U. S. Geological Survey, are located at Philadelphia, Pottstown and Berne, thereby supplying flow data for the entire length of the Schuylkill under study. The statistical characteristics of the low flows at these stations are presented in Table 3. Since runoff is not substantially controlled in the Schuylkill, the flow records of the Berne and Pottstown gages and their associated statistical parameters closely reflect natural streamflow conditions. The flow record for the Philadelphia gage was adjusted to natural conditions by adding to it the upstream water supply diversions made by the city of Philadelphia. The importance of base flow is demonstrated by the data in Table 3, which show that in the Schuylkill River, there is little difference between a 1 in 20 drought and a 1 in 50 drought.

The extent of the flow data provided made it possible to reliably interpolate between U.S.G.S. gages to get the flow characteristics at Norristown and Reading. Thus, substantial streamflow information became available for each of the sub-areas in the study area.

Ground water is widely used in the study area but yields from wells change significantly from one locality to the other because of the structural variety in underlying geological formations. Most public supplies using ground water are small, serving a few thousand persons

TABLE 3

Low Flow Statistics - Schuylkill River Basin

Location of Streamflow Gage	Number of Consecutive Days of Low Flow	Streamflow at Various Recurrence Intervals (CFS)		
		1 in 10	1 in 20	1 in 50
Schuylkill R. at Philadelphia	7	320	300	290
	30	360	330	320
	60	430	380	360
	120	540	460	420
Schuylkill R. at Pottstown	7	250	220	210
	30	280	250	220
	60	320	280	250
	120	380	320	270
Schuylkill R. at Berne	7	70	55	40
	30	80	65	50
	60	100	80	60
	120	120	90	70

or less. One of the few larger supplies using ground water, serves approximately 13,000 persons from 8 wells having a combined dependable yield of 1.2 MGD or 104 gpm per well. It has been reported that in Berks County, "the (underlying) rocks have been so altered in texture, or folded or faulted to expose the beveled edge of the strata at land surface, that the characteristics of the rocks are seldom uniform throughout any large area. Thus, ground water does not occur uniformly. Average yields are in the order of 40 to 50 gpm."[2] Large quantities of ground water may be present in the study area, but generally, their location is uncertain and their occurrence sporadic. High yield wells do exist but on the average, yields tend to vary between 30 and 100 gpm.

By flanking the Schuylkill basin, the Lehigh and Susquehanna Rivers present the possibility of diverting water from either into the study area. The average annual discharge of the Lehigh River at Bethlehem and the Susquehanna River at Harrisburg are 2,236 c.f.s. and 33,870 c.f.s., respectively, as published in "1966 Water Resources Data for Pennsylvania, Part 1, Surface Water Records" by the U. S. Geological Survey. The minimum flows are given as 125 c.f.s. and 1,700 c.f.s., respectively.

Quality of Water Available

The uses of a river can be a good measure of its immediate and potential water quality, and the Schuylkill River is extensively used. It touches the public through large water supply systems. It becomes part and parcel of many industrial processes and its watercourse is home to fish. However, this picture of health is not entirely

accurate. The river receives the waste of its surrounding society and this unpretentious use reduces the wholesomeness implied by the river's more prominent uses. Prior to public distribution, the river waters are disinfected through pre-and post chlorination; hardness and suspended matter are removed through coagulation, sedimentation and filtration; and tastes and odors in the water require further treatment. Industrial processes necessitate more specialized treatment of the water and maintenance of the fish population must be supported through restocking by the State.

The Schuylkill is recovering from past injustices. Most wastes within the study area are now receiving secondary treatment or its equivalent; and accumulations of coal culm originating from the mining activities in the headwaters of the basin have been removed and are being adequately controlled by upstream de-silting dams. While the Schuylkill is no longer a dirty stream, it is still not a clean stream. With flows on the order of 300 cfs, as measured at Pottstown, the Schuylkill has exhibited dissolved oxygen concentrations below 4.0 mg/l. Low flows have also seen concentrations of organic chemicals beyond the recommended limit of 0.2 mg/l CCE*[3]. Algae have flourished[4] and calculations show that the residuals from adequately treated waste discharges still result in high concentrations of biochemical oxygen demand. With streamflows between 200 and 300 cfs, BOD's range from 7 to 12 mg/l.

*Carbon Chloroform Extractables

Although widely variable, ground water quality in the Schuylkill River Basin is generally acceptable for municipal and industrial uses. The ground water hardness ranges from soft to very hard; in some areas the water contains dissolved solids in concentrations up to 400 mg/l, while in others it contains less than 100 mg/l; and a few wells have produced water containing excessive amounts of iron in solution. These conditions are of natural origin, since the ground water is relatively free from man-made pollution. In general, the study area's ground water can be qualitatively characterized as good and, where necessary, objectionable chemical constituents can be removed through treatment.

The Lehigh and Susquehanna Rivers are adjacent to the Schuylkill and therefore becomes possible alternative sources of supply for the study area. At present, the water quality of the Lehigh above Allentown is suitable for municipal and industrial purposes, but downstream, the River receiving the waste discharges of Allentown and Bethlehem, becomes degraded. Although these wastes are adequately treated prior to discharge, the Lehigh River below the Allentown-Bethlehem complex will be in need of low flow augmentation by the year 1970. By the year 2010 an annual draft on storage of approximately 110,000 acre-feet will be necessary to maintain desirable quality.[5]

Water quality in the upper Susquehanna River adjacent to the study area is poor. It receives raw sewage and is further degraded by abundant amounts of mine drainage. As the river approaches Harrisburg, quality improves but remains marginal. After receiving that city's treated wastes, quality again declines and does not recover for some miles downstream.

VI. THE ECONOMY

Introduction

Effective planning for water resources development requires an economic base from which to evaluate and project the various needs for water. In this study the concern is for municipal and industrial water needs and for instream water quality control. Population and index of production, both projected to the year 2020, are the economic characteristics used to anticipate water supply withdrawals and subsequent waste dishcarges that alter stream quality.

The Delaware River Basin Commission, which has the authority and the responsibility to approve all water resource developments in the Delaware River Basin, provided the economic analysis of population and industrial growth for this study. The basic method used was extrapolation of past trends with consideration given to special circumstances such as saturation of an area or foreknowledge of new plant construction.

Since this report is intended to focus on the water and not the economy of the study area, only economic information immediately relevant to defining water needs is presented in the following paragraphs. Although inter-related with the economic forces that create water needs, other aspects of the study areas' economy are not presented.

Present

Water needs in the study area are associated primarily with the population and manufacturing industries. In 1965, the study area population was apportioned among its regional sub-areas as follows:

Reading sub-area	217,000	persons
Pottstown sub-area	218,000	persons
Norristown sub-area	834,000	persons
Philadelphia sub-area	385,000	persons

The total study area populations was 1,654,000 persons. The central city in each sub-area, after which it was named, contained the following number of persons; Reading 97,000, Pottstown 28,000, Norristown 39,000 and Philadelphia 385,000.*

The industrial categories in each sub-area which either use large quantities of water or produce substantial amounts of waste are listed in Table 4. The connection between industry and water was established through a 1965 inventory of industrial withdrawals and discharges in the Schuylkill Basin. The inventory compiled by the Delaware River Basin Commission is very complete accounting for at least 95 percent of manufacturing industry self-supplied withdrawals.

Future

Population in the study area is expected to grow from 1,740,000 in 1970 to 2,940,000 in 2020. This projection was made within the context of census historical population trends and projections for the United States, the Northeast Region of the United States, and the four Delaware River Basin States. Sub-area population projections for each 10-year increment from 1970 to 2020 are presented in Table 5.

* Total 1965 population of Philadelphia estimated at 2,040,000 persons. Portion within study area estimated at 385,000 persons.

The growth of water related manufacturing is indicated in Table 6, which lists the projected index of production for each industrial category. Industrial employment characteristics in the Schuylkill Basin as well as national trends in production were considered in preparing these projections. The projections are equally applicable to any of the sub-areas because the entire study area is considered neither large enough nor of such a geographical orientation as to present significant differences in either the type of workers employed or manufacturing processes used by similar industries located in different sub-areas.

TABLE 4

WATER RELATED INDUSTRIES

Sub-area	Manufacturing Category	Number of Plants
Reading	Food	1
	Paper	1
	Chemicals	1
	Petroleum	1
	Primary Metals	1
Pottstown	Food	3
	Paper	1
	Chemicals	2
	Petroleum	1
	Rubber	1
	Primary Metals	1
Norristown	Food	1
	Paper	4
	Chemicals	6
	Rubber	3
	Primary Metals	2
Philadelphia	Industries in the Philadelphia sub-area are not included here since they withdraw water from and discharge waste to those waters under study by the Delaware Estuary Comprehensive Study.	

TABLE 5

Blue Marsh Study Area - Population

Sub-Area	Population Projections					
	1970	1980	1990	2000	2010	2020
Reading	229,000	250,000	272,000	237,000	325,000	355,000
Pottstown	241,000	287,000	334,000	390,000	453,000	527,000
Norristown	883,000	1,015,000	1,151,000	1,296,000	1,491,000	1,660,000
Philadelphia	390,000	392,000	394,000	396,000	398,000	400,000
TOTAL	1,743,000	1,944,000	2,151,000	2,319,000	2,667,000	2,942,000

TABLE 6

Projected Production of Water Related Industries

Manufacturing Category	Index of Production (1960 = 100)					
	1970	1980	1990	2000	2010	2020
Food and Kindred Products	116	152	191	234	276	315
Paper and Allied Products	125	165	209	260	302	328
Chemicals and Allied Products	161	232	340	500	614	750
Petroleum and Coal Products	131	171	228	316	412	515
Rubber Products	145	195	254	340	450	600
Primary Metals	136	175	230	310	388	465

VII. WATER REQUIREMENTS - MUNICIPAL AND INDUSTRIAL

Present Water Use

Water is presently withdrawn and used to support the municipal and industrial activities of the study area in the quantities listed in Table 7. It is also noticeable from this table that industrial water use increases as the sub-areas get closer to Philadelphia.

Most of the current population of 1.7 million persons receive their water from public or municipal supplies that rely substantially on surface water as a source. To a minor degree, many subdivisions and people in rural areas find that private low yield wells are sufficient. These supplies, first and foremost, serve the personal needs of the population by supplying them with water for drinking, cooking, cleaning, and watering their lawns, etc. In addition, the municipal supplies provide most commercial establishments and many small industrial plants with the water they need for their various processes and cleaning jobs.

The large industrial plants usually find it more economical to supply their own water. Most of the process water used by the plants, tabulated in Table 4, in the "Economics Chapter," comes from their own supplies. Cooling water, also being a requirement for some but not all of these industries, is self supplied. The Primary Metals industry in the Norristown sub-area is currently the largest user of cooling water.

TABLE 7

PRESENT WATER USE

Sub-Area	1965 Population Served	Municipal Water Use-mgd Average Day	Municipal Water Use-mgd Peak Day	Industrial Water Use-mgd Self Supplied
Reading	217,000	35	53	0.6
Pottstown	218,000	30	45	1.3
Norristown	834,000	74	111	17.9
Philadelphia	385,000[1.]	198[2.]	258[2.]	N.A.[3.]
Totals	1,654,000	337	467	19.8

1. This is just that portion of the Philadelphia population living within the study area.

2. Average day use represents amount of Schuylkill water used in the water system for the entire City of Philadelphia. Peak day use is the legal allotment of Schuylkill water given to Philadelphia by Commonwealth of Pennsylvania.

3. N.A. - not applicable. Philadelphia industries withdraw and return their water entirely within the DECS study area.

Total peak day water use in the study area is 487 mgd. The Philadelphia Suburban Water Company contributes 47 mgd of this from ground water sources and from surface sources outside the Schuylkill Basin. It is estimated that the City of Philadelphia diverts 148 mgd of this total for water supply use in that portion of the city outside the study area.

According to estimates made in preparing the "Tocks Island Water Quality Control Study", the Chester sub-area during 1965 had an average daily water usage of 27 mgd and a peak daily water usage of 40 mgd. This water was supplied entirely by the Chester Municipal Authority for domestic, commercial, and industrial purposes. Since the analysis of the Chester sub-area was presented in detail in the "Tocks Island Study", only this summary of the sub-area's water use is offered here.

Existing Sources of Water - Surface and Ground

The Blue Marsh study area was divided into a few large sub-areas so that water supply needs could be considered on a regional basis rather than community by community. This approach was chosen because greater reliance can be placed on economic projections for large sub-areas than for each of the more than 150 communities dispersed throughout the study area. A practical framework for this regional analysis is presented in Table 8 which directs attention toward the larger water supplies in each sub-area. From this table, it is apparent that each sub-area depends heavily on surface water as the source of its supply and that the yields developed by existing structures

TABLE 8

Larger Water Supply Systems in the Blue Marsh Study Area

Sub Area	Water System	% of Sub Area Population Served	1965	Source	River Basin	Yield Developed (1) mgd
Reading	Reading Municipal System		50%	Surface	Schuylkill	42
Pottstown	Pottstown Municipal System	15%	27%	Surface	Schuylkill	N.A. (2)
	Royersford, Home Water Co.	5%		Surface	Schuylkill	N.A.
	Phoenixville Municipal System	7%		Surface	Schuylkill	N.A.
Norristown	Norristown Water Co.	9%	95%	Surface	Schuylkill	N.A.
	Philadelphia Suburban Water Co.	86%		Surface	Schuylkill	29.5
				Surface	Small basins adjacent to Schuylkill	30.0
				Ground	12 Wells	13.0
				Surface (3)	Susquehanna	4.0
Philadelphia	Philadelphia Municipal System		100%	Surface	Schuylkill	N.A.
Chester	Chester Municipal Authority		100%	Surface	Susquehanna	70

(1) Refers to yield available either from constructed water supply reservoirs or wells.

(2) N.A. - not applicable. Water system uses neither water supply reservoirs nor wells.

(3) Purchased from the Chester Municipal Authority.

do not provide much of a margin for growth in the sub-areas of Reading and Norristown. During the drought which had prevailed upon this section of the country for the period 1961 - 1966, stream flows have been just large enough to enable the study area water suppliers to meet demands for water without resorting to emergency measures. However, the combined yield from reservoir structures and from low stream flows has approached water supply demands closely enough to require constant surveillance in anticipation of an emergency.

The varying amounts of municipal and industrial waste which are discharged to most surface waters in the study area have resulted in many water supplies being filtered and treated for taste and odor control. This includes the supplies listed in Table 8, except the Chester Municipal Authority which does not have taste and odor problems. Quality in the Schuylkill River, the largest source of water in each of the sub-areas, except Chester, can be improved through stream flow regulation in combination with additional quality control methods such as advanced waste treatment. In fact, if these quality control practices are not instituted, the present marginal quality of the Schuylkill, as described in Chapter V "Water Resources of the Study Area", will deteriorate despite adequate treatment of wastes.

Future Municipal and Industrial Water Requirements

The present pattern of per capita water use, shown by Table 9, was established through a sampling of water use data for the more populated and established communities of each sub-area. This pattern served as the datum for projecting the municipal requirements of the future, since it is assumed that the characteristics of the expanding population will be similar to those of presently established communities. In accordance with national and regional trends, only small increases in per capita water use are expected to occur in these established areas. Therefore, the use rates shown in Table 9 were increased by just a few gallons over the length of the study period. Although these rate increases are small, less than 20 gpd per capita over 50 years, they are slightly different for each sub-area.

The municipal water demands for each decade between 1970 and 2020 are presented in Table 10. The average daily demands presented are based on population projections and per capita use rates, while peak daily demands are estimated at 150% of the average daily figures.

The average and peak municipal demands of the Chester sub-area as calculated from the Tocks Island study, are:

1970	1980	1990	2000	2010	2020
29 & 43	36 & 54	50 & 75	61 & 91	74 & 111	88 & 132

(The units used are mgd)

TABLE 9

Average Daily Per Capita Water Use. - 1965

gpd

Sub-Area	Water Use.
Reading	161
Pottstown	136
Norristown	89
Philadelphia	186

TABLE 10

Future Municipal Water Demands

Average Daily Demand - Peak Daily Demand

mgd

Sub-Area	1970		1980		1990		2000		2010		2020	
Reading	37	56	41	62	46	69	51	77	56	84	62	93
Pottstown	33	50	41	62	48	72	57	86	68	102	81	121
Norristown	79	119	92	138	106	159	121	181	140	210	156	234
Philadelphia	198	258	198	258	198	258	198	258	198	258	198	258

It is significant to recall at this point that 47 mgd of the Norristown demand will be yielded by sources presently developed outside the surface resources of the Schuylkill Basin. These are sources used by the Philadelphia Suburban Water Co. Therefore, in using Table 10 to anticipate the demand that might be placed on the surface waters of the Schuylkill Basin, one should first subtract 47 mgd from the values listed for the Norristown sub-area.

A word of explanation is necessary about the Philadelphia sub-area. The average and peak day demands of 198 and 258 mgd are more than twice the projected needs of the Philadelphia population within the sub-area. However the excess will be diverted out of the sub-area to serve other portions of the City's population. The demands which are shown constant throughout the study period, represent the average and peak rate capacities of the Philadelphia water plants drawing from the Schuylkill. The peak rate of 258 mgd is also the entitlement of Schuylkill water given to the city of Philadelphia by the Commonwealth of Pennsylvania. Therefore, since the city of Philadelphia has the capability, the authority, and the need to withdraw water from the Schuylkill River, it is reasonable to assume that they will withdraw at the rates shown in Table 10. It is further reasonable to assume that these rates will not increase but remain constant. According to representatives from the City Water Commissioner's Office, increasing demands of the population outside the sub-area

will be met by the City's Torresdale water plant. This plant draws from the relatively unlimited supply of the Delaware River.

The present pattern of industrial water use, as presented in Appendix A, was constructed by the Delaware River Basin Commission from their industrial water use inventory collected in 1965. This pattern served as the datum for projecting the industrial requirements of the future, under the assumption that water use per unit of product will remain essentially the same as time goes on. The future water requirements of industry, as shown in Table 11, are the result of multiplying present water use by the appropriate index of production. Projections of this index for the manufacturing categories involved have been presented in Table 6, in the Economic Chapter.

The projections of industrial water use include cooling as well as process needs. However, the cooling need was included on the basis of the amount of make-up water needed to replace that lost through evaporation, and not on the amount of water actually passed through the industrial heat exchangers. Industry would need so much water to pass through their exchangers that it became obvious large reservoir releases would become necessary to meet the need. For example, in the Norristown sub-area the need for water passing through heat exchangers is estimated to grow from 115 mgd in 1970 to 390 mgd in 2020. Instead of paying for storage in Federal reservoirs it seems reasonable to assume that industry would recirculate the needed amounts through cooling towers. In any case, cooling towers will have to be built if stream temperatures

TABLE 11

Future Self-Supplied Industrial Water Demands - mgd

Sub-Area	1970	1980	1990	2000	2010	2020
Reading	0.7	0.9	1.1	1.4	1.6	1.8
Pottstown	1.5	2.1	2.8	3.8	4.9	6.5
Norristown	21.7	29.3	41.8	59.4	74.2	89.9
Philadelphia	Self-supplied industrial demands in the Philadelphia sub-area are not included here since they withdraw water from those waters under study by the Delaware Estuary Comprehensive Study.					

are to be kept within the limit of 93°F, as prescribed in Pennsylvania. Using this rationale, make-up water became the only need associated with cooling uses.

If the water supplies of each sub-area consolidate to become regional rather than local in scope, the most likely source of their supply will be the Schuylkill River. Therefore, the pattern of stream flow in the Schuylkill was matched against the regional demands of each sub-area to determine the capability of the River to meet the water needs of the future. The conclusion of this analysis is that the Schuylkill River will have sufficient flow to meet the average daily municipal needs and industrial needs of each sub-area, throughout the study period. However, by the year 2000 stream flows will not be sufficient to meet both the peak daily municipal demand and the industrial needs of the Norristown sub-area. Also, stream flows are not currently sufficient to insure the municipal allotment of 258 mgd granted to the city of Philadelphia by the Commonwealth of Pennsylvania. This insufficiency is due primarily to two causes: first, drought flows are not capable of yielding 258 mgd and second, the lower yield that could be provided by drought flows is reduced further by diversion of Schuylkill water out of the basin. The Philadelphia Suburban Water Co., in the Norristown sub-area,is the source of this diversion and if the population served by this company is to continue its growth, the amount of the diversion will increase as follows:

Diversion From The Schuylkill Basin - mgd

Average and Peak Day Values

1970	1980	1990	2000	2010	2020
5 & 7	9 & 14	13 & 20	17 & 26	23 & 35	29 & 43

The preceding assumes, of course, that the Philadelphia Suburban Water Co. will continue to use the Schuylkill River as the main source of its supply.

The low flow characteristics of a 1 in 50 drought occurrence were used in this study to determine the capability of the Schuylkill River to meet future municipal and industrial water needs.

VIII. WATER QUALITY CONTROL

Municipal and Industrial Pollution

Pollution from organic waste is presently the most significant and obvious cause of quality degradation in the Schuylkill River downstream from the proposed project, and projections of both population and industrial production indicate that organic wastes will continue to be the dominant factor necessitating water quality control. One measure of organic wastes is their potential to deplete the oxygen content of water. Therefore, Table 12 shows both the present and projected organic waste discharges in terms of biochemical oxygen demand. This table lists the amount of waste discharged directly to the stream, assuming that at least 85 percent of the total waste produced will have been removed through various treatment processes.

The population projections of Table 5, presented in Chapter V - The Economy, were used to estimate the quantities of municipal waste discharges. However, the projections for the Norristown sub-area had to be adjusted to exclude from the calculations, that portion of the population not returning its waste to the Schuylkill basin. As a result, the population projections used for the Norristown sub-area are:

1970	1980	1990	2000	2010	2020
435,000	509,000	593,000	692,000	813,000	955,000

The factor of 0.25 lbs. per capita per day, ultimate BOD was used to relate population with waste production.

TABLE 12

Municipal and Industrial Waste Discharges

lbs. of BOD

Sub-Area	1965	1970	1980	1990	2000	2010	2020
				Municipal Discharges			
Reading	8,100	8,600	9,400	10,400	11,100	12,200	13,300
Pottstown	8,200	9,000	10,700	12,500	14,600	17,000	19,800
Norristown	15,100	16,400	19,100	22,200	26,000	30,400	35,800
				Industrial Discharges			
Reading	2,300	2,900	4,000	5,900	8,500	10,500	12,700
Pottstown	1,700	2,000	2,700	3,700	5,100	6,200	7,400
Norristown	2,400	2,900	4,000	5,600	7,800	9,600	11,900

Industrial wastes were estimated using the inventory of surface water discharges collected by the Delaware River Basin Commission (refer to Appendix B). The information it provides on the volume of waste discharges and the type of manufacturing involved enabled estimates to be made of the character and concentrations of the discharges. These estimates are presented in Table 12.

Wastes from the Philadelphia sub-area were not considered because these discharges either go directly to the Delaware River or to the estuarine portion of the Schuylkill River, both of which are outside the study area of this report. The Chester sub-area was also excluded for the same reason.

The characteristics of the larger municipal discharges in each sub-area are presented in Table 13.

Water Quality Objectives

The objectives of water quality control are to preserve and promote the reasonable and legitimate uses of water in accomplishing ends dependent upon certain quality requirements. This refers to both present and anticipated uses of water in the stream and on the land. It is well to note that water quality is an important consideration in safeguarding public health and in securing economic benefits.

The water quality objectives used in this study apply to uses of the Schuylkill waters as a source of municipal water supply, the enhancement of aquatic life, aesthetic appeal, and for prospective recreation. To properly insure the waters of the river for these

TABLE 13

Larger Municipal Waste Discharges in the Blue Marsh Study Area

Sub-Area	Community	Population Served	Type of Treatment
Reading	Reading	120,000	Secondary
	Joint Municipal Authority of Wyomissing Valley	39,000	Secondary
Pottstown	Pottstown	35,000	Secondary
	Royersford	4,000	Secondary
	Phoenixville	15,000	Secondary
Norristown	Norristown	60,000	Secondary
	Conshohocken	13,000	Secondary

widespread public uses, the dominance of organic waste will have to be removed. Therefore, either natural or regulated stream flows should contain at least 5 milligrams per liter of dissolved oxygen and no greater than 6 milligrams per liter of biochemical oxygen demand.* These goals were used to determine whether or not storage releases will be necessary to secure quality control in the Schuylkill River.

Flow Regulation

Analyses of presently available data indicate various zones of quality degradation along the Schuylkill from Reading to Philadelphia. As population and industrialization grow, further degradation of water quality is expected in spite of currently defined levels of adequate waste treatment. To prevent this and to insure the water quality objectives, it will be necessary to maintain the flows indicated in Table 14 or provide some other combination of quality control measures. To provide these flows during a once-in-50 drought, the natural streamflow would have to be supplemented with the annual drafts on storage also indicated in Table 14. If quality control is not provided, severely degraded quality will occur throughout the length of Schuylkill. For example, during the year 2020, water quality in the

*Water Quality Criteria", 2nd Edition, edited by McKee & Wolf indicates a good source of water supply as having a raw water quality not in excess of 4.0 mg/l of 5-day BOD. This criteria was used assuming 4 mg/l of 5-day BOD as equivalent to 6 mg/l of ultimate BOD.

TABLE 14

Streamflow Required To Maintain Quality Control - CFS

Month	Year					
	1970	1980	1990	2000	2010	2020
January	980	1140	1650	2100	2450	2820
February	920	1140	1650	2100	2400	2760
March	860	1050	1450	2030	2330	2720
April	780	960	1300	1870	2180	2590
May	700	880	1200	1670	2000	2380
June	620	800	1100	1500	1830	2250
July	580	770	1050	1450	1800	2250
August	610	770	1050	1450	1800	2250
September	620	800	1100	1500	1880	2330
October	730	920	1280	1760	2100	2520
November	820	1000	1390	1920	2230	2660
December	900	1100	1500	2030	2350	2760

Annual Draft on Storage Required

To Maintain Quality Control

Acre - Feet

1970	1980	1990	2000	2010	2020
53,000	130,000	243,000	1,076,000	1,794,000	3,172,000

pools below Norristown would approach septic conditions during a drought having a once-in-50 occurrence. Droughts of lesser occurrence, of course, would not result in such severe quality degradations. However, the statistics show little difference between the low flows occurring on a once-in-20 interval and those occurring on a once-in-50 year interval.

It should be noted that the drafts on storage for quality control are for amounts over and above the drafts needed to insure the quantity of flow necessary for water supply.

As a final point toward obtaining the optimum water quality necessary for maximum realization of benefits, it is recommended that a means of destratification be included in the reservoir. The recommendation is prompted by the likely occurrence of vertical gradations in the quality of the impounded waters due to thermal stratification. Under such conditions, the epilimnion of the impoundment remains aerobic because of wind mixing and contact with the atmosphere, while the water in the hypolimnion is trapped below the thermocline and is prevented from undergoing atmospheric reaeration. Subsequently the original dissolved oxygen content may be reduced. Then, if anaerobic conditions develop, other detrimental reactions take place. For example, iron, manganese and color may go into solution, and the pH may decline. A lower pH in Tulpehocken Creek would result in a reduction of neutralizing power. The effect on the Schuylkill River would be that the low quality of water due to acid mine drainage would travel further downstream before being neutralized.

Storage releases of low quality could reduce the potential benefit of the downstream waters, in addition to causing harmful effects. Consideration for a means of destratification such as mechanical mixing, aeration or a multiple level outlet to insure optimum quality of the releases is advisable.

IX. BENEFITS

It is the conclusion of this study that there are current and future water supply needs and water quality control needs in the Schuylkill Basin that can be met with storage releases from the proposed project. The least cost alternative method of getting this supplemental water in absence of the proposed project is taken as a minimum measure of the value of these storage releases. Since the alternative methods considered could provide water for supply purposes as well as for quality control, the feasibility of these alternatives will be discussed prior to evaluating and describing benefits associated individually with either water supply or quality control.

Three alternative methods were considered; importation of water from adjacent river basins, use of groundwater, and storage of water in a single purpose reservoir. The basins adjacent to the Schuylkill are the Lehigh Basin and the Susquehanna Basin. Since the Lehigh River will itself be in need of flow regulation for quality control by the year 1970, it seems inadvisable that water be diverted from this basin to serve similar purposes in another basin. Diverting water from the upper reaches of the Susquehanna also seems inadvisable, because of the poor quality conditions in the river. It cannot be said with acceptable certainty when the pollution of the Susquehanna will be reduced, particularly that caused by mine drainage. Therefore, the wisdom of expending funds to install a pipeline and pumping stations in over 20 miles of mountainous terrain is considered doubtful. In the

lower portion of the Susquehanna Basin where water quality is better, there is a current legal question over diversion rights. Concern over diversion from the Susquehanna, which is an interstate body of water, has been expressed by the city of Baltimore, Maryland. The Chester Municipal Authority has been granted an increase in their present diversion from the Susquehanna Basin, by the Pennsylvania Board of Water and Power Resources, and the city of Baltimore feels that this might be an unsound principle inasmuch as further interstate diversion could ensue. This further diversion would become a reality if the Susquehanna were proposed as an alternative source of water for the Schuylkill Basin. Therefore, the problem with quality conditions in certain portions of the Susquehanna in addition to possible legal complications led to the decision to reject importation from the Susquehanna Basin as a practical alternative.

Since the potential for locating high yield wells is uncertain and the yields available from most other wells would vary between 30 and 110 gpm, it was decided that the use of ground water could not be a reasonable alternative toward meeting the large regional water demands of the study area.

There are no apparent reasons why single purpose reservoirs could not assist in meeting the water supply and quality control needs of the study area. The Corps of Engineers has already determined that there are reservoir sites available on Tulpehocken and Maiden Creeks. Therefore, the use of single purpose reservoirs was chosen as the alternative method of providing the needed water in lieu of the proposed projects.

However, the augmentation capacity of the Schuylkill basin is not sufficient to provide all of the draft on storage necessary for quality control, shown in Table 14. Therefore, additional quality control practices must be instituted, most probably advanced waste treatment. Research on methods of advanced waste treatment is already well under way, so the outlook is optimistic that practical applications of these methods will be developed in time to assist streamflow regulation practices in controlling the problems of water pollution. Exportation of the wastes for discharge to adjacent basins cannot be recommended since such a practice would only compound the pollution problems already inherent in these waters.

Water Supply - Municipal and Industrial

At present, flow augmentation would be necessary during a 1 in 50 drought occurrence, to provide the city of Philadelphia with that portion of its legal allotment of Schuylkill River water, diverted out of the basin by the Philadelphia Suburban Water Company. This need for flow augmentation will increase throughout the study period as the Philadelphia Suburban Water Company increases its diversion to serve the needs of its expanding population. By the year 2000, the 1 in 50 drought flows will not be sufficient to meet the peak daily needs of the Norristown sub-area, of which the Philadelphia Suburban Water Company is a part. As it turns out, the water that is required to replace for the city of Philadelphia, what is diverted out of the basin,

is approximately the same amount of water required to insure the needs of the entire Norristown sub-area. Therefore the one parcel of water serves two water supply needs and has a dual benefit. Releases of approximately 8000 acre-feet will be required at each point of need to insure the diverted portion of Philadelphia's allotment of 258 mgd and the Norristown sub-area demand of 240 mgd. Since there will be importation in the Norristown sub-area from presently developed sources, as well as diversion; and since there will be re-use of Schuylkill water within the sub-area, between the Philadelphia Suburban Water Co. and the rest of the sub-area, the net water demand on the resources of the River reduces from the 324 mgd M & I need, tabulated in Chapter VII, to 240 mgd.

The minimum measure of the value of water supply benefits is based on supplying an annual release of 8000 acre-feet and is estimated at $10,300,000. Amortizing this cost over 100 years, from 1970 to 2020, at an interest rate of 3 1/8% and including operation and maintenance costs, the annual value of water supply benefits is $370,000.

In the Tocks Island study, various alternatives were presented for obtaining water to meet the future demands of the Chester Municipal Authority. One alternative that was explored was the possibility of connecting the Chester Authority with the Schuylkill River. The cost

of constructing a pipeline to provide this connection and for storing the needed water in a single purpose reservoir, is estimated at $8,950,000 per year. In comparing this cost with that of the least cost alternative, a pipeline from mile point 87 on the Delaware River, priced at $1,100,000 per year, it became evident that the Schuylkill River was a more expensive and therefore less reasonable source for the Chester Authority.

Water Quality Control

The control and supplementation of stream flow can improve water quality to the extent that the water will be more beneficial as a source for drinking supply, in supporting fish life, in developing aesthetic enjoyment, and in expanding opportunities for recreation. These widespread benefits will materialize through use of the waters in the Schuylkill River from Reading to Philadelphia, a distance of approximately 60 river miles.

Description of Benefits:

Drinking Water - Quality control would reduce the concentrations of many constituents which cause quality degradation in the water that is processed for drinking supplies. For example, the "musty" odor in the river water would be reduced; water treatment difficulties would be alleviated through the dilution and further removal of algae producing nutrients; and public health would be further insured

through the better water quality provided when the residual concentrations of bacteria and dissolved solids inherent in the waste discharges, are given further treatment and dilution.

Fish Life - Pollution in the Schuylkill River is presently a limiting factor in the development of an adequate stream fishery, and maintenance of the fish population requires continued re-stocking by the Pennsylvania Fish and Game Commission. Present species in the river are largemouth bass, smallmouth bass, walleye, sunfish, crappie, carp, sucker and other rough fish. Quality control would enable this fish population and other aquatic life to thrive by providing adequate levels of dissolved oxygen and by removing and diluting out the harmful environmental effects of waste discharges. Since this fishery would be easily available to the 2 to 3 million people of the study area, it is evident that the potential benefit of the fishery is quite significant.

Aesthetics - Quality control would prevent the obnoxious odors and appearance of water associated with septic conditions. The appearance of the river would be further improved through reduction in the occurrence of unsightly algae blooms.

Recreation - Boating is popular in the pools created by the dams in the river and opportunities are also afforded for swimming and other bodily contact with the water. Unless quality control is provided, the residual wastes from the growing population and its industries,

will make these pools essentially unacceptable for any recreational use. Since the pools retain stream flows longer than comparable stretches of free flowing stream, they provide more of an opportunity for wastes to stabilize. This situation magnifies quality problems and so the pools in particular, necessitate quality control.

Value of Benefits:

Investigation has shown that under present methods, adequate treatment of organic wastes will not produce the water quality improvements required to secure the foregoing benefits. Therefore, it becomes necessary to complement the effects of such waste treatment by providing supplemental streamflow during periods of low flow, in combination with other means of quality control such as advanced waste treatment. Since cost data on the degree of advanced waste treatment that would be required in the Schuylkill basin is not available at this time, only the value of that portion of the benefits attributable to stream flow regulation will be presented.

Increases in low flow will reduce the concentration of the residual pollutants imparted to the stream from the various treated waste effluents. This supplemental flow in the absence of the proposed projects would have to be provided by a suitable alternate structure. Therefore, the cost of such a structure is taken as a measure of the minimum value of the benefits attributable to streamflow

regulation, under the assumption that the benefits are worth at least what it costs to provide them, if the water quality goals are to be achieved.

As previously described, the most likely alternative is a single purpose reservoir that would provide a draft on storage equal to that available from the proposed multi-purpose project. Such a reservoir would have an active storage capacity of 14,500 acre feet and an approximate dead storage of 1500 acre feet, for a total cost of $15,305,000. Amortized over a 100 year period from 1970 to 2070 at a 3-1/8% interest rate plus operation and maintenance charges, the annual cost of this alternative would be approximately $550,000. It should be noted, however, that this value of the water quality control benefits is applicable only if releases are not made for water supply. If releases to the Schuylkill River for water supply purposes are provided by the Blue Marsh Project, these releases will also produce water quality control benefits. To avoid double counting the value of these releases, they should be subtracted from the total release that could be provided by Blue Marsh for water quality control. Therefore, the minimum value of quality control benefits developing from stream flow regulation in this case, becomes equal to the cost of a single purpose reservoir having an active storage capacity of 6500 acre feet. This storage figure represents the difference between the total available

in Blue Marsh of 14,500 acre feet and that necessary for water supply, 8000 acre feet. Assuming dead storage of 1500 acre feet, the cost of this single purpose reservoir for water quality control is estimated at $8,950,000. Amortizing this cost in the same fashion as with the previous reservoirs, results in an annual cost or benefit of approximately $321,000.

Since the need for quality control streamflow is immediate, the cost of neither quality control reservoir has been discounted.

BIBLIOGRAPHY

NO.	REFERENCE
1	Department of the Interior, Federal Water Pollution Control Administration, New York, New York, "Water Quality Control Study, Tocks Island Reservoir, Delaware River Basin." (June 1966)
2	Berks County Planning Commission, "Physical Characteristics and Land Use, A Comprehensive Plan Study." Comprehensive Plan Report 11. (1964)
3	U. S. Public Health Service, "Drinking Water Standards" (1962)
4	City of Philadelphia, Water Department, "Annual Report" (1964)
5	U. S. Department of Health, Education, and Welfare, Public Health Service, Region II, New York, New York, "Water Supply and Water Quality Control Study, Beltzville Reservoir, Lehigh River Basin, Pennsylvania." (November 1964)

Appendix A

Surface Water Withdrawals - Schuylkill River Sub-Basin
By Manufacturing Centers In Hydrologic Order
By Plant And SIC Industry Code

PAGE NOT

AVAILABLE

DIGITALLY

APPENDIX A

SURFACE WATER WITHDRAWALS - SCHUYLKILL RIVER SUB-BASIN
BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT
AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION MINOR CIVIL DIV. OR MUNICIPALITY	COUNTY	SIC CODE (2 or 4 DIGIT)	NO. OF EMPLOYEES	SURFACE WATER WITHDRAWALS IN M.G.D. (DRBC INVENTORY)
1/	Central Asphalt Materials, Inc.	Frackville	Schuylkill	29	4	.001
1/	Modern Concrete Products, Inc.	Bethel	Berks	32	23	.0315
1/	Reading Metals Refining Corp.	Ontelaunee Twp.	Berks	33	105	.490
1/	Whitmoyer Laboratories, Inc.	Myerstown	Lebanon	28	160	.04
READING	Great American Knitting Mills, Inc.	Bechtelsville	Berks	22	355	.065
READING	Federal Paper Board Co, Inc.	Reading	Berks	26	39	.432
READING	Wm. G. Leininger Knitting Co.	Mohnton	Berks	22	269	.129
READING	Briskin Dyeing & Finishing Co.	Mohnton	Berks	22	76	.02
READING	Longacre Modern Dairy	Barto	Berks	20	38	.095
READING	Carl P. Strunk, Sr.	Sinking Spring	Berks	32	1	.0017
REPORTED TOTAL: READING						.6527
POTTSTOWN	Cryochem Engineering & Fabricating, Inc.	Boyertown	Berks	34	23	.002
POTTSTOWN	Kawecki Chemical Co.	Boyertown	Montgomery	28	416	.172
POTTSTOWN	Berks Associates, Inc	Douglassville	Berks	29	31	.024
POTTSTOWN	Firestone Tire & Rubber Co.	Pottstown	Montgomery	30	3,168	2.505
REPORTED TOTAL: POTTSTOWN						2.703
1/	Bethlehem Mines Corp.-Grace Mine	Morgantown	Berks	3312	Unknown	.105
1/	Exton Paper Mfg., Inc.	West Whiteland Twp.	Chester	26	25	.05
1/	Phoenix Steel Corp.	Phoenixville	Chester	3312	918	1.296
1/	Eastern Prestressed Concrete Co.	Hatfield	Montgomery	32	90	.0015
NORRISTOWN	Highland Tool & Machine Co.	Trooper	Montgomery	35	?	.0027
NORRISTOWN	Taylor Corp.	Valley Forge	Montgomery	28	611	1.32
NORRISTOWN	Nicolet Industries, Inc.	Norristown	Montgomery	26	104	.58
NORRISTOWN	The Budd Co.	Bridgeport	Montgomery	28	529	5.7
NORRISTOWN	Nicolet Industries, Inc.	Ambler	Montgomery	26	Unknown	.426
NORRISTOWN	Certain-Teed Products Corp.	Ambler	Montgomery	32	161	.03
NORRISTOWN	Alan Wood Steel Co.	Conshohocken	Montgomery	3312	2,712	92.5
NORRISTOWN	Wyerhauser Co.	Miquon	Montgomery	26	Unknown	.22
NORRISTOWN	Penn Valley Polymers Co.	Gladwyne	Montgomery	28	4	.0007
REPORTED TOTAL: NORRISTOWN						100.7789
PHILADELPHIA	The Fredericks Co.	Bethayres	Montgomery	32	173	.008
PHILADELPHIA	The Atlantic Refining Co.	Philadelphia	Philadelphia	2911	2,638	17.62
PHILADELPHIA	Gulf Oil Corp.	Philadelphia	Philadelphia	2911	1,271	47.8
REPORTED TOTAL: PHILADELPHIA						65.428
TOTAL SURFACE WATER WITHDRAWALS						180.8089

1/OUTLYING REGION

Appendix E

Surface Water Discharges - Schuylkill River Sub-Basin
By Manufacturing Centers In Hydrologic Order
By Plant And SIC Industry Code

APPENDIX B

SURFACE WATER DISCHARGES - SCHUYLKILL RIVER SUB-BASIN
BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT
AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION		SIC CODE	NO. OF	SURFACE WATER
		Minor Civil Div. or Municipality	County	(2 or 4 Digit)	EMPLOYEES	DISCHARGES IN MGD (DRBC INVENTORY)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hamburg	Reading Metals Refining Corp.	Ontelaunee Twp.	Berks	33	105	.490
Hamburg	Fairmont Foundry Inc.	Hamburg	Berks	33	134	.0038
Hamburg	Price Battery Corp.	Hamburg	Berks	36	286	.16
Hamburg	Ortho Magnetics, Inc.	Kutztown	Berks	36	43	.03
Hamburg	Wolfe Dye-Bleach Works, Inc.	Shoemakersville	Berks	22	78	.175
Hamburg	Brush Beryllium Co.	Shoemakersville	Berks	33	70	.104
Hamburg	Wyomissing Corp.-Tuckerton Rd.	Muhlenberg Twp.	Berks	26	Unknown	.08
REPORTED TOTAL: HAMBURG						1.0428
1/	Garden State Tanning, Inc.	Fleetwood	Berks	31	126	.0104
1/	Whitmoyer Laboratories	Myerstown	Lebanon	28	160	.01
Reading	Western Electric Co.	Laureldale	Berks	36	2,304	.124
Reading	Prestolite Co.	Reading	Berks	36	Unknown	.380
Reading	Federal Paper Board Co. Inc.	Reading	Berks	26	39	.432
Reading	The Carpenter Steel Co.	Reading	Berks	3312	2,691	2.749
Reading	Orr & Sembower, Inc.	Reading	Berks	34	15	.251
Reading	Briskin Dyeing & Finishing Co.	Mohnton	Berks	22	76	.02
REPORTED TOTAL: READING						3.956

1/ OUTLYING REGION

APPENDIX B

SURFACE WATER DISCHARGES - SCHUYLKILL RIVER SUB-BASIN BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION		SIC CODE	NO. OF EMPLOYEES	SURFACE WATER DISCHARGES IN MGD (DRBC INVENTORY)
		Minor Civil Div. or Municipality	County	(2 or 4 Digit)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Boyertown	Longacre Modern Dairy	Barto	Berks	20	38	.095
Boyertown	Great American Knitting Mills Inc.	Bechtelsville	Berks	22	355	.050
Boyertown	Tung-Sol Electric, Inc.	Boyertown	Berks	36	315	.107
Boyertown	Kawecki Chemical Co.	Boyertown	Montgomery	28	416	.120
Boyertown	Vincent A. Savarese	E. Greenville	Montgomery	35	Unknown	.004
REPORTED TOTAL: BOYERTOWN						.376
Pottstown	Berks Associates, Inc.	Douglassville	Berks	29	31	.036
Pottstown	Doehler Jarvis Div.-National Lead Co.	Stowe	Montgomery	33	1,036	.15
Pottstown	Neapco Products, Inc.	Pottstown	Montgomery	37	220	.022
Pottstown	Dana Corp.	Pottstown	Montgomery	37	903	.35
Pottstown	Firestone Tire & Rubber Co.	Pottstown	Montgomery	30	3,168	2.760
REPORTED TOTAL: POTTSTOWN						3.318
Lansdale	Philco Corp.	Lansdale	Montgomery	36	1,843	.5
Lansdale	American Olean Tile Co. Inc.	Lansdale	Montgomery	32	Unknown	.009
Lansdale	Frank M. Weaver, Inc.	Lansdale	Montgomery	34	168	Unreported
Lansdale	Martin Century Farms, Inc.	Lansdale	Montgomery	20	1,014	.12
REPORTED TOTAL: LANSDALE						.629

APPENDIX B

SURFACE WATER DISCHARGES - SCHUYLKILL RIVER SUB-BASIN
BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT
AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION		SIC CODE (2 or 4 Digit)		NO. OF EMPLOYEES	SURFACE WATER DISCHARGES IN MGD (DRBC INVENTORY)
		Minor Civil Div. or Municipality	County				
(1)	(2)	(3)	(4)	(5)		(6)	(7)
Collegeville	Krasley Bleach & Dye Works	Royersford	Montgomery	22		40	.2
Collegeville	T.J.Cope Div-Rome Cable Corp.	Collegeville	Montgomery	34		85	.1035
Collegeville	Ajax Stamping & Mfg. Inc.	Collegeville	Montgomery	34		44	.006
REPORTED TOTAL: COLLEGEVILLE							.3095
1/	Sunnyside Dairy	Elverson	Chester	20		Unknown	.010
1/	Bethlehem Mines Corp.- Grace Mine	Morgantown	Berks		3312	Unknown	1.665
REPORTED TOTAL: OUTLYING REGION D							1.675
Phoenixville	Roberts Packing Co.	Kimberton	Chester	20		143	.060
Phoenixville	Exton Paper Mfg., Inc.	West Whiteland Twp.	Chester	26		25	.004
Phoenixville	Phoenix Steel Corp.	Phoenixville	Chester		3312	918	13.44
Phoenixville	J. R. Hollingsworth Co.	Phoenixville	Chester	36		84	.003
Phoenixville	Taylor Corp.	Valley Forge	Montgomery	28		611	1.2
Phoenixville	Mrs. Sands Food Products	West Norristown Township	Montgomery	20		5	Unreported
Phoenixville	Bethlehem Limestone Co.	Upper Merion Twp	Montgomery	32		Unknown	12.
REPORTED TOTAL: PHOENIXVILLE							26.707

1/ CUTLYING REGION

APPENDIX B

SURFACE WATER DISCHARGES - SCHUYLKILL RIVER SUB-BASIN
BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT
AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION		SIC CODE	No. OF	SURFACE WATER
		Minor Civil Div. or Municipality	County	(2 or 4 Digit)	EMPLOYEES	DISCHARGES IN MGD (DRBC INVENTORY)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1/	Foote Mineral Co.	Exton	Chester	28	151	.004
1/	Synthane Corp.	Oaks	Montgomery	30	679	.2024
Norristown	Evans-Roberts Co.	Norristown	Montgomery	32	6	.432
Norristown	Nicolet Industries, Inc.	Norristown	Montgomery	26	104	.250
Norristown	Bethlehem Mines Corp. - Bridgeport Quarry	Bridgeport	Montgomery	33	Unknown	1.0
Norristown	The Budd Co.	Bridgeport	Montgomery	28	529	5.7
Norristown	Martin Witchwood Ice Cream Co.	Lower Gwynedd Twp.	Montgomery	20	14	.107
Norristown	Nicolet Industries, Inc.	Ambler	Montgomery	26	Unknown	.540
Norristown	Gessner Mfg. Co.	Ambler	Montgomery	30	20	.515
Norristown	Certain-Teed Products Corp.	Ambler	Montgomery	32	161	.2
Norristown	Chemical Concentrates Corp.	Ft.Washington	Montgomery	28	78	.010
Norristown	McNiel Laboratories, Inc.	Ft.Washington	Montgomery	28	340	.002
Norristown	Nypel Corp.	West Conshohocken	Montgomery	30	46	2.5
Norristown	Essex Wire Corp.	Conshohocken	Montgomery	36	Unknown	.360
Norristown	Alan Wood Steel Co.	Conshohocken	Montgomery	3312	2,712	16.0
Norristown	Quaker Chemical Corp.	Conshohocken	Montgomery	28	270	.030
Norristown	Weyerhauser Co.	Miquon	Montgomery	26	Unknown	3.53
REPORTED TOTAL: NORRISTOWN						31.176

1/ OUTLYING REGION

APPENDIX B

SURFACE WATER DISCHARGES - SCHUYLKILL RIVER SUB-BASIN
BY MANUFACTURING CENTERS IN HYDROLOGIC ORDER BY PLANT
AND SIC INDUSTRY CODE

MANUFACTURING CENTER	NAME OF PLANT	LOCATION		SIC CODE	NO OF EMPLOYEES	SURFACE WATER DISCHARGES IN MG
		Minor Civil Div. or Municipality	County	(2 or 4 Digit)		(DRBC INVENTORY)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Philadelphia	Drever Co.	Bethayres	Montgomery	34	Unknown	.050
Philadelphia	The Fredericks Co.	Bethayres	Montgomery	32	173	.004
Philadelphia	Merck, Sharp & Dohme	West Point	Montgomery	28	1494	.525
Philadelphia	The Atlantic Refining Co.	Philadelphia	Philadelphia	2911	2638	16.7
Philadelphia	Gulf Oil Corp.	Philadelphia	Philadelphia	2911	1271	41.27
REPORTED TOTAL: PHILADELPHIA						58.549
TOTAL						128.6686