COMMONWEALTH OF PENNSYLVANIA
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DEPARTMENT OF ENVIRONMENTAL RESOURCES
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RESOURCES MANAGEMENT
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THE STATE WATER PLAN

SUBBASIN 5

UPPER CENTRAL SUSQUEHANNA RIVER

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Prepared by

OFFICE OF RESOURCES MANAGEMENT
BUREAU OF RESOURCES PROGRAMMING
DIVISION OF COMPREHENSIVE RESOURCES PROGRAMMING
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SWP-1
Planning Principles

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INTRODUCTION

The history of Pennsylvania can be traced through the development of its water and related land resources. From its founding as a settlement in the port of Philadelphia to its present position as a leading industrial, agricultural, and financial center, Pennsylvania's growth has depended on its varied and ample water resources. As the Commonwealth continues to mature and change, its dependency on these water resources will increase dramatically; consequently, the value of water itself will increase as more diversified uses compete for this renewable, but limited resource.

Such competition is leading to increasingly complex problems regarding the management of our vital water resources. The past decade has seen heavy emphasis placed on the environment, and water resources in particular, through the adoption of more sophisticated laws, policies and institutional arrangements at the State and Federal levels to protect, conserve, and manage water.

The Upper Central Susquehanna River subbasin, which is the subject of this report, encompasses many forms of man's effect on the environment and its effect upon him. The present and future importance of water and related land resources is realized throughout this area, as it is throughout the Commonwealth.

In recognition of the growing urgency for statewide management of water and related land resources, the General Assembly charged the former Department of Forests and Waters with the responsibility of developing water resources management policy. This authority was then transferred to the Department of Environmental Resources through Act No. 275 of 1970, which created the new Department.

The State Water Plan has been developed as a management tool to guide the conservation, development, and administration of the Commonwealth's water and related land resources on a comprehensive and coordinated basis. Only through the practice of such management will the Commonwealth be able to maintain its current prosperity, provide adequate flood control for its citizens and assure the supplies of good quality water necessary to meet its future needs.

This report is one of 23 reports being published as a result of the initial investigations and studies conducted in connection with the State Water Plan. The first report in the State Water Plan series, "Planning Principles SWP-1", was published in March 1975. That report, which expressed the goals, objectives, standards and criteria, and outlined the work program as well as described planning methodology, is referred to throughout this report. Three other reports; "Statewide Summary Report", "Water Laws and Institutional Arranagements", and "Water Resources Data System—WARDS", like "Planning Principles" deal with their respective subjects in a statewide manner. Nineteen subbasin summary reports deal with the water resources problems and solutions to those problems for each of the 20 subbasins[1] delineated in the Commonwealth for this study. This subbasin report provides background material, identifies problems, and presents alternative and recommended solutions to both the short- and long-term problems in Subbasin 5, the Upper Central Susquehanna River subbasin.[2]

Development of the Plan in itself will achieve little. Successful implementation of the Plan, including continued development and use of the planning resource, is the key to Pennsylvania's future. Such implementation will be carried out under the laws and policies established by the General Assembly to manage our water resources in the interests of all the Commonwealth's citizens, including generations yet to come.

This report, along with the others comprising the State Water Plan, is intended to provide the General Assembly, State and local governments, business, industry, water suppliers, and all interested citizens with the information necessary to comprehend the scope of Pennsylvania's water problems and to enable administrators to wisely manage the Commonwealth's water and related land resources through the use of the developed planning resources including data bases, analytical methods and staff expertise.

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[1]Because of its relatively small land area, Subbasin 14 is included in the Subbasin 16 report.

[2]The terms "subbasin" and "watershed" as used throughout this report are not used in their true hydrologic sense, but rather refer to water resources study areas which were arbitrarily defined, taking into account similar hydrologic and physical features of the Commonwealth's land mass.

I. SUMMARY AND RECOMMENDATIONS

The purpose of this report is to provide a general understanding of the water resources of the Upper Central Susquehanna River Basin and sufficient insight into the relationships between man, economy and environment to rationally examine the problems associated with water resources and determine viable solutions which could support man's continued well-being while living in harmony with his surroundings. The report examines the physical features of the basin and the impacts from man's development of the area's natural resources. Both population and economy were forecast based on existing trends. Those forecasts were used as the future baseline upon which water resources problems could be examined. In the absence of actions to change existing trends, these forecasts are estimates of conditions which are likely to occur. The forecasts provided the basis for examining the range and costs of available alternatives for identified problems if current trends prevail.

While the problems and identified solutions are derived from trend conditions, it is important to note that State government and many regions throughout the Commonwealth are questioning the desirability of perpetuating existing trends. At the State level, recommendations of the Land Policy Program and policies adopted for the State's Environmental Master Plan propose policies which would result in changes to past trends and resource management practices. Currently, through the Comprehensive Water Quality Management Planning Program, local values important for maintaining community character and protecting the environment are being utilized as the basis for developing various alternative futures. This subbasin report, while describing the impacts and consequences of existing trends, is also providing useful information for decision-makers to determine whether or not trend forecasts should be modified.

As State policies, regional plans, and community actions continuously define the desired character of future development, the ongoing State Water Planning program can readily identify potential impacts and propose subbasin alternatives consistent with State policy and compatible with community goals.

The scope of this study includes major aspects of water use and water management which can be affected by changing conditions in the future. Pennsylvania's intense water resources development dictated that problems be explored on a watershed, municipality and even company basis. For each problem which was identified, feasible solution alternatives have been examined and discussed, with consideration given to their physical, economic, environmental and social implications in order to determine and recommend solutions. In some instances, no single solution was recommended because more detailed studies are required.

In deriving its summary and recommendations this study has: (1) utilized the trend analyses as well as the many assumptions expressed in this text and "Planning Principles SWP-1", (2) solicited extensive public participation and reflected local desires and wishes to the maximum extent possible, and (3) considered both the natural physical features and socio-political jurisdictions and restrictions imposed by society.

Subbasin 5 includes the drainages of the Lackawanna River and the Susquehanna River from the mouth of the Lackawanna River to the confluence with the West Branch Susquehanna River. The entire subbasin is within the Appalachian Mountain Section of the Valley and Ridge Province, which characteristically has high, flat-topped mountain ridges and narrow valleys. The northern and eastern portions of the subbasin include parts of the anthracite coal region. Major urban centers include Scranton, Wilkes-Barre, Hazleton, Berwick, Bloomsburg, and Danville.

Historically, the subbasin's waterways were very important because they were used for powering gristmills and sawmills. In 1840, the Scranton brothers began to develop the iron ore and anthracite found in the area. Their Lackawanna Iron and Steel Company shipped iron to Philadelphia and Baltimore by using the Susquehanna River and the Union Canal during periods of high flow. Because the river flows would not allow shipping on a continuous basis, railroads quickly replaced navigation. Coal mining continued to grow and expand, hitting its peak in 1917. Since that time, there has been a shift from the coal industry to textile and other manufacturing industries.

Population, which was closely associated with the coal boom, declined in the area until the mid 60's when the trend was reversed. In the lower portion of the basin, agriculture plays an important role in the economy.

Past coal mining activities have left many of the streams severely polluted with acid mine drainage. In addition, municipal wastes are degrading the streams. The most serious problem of all in the basin is flooding. In the 1972 Tropical Storm Agnes, the Wilkes-Barre metropolitan area alone experienced over one billion dollars (1976 price level) in damages. This occurred in spite of the fact that many communities which experienced significant damages in the area were protected by some sort of flood protection project which had been built since the tropical storm floods of the 1950's. These water resources problems, as well as many others, must be addressed in the future; and the following sections summarize the more prominent problems in the subbasin as well as recommended solutions.

A. FLOOD DAMAGE REDUCTION

Because of the steep, mountainous terrain and the location of communities in the stream valleys, this basin is highly susceptible to flooding. In the last half century, major floods have occurred in this basin in 1936, 1942, 1955, 1968, 1969, 1972, and 1975. There are 61 identified flood damage centers and 22 damage reaches. Curiously, the 1942 flood was the most severe event which has occurred on the Lackawanna River. The Agnes Flood in 1972 was the most severe for the remainder of the subbasin. During the Agnes event, 22 communities experienced flood damages in excess of $1,000,000 (1976 price level). The communities of Wilkes-Barre, Kingston, Edwardsville, Swoyersville, Pittston and Forty Fort were the hardest hit when flood water overtopped the levees. Subbasin 5 has benefitted from the most active and concentrated State and Federal investment in structural flood control measures in Pennsylvania. The Corps of Engineers has built flood control projects which provide considerable protection for Scranton, Swoyersville, Forty Fort, Wilkes-Barre, Hanover Township, Kingston, Edwardsville and Plymouth. Major flood control dams include Stillwater Lake, Aylesworth Creek Lake, Arkport Dam, Almond Lake, and Whitney Point Lake, in addition to Tioga-Hammond Lakes and Cowanesque Lake which are under construction. The Department of Environmental Resources has built local flood protection projects in Mayfield, Olyphant, Dickson City, Scranton, Duryea, Moosic, Plymouth, Wyoming, West Wyoming, Blakely, Mocanaqua, and Danville. The U.S. Soil Conservation Service has built one dam and has another under construction on Briar Creek, which will offer protection to the town of Berwick in Watershed D.

The average annual natural damages which would occur to this subbasin would amount to $47,000,000, were it not for the many projects already built or under construction. With the protection provided by the flood control projects now completed or under construction, the residual damages have been reduced to $5,200,000 per year. Included in this calculation are the Tioga-Hammond and Cowanesque Lakes which should be completed as soon as possible.

It is clear, from the foregoing, that existing structural flood control measures have provided significant damage reduction for subbasin communities. But this subbasin also provides a prime example of the limits of structural measures and the dangers of a false sense of security encouraging construction in "protected" flood-plain areas. Dams, dikes and levees are only effective within their design limits. When those limits are exceeded, as occurred in Wilkes-Barre in 1972, the results are devastating in both property damage and threats to life.

The plan's analyses indicate there are few additional structural measures which can provide cost-effective protection in this subbasin. In any case, the emphasis of future flood damage reduction must be placed on flood plain management, control of accelerated runoff, stormwater planning on a watershed basis and other nonstructural measures. It is becoming increasingly important that flood prone municipalities develop and enforce stronger policies and regulations governing development and construction on the flood plains. Progress has been made as a result of the recent National Flood Insurance program; however, much remains to be accomplished. Cooperation among municipal governments must be enhanced to insure against upstream development which may result in increased flood hazards downstream. The environmental values, including the recreational potential of flood plains, must be afforded greater recognition in future planning and regulation.

The proposed Towanda Reservoir could offer some additional flood control to this basin and is recommended for further study from a comprehensive standpoint including recreation, water supply, and hydropower. The proposed Soil Conservation Service dam, PA 665 on Nescopeck Creek in Watershed D, is recommended for early construction. Land acquisition is presently in progress at this site. Additional projects that appear to be feasible are dam site #37-9 and channel modification projects for the communities of Moscow and Conyngham. It is recommended that these projects be further studied by the Commonwealth and implemented if found feasible. Design and/or construction of local flood protection projects or additions to existing projects in Duryea, Danville, Wyoming, West Wyoming, Exeter and Harveys Lake should be completed as soon as possible. In addition to these projects, budget requests have been submitted by DER for a channel modification in Wadhams Creek in Plymouth Borough and Units III and IV of the Moosic Flood Protection Project. For the remainder of the communities having problems, nonstructural solutions appear to be the only alternative. All damage centers have had their flood plains mapped, and all but three are eligible for Federal flood insurance. Therefore, the local communities should implement flood plain zoning to prevent future damages and to reduce existing flood problems. Flood forecasting is feasible along the Lackawanna and Susquehanna Rivers. In addition, relocation and floodproofing should be considered.

B. WATER QUALITY

Water quality problems within the basin result from sedimentation, acid mine drainage, and domestic and industrial waste discharges. The worst problem in the Lackawanna River is AMD[3], especially along the lower two miles in the Old Forge area, where some 121,000 lbs./day (90 percent of the total AMD load) of acid loading occurs. In addition, the river is polluted by malfunctioning on-lot disposal systems, combined sewer overflows in the Scranton-Dunmore areas, industrial wastes and coal silt sedimentation from coal waste banks and silt ponds. Planned or completed AMD abatement projects are expected to improve 23 miles of the river from Carbondale to Old Forge. Many waste banks and silt ponds are being removed for coal reprocessing and use in subsidence control flushing projects.

In Watershed B, the main problems are AMD and organic wastes from municipal sewage plants and industrial discharges. Completion of the proposed AMD abatement projects in Solomon's Creek, Mill Creek, Nanticoke Creek and Warrior Run will significantly alleviate the AMD problems during low flows. Big Wapwallopen Creek suffers from domestic and industrial wastes, while Harvey, Hemlock, Toby, and Black Creeks are polluted by domestic wastes. Few problems exist in Fishing Creek and Briar Creek. Pesticides have been found in Neal's Run. The main problem in Catawissa and Tomhickon Creeks is AMD, which has reduced the pH to as low as 3.6. These creeks are being evaluated for possible AMD treatment projects by DER.

Although only about one-fourth of the subbasin is in agriculture, most of that land is intensively farmed. The sediment yield for the basin is 382,000 tons/sq. mi./yr, excluding mined areas. It is recommended that better conservation measures be implemented to reduce this problem.

Groundwater in the Lackawanna and Wyoming Valleys above the coal limits is of good quality and reasonable quantity. This is a possible source of water supply because any degradation occurs upon movement down slope into the acid-forming coal-bearing structure. The groundwaters of the rest of the basin are generally of good quality, although incidents of localized groundwater pollution have been numerous. Sources of pollution have been septic tanks, landfills, oil tank leaks, and seepage from industrial waste treatment lagoons and salt storage.

[3]AMD – acid mine drainage

The Susquehanna mainstem suffers from several quality problems including excessive sedimentation, AMD, domestic waste discharge and industrial waste discharges.

Water quality problems of Subbasin 5 are being examined, and water quality standards and wastewater treatment plans are being developed in the Comprehensive Water Quality Management Plan (COWAMP) currently underway within the Department. That plan will determine the facilities, costs and institutional arrangements to meet existing and future water quality needs. COWAMP is being prepared as part of the overall State Water Plan and will be presented under separate reports.

C. WATER SUPPLY

The most significant water use occurs in the northern part of the subbasin in the vicinity of the metropolitan areas of Wilkes-Barre and Scranton. Of the total water use of 286.5 mgd[4] in the basin, 233 mgd occurs in that area. There are 58 public water suppliers in the basin, one of which, Pennsylvania Gas and Water Company, provides 84 percent of all public water supply. In 1970 there were six suppliers whose sources of supply would be insufficient to meet their existing demands in time of drought. Based on trend projections, there will be 17 suppliers in 1990 and 27 suppliers in 2020 who will have problems unless they develop additional supplies and/or reduce demands.

The most pressing public water supply problem is within the Pennsylvania Gas and Water Company, which services approximately 428,000 people. By 1990 their sources of supply will be inadequate to meet the demand under drought conditions. Their system presently experiences extensive leakage problems because of subsidence. There is a need for additional treatment (filtration) of several existing sources. It is recommended that this company provide filtration at existing sources where necessary and institute universal metering. In addition, a leakage and loss reduction program should be instituted along with residential and industrial conservation measures.

There are seven water suppliers in the Back Mountain region who are projected to have yield deficiencies. It is recommended that these suppliers be served water from the Pennsylvania Gas and Water system. If projected yield deficiencies still exist after demand reduction measures are fully employed, the Pennsylvania Gas and Water Company will need to develop a new source. Source alternatives would include a Susquehanna River intake, well field development, or additional reservoir storage. The majority of the other public water supply problems can be solved by additional groundwater development. Detailed recommendations for each water supplier are given in Table 17 of Chapter V. The promotion of water conservation practices is recommended for all water suppliers.

[4]mgd – million gallons per day

A new power generating plant is under construction along the Susquehanna River at Berwick. This one project is expected to evaporate an average of 28.8 mgd with peak consumptive requirements of 41.2 mgd. The Berwick project, along with other consumptive uses such as irrigation, portend a problem during low flow conditions on the Susquehanna River. In accordance with the low flow makeup regulation of the Susquehanna River Basin Commission, 52.6 mgd of makeup, for all uses, will be required during low flow periods, requiring storage of over 4.3 billion gallons. Various alternatives such as use of existing reservoirs, proposed reservoirs and groundwater development have been explored. This information is presented in Table 20 of Chapter V.

D. WATER-RELATED OUTDOOR RECREATION

There are many opportunities for water-related outdoor recreation in Subbasin 5; although many of the streams, because of degradation from coal mining, do not provide as high quality experience as they might. Warm-water fishing is available in the Susquehanna River, South Branch Roaring Creek, and the lower reaches of Nescopeck and Little Fishing Creeks, in addition to many small lakes and ponds. Trout fishing can be enjoyed on Fishing Creek, Wapwallopen Creek, Little Wapwallopen Creek, Roaring Brook, headwater tributaries of the Lackawanna River, Hunlock Creek, the upper reaches of Nescopeck and Little Fishing Creeks, Harvey Creek, Hemlock Creek and Roaring Creek. Streams suitable for canoeing and boating include the Susquehanna River, Catawissa Creek, Fishing Creek, the Lackawanna River, Toby Creek and Harvey Creek. Archbald Pothole, Frances Slocum, Rickett's Glen, and Shikellamy Marina State Parks provide a variety of experiences including picnicking, boating, fishing and camping. The Archbald Pothole is a geologic rarity and the largest of its kind in the world.

There is potential for use of additional picnic tables, more swimming pools, and more large bodies of water for power boating. When the proposed Nescopeck State Park is completed, some of those uses will be provided for partially. Some additional power boating acreage may be provided in nearby Prompton and Frances E. Walter Reservoirs, if they are modified, or Tocks Island Lake Project if it is constructed. Additional picnic facilities should also be developed locally. Opportunities for recreational enhancement should be considered in conjunction with future flood plain management wherever possible.

E. WILD AND SCENIC RIVERS

Seven stream reaches have been nominated as candidates for the Pennsylvania Scenic Rivers System. The 52-mile stretch of the Susquehanna River has been selected as a first priority candidate.

Second priority candidates include portions of Wapwallopen and Fishing Creeks, while reaches of the Lackawanna River, Harvey Creek, Nescopeck Creek and Roaring Creek were chosen as third priority candidates. In all, 185 miles of stream have been suggested for consideration.

The Commonwealth recognizes the irreplaceable qualities of many of its waterways. The management of these resources for aesthetic and utilitarian purposes is dependent upon the diligence of both the governmental and private sectors. Water resources projects whose necessity has been proven by thorough study of the alternatives, must be planned so as to minimize disruption of the natural environment.

Because of their outstanding characteristics, all streams listed in Table 36 of Chapter V should be subject to careful environmental assessments with full consideration of all alternative solutions before any projects are proposed, which may affect the nominated reaches. Streams listed including second or third priority, although not priorities for immediate in-depth investigation by the Scenic Rivers Program, should be preserved or improved to the extent possible by all levels of government, as well as private interests, until such time that they may be studied to determine their eligibility as components of the Pennsylvania Scenic Rivers System.

II. GOALS AND OBJECTIVES

The Commonwealth recognizes the importance of citizen participation in any program which has the potential for such direct impact upon the everyday lives of the public as does the State Water Plan. In order that an effective level of citizen participation might be achieved in this important program, the Department established through the Economic Development Council of Northeastern Pennsylvania, a Water Resources Advisory Committee. Membership on this committee was open to the general public and participants included representatives from many public, industrial and governmental organizations.

Development of the materials contained in this report was coordinated with this committee through a series of meetings conducted in Scranton. As work on various sections of the report was completed, meetings were held to allow discussion of the information which had been developed to that point. Modifications and corrections were then incorporated.

One of the committee's coordinative functions was the development of a set of subbasin goals and objectives which, when merged with those for the overall State, would provide the basis upon which decisions could be made in the water resources planning process for this area. This section outlines the Subbasin Goals and Objectives which are the final product of that effort.

A. WATER SUPPLY

1. *Goal*

Water supplies of adequate quantity and quality to meet both short- and long-term needs.

2. *Objectives*

a. Inventory the available surface and groundwater resources.

b. Identify existing and potential water supply problems.

c. Identify feasible alternative solutions taking into account physical, social, political, economic, and environmental factors, to make possible the selection of practicable solutions.

d. Encourage the reuse of water, and the development and use of new water-saving technology

e. Stress conservation measures to help ensure the future availability of water resources.

f. Suggest those changes in water laws and institutional arrangements deemed necessary to ensure the adequacy of present and future water supplies and the equitable distribution thereof.

g. Protect public drinking water supplies from degradation of quality and reduction in yield.

h. Develop water resources to ensure adequate supplies during water shortages, droughts, and other possible emergencies.

B. FLOOD DAMAGE REDUCTION

1. *Goal*

The mitigation of existing flood problems with the resulting minimization of future flood damages and loss of life.

2. *Objectives*

a. Establish a list of urgent flood control needs for the purpose of guiding flood control investments.

b. Identify feasible alternatives (i.e., structural measures and nonstructural measures) to the flood problem, taking into account physical, social, political, economic, and environmental factors.

c. Promote flood plain management and its integration with local land use management.

(1) Encourage appropriate State legislation to manage flood plains.

(2) Regulate new structural development in flood prone areas.

(3) Require that construction of essential development on flood prone areas be flood proofed and designed to minimize obstruction to flood flows.

(4) Encourage the relocation of flood plain development to nonflood prone areas, where economically feasible.

d. Advocate and apply a basinwide system approach to flood damage reduction measures.

e. Stress the interrelationship between traditional State-Federal flood control measures and urban storm drainage.

f. Encourage municipalities to participate in the National Flood Insurance Program.

C. OUTDOOR RECREATION

1. *Goal*

Adequate water and related land resources to meet present and future water-oriented and water-enhanced recreational needs.

2. *Objectives*

a. Protect natural and free flowing streams to preserve their recreational potential.

b. Inventory all water-related and water-enhanced public recreation facilities.

c. Examine existing and potential recreational facilities and water projects to determine future potential for recreation development.

d. Determine water-related recreation needs to guide recreation investment in conjunction with water resources project development.

e. Give highest priority to those recreation projects that meet the greatest needs within minimum required travel time.

f. Provide adequate fishing and boating opportunities through the development of access areas on public water and by promoting access to additional private waters.

g. Coordinate the water-related outdoor recreation planning activities and responsibilities of Federal, State, local and private entities.

h. Coordinate water-related outdoor recreation planning with other related State planning efforts.

i. Encourage local government participation in the development of future recreation opportunity.

D. WATER QUALITY MANAGEMENT

1. *Goal*

Prevent further pollution of the waters of the Commonwealth, and restore to an unpolluted condition all presently polluted waters, so that future uses will be protected.

2. *Objectives*

a. Establish water quality standards designed to protect all probable uses of the Commonwealth's waters.

b. Provide for the development of water quality management programs which include both individual and regional waste collection and treatment systems designed to protect and conserve the Commonwealth's waters.

c. Identify and develop institutional arrangements for implementation of regional or basinwide water quality plans.

d. Control nonpoint source pollution and prevent pollution incidents by requiring adequate product and waste handling safeguards.

e. Develop and institute programs for control and abatement of acid mine drainage from abandoned mines.

E. ENVIRONMENTAL QUALITY

1. *Goal*

Management of water and related land resources to abate and prevent pollution, protect and preserve environmental values, and enhance and maintain ecosystems.

2. *Objectives*

a. Protect wetlands, wild areas, natural areas and other resources which may be fragile, rare or endangered.

b. Develop criteria to maintain aquatic ecosystems and protect other instream environmental values.

c. Protect the character of streams having wild and scenic values, and prevent degradation of streams.

d. Encourage land and water resources management which is compatible with the protection of prime farmlands.

e. Promote floodplain management which maintains the floodplain ecosystems, protects natural resource values and provides community open space opportunities.

f. Develop a groundwater management program to prevent groundwater contamination, facilitate recharge and reduce runoff.

g. Manage water and related land resources to protect habitats for fisheries and wildlife resources.

h. Identify areas where frequent or severe low flows caused by man's activities may threaten environmental values.

i. Encourage environmentally sensitive land and water planning by all levels of government such that the natural hydrologic character of watersheds is respected.

III. PHYSICAL FEATURES & RESOURCES

The term *water resources management* typically brings to mind the concept of controlling rivers and streams to provide water for man's use. However, one should be reminded that what is really being managed is a resource that is all-pervasive. Groundwater saturates much of the Commonwealth's bedrock. Surface water in the form of streams and lakes occupies over one percent of the Commonwealth's land surface. Water vapor, or moisture in the air, while not readily available for man's use, is the source of water in its other usable forms. Physical features of the environment affect water in all forms by controlling flows, natural storage, evaporation and precipitation.

Physical features of the land also affect water resources management, not only because of their direct effects on water in quantity and quality, but also because of their indirect effects on its use, resulting from their influence on man's activities. This chapter discusses in general terms the physical features of Subbasin 5. For the reader who is unfamiliar with the area, it should provide a description sufficient to understand the physical characteristics of the subbasin; and for all readers it should provide insight into the general relationships between physical land features and water resources.

Much of the material presented in this chapter was either developed by other State or Federal agencies, or was developed from information provided by those agencies, including the Pennsylvania Fish and Game Commissions, the U.S. Weather Bureau, the Bureau of Topographic and Geologic Survey of DER, the U.S. Department of Agriculture's Soil Conservation Service and Forest Service, as well as the State Forestry and Soil Conservation Bureaus. In some cases the planning process involves the use of information of greater detail than that which is presented here. It is not intended that this report present a detailed description of physical features. More detailed information is available in reports and publications from the respective agencies with specific authority in given program areas. In addition, development of more localized physical features data will occur as the State Water Plan program examines in greater detail those water resources problems which have been identified as being of urgent concern to Pennsylvania's future.

A. BASIN ORIENTATION

Located in northeastern Pennsylvania, the Upper Central Susquehanna River subbasin is referred to as Subbasin 5. The subbasin includes almost all of Luzerne and Columbia Counties, most of Lackawanna County, and portions of Schuylkill, Northumberland, Montour, Lycoming and Sullivan Counties. Overall the drainage of the subbasin encompasses 1,759 square miles.

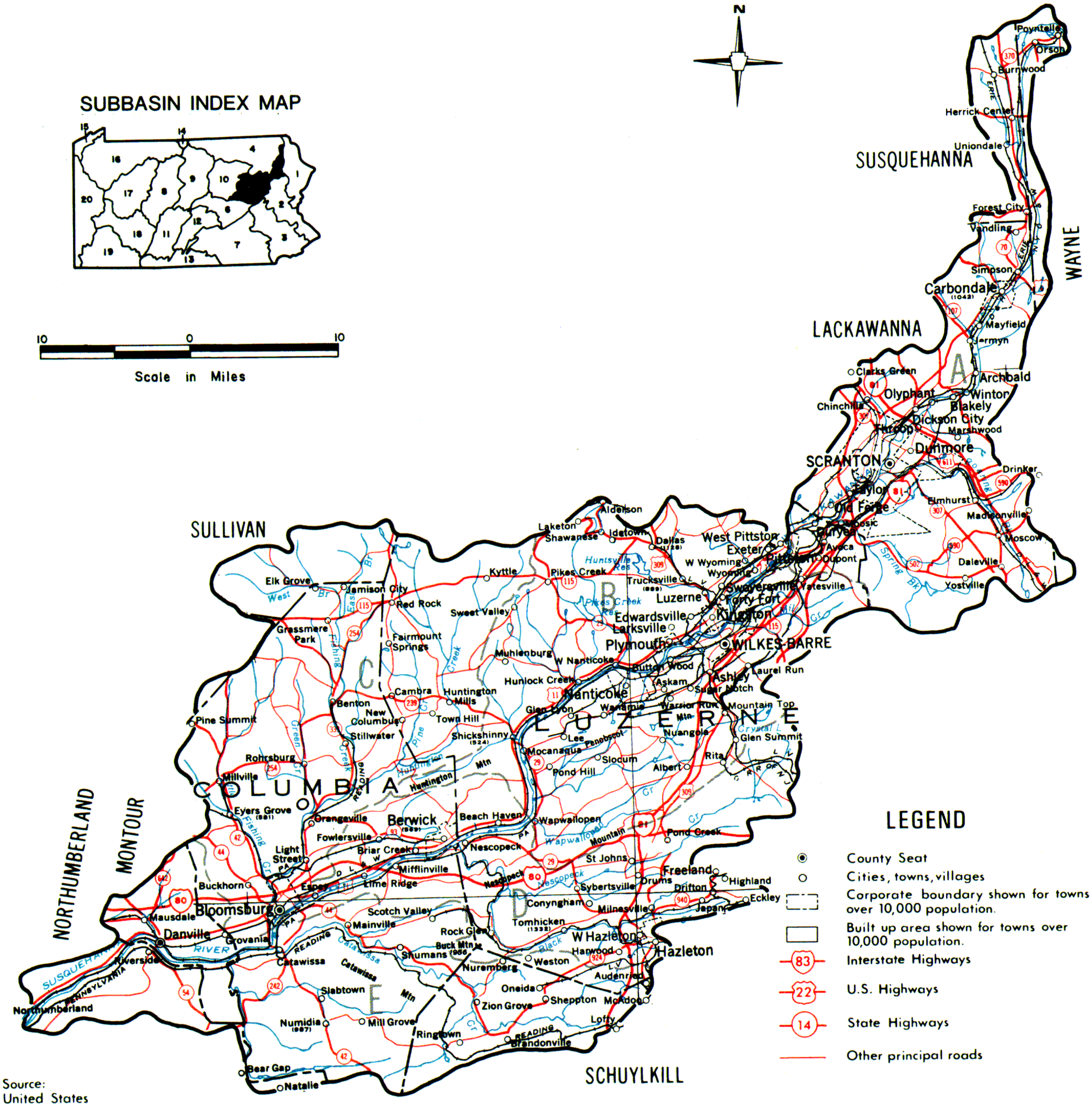
The Upper Central Susquehanna is pear-shaped, as shown in Figure 1. The subbasin is approximately 84 miles in length from Carbondale in the northeast to Northumberland in the southwest, and averages 24 miles in width. Surrounding the Upper Central Susquehanna are six other subbasins. To the east Subbasin 5 is bordered by three Delaware River subbasins: the Upper, Subbasin 1; the Central, Subbasin 2; and the Lower, Subbasin 3. To the north, west, and south three Susquehanna River subbasins; the Upper Central, Subbasin 4; the Lower West Branch, Subbasin 10; and the Lower Central, Subbasin 6, border the Upper Central Susquehanna.

Subbasin 5 falls within the Appalachian Mountain Section of the Valley and Ridge Province. The topography of this area is generally characterized by flat-topped mountains and hills, disected by steep-sided stream valleys. This area is underlain by generally flat-lying rock strata which have been only slightly upwarped in some places. This gentle upfolding has given rise to some of the observed relief; however, most of it has been produced by streams cutting down through the flat-lying strata.

The largest population center in the subbasin is the Scranton/Wilkes-Barre metropolitan area. This population concentration extends from Carbondale, in the north along the Lackawanna River, to Nanticoke in the south along the Susquehanna River. A second population concentration includes the City of Hazleton located in the southeast corner of the subbasin. Other population centers located along the north side of the Susquehanna River include Berwick, Bloomsburg and Danville.

Major transportation routes in the subbasin include the Northeast Extension of the Pennsylvania Turnpike and Interstates 80, 81, 84 and 380. Other transportation arteries include U.S. Routes 6 and 11 and Pa. Route 309.

Employment in the subbasin is concentrated in the apparel, electrical machinery, fabricated metal products, and textile industries. The pronounced decline in the mining sector, which resulted fromdepressed conditions in the anthracite coal industry, has been a major factor in the lethargic performance of overall employment. However, while manufacturing has shown a steady decline as a share of total employment, service-



Source:
United States
Department of the Interior
Geological Survey

FIGURE 1. Basin Orientation

Table 1

MAJOR RIVERS AND WATERWAYS

Watershed	Drainage Area (Sq.Mi.)	Major Waterway	Minor Waterway
A	348	Lackawanna River	Roaring Brook Creek
B	403	Susquehanna River	Wapwallopen Creek
C	386	Fishing Creek	Little Fishing Creek
D	261	Susquehanna River	Nescopeck Creek
E	363	Susquehanna River	Catawissa Creek
Total	1,761		

related activities have represented an increasing share.

Water orientation of the subbasin is along the axis of the Susquehanna River as it flows southwest through the subbasin.

For water resources study purposes, Subbasin 5 has been divided into five watersheds as indicated in Table 1. The Susquehanna River is the major waterway in three of the watersheds (B, D and E), while the other primary waterways are the Lackawanna River in Watershed A and Fishing Creek in Watershed C. The combined drainage of Watersheds A and C is slightly less than half that of the total subbasin. The largest individual watershed is Watershed B, with a drainage of 403 square miles. Minor waterways in each of the five watersheds are also listed in the table.

B. CLIMATE

The study area is dominated by atmospheric flow patterns relevant to the Humid Continental type climate. Most of the weather systems that influence the study area originate either in Canada or the Central Plains of the United States and are steered eastward by the prevailing westerly flow aloft. Another flow pattern and primary source of heavy precipitation associated with cyclonic circulation is from the Gulf of Mexico northward through the study area. As a result of the dominant westerly air flow into the area, the moist air flow from the Atlantic Ocean, to the east, is a modifying rather than a controlling climatic factor. Periodically, considerable moisture is picked up by storms developing and moving up along the southeastern coastline of the United States. A disturbance of this type usually brings moderate to heavy precipitation to the upper Susquehanna River Basin areas, due to the general upslope motion of moist air over the area's rugged topography. In the colder months when temperatures are near or below freezing, these storms many times deposit heavy amounts of wet snow throughout the area. The Great Lakes have little influence on the climate of the study area because the weather systems formed over the Great Lakes region migrate northeastward from the vicinity of Pennsylvania.

The normal successions of high and low pressure systems moving eastward across the United States produce weather changes in the area every few days in the winter and spring of the year. In summer and fall the weather changes are less frequent due to the slowing down of the general atmospheric circulation during the warmer months. Low pressure cyclonic systems usually dominate the area with southerly winds, rising temperatures and some form of precipitation. The high pressure anticyclonic systems normally bring west to northwest winds, lowering temperatures and clearing skies to the area.

Hurricanes or tropical disturbances, as they move northward, follow a northeasterly path in the middle latitudes and produce heavy rainfalls and strong surface winds in the study area. Frequently affecting water supplies and causing floods, these tropical storms are observed during the hurricane season, June through November.

Weather elements or activities of the atmosphere such as precipitation, temperature, wind direction and speed, relative humidity, and sunshine, are measurable quantities which affect the study area.

Precipitation in both liquid and solid forms is the initial source of all water supplies. The study area normally receives about 41 inches of precipitation annually. The normal monthly precipitation totals average from a minimum of 2.8 inches in January to a maximum of 4.3 inches in July. Snowfall is moderately heavy, averaging about 50 inches annually. The mean annual number of days with snow cover of one inch or more is about 70 days.

Air temperatures are important to the management of water resources and water quality. The average annual temperature for the study area is about 50°F. The mean annual freeze-free period is about 150 days. Because of the topography the freeze-free season is variable, ranging from 135 days in the north to 165 days in the south. Temperatures have been recorded as high as 102°F in the northern portion of the study area during the month of August, and as low as –20°F in the southern part during the month of February. In the study area, the summer mean is about 71°F and the winter mean about 29°F.

Winds are important hydrologic factors because of their evaporative effects and their association with major storm systems. The prevailing wind direction in the area is westerly, with an average wind speed of 8 mph. Extreme wind speeds up to 65 mph associated with severe storms have been reported in the Scranton/Wilkes-Barre area.

Relative humidity also affects evaporation processes. The mean monthly relative humidities for the months of January, April, July and October are about 74 percent, 64 percent, 74 percent and 75 percent respectively.

Sunshine, which varies with latitude and time of the year, is a factor to be considered in the various aspects of waste treatment processes. The mean annual sunshine in hours per year for the study area is about 2,400 hours.

The evaporation process is controlled by temperature, wind, sunshine and humidity. The rate of evaporation during the warmer months has an important impact on water storage in reservoirs and on irrigation. High evaporation rates can cause humid regions to become vulnerable to droughts. The mean May to October evaporation for the study area accounts for about 75 percent of the annual total evaporation.

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1. U.S. Weather Bureau, *Climates of the States – Pennsylvania Climatography of United States No. 60-36*, (U.S. Department of Commerce, Washington, D.C., 1960–1971).
2. U.S. Weather Bureau, *Climatic Date – Section 88 – Central Pennsylvania*, (U.S. Department of Agriculture, Washington, D.C., 1930).
3. Department of Interior, Geological Survey, *The National Atlas of the United States*, (Washington, D.C., 1970).
4. Hoyt and Langbein, *Floods*, Princeton University Press, (Princeton, New Jersey, 1955).

C. HYDROLOGY

Management of water resources requires a knowledge of the quantity of water which is available for use and which must be managed in order to provide for the safety and welfare of the public. For studies of water use and quality, low flow conditions are of general concern; whereas, for flood management it is necessary to know the high flow characteristics of streams. Hydrologic factors discussed in this section include main stream systems, annual basin runoff, low flows, and flooding.

The Susquehanna River, draining Watersheds B, D, and E, is the largest river within the subbasin. Tributaries to the Susquehanna River include the Lackawanna River and Fishing Creek, draining Watersheds A and C respectively.

Average annual runoff in Subbasin 5 ranges from 20 inches to 26 inches and is primarily influenced by precipitation distribution. However, other factors such as land cover and use, geology, and physiography influence the variability of flows from individual watersheds. Table 2 contains average annual runoff values for selected gaging stations within the subbasin[5].

Runoff has a distinct seasonal variation, with the period of highest runoff occurring in late winter or early spring, and the period of lowest runoff occurring in late summer and early fall. The seasonality of evapotranspiration accounts for most of this variation.

Low flow deficiencies develop after prolonged periods of little or no precipitation and persist until sufficient rainfall relieves the situation. Flow deficiencies of significant duration may cause new water supply problems and may magnify existing water quality problems.

The 7-day 10-year low flow, a common description of low flow characteristics, is frequently used as a basis for water management. Table 2 lists values of this statistic for selected gaging sites in Subbasin 5. For other stream gaging stations in the subbasin, the magnitude and frequency of low flows for this and other durations are contained in two bulletins (Bulletin No. 12[7] and Bulletin No. 7[8]) published by the Pennsylvania Department of Environmental Resources.

The higher 7-day 10-year low flows for the Lackawanna River at Old Forge (0.28 csm[8]) and for Solomon Creek at Wilkes-Barre (0.18 csm) reflect the effects of mining activities within the subbasin. Pumping of water from the mines tends to supplement low flows.

Although floods occur in all seasons, studies of the relationships among storm intensity, duration, affected area, and seasonality suggest a tendency for flooding on principal streams to occur in winter and for floods on small streams to occur mostly in summer. Large area floods are caused by storms of low rainfall intensity and long duration covering the entire area of principal watersheds. Small area floods, on the other hand, are caused by storms of high rainfall intensity and relatively short duration. An exception to this is tropical storms, which normally occur during the summer months and cause extensive flooding over large areas.

Magnitudes of mean annual floods for selected gaging sites in Subbasin 5 are given in Table 2. This data was obtained from a U. S. Geological Survey computer analysis of annual peak discharge records for a statewide study of flood magnitude and frequency relations.

D. TOPOGRAPHY

The topography, or the physical land features, of the study area determines the drainage patterns and

[5] U.S. Geological Survey, *Water Resources Data for Pennsylvania, Part 1: Surface Water Records*, (1972).

[6] L.V. Page and L.C. Shaw, *Water Resources Bulletin No. 12, Low Flow Characteristics of Pennsylvania Streams*, (Pennsylvania Department of Environmental Resources, 1977).

[7] Office of Engineering and Construction, *Water Resources Bulletin No. 7, Long Duration Low Flow of Pennsylvania Streams*, (Pennsylvania Department of Environmental Resources, 1972).

[8] csm – cubic feet per second per square mile

Table 2

STREAMFLOW STATISTICS FOR SELECTED GAGING STATIONS

Station	Period And Years of Record Used	Drainage Area (Sq.Mi.)	Average Annual Runoff (csm[a])	Mean Annual Flood (csm[a])	Ratio of 100-Year to Mean Annual Flood	7-Day 10-Year Low Flow (csm[a])
Lackawanna River at Old Forge	1938–72 34	332	1.5	29.7[b]	3.8[b]	0.28
Susquehanna River at Wilkes-Barre	1899–72 73	9,960	1.3	12.8	2.3	0.08
Solomon Creek at Wilkes-Barre	1940–72 32	15.7	1.3	47.8	4.0	0.18
Wapwallopen Creek near Wapwallopen	1919–72 53	43.8	1.4	30.9	3.2	0.06
Fishing Creek near Bloomsburg	1938–72 34	274	1.7	34.5	3.5	0.06
Susquehanna River at Danville	1899–72 73	11,220	1.3	12.3	2.2	0.09

[a]Cubic feet per second per square mile.

[b]Flood data for period 1939–59, 21 years.

Source: United States Geological Survey

surface flow characteristics. Steeper slopes cause increased runoff and erosion and discourage infiltration to the water table. Unconfined (nonartesian) groundwater flow direction is controlled in part by the topography.

Subbasin 5 is located within two physiographic provinces, the Valley and Ridge Province (Appalachian Mountain Section) and the Appalachian Plateaus Province (the Glaciated Low Plateaus Section and the Pocono Plateau Section) as shown on Figure 2. Because over 90 percent of the area lies within the Appalachian Mountain Section, the topography, geology, and groundwater occurrence will be discussed without reference to individual physiographic divisions.

This subbasin is characterized by a series of long, high ridges separated by narrow valleys. The Susquehanna River flows southwestward through the center and drains the entire subbasin. The major valley through which it flows is commonly referred to as the Wyoming Valley. Elevations range from a minimum of 443 feet near Sunbury to a maximum of 2,450 feet near the intersection of the Luzerne, Columbia and Sullivan County lines.

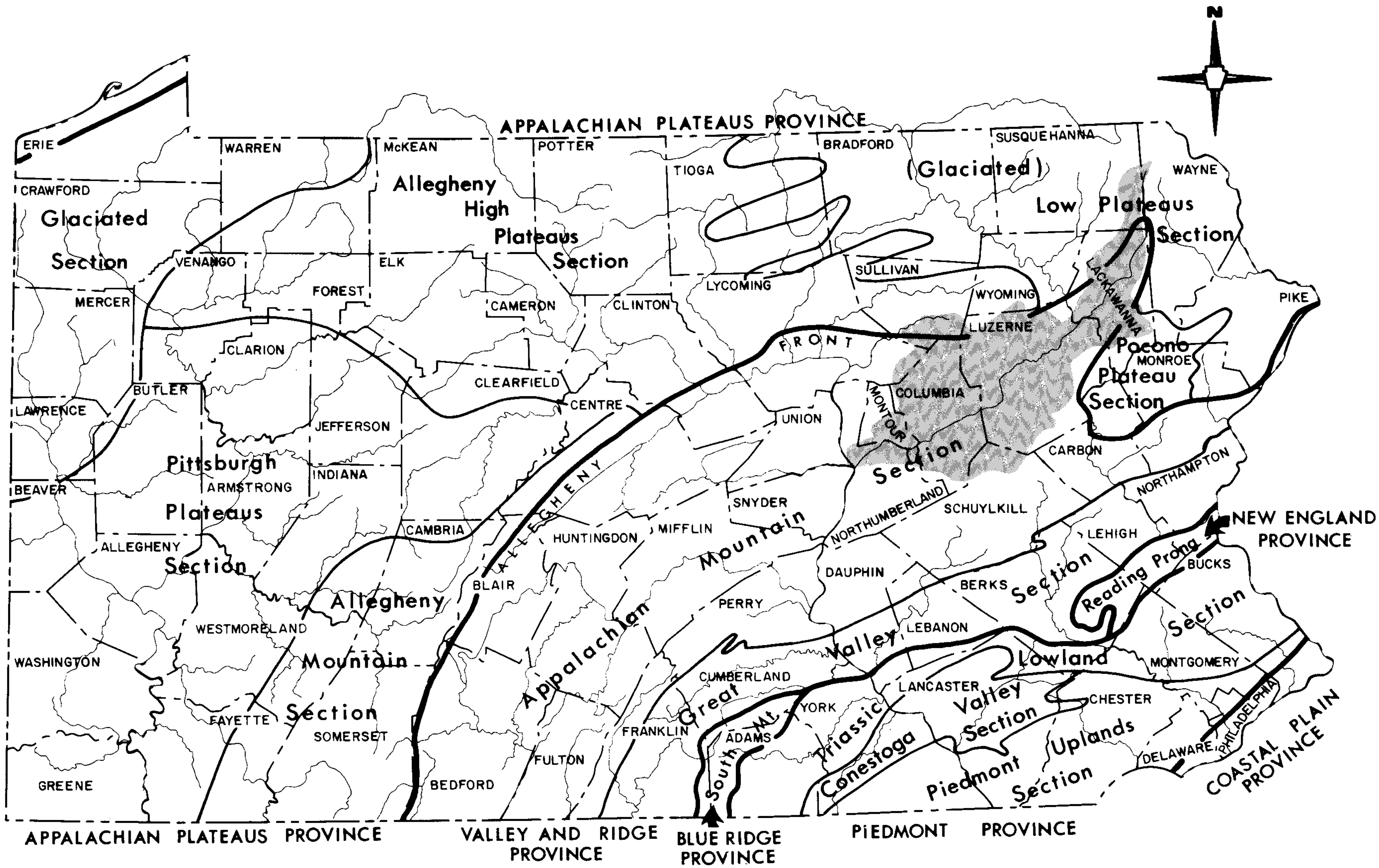
E. GEOLOGY

Bedrock geology has ultimate control on the storage, transmission, and utilization of groundwater. Geologic factors such as rock type, intergranular spacing, rock strata inclination, faults, joints, folds, bedding planes, and solution channels affect groundwater movement and availability. Natural groundwater quality is a result of the interaction between the groundwater and the bedrock with which it is in contact. The more soluble bedrock types will allow more compounds to become dissolved in the groundwater. For example, groundwater in highly soluble limestone aquifers will commonly have high hardness values. Groundwater quality will eventually affect surface water quality as it percolates into surface streams as base flow.

The areal distribution of the rocks exposed at the surface of the subbasin is shown on the Geologic Map (Figure 3 in cover pocket). These rock units or formations form aquifers with distinct hydrologic characteristics. The aquifers of Subbasin 5 are composed of both unconsolidated and consolidated rock, with glacial outwash being the only unconsolidated material. Water occurs in the pore spaces of the unconsolidated materials, and in fractures, bedding planes, and solution openings in the consolidated rocks. The more and the larger the saturated openings penetrated by a well, the higher the yield. Typical well characteristics for the principal aquifers of the subbasin are shown in Table 3.

Glacial outwash deposits consisting of soil and rock particles deposited by glaciers are porous and, where saturated, will yield moderate to very large quantities of groundwater. Outwash partly fills the Susquehanna Valley. Other small pockets of outwash are scattered along the valleys of some of the larger streams in this subbasin. At many places the outwash deposits are known to be several hundred feet thick. Yields in excess of 200 gpm[9] are not uncommon. The quality of the water is

[9]gpm – gallons per minute



Source:
Commonwealth of Pennsylvania
Topographic and Geologic Survey

FIGURE 2. Physiographic Provinces

Table 3

CHARACTERISTICS OF WELLS IN PRINCIPAL GEOLOGIC UNITS[a]

Map Symbol	Rock Units		Well Depth (Feet)	Number of Wells Sampled	Casing Length (feet)	Number of Wells Sampled	Static Water Level (feet)	Number of Wells Sampled	Drawdown (Feet)	Number of Wells Sampled	Well Yield (Gal.Per Min.)	Number of Wells Sampled	Remarks
	Glacial outwash	m[b]	29	29	26	26	18	29	1	7	200	22	Water quality problems in some areas.
		R[c]	7–125		6–69		5–36		0–40		5–1000		
Ppp	Llewellyn Fm.	m	300	72	40	50	50	49	2	10	12	52	Water quality is a problem in the Llewellyn Fm. The Pottsville is relatively unused as a source of public water supplies.
	Pottsville Gp.	R	55–1950		6–901		F[d]-350		1–181		1–400		
Mmc	Mauch Chunk Fm.	m	398	110	40	64	21	55	107	31	50	75	The Pocono Gp. has slightly lower yields.
Mp	Pocono Gp.	R	27–1557		5–435		F-300		8–350		2–350		
Dck(Ds)	Catskill	m	302	184	58	144	60	125	70	94	45	163	In the Appalachian Plateaus Province this unit is extensively utilized for public supply wells.
	(Susquehanna) Gp.	R	73–1000		2–285		F-306		1–400		4–352		
Dm	Marine Beds	m	102	21	21	14	30	16	40	7	5	14	
		R	50–234		5–125		9–127		1–107		< 1–40		
Dho	Hamilton Gp.	m	135	123	37	109	27	103	65	87	10	107	Oriskany Gp. is very limited in areal extent. Where thick enough well yields exceed 100 gpm. A few wells in the Skw may also yield over 100 gpm. Some solutional cavities may be encountered in drilling these units.
Doh	Oriskany Gp.	R	33–576		12–330		1–180		1–260		< 1–380		
Skw	Keyser-Tonoloway-Wills Creek Fms.												
Sbm	Bloomsburg-McKenzie Fms.	m	186	36	34	33	50	30	81	26	20	34	Water quality is a common problem.
Sc	Clinton Gp.	R	44–644		6–115		0–127		7–390		2–190		
St	–		–		–		–	–	–		–	–	No wells

[a]Data are primarily from public and industrial water supply wells. In instances where there is an insufficient number of public and industrial wells, domestic wells are used to supplement data. Median well characteristics, in most cases, correspond to typical values obtained from randomly located wells. Considerably larger well yields may be obtained by using scientific well location and development techniques.

[b]Median

[c]Range

[d]Static water level above land surface (flowing well).

Source: DER, Bureau of Topographic and Geologic Survey excellent. The water is soft and contains small amounts of dissolved mineral matter. However, in the Wyoming Valley acid water from the coal mines is leaking into these deposits, and water quality could be poor near those points of discharge.

The Llewellyn Formation contains considerable quantities of groundwater. However, in the coal basins much of this water becomes contaminated with acid. Records from the few potable water wells available show yields ranging up to 50 gpm. In general, the quality of the groundwater is poor. Much of the water is used only in certain washing operations.

The Pottsville Group is an adequate water-bearing unit in Subbasin 5 except where it crops out on the high ridges. It yields moderate supplies of good quality water with a median yield of 15 gpm. Water from this aquifer is very soft and contains a relatively small amount of dissolved mineral matter. Artesian conditions are common.

The Mauch Chunk Formation is one of the better water-bearing formations in the subbasin. Municipal and industrial water supplies can be obtained from deep wells. Sandstone layers are usually the best producing zones, but the fractured shale beds have been reported to yield more water than the sandstone in places throughout the subbasin. Most wells that are drilled over 200 feet deep yield 25 gpm or more. Public supply wells average 400 feet in depth and have a median yield of 65 gpm. Groundwater in the Mauch Chunk Formation is of good quality. The water is soft and contains only small amounts of dissolved mineral matter.

Groundwater in the Pocono Group moves through a system of interconnected joints and fractures. Well yields are slightly lower than those in the Mauch Chunk Formation. Groundwater from the Pocono Formation is generally low in dissolved mineral matter; but reported analyses have shown that high concentrations of sodium chloride and sodium bicarbonate do exist.

Groundwater in the Catskill Group of rocks is found in both primary and secondary openings. In Subbasin 5, the areal extent of these rocks is considerable. Wells drilled to depths of at least 200 feet are advisable if yields of 25 gpm or more are desired. Public supply wells have a median depth of 310 feet and a median yield of 45 gpm. Sufficient water for domestic purposes can usually be obtained at almost any location within the subbasin from wells that are drilled 40 to 50 feet below the water table. Groundwater from these rocks is generally of good quality. Hardness and dissolved solids are low. However, brackish or saline water has been reported in the western part of the subbasin where an oil-test well encountered salt water at 361 feet below the land surface.

The pore spaces in the Marine Beds are very small. Most of the groundwater occurs in and moves through secondary openings, such as joints and fractures. The Marine Beds are a reliable source of small to moderate supplies of groundwater. The median well yield is 5.0 gpm. Sufficient groundwater for domestic purposes can usually be obtained from wells drilled 60 to 80 feet below the water table. Large yields needed for industrial and municipal purposes are very difficult to obtain. Chemical analyses show the water to be hard, high in iron, and containing hydrogen sulfide. Deeper wells are likely to yield salty or brackish water.

The rocks of the Hamilton Group are dense and well cemented. Groundwater moves only through secondary openings. Most of the wells in this rock unit have small yields. The water is usually hard and high in dissolved solids. Several reported wells yielded water that contained hydrogen sulfide.

The Oriskany Group is an available aquifer in the Bloomsburg-Danville-Sunbury area. However, the areal extent of this aquifer is very limited. Yields in excess of several hundred gpm are possible. The groundwater from the Oriskany Group is of good to excellent quality for most uses. The water contains low to moderate amounts of dissolved solids, hardness, and iron.

The Keyser, Tonoloway, and the Wills Creek Formations in the Berwick, Bloomsburg, Danville, and Milton areas are fair aquifers. The median yield of these formations is 10 gpm. The groundwater is of fairly good quality with moderate amounts of dissolved solids and hardness. The iron content is low. However, wells from a few areas contain large amounts of calcium sulfate and iron. In certain areas, the groundwater is too hard for many industrial uses.

The Bloomsburg and McKenzie Formations are also fair aquifers in the southwestern part of the subbasin. The median yield of these formations is 20 gpm. The groundwater contains a moderate amount of dissolved solids, low to moderate amounts of hardness, and a low iron concentration. A few wells have been reported to contain large amounts of calcium sulfate. Wells tapping only the Bloomsburg shale will probably yield fairly soft water.

The Clinton Group is another available aquifer from Bloomsburg through Danville to the Susquehanna River north of Sunbury. The median yield of this rock unit is also 20 gpm. Groundwater from the Clinton Group is of good quality. The water contains a low amount of dissolved solids and hardness. The iron content ranges from low to moderate. Brackish to saline water has been reported in deep wells.

The Tuscarora quartzite is of very limited areal extent in Subbasin 5 and is unimportant as a source of groundwater, due to its topographic position on the summits of high ridges. Low-yield springs are found along the talus slopes of the Tuscarora. These springs yield very soft water that is low in dissolved solids and of excellent quality.

A major groundwater problem that has resulted from the activities of man throughout much of Subbasin 5 is the contamination of groundwater reservoirs by acid mine water. Very large quantities of acid water are draining or being pumped from the coal mines in Luzerne County, the Wyoming Valley and in the vicinity of Hazleton.

Many of the inactive coal mines of the area are full of water and are overflowing. Some of the acid water from the flooded mines is leaking into the overlying shallow aquifers and contaminating them.

References

1. Jerald R. Hollowell and Harry E. Koester, *Ground Water Resources of Lackawanna County, Pa.*, (Pa. Geological Survey, Bulletin W-41).
2. Stanley W. Lohman, *Ground Water in Northeastern Pennsylvania*, (Pa. Geological Survey, Bulletin W-4, 1937).
3. Thomas G. Newport, *Summary of Ground Water Resources of Luzerne County, Pa.*, (Pa. Geological Survey, Bulletin W-41).
4. Paul R. Seaber, *An Appraisal of the Ground Water Resources of the Upper Susquehanna River Basin in Pennsylvania*, (U.S. Geological Survey, 1968), Interim Report.
5. Department of Environmental Resources, Bureau of Topographic and Geologic Survey Water Well Inventory
6. G-WAMIS, Bureau of Water Quality Management

F. MINERAL RESOURCES

Mineral resources and mining areas that are near the water table can have a large influence on groundwater quality, as evidenced by acid mine drainage in the coal mining districts. Mine shafts and quarries commonly alter the groundwater flow pattern by developing new flow channels. Where the water table must be lowered to continue mining activity, large cones of depression will develop that may adversely affect local groundwater availability and stream baseflows.

Surface mining produces large areas of disturbed land that is highly erodible, and if techniques for sediment control are not used, large quantities of sediment are contributed to surface streams. In addition, the processing of many mined materials produces large quantities of silt which can be damaging to surface streams. Where possible, settling ponds or lagoons should be used to allow suspended solids to settle out so clear water can be recycled. Closed water circuits are often used for economic reasons for the prevention of stream pollution.

In general, the noncoal mining industries in the study area cause only siltation problems. However, one possible exception is the mining of shale associated with coal, in which case acid mine drainage is produced because of the pyrite in the shale.

1. *Coal*

Anthracite is the major mineral resource of Subbasin 5 as shown on Figure 4. The most valuable anthracite seams occur in the Post-Pottsville Group, of Pennsylvanian Age. The beds have complex folding and faulting, enhancing access to the numerous seams. Coal seams crop out at elevations up to 1,400 feet above sea level, and some seams have been traced to depths of 1,500 feet below sea level. Twenty-three separate coal beds can be differentiated in a columnar section through the Northern Coal Field, which is located in this area.

Anthracite is mined primarily by strip and deep mining, and to a lesser extent, dredging methods in Lackawanna and Luzerne Counties. These counties contain the Northern and Eastern Middle Anthracite Coal Fields. Production in 1973 was slightly over two million tons, following a general decrease until 1972.[10]

As a result of the oil embargo and the newly-recognized energy "crisis", the production of anthracite has begun to increase. The low sulfur content of anthracite makes it environmentally attractive for utility and industrial use in the populous eastern states, which are concerned about air pollution.

Recent estimates indicate that approximately one-third of the valuable coal has been mined. The remaining coal comprises the seams that are more difficult to mine; hence, further recovery will be increasingly expensive. However, since the oil embargo, anthracite prices have risen dramatically, resulting in increased production. Reserves of potentially recoverable coal[11] are estimated at 390 million short tons for Lackawanna County and 1,735 million short tons for Luzerne County. New technology is capable of economically mining much of these reserves, particularly at the new price levels.

An assessment of coal as a valuable commodity and resource in the study area must consider the economic trend of the Nation and the new interest in domestic, low sulfur substitutes for oil and gas. Present conditions (cost to mine versus price per ton) relegate much of the spectacular numerical reserves to the status of "well worth mining". This is especially true of the anthracite fields. Increases in price or uses, as in conversion from oil or gas, coupled with new advances in mining technology, could render mining more of this coal a worthwhile opportunity.

2. *Shale and Clay*

Shale is used for fill by township road departments throughout the study area. It is generally quarried in small pits near the site of use. In one case, shale is mined from accumulations of carbonaceous shale left by early anthracite mining near Wilkes-Barre. Clay for brick is mined near Hazleton. Large reserves of clay are available in the subbasin.

3. *Peat*

Peat occurs in swamps and bogs in Lackawanna and Luzerne Counties. The swamps are in closed-surface depressions over glaciated Paleozoic sedimentary rock, and in ponds left after the retreat of the Wisconsin Age glaciers. A recent study by Cameron (1970) indicated reserves of approximately 13 million short tons. Use of peat as a soil conditioner and proximity to the populated eastern seaboard would indicate a favorable future economic output. In 1966, Pennsylvania's output of 50,000 tons was second in the United States. Although peat remains a significant economic resource of the area,

[10] U.S. Bureau of Mines, *The Mineral Industry of Pennsylvania*, (1972).

[11] William E. Edmunds, *Coal Reserves of Pennsylvania - Totally Recoverable and Strippable*, (Pennsylvania Topographic and Geologic Survey, IC. 72, 1970).

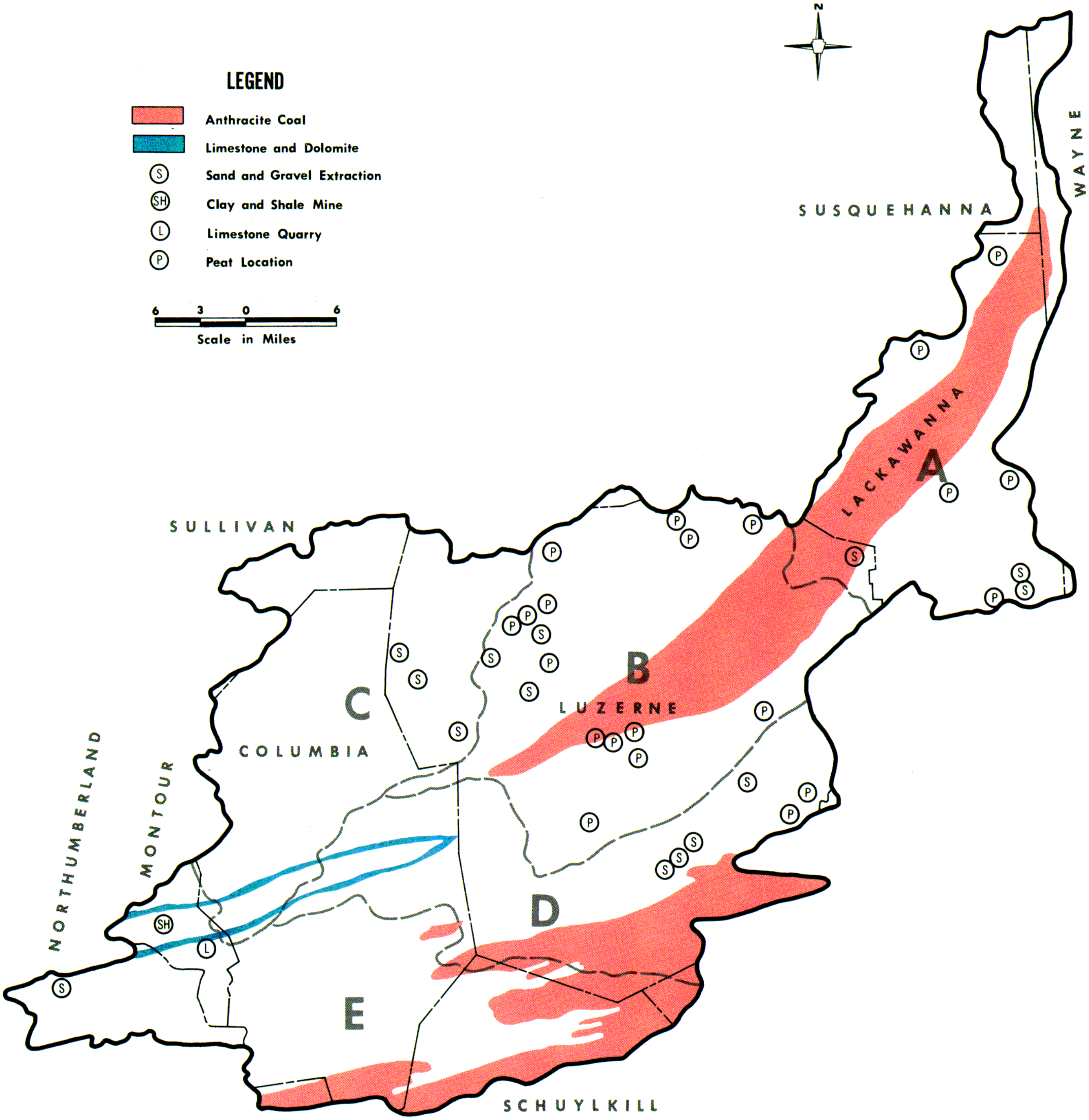


FIGURE 4. Mineral Resources

recent Commonwealth policy proposals for protection of wetlands may have effects on future production levels.

4. *Sandstone*

Crushed sandstone is marketed by at least two firms in Luzerne County. With large reserves, this production is likely to continue for a great many years.

5. *Sand and Gravel*

Deposits of sand and gravel occur primarily along the Susquehanna River and its major tributaries. Inspection of USGS topographic maps reveals hundreds of small sand and gravel pits. These deposits are generally for one-time usage.

G. SOILS

Soil characteristics influence precipitation after it comes in contact with the earth's surface. Coarse-textured soils enhance infiltration to the water table, while fine-textured soils have slow infiltration rates and produce high runoff. Water in contact with soil may leach out soil ions, thereby changing the chemical composition of both the infiltrating water and the soil. The general properties of soils help to determine their suitability for on-lot disposal and land disposal through their wastewater renovating potential. Poor soil suitability means disposal systems will eventually pollute the groundwater or surface waters, or both. The suitability of subbasin soils for waste disposal is mapped and discussed in more detail in the Comprehensive Water Quality Management Planning (COWAMP) study area reports.

The soils of Subbasin 5 can be divided into three broad groups based on association with a specific parent material. These groups are: 1) soils formed in materials weathered from noncarbonate sedimentary rocks, 2) glacial till, and 3) unconsolidated water sorted materials. The groups are listed in Table 4 along with soil substrata and association, and displayed on the general soil map, Figure 5. In addition, soils can be further categorized by hydrologic groups, which are also listed on Figure 5. The hydrologic groups are determined by a soil's infiltration rate, which is dependent on the soil's physical and chemical composition, dominant slope, and depth of soil profile as discussed in Appendix A-1.

Subbasin 5 lies within the Appalachian Mountain Section of the Valley and Ridge Province and contains three main streams whose surrounding soils were formed from unconsolidated water sorted materials. The three streams are Fishing Creek, the Susquehanna River, and the Lackawanna River. The bands of soil that follow these streams are 72 inches or more deep and well drained, and they have moderate to high infiltration rates. As a result, runoff potential is low, even when the soil is thoroughly wetted.

In the southern portions of the subbasin, the soils have been formed from materials weathered from noncarbonate sedimentary rocks. These substrata are mainly composed of sandstones and shales that form synclines containing mineable anthracite coal beds. With the exception of the southern tip of Luzerne County, which has soils in the B group, the soils of this area have slow infiltration rates typical of the C group. Throughout the whole southern portion of the subbasin, the dominant slope ranges from 3 to 35 percent and soil depths vary from 30 to more than 70 inches.

Soils in the remainder of the subbasin were formed from glacial till. The majority of these soils have slow infiltration rates. However, a large portion of glacial soils near the southern portions of the Susquehanna River and Fishing Creek have faster infiltration rates representative of the B hydrologic group. All of the soils of glacial origin have depths ranging from 30 to 60 inches and dominant slopes varying from 3 to 45 percent. Under these soils lie substrata of sandstones, shales, and some limestone. In addition, an elongated basin or syncline extends from the northeastern tip of the subbasin down through the center of Luzerne County. This syncline contains anthracite coal that is preserved in the surrounding shales and sandstones of the area. Heavy mining in the area has greatly affected infiltration, drainage, and runoff rates.

H. FOREST RESOURCES

Forests affect water resources in both a protective and a depletive manner. They offer protection from floods and erosion, while at the same time contributing to the depletion of streamflows. The latter occurs primarily during the growing season.

Forest soils are covered with litter (leaves and twigs), which acts as a protective layer to the soil and reduces the possibility of sheet erosion caused by raindrop splash and impact on soil. In addition, litter decays and becomes humus, which helps to form a highly permeable layer of soil, in which infiltration rates usually exceed rainfall intensities[12]. This retards runoff from heavy rainfall, thus reducing downstream flood peaks.

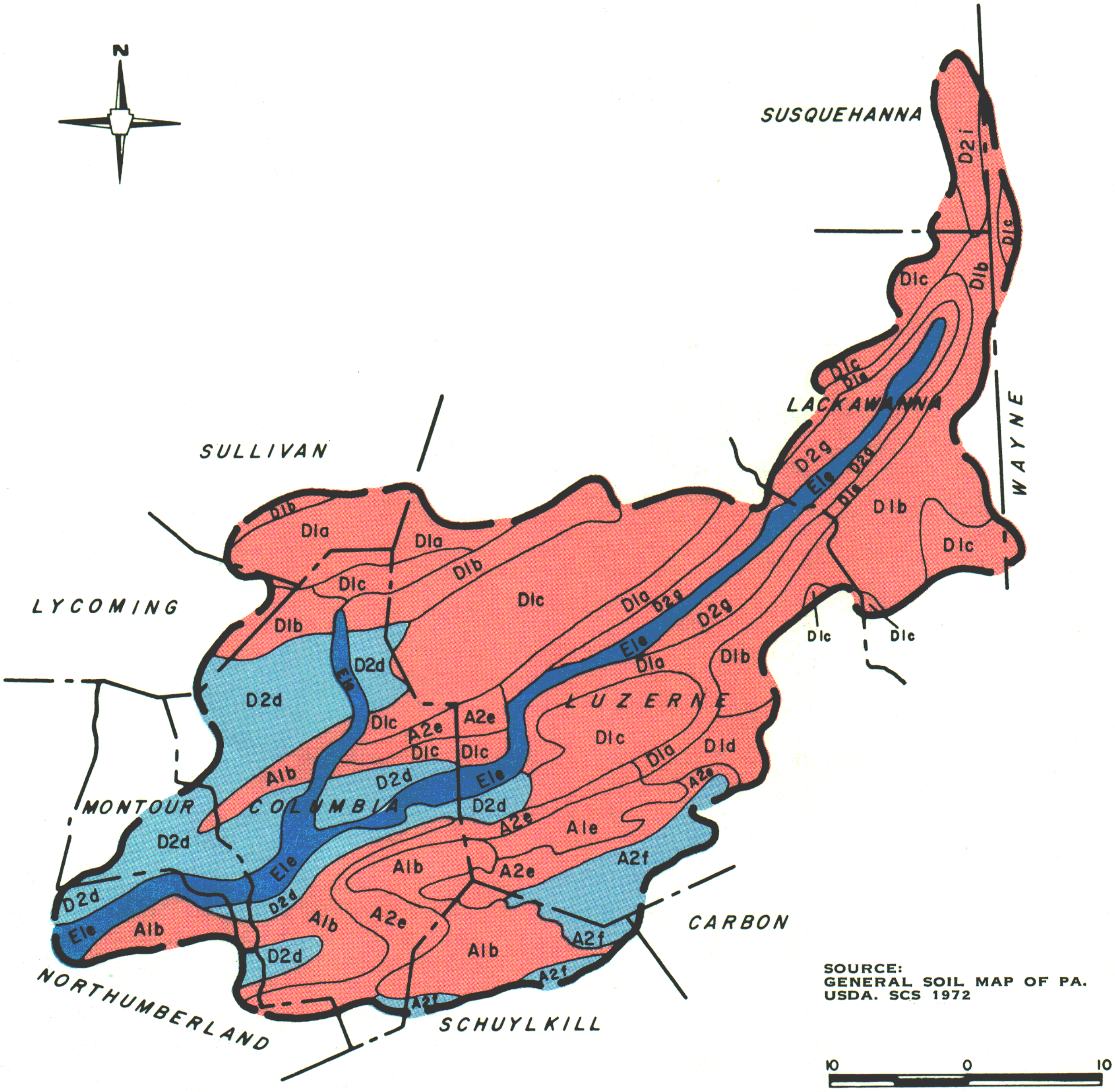
However, where the forest floor becomes disturbed, particularly through activities associated with logging, such as the construction of roads, skid trails, and landings, the potential for erosion increases. Soil loss then becomes a function of soil erodibility as well as the length and steepness of slopes.

The amount of soil reaching a stream is affected by the care used in locating and draining the logging road system and maintaining it after logging. For example, one study found that the maximum turbidity from a cutover watershed with no road plan and no provision for drainage was 56,000 parts per million.[13] However, on a similar cutover watershed, with careful planning and drainage, the maximum turbidity was only 25 ppm.[14] For an uncut watershed, the maximum was 15 ppm.

[12]H.W. Lull and K.G. Reinhart, *Research Paper NE-226, Forests and Floods in the Eastern United States*, (USDA Forest Service, Upper Darby, Pennsylvania, 1972).

[13]K.G. Reinhart, A.R. Eschner and G.R. Trimble Jr., *Research Paper NE-1, Effect on Streamflow of Four Forest Practices in the Mountains of West Virginia*, (USDA Forest Service, Upper Darby, Pennsylvania, 1963).

[14]ppm – parts per million



LEGEND

A	(Low runoff potential.) Soils having high infiltration rates even when thoroughly wetted. These consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission in that water readily passes through them.
A–B	Combined properties of soil groups A and B.
B	Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
B–C	Combined properties of soil groups B and C.
C	Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
C–D	Combined properties of soil groups C and D.
D	(High runoff potential.) Soils having very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

FIGURE 5. General Soils and Hydrologic Characteristics

Table 4

SOIL ASSOCIATIONS

A. Soils formed in materials weathered from noncarbonate sedimentary rocks.

- A1. Substrata of reddish sandstone, shale and siltstone
  - A1b. Calvin-Leck Kill-Meckesville association
  - A1e. Meckesville-Albrights association
- A2. Substrata of yellowish and brownish sandstone, shale and siltstone
  - A2e. Dekalb-Laidig-Buchanan association
  - A2f. Edgemont-Hazleton association

D. Soils formed in glacial till

- D1. Substrata reddish
  - D1a. Oquaga-Lordstown association
  - D1b. Oquaga-Wellsboro-Morris association
  - D1c. Morris-Wellsboro-Oquaga association
  - D1d. Wellsboro-Morris-Lackawanna association
- D2. Substrata grayish
  - D2d. Hartleton-Berks-Watson association
  - D2g. Swartswood-Wurtsboro association
  - D2i. Volusia-Mardin-Lordstown association

E. Soils formed in unconsolidated water sorted materials

- E1. Substrata of stratified fluvial sand, silt, gravel
  - E1a. Chenango-Howard-Pope association

A more recent study in central Pennsylvania reported similar results[15]. Maximum storm turbidity during logging was 550 ppm and could be traced to scarified log loading areas. This decreased immediately after completion of logging and averaged only 11 ppm the following year. On an adjacent watershed, storm turbidity never exceeded 25 ppm during the logging period and averaged less than 5 ppm after logging. These studies emphasize the fact that with careful planning of timber harvesting operations, water quality can be preserved through the reduction of erosion and sedimentation.

Forests reduce water yield because they consume large amounts of water through transpiration. It has been estimated that, in the northeast, 40 to 60 percent of all precipitation is returned to the atmosphere through the combined processes of evaporation and transpiration and never reaches the groundwater or streams[16].

In view of this, the potential for increasing water yield through properly managed forest cutting practices exists. Several studies, carried out by the U.S. Forest Service, The Pennsylvania State University, and others have documented this potential. Maximum annual increases in water yield by harvest cutting under an even-aged management program, with provision for a protective ground cover, have been found to be about 10 inches or 270,000 gallons per acre cut[17]. In contrast, for an equal volume of timber removed, a selection cutting will provide no more than one-fourth of the increase resulting from the clearcut[16].

Experiments have shown that streamflow increases are largest the first year after timber harvesting. In subsequent years, as regrowth continues, the transpiring surface area increases and the streamflow increase diminishes[18]. Therefore, if maintaining the maximum yield is the primary objective of the watershed management program, forest regrowth will have to be controlled. This will eventually result in a closed cover of herbaceous and low shrubby growth which will prevent

[15]J.A. Lynch, W.E. Sopper, E.S. Corbett and D.W. Aurand, *Technical Report NE-13, Effects of Management Practices on Water Quality and Quantity: The Penn State Experimental Watersheds,* (USDA Forest Service, Upper Darby, Pennsylvania, 1973).

[16]H.W. Lull and K.G. Reinhart, *Paper NE-66, Increasing Water Yield in the Northeast by Management of Forested Watersheds,* (USDA Forest Service, Upper Darby, Pennsylvania, 1967).

[17]H.W. Lull, *Effects of Trees and Forests on Water Relations,* (University of Massachusetts, Symposium on Trees and Forests in an Urbanizing Environment, 1972).

[18]James E. Douglas and W.T. Swank, *Research Paper SE-94, Streamflow Modification through Management of Eastern Forests,* (USDA Forest Service, 1972).

site deterioration and adverse water quality effects. Because of variability in factors such as climate, slope, direction of slope, soils, and geology, a considerable variation in the amount and timing of the water yield increase may exist between different watersheds.

Presently, 56 percent or 628,893 acres of Subbasin 5 is forested. However, by 2020 this is expected to increase to 65 percent or 717,751 acres. Most of this increase will be due to abandoned crop and pasture land reverting to forest cover. Table 5 indicates the forested acreage within the subbasin portion of each county in Subbasin 5.

Table 5

FOREST LAND DISTRIBUTION

County	Total Acres Within Subbasin (1,000's)	Forested Acres (1,000's)	Percent Forested
Carbon	1	1	100
Columbia	291	144	49
Lackawanna	167	79	47
Luzerne	457	274	60
Lycoming	6	5	83
Montour	33	14	42
Northumberland	42	15	36
Schuylkill	50	32	64
Sullivan	35	35	100
Susquehanna	27	15	56
Wayne	17	14	82
Total	1,126	629	56

Source: U.S.D.A. Forest Service, 1974

Table 6

FOREST LAND BY FOREST COVER TYPE

Forest Cover Type	Acres	Percent
Oak-Hickory	271,102	43.1
Maple-Beech-Birch	118,232	18.8
Aspen-Birch	83,593	13.3
Elm-Ash-Red Maple	76,725	12.2
White Pine	60,375	9.6
Virginia-Pitch Pine	12,578	2.0
Other Oak Types	6,288	1.0
Total	628,893	100.0

Source: U.S.D.A. Forect Service, 1975

Major forest cover types existing in the subbasin include oak-hickory, maple-beech-birch, and aspen-birch. Other cover types include elm-ash-red maple, white pine, Virginia-pitch pine, and other oak types. Table 6 contains the acreage distribution of each of these categories.

With the majority of the subbasin's timber resources belonging to the oak family, insect damage that is limited primarily to oaks can have a serious effect. Studies indicate that two consecutive years of heavy defoliation may kill about 30 percent of the oaks, and after three years of heavy defoliation the oak mortality may be 60 percent or more.

During 1976, statewide gypsy moth defoliation increased by an unexpected 130 percent over that reported in 1975. Much of this increase resulted from a rebuilding of gypsy moth populations where infestations had largely collapsed following severe defoliation in 1973. For example, in 1975, Columbia, Lackawanna, Luzerne, and Montour Counties had 1,215, 2,410, 19,340, and 15 acres defoliated respectively. However, in 1976 these totals increased to 27,530, 22,770, 43,960, and 9,600 acres respectively.

I. FISH, WATERFOWL, AND FURBEARER RESOURCES

1. *Fish*

The fisheries resources of Subbasin 5 have been and are being impacted by acid mine drainage, industrial and municipal waste discharges and nonpoint sources of siltation. Almost half of the main stem of the Lackawanna River and smaller tributaries to the North Branch Susquehanna River, such as Solomon Creek, Warrior Creek, Nanticoke Creek, Newport Creek, Nescopeck Creek and Black Creek in Luzerne County and Catawissa Creek in Schuylkill and Columbia Counties have nonexistent fish populations. As a result of acid mine drainage, the fishery resources potential of the North Branch Susquehanna River within the subbasin has been far below its full potential. As a result of this impact, all of the significant fisheries throughout the subbasin are located on the few smaller watersheds that have no mining activities and on a few small impoundments in the subbasin.

The major drainages that support naturally reproducing trout populations in the subbasin consist of the East and West Branches of the Lackawanna River in Susquehanna and Wayne Counties; Roaring Brook, Spring Brook and Rattlesnake Creek in Lackawanna County; Harvey Creek, Hunlock Creek, Big and Little Wapwallopen Creeks, Pine Creek, Arnold Creek, Kitchen Creek and Phillips Creek in Luzerne County; Huntington Creek, Big and Little Fishing Creeks, and Roaring Creek in Columbia County; Mahoning Creek in Montour County; and Little Catawissa Creek in Schuylkill County. Many other groups of streams with water quality suitable

Table 7

TOTAL NUMBERS OF FISH STOCKED

County	Cold-Water 1970[a]	Cold-Water 1975[a]	Warm-Water 1970[a]	Warm-Water 1975[a]	Total 1970[a]	Total 1975[a]
Columbia	48,150	65,970	2,250	1,260	50,400	67,230
Lackawanna	45,250	83,450	1,430	3,380	46,680	86,830
Luzerne	168,090	151,000	6,800	361,700	174,890	512,700
Montour	2,970	10,000	415,090	–	418,060	10,000

[a]Fiscal year (1970 would be June 1, 1970 to June 30, 1971)

Source: Pennsylvania Fish Commission

for a catchable trout program are located within the subbasin and are used to the maximum extent permitted by Pennsylvania Fish Commission policy. In addition to the streams that can support a catchable trout fishery, several lakes and small impoundments in the subbasin support an intensive winter and spring catchable trout program. Most notable of these are Harveys Lake and Sylvan Lake in Luzerne County.

The lower half of the Lackawanna River is depressed by acid mine drainage, treated and untreated industrial and municipal wastes, and it is devoid of fish life. The main warm-water stream fishery in the subbasin consists of the North Branch Susquehanna River, which supports natural walleye and smallmouth bass populations along with stocked muskellunge. The major impounded waters in the subbasin that contain significant largemouth bass and esocid populations are Frances Slocum State Park Lake, Lily Lake and Lake Jean in Luzerne County, and Briar Creek Reservoir in Columbia County. The majority of impoundments in the area are water supply reservoirs, which provide a very limited fishery by permit only.

Considering the population density of Subbasin 5 and the high demand for recreational fishing, the only hope for expanding the resource to meet the demand is through mine drainage reclamation in the entire lower Lackawanna River and North Branch Susquehanna River drainage and the upgrading of industrial and municipal waste treatment. Much of the present habitat in the Lackawanna River is ideal for smallmouth bass and walleye.

A specific list of the gamefish that are stocked and/or reproduce in the subbasin includes brook, brown, rainbow and lake trout, small and largemouth bass, walleye, and muskellunge. Nongame species include brown bullhead, channel catfish, smelt, carp, numerous sunfish and minnows. Figure 6 shows the streams which presently support cold- and warm-water fisheries.

As indicated by Table 7, the total number of trout stocked within each county has increased substantially during the past six years. This increase reflects the general statewide increase of hatchery production. The initiation of a different allocation formula that considers the acres of public land, number of licenses sold and population in each county, has enabled the Fish Commission to better manage the available water resources in the subbasin as far as a catchable trout fishery is concerned.

There has been no substantial increase in warm-water fish committed to the streams and lakes of the area. At the present time, the impoundments of the area are managed as closely as possible under present programs, as are the small reaches of warm-water streams and rivers. The problem of poor or marginal water quality is evident and reduces the manageable resources considerably.

The most promising possibility for expanding the warm-water fishery resource of the area lies in the restoration of anadromous fishes to the North Branch Susquehanna River and in obtaining fishing rights on the private lakes and water supply reservoirs within the subbasin. At the present time, there are approximately four or five times as many surface acres of impounded private waters within the subbasin as there are surface acres of public impoundments. This represents a substantial potential for expanding the fishery resource of the area if negotiations with reservoir owners are successful. Another substantial area for expanding the fishery resources is the possibility of getting fishing-permitted areas on waters owned by private individuals along the smaller streams of the subbasin.

2. *Waterfowl and Furbearers*

Numerous lakes and ponds are found throughout the northeast portion of Subbasin 5. Although most of these have a low to moderate value as waterfowl habitat, there is a resident population consisting primarily of black, mallard, and wood ducks. In addition to providing habitats, these lakes, ponds and surrounding wetlands are highly valuable as resting areas for migrating waterfowl following the Atlantic flyway.

Furbearers needing water as a habitat include beaver and muskrat. In addition, mink prefer watercourses as part of their habitat. All of these species are found within the subbasin, with a high population of beaver occurring in Luzerne County, a medium population in Lackawanna County, and a low population in Columbia County. Occasionally an otter sighting is reported in Luzerne or Susquehanna Counties.

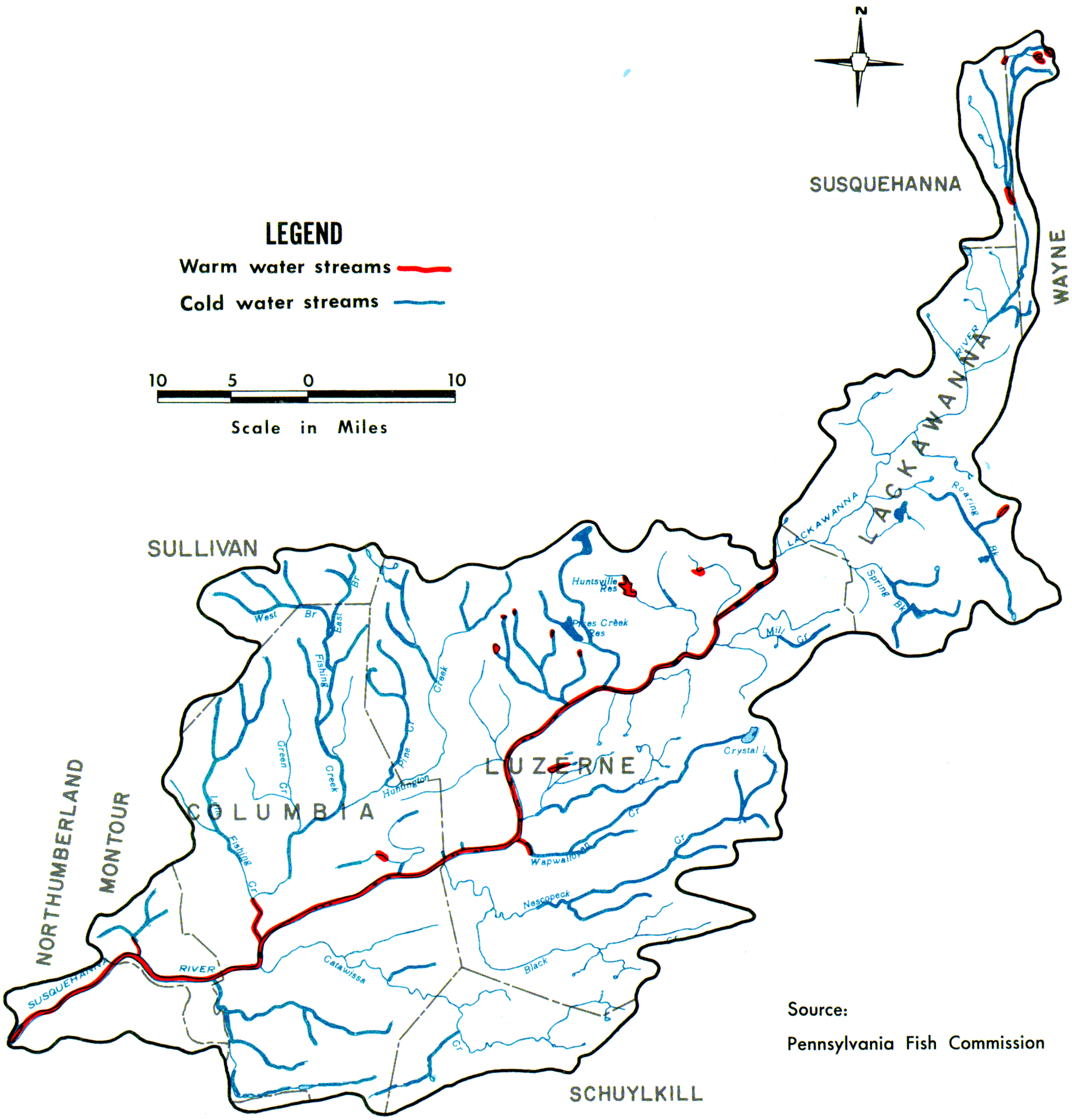


FIGURE 6. Warm- and Cold-Water Fisheries

IV. SOCIO-ECONOMIC FEATURES

Water resources cannot be managed based on physical characteristics alone. Socio-economic factors play just as much a part in water management as do physical and environmental factors. This chapter, after an initial discussion of the historical development of the area, describes the basic social and economic characteristics which were used in developing this study's conclusions and recommendations. As was true of Chapter 3, the information presented in this chapter was developed by or from information provided by other agencies. The Office of State Planning and Development was responsible for much of the information presented in this chapter, along with the U.S. Department of Agriculture's Economic Research Service and the Economic Development Council of Northeast Pennsylvania.

Again the discussions in this chapter are not rigorous. More detailed data for the subjects presented is available from the responsible agencies. In the particular case of land use, significantly more detailed data is now available from several sources including the LUDA system of the United States Geological Survey. Although this more recent land use data was not available for use in the development of this planning report, future water resources planning in conjunction with the State Water Plan will certainly make use of the most up-to-date information available.

It should also be emphasized that statewide plans involving economic development and land use management as well as transportation planning are currently in progress within the responsible State agencies, and coordination with those planning efforts has been a key element in the development of the State Water Plan.

A. HISTORICAL SETTING

The Lackawanna and Wyoming Valleys are located within Subbasin 5. This area is located in the heart of the anthracite region, through which the Susquehanna River winds in a southwesterly direction. Major towns and cities are situated along or near the river, the main artery for communication and trade. In the past it was also the source of power for the gristmills and sawmills which provided flour and building materials for the early settlers.

About the middle of the eighteenth century, white settlers came and lived amicably with the Indians for a time. Many of these settlers were from Connecticut, as Wilkes-Barre and the surrounding region became a strategic point in the long conflict between Pennsylvania and Connecticut over the Wyoming lands. As early as 1755, the Susquehanna Company from Connecticut tried to colonize the region, although the Penns claimed ownership under the Royal Deed of 1681. The Connecticut settlers built Fort Durkee and laid out Wilkes-Barre; and by 1771, they controlled the Wyoming Valley. Seven years later the Indians and Tories swept through the valley leaving the town of Wilkes-Barre in smoldering ruins. The "Wyoming Massacre" at Forty Fort in 1778, spread panic throughout the region, and the valley was depopulated by white settlers; it remained virtually uninhabited until 1788. Then Philip-Abbott, who had migrated from Connecticut to the Wyoming Valley before the Revolution, came to the area and built a log hut and gristmill beside Roaring Brook. Eventually other settlers followed. After a period of confusion during which Pennsylvania governed a region populated by settlers loyal for the most part to Connecticut, the controversy was brought to the new Congress. Pennsylvania's claim to the Wyoming Valley was favored, and Connecticut formally released its claims to the area by 1800.

Meanwhile, the County of Luzerne was created; and in 1806, Wilkes-Barre was incorporated as a borough. A few years later, veins of hard coal discovered in the early 1760's were recognized as a source of great potential wealth and the anthracite industry in the Wyoming Valley was born. By 1812, Wilkes-Barre had grown from a handful of people to a small town, but it was many years before it changed from a farming to an industrial center. Development of canals and railroads in the second quarter of the century, in addition to the growing demand for hard coal as a domestic fuel, gave impetus to the anthracite industry.

Scranton, capital of the anthracite basin, lies in the narrow, crescent-shaped Lackawanna Valley. Mountains surround most of the city; to the north and east lies Moosic Mountain, and to the west the West Mountain. Now larger than Wilkes-Barre, Scranton's development was started in 1840, when George and Selden Scranton, attracted by the abundance of iron ore and anthracite, organized the firm of Scranton, Grant and Company and built a forge. This firm was the nucleus of the Lackawanna Iron and Steel Company, which developed when the Scrantons successfully manufactured iron using anthracite as a fuel. The Scrantons called the settlement Harrison, in honor of President Harrison, but the post office was Scrantonia. Eventually, the town and the post office were called Scranton.

Iron was shipped either to Philadelphia, down the Lackawanna and Susquehanna Rivers to the Union Canal, or down the Susquehanna to Baltimore. The trips down the river were long, dangerous and expensive. Often, the rafts and arks broke up in the rapids, since the trips could only be made when the river was at flood stage. Because the river was only navigable for a short season, everyone's cargo arrived at the market place simultaneously, which drove prices down. However, in 1853 the first locomotive of the Delaware and Lackawanna Railroad came to the area, greatly expanding the market for the iron industry. Shipments could be made safely, continuously and cheaply.

Development of the coal mines in this subbasin attracted thousands of immigrants. Until 1870, most immigration was from northern Europe and the British Isles, with the Irish predominating. Then, mine operators sent representatives to central and southern Europe to induce peasants to come to the coal fields. Many came and the population thereafter increased rapidly.

During the latter decades of the nineteenth century, a number of large manufacturing plants were drawn to the area by cheap coal, and extensive railroad facilities were established. These plants manufactured everything from miner's caps to small locomotives and cables. The supply of female labor and available water power attracted textile mills; the first lace manufactured in the United States was made in this area in 1885. Scranton and Wilkes-Barre became lace manufacturing centers.

Although there was diversified manufacturing, the most significant economic activity depended upon coal. By 1917, the anthracite industry had reached its peak; and by 1922, it had dropped one-half in production and thereafter continued a general decline. Because it was cleaner than soft coal, anthracite had been the fuel used for domestic heat, but fuel oil and natural gas later became more convenient for the home owner and the market for anthracite was lost.

The decline of the anthracite industry caused hardship and unemployment for many in the area. Moreover, years of careless mining had left blackened hills, scarred mountains, and unsightly coal refuse piles. There recently has been a strong local movement to attract new industry and improve the environment in this region. With much community and State effort, new jobs have been created and the region has exhibited some growth.

B. ECONOMY AND EMPLOYMENT

Economic development is closely related to the availability, development, and use of water resources. Past economic conditions have dictated the extent to which water resources have been utilized. Therefore, a forecast of economic conditions will help to determine when and to what extent future water resources development is likely to occur. The most fundamental concept which can be used to define Pennsylvania's future economy is employment[19]. By observing which types of employment exist in the subbasin and the trends of each type, general observations concerning the possible trends in water resources development and use can be made.

Subbasin 5 falls within three labor market areas whose boundaries do not strictly coincide with the subbasin. The Berwick-Bloomsburg Labor Market Area, which includes all of Columbia County, is located almost entirely within the subbasin. The Wilkes-Barre Labor Market Area includes all of Luzerne County; however, certain portions of the county lie outside the subbasin. These sections include approximately the northern fifth and southern fifth of the county. Similarly in the Scranton Labor Market Area, which includes all of Lackawanna County, only the central portion of the county lies within the subbasin.

Employment by industry for 1970 and projections for 1990 for each of the three labor market areas are listed in Table 8[20] Most of the categories in all three labor market areas are expected to increase in employment during the twenty-year period. Those categories expected to decline in employment include *Agriculture* and *Mining* in all three labor market areas. The *Transportation, Communication and Public Utilities* category is projected to decline in employment in the Scranton Labor Market Area only.

Employment trends in *Agriculture, Mining, Contract Construction* and *Manufacturing* industries are more closely related to water use than are the remaining five categories in Table 8. Although employment in the *Agriculture* category is projected to decline, two key factors, the value of farm produce and total acres harvested, have both increased during the past five years[21]. In addition, the amount of vegetable acres, on which irrigation may be used, has also increased. Therefore, even though employment in *Agriculture* is projected to decline, it would appear the use of water, especially for irrigation, is going to continue to expand.

Similarly, although the number of employees in mineral industries is expected to decline, DER information indicates that water use by mineral industries will continue to grow gradually for the next 20 years. For all three labor market areas, increases in employment are projected in the *Contract Construction* industry. Some of this construction represents new development, including urbanization. Water use will increase with this apparent build-up. The most important category as far as water use is concerned is *Manufacturing*, which also shows an increase in employment. This implies increased production which could require more water use. In this subbasin, primary water users include paper, food processing, tobacco, fabricated metals, ceiling tile and asphalt paving industries.

Another measure of the subbasin's economy is found in the ranking of individual counties with regard to two factors: 1) Economic Growth and 2) Level of Economic Development. Economic Growth is based on a composite of equally weighted factors which generally describe each county's growth in terms of changes in population, market value of real estate, aggregate personal

[19]Office of State Planning and Development, *Pennsylvania's Economy, Interim Report Technical Working Memorandum No. 1, Pennsylvania Economic Program for Balanced Growth*, (Harrisburg, 1974), p.1.

[20]Office of State Planning and Development, *Employment, Pennsylvania Projection Series*, (Harrisburg, 1973).

[21]Bureau of Statistics, *Pennsylvania Statistical Abstract 1971 and 1973*, (Department of Commerce, Harrisburg).

Table 8

HISTORICAL AND PROJECTED EMPLOYMENT BY INDUSTRY

	Labor Market Area					
	Berwick/ Bloomsburg		Wilkes-Barre/ Hazleton		Scranton	
Industry	1970	1990	1970	1990	1970	1990
Agriculture	1,100	421	1,000	346	900	309
Mining[a]	32	19	2,141	379	425	111
Contract Construction	873	1,125	6,542	7,978	3,363	4,187
Manufacturing	11,771	15,520	52,406	60,858	34,112	38,544
Transportation Communication and Public Utilities	640	830	7,616	8,257	5,435	4,789
Wholesale and Retail Trade	3,125	3,633	24,878	27,384	20,525	24,192
Finance, Insurance and Real Estate	441	586	4,457	5,130	2,999	3,757
Services	3,026	3,655	20,956	27,297	19,348	26,536
Government	2,400	3,402	15,600	24,601	10,000	13,713
Totals	23,407	29,190	135,596	162,230	97,106	116,137

[a]Employment in mining category may be affected by recent National energy policies.

Source: Pennsylvania Office of State Planning and Development, *Pennsylvania Projection Series*, 1973.

income and value added by manufacture. The level of Economic Development is also based on a composite of equally weighted factors which generally describe each county's status in terms of standards of living, industrial sophistication, economic diversification, urbanization, and infrastructure development. Growth was not a factor used in determining a county's development status. By utilizing a breakdown of counties into five categories: (1) high, (2) moderately high, (3) moderate, (4) moderately low, and (5) low, rankings of economic growth and economic development have been established by the Office of State Planning and Development[22]. Two counties, Columbia and Lackawanna, are experiencing moderate economic growth, while moderately high growth is occurring in Luzerne County. Luzerne County also enjoys the second or moderately high level of economic development, and Columbia County has attained the third or moderate level of economic development. In contrast to its third level of economic growth, Lackawanna is in the moderately high level of economic development along with Luzerne County.

C. POPULATION

Population projections for each of Pennsylvania's counties have been developed by the Office of State Planning and Development. Their projections of population are conceptually tied to the projections of economic trends, as discussed in the Economy and Employment section. To allocate the projected county populations to the watershed areas, population allocation models developed by State Water Plan staff were employed.

Projected populations were used directly to evaluate future water supply and waste treatment requirements. In addition, population distributions and concentrations are important factors in the analysis of the flood damage reduction needs, including urban storm runoff management, and industrial water supply and power generation cooling requirements.

Population figures and projections for Subbasin 5 from 1970 to 1990 are listed by watershed and county in Table 9. The majority of watersheds, and all but one county, are projected to experience increases in population from 1970 to 1990. Only Montour County is projected to decrease in population for one 10-year period, 1970 to 1980. During the overall 20-year period, however, all watersheds and counties are expected to increase in total population. The largest percentage increase in population should occur in Watershed C located in Columbia County, although it should be noted Watershed C has the smallest population base of all five watersheds.

The largest population centers are located in Watersheds A and B in Lackawanna and Luzerne Counties, as indicated on Figure 7. In Watershed A, population is concentrated along the Lackawanna River from Old Forge in the south to Carbondale in the north, including the City of Scranton. The Scranton urbanized area has experienced a three percent decrease in

[22]Fritz J. Fichtner Jr. and Fong L. Ou, *Comparative Study of Economic Development in Pennsylvania*, (Office of State Planning and Development, Harrisburg, 1973).

Table 9

WATERSHED AND COUNTY POPULATIONS

Watershed	1970	1980	1990	Percent Increase
A	230,742	238,258	253,822	10.0
B	240,353	250,080	264,850	10.2
C	21,750	24,305	27,190	25.0
D	74,620	80,942	87,269	17.0
E	42,572	44,445	48,396	13.7
Total	610,037	638,030	681,527	

Source: DER allocations of O.S.P.D. county projections, 1973.

County	1970	1980	1990	Percent Increase
Lackawanna	234,192	249,456	273,500	16.8
Luzerne	342,478	360,661	384,510	12.3
Columbia	55,163	60,325	66,572	20.7
Montour	16,520	16,476	17,735	7.4

Source: Office of State Planning and Development, 1973.

population from 1960 to 1970. Although the central city population declined seven percent during the 10-year period, the decline in central city population was slightly offset by a rise of one percent in the population of Scranton's urban fringe.

In Watershed B population is concentrated along the Susquehanna River from Nanticoke in the south to Pittston in the north, centered on the City of Wilkes-Barre. The Wilkes-Barre urbanized area experienced a four percent decrease in population from 1960 to 1970. The central city population has, like Scranton, decreased seven percent during the 10-year period. Unlike Scranton's, Wilkes-Barre's urban fringe has experienced a population decrease of three percent from 1960 to 1970.

Population concentrations in Watershed D are located along the Susquehanna River in the communities of Berwick and Bloomsburg in Columbia County, and in the City of Hazleton on the southeast border of Subbasin 5 in Luzerne County. Watershed E population is concentrated along the Susquehanna River in the community of Danville in Montour County.

D. TRANSPORTATION

Transportation is a key factor in the establishment of a sound economic base in any area. Historically, early waterborne transportation was important to the development of this subbasin, as was rail transportation later. In more recent times, highway networks have affected water resources development in many ways. Construction of the National Defense Interstate Highway System in Pennsylvania was used to spur economic development in the Commonwealth's more remote areas. Interstate spurs and State highway projects open new areas to all forms of residential, commercial and industrial construction. Such development creates new demands on water as well as land resources. Highway construction may also affect water resources directly by interfering with natural drainage patterns over extensive areas.

The most important method of transportation available today in terms of moving people and goods, as well as influencing land development, is the highway system. Two major highways traverse the subbasin in a north-south direction. The first is the Northeast Extension of the Pennsylvania Turnpike connecting Scranton/Wilkes-Barre with Philadelphia. The second, Interstate 81, links Scranton/Wilkes-Barre with Binghamton, New York to the north and Harrisburg to the south. A shorter major highway, Interstate 380, connects Scranton with the Pocono region. Two major east-west highways cross the subbasin: Interstate 80, the Keystone Shortway, which passes through the southern portion of the subbasin connecting eastern and western Pennsylvania with New Jersey and Ohio; and Interstate 84, a much shorter route connecting Scranton with New York State to the east.

Railroads provide a necessary service to industrial and commercial establishments. Most of the railroad freight service in the subbasin is provided by the former Penn Central Railroad, now part of the Conrail

System. The former main line of the Delaware, Lackawanna, and Western Railroad, later the Erie-Lackawanna, is now a ConRail main line. It runs from Hoboken, New Jersey through East Stroudsburg and Scranton to Binghamton, New York. ConRail is downplaying the role of this line in moving east-west traffic. On the other hand, it has increased use of the former Lehigh Valley main line which runs along the Lehigh River and then ascends Penobscot Knob, dips down into Dupont, across the valley to Duryea, and then proceeds up the Susquehanna River to Tunkhannock and Elmira.

The Delaware and Hudson Railroad provides run-through service from New England and Canada to Washington, D. C. It parallels the Lackawanna River north of Scranton. Then it uses a former Penn Central line on the south side of the Susquehanna River. On the north side of the Susquehanna River, there used to be a parallel line all the way from Scranton to Northumberland, but with the advent of ConRail, service ceased in the mid-section between Phymouth and Beach Haven.

There are six airports in the subbasin, of which onlv one, the Wilkes-Barre/Scranton International Airport, provides daily commercial airline service to major east coast cities. Two general service airports are located near East Berwick and Pittston in Luzerne County, while two other general service airports are located to the north and west of Wallsville in Lackawanna County. In addition to airline and general service airports, a heliport exists to the northeast of Scranton near Dunmore.

With the exception of the Scranton/Wilkes-Barre urban areas, mass transit coverage is spotty. All passenger trains have disappeared except south of Pottsville, and intercity bus service has diminished in most areas over the years, leaving many small communities with little or no public transportation. Several bus companies are in immediate danger of terminating service because of heavy operating losses. These include the East Penn Transportation Company which serves a widespread area of Schuylkill County and the Jim Thorpe Transportation Company. All of these systems are eligible for PennDOT and Federal grants to help meet capital and operating costs. Taxicab service exists in 36 communities in the subbasin. It ranges from excellent in some parts of the region such as Wilkes-Barre, to nonexistent in many rural areas.

E. LAND USE

1. *Water Resources Implications*

The wise utilization of our land and water resources has emerged as an important concern during this decade. Because of the close environmental interrelationship existing between land use and water management, land and water resources cannot be viewed as separate entities. Land use patterns and decisions can exert a tremendous impact on the quantity, quality, and utilization of surface and groundwater. Also, hydrologic processes and water resources management decisions profoundly influence existing and future land use patterns in the subbasin.

Land uses have been broken into four categories for this report: *Urban or Built-Up, Agriculture* (including open, cropland and pasture), *Forest*, and *Other* (including Federal noncropland, water areas, disturbed land, and miscellaneous uses). Each of the land use categories can have a significant impact on water resources.

Urban or Built-Up areas consist of residential, commercial and industrial development. If the location, intensity and type of urban development is not properly planned and compatible with the surrounding natural environment, urbanization can adversely effect an area's water resources and overall environmental quality. For example, increases in impervious ground cover and the alteration of natural drainage patterns associated with urban development lead to increased surface runoff. Increased surface runoff causes greater flood magnitudes to occur more frequently, and increases the potential for increased erosion of the land and sedimentation of the streams. Impervious surfaces also decrease the amount of water infiltrating into the soil, thereby reducing recharge of groundwater supplies and lowering stream flows during droughts.

In addition, urbanization can also adversely influence surface water and groundwater quality. Water pollutants emanating from urban environments include discharges from sewage treatment facilities and industrial plants, as well as contaminants picked up by stormwater runoff. Finally, urban development of the floodplain increases flood damages and destroys the valuable resources and amenities of the floodplain environment.

Agricultural lands are important environmental resources because of their capability to produce food and fiber, to serve as valuable wildlife habitat and open space, and to provide attractive landscapes. Agricultural lands can serve as important groundwater recharge areas. Geological formations associated with prime agricultural soils often yield high quantities of groundwater.

Mismanagement of agricultural lands can create water pollution problems. Groundwater near agricultural areas becomes contaminated with nitrates and bacteria unless proper precautions are taken. Soil erosion increases the amount of sediment entering streams. Excessive applications of fertilizers and pesticides also degrade the water quality of surrounding streams.

Forests and woodlands provide valuable timber resources, wildlife habitat, recreational opportunities, and are important components of basin hydrology and water resources management. Vegetative cover decreases storm runoff, thereby reducing flood potential and soil erosion. Vegetative cover also increases the infiltration of water into the ground, which enhances groundwater recharge and supplies. Streams located in forested areas often serve as public water supplies, and properly managed forests will assure the protection of these supplies. However, the misuse of forest resources can degrade forest resource values and aggravate water resources problems.

The impacts of *Other* lands on water resources will depend upon the type of land use. Federal noncropland, water areas, and miscellaneous lands preserve land and water areas which can be used for water storage and supply. Disturbed lands or areas utilized for mineral extraction, on the other hand, could adversely affect water resources. Mineral extraction, especially for coal, can have a significant impact upon environmental quality and water resources management. The potential for blighted landscapes, interference with groundwater recharge, and water pollution are some of the problems which may be related to mining.

Conversely, water resources also play an important role in determining land use patterns. The Historical Setting section in this chapter describes how water resources influenced past settlement and economic development patterns in the subbasin. Water resources and decisions affecting their use will continue to exert a significant impact on emerging land use patterns.

For example, the construction of reservoirs may lead to the inundation of agricultural, forested and urban land, as well as increasing secondary development in surrounding areas by enhancing water supply and recreational opportunities. The extension of public sewer and water supply systems into rural areas can accelerate the conversion of agricultural and forested lands to urban uses. Flood plain management by local governments can decrease the amount of urban development occurring on the floodplain. Water supply deficiencies and consumptive water makeup requirements could also impact upon the expansion of urban development and agricultural water use in many watersheds throughout the State.

Many existing water resources problems have been precipitated and augmented by past land use practices. The historical development of Pennsylvania's floodplains has magnified the devastation and hardship created by recent floods. The impact of historic mining abuses continues to blight Pennsylvania's landscape and pollute water resources. Because of these precedents, current and future decisions affecting the management and development of land and water resources should not overlook the inherent and complex interrelationships between these resources.

The careful consideration of environmental factors in land and water resources planning and decision-making processes will help minimize environmental quality and resource management problems. Although environmental concerns comprise only one aspect of water resources management plans and decisions, their consideration in the planning process can establish a sound basis upon which social and economic land use objectives can be guided.

2. *Existing Land Use*

The number of acres and the percent in each land use category in the subbasin are shown in the left side of Table 10 and illustrated on Figure 7. At the present time, *Forest* is the dominant land use comprising 628,893 acres, which accounts for 57 percent of the total area. A second less extensive land use, *Agriculture*, encompasses 258,896 acres which amounts to 23 percent of the subbasin's area. *Urban* land use accounts for 13 percent of the total land area, or 146,980 acres. The smallest land use, *Other*, occupies approximately one-half the percentage and acreage of Urban.

Although a detailed breakdown of the four land use categories by acres and percent is not available on a watershed basis, this information is presented at the county level in Table 11. Using this table in conjunction with the Land Use Map (Figure 7), certain inferences regarding land use in the subbasin can be made. Located along the Susquehanna River Valley from Carbondale in the north to Nanticoke in the south, the population of Watersheds A and B in Lackawanna and Luzerne Counties is centered in the Scranton/Wilkes-Barre metropolitan area. Because of their large population bases, Watersheds A and B have the highest level of development in the subbasin. Nevertheless, the dominant land use in both watersheds is not *Urban*, but rather *Forest*, the original and least intensely developed of the four land use categories. The population and level of development in Watersheds C, D and E in Columbia and Luzerne Counties is less than that of Watersheds A and B. As was the case with Watersheds A and B, however, *Forest* is still the dominant land use in those three watersheds.

Some changes in land use patterns can be detected when comparing two land use maps compiled by the Office of State Planning and Development at the beginning and end of a thirty-year interval. The amount of land classified as *Urban* on the 1967 map, Figure 7, compared to the *Urban* land area on a 1937 map (not shown), has increased markedly in several areas[23]. Along the Susquehanna River Valley, expansion of Urban land has occurred in the communities of Danville, Bloomsburg, and Berwick. To the northwest of Wilkes-Barre, recreational stimulus has contributed to urban growth around the Dallas-Harvey Lake area. A third area of urban expansion is located in the community of Clarks Summit northwest of Scranton. In all cases, urban growth has taken place at the expense of land designated as average or above average farmland, according to the 1937 land use map. As new urban areas continue to expand into average and above average farm land, the diminution of prime agricultural land will be assured. The extent of possible loss in prime agricultural land is indicated by Table 12, which shows how much agricultural land is currently available and could potentially be lost to urban expansion in the absence of any zoning controls. In contrast to Montour and Columbia Counties, the loss of prime agricultural land to urban growth could be less pronounced in Lackawanna and Luzerne Counties. Nevertheless, the loss of prime agricultural land to urban use stimulates the cultivation of lands of lesser quality. The result is lower crop yield, higher cost, and more important, increased erosion and sedimentation which, in turn, adversely affects water quality and supply. Some mechanisms to preserve agricultural land which is subject to intense urban development pressure are listed in "A Land Policy Program for Pennsylvania,"[24] prepared by

[23]Pennsylvania State Planning Board, *Susquehanna, Potomac, Genesee River and Chesapeake Bay, Part III, Drainage Basin Study of Pennsylvania*, (Harrisburg, 1937), Map, p.4.

[24]Office of State Planning and Development, *Land Policy Program for Pennsylvania, an Interim Policy Report*, (Harrisburg, April 1976), p.40.

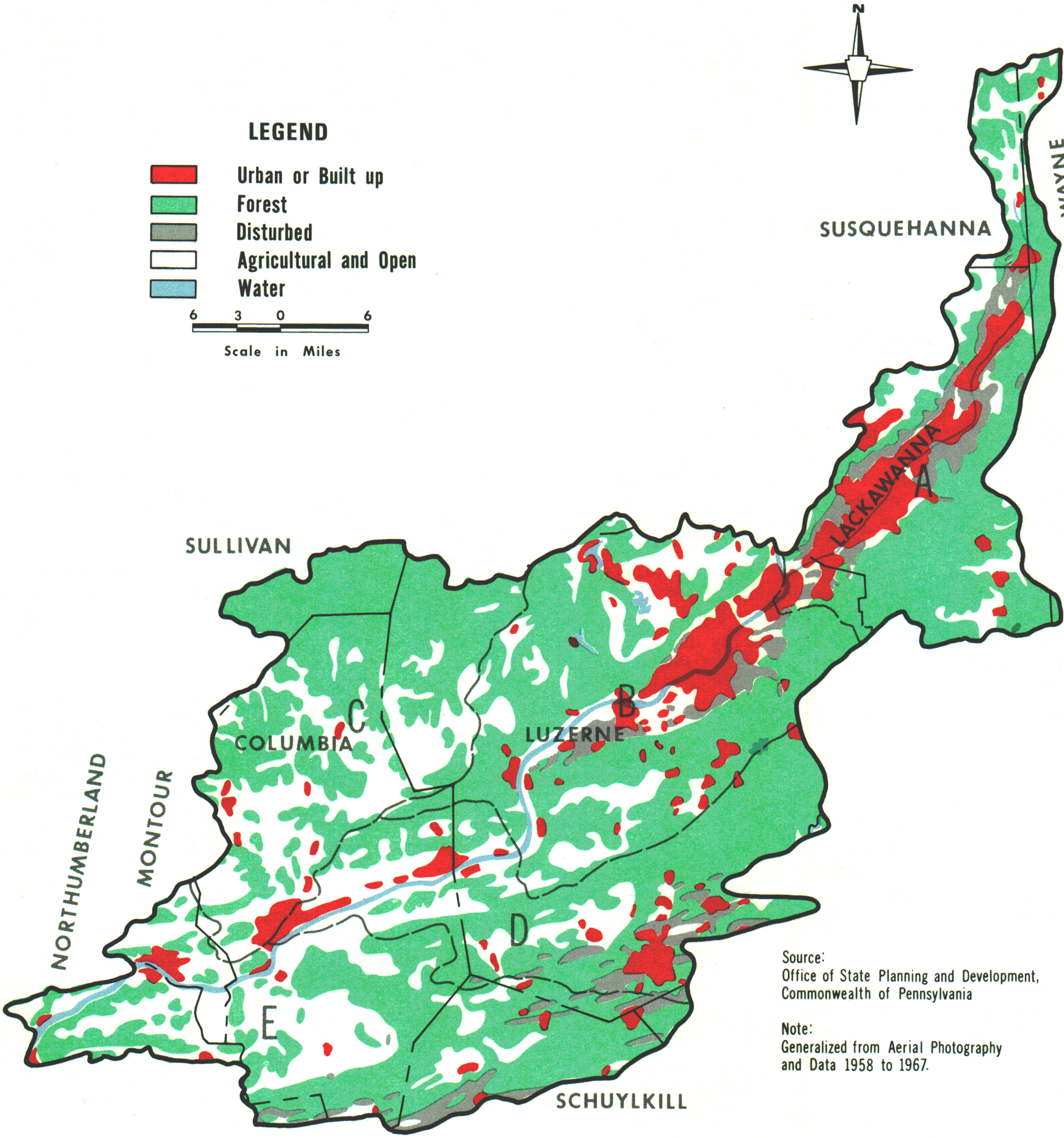


FIGURE 7 Land Use

Table 10

EXISTING AND PROJECTED SUBBASIN LAND USE

Land Use	1974 Acres	1974 Percent of Total Area	2020 Acres	2020 Percent of Total Area	Change Acres	Change Percent
Urban or Built-Up	146,980	13	147,439	13	459	.3
Agriculture or Open	258,896	23	164,703	15	94,193	–36.4
Forest	628,893	57	717,752	64	88,858	14.1
Other	76,858	7	81,733	8	4,875	6.3
Total	1,111,627	100	1,111,627	100		

Source: U.S. Department of Agriculture, Economic Research Service

Table 11

EXISTING COUNTY LAND USE

County	Urban Acres	Urban %	Agriculture Acres	Agriculture %	Forest Acres	Forest %	Other Acres	Other %	Total Acres	Total %
Lackawanna	50,738	17.5	41,700	14.4	174,706	60.1	23,416	8.1	290,560	100
Luzerne	64,760	11.4	80,600	14.1	380,305	66.7	44,575	7.8	570,240	100
Columbia	18,932	6.1	112,600	36.4	157,800	50.9	20,428	6.6	309,760	100
Montour	5,608	6.7	42,850	51.5	30,100	36.2	4,642	5.6	83,200	100

Source: U.S.D.A., Economic Research Service, 1974.

Table 12

EXISTING PRIME AGRICULTURAL SOILS

County	Class I Soils[a] Acres	Class I Soils[a] % in County	Class II Soils[a] Acres	Class II Soils[a] % in County	Classes I and II Acres	Classes I and II % in County
Columbia	8,926	2.9	91,231	29.4	100,157	32.3
Lackawanna	914	0.3	12,785	4.4	13,699	4.7
Luzerne	11,660	2.1	85,920	15.1	97,580	17.2
Montour	–	–	19,950	26.0	19,950	26.0

[a]Class I and II soils are often considered prime agricultural land or land with high potential productivity

Source: U.S.D.A. Economic Research Service, 1974.

Table 13

PROJECTED CHANGE IN WATERSHED POPULATION AND URBANIZED LAND

Watershed	Population 1970	Population 1990	% Change	Percentage of Urbanized Land in Watershed 1970[a]	1990	Change
A	230,742	253,822	10.0	18.4	20.2	1.8
B	240,353	264,850	10.2	14.8	16.3	1.5
C	21,750	27,190	25.0	2.1	2.6	.5
D	74,620	87,269	17.0	5.2	6.1	.9
E	42,572	48,396	13.7	3.0	3.4	.4

[a]Source: *Generalized Existing Land Use* map, Office of State Planning and Development, 1967.

the Office of State Planning and Development.

3. *Future Changes*

A comparison of the subbasin's present land use with its projected 2020 land use is shown in Table 10. Also shown in the last columns is the projected acreage and percent of change within each land use category. From 1974 to 2020, the projected ranking of the four land use categories will remain unchanged with *Forest* as the dominant land use followed by *Agriculture*, *Urban* and *Other* land uses. By 2020, it is projected that 64 percent of the land use in the subbasin will be classified as *Forest*. This is an increase of 88,858 acres or 14 percent over the 1974 *Forest* land use total. It appears that forestland will increase at the expense of marginal agricultural land which will revert back to its original forest cover. At the end of the 46-year period, *Urban* land use is projected to continue to occupy 13 percent of the subbasin despite an increase of 459 acres or three-tenths of one percent. This slight expansion in urban land could take place at the expense of prime agricultural land which has the best characteristics for development. By 2020, *Other* land use is projected to occupy eight percent of the subbasin, an increase of 4,875 acres or six percent.

As was the case with *Forest* and *Urban* land uses, *Other* land may also increase at the expense of *Agriculture* land use. Agricultural land is expected to occupy only 15 percent of the subbasin by 2020. This represents a decrease of over 36 percent, which will account for a loss of 94,193 acres of agricultural land. Of all four land uses, *Agriculture* is projected to have the greatest percentage and acreage change.

As previously stated, present land use categories are based on the intensity of development as reflected in population concentrations. The projection of future land use categories by watersheds can also be determined by intensity of development based on projected increases in population and urbanization. Urbanization of land is defined as clustered construction of residential, commercial and industrial establishments, the extension of a sewage collection infrastructure, the extension and widening of roads, etc. This process includes suburbanization, which may be seen as an early stage in the urbanization process.

The projected percentage increase in population and urbanization from 1970 to 1990 for each watershed in the subbasin is listed in Table 13. As indicated in the table, Watersheds A and B have the largest population bases, the greatest amount of urbanized land, and the highest projected percentage increases in urbanization. These facts indicate that *Forest*, as the dominant land use in Watersheds A and B, will continue to receive its greatest land use challenge from a more intense *Urban* land use. If anthracite coal mining experiences a significant resurquence, *Other* land or land used in the mining of coal could supplant *Urban* as the chief challenge to the existing land use. In contrast, Watersheds C, D and E show larger percentage increases in population than Watersheds A and B but smaller population bases and, therefore, smaller percentage increases in urbanized land. In the future it is likely that *Forest*, as the dominant land use throughout the subbasin, will receive less of a land use challenge in Watersheds C, D and E than in Watersheds A and B.

V. WATER RESOURCES PROBLEMS AND SOLUTION ALTERNATIVES

Based on analyses of existing and projected conditions, future water supply, flood control, water-related outdoor recreation, water quality, and wild and scenic rivers problems have been identified. Possible alternative solutions to water supply, flood control and water-related outdoor recreation problems have been identified and examined.

Through a preliminary reconnaissance level assessment of physical, economic, environmental and social factors, supplemented by regional Water Resources Advisory Committee comments and input, the alternative solutions have been narrowed. The "recommended projects or actions" listed in this chapter are those which merit further detailed consideration as indicated by initial analyses. It should be emphasized that full environmental, social or economic analyses have not been conducted for each alternative. The purpose of this assessment is to screen those potential projects, programs and actions which, as concepts, deserve further study, refinement and possible implementation. If detailed studies of an alternative have been conducted, including where necessary an assessment of social, environmental and economic effects, the State Water Plan may recommend implementation by the appropriate agencies or parties.

The State Water Plan is a plan for resource management; it has been prepared as a tool for decision-making at the State, regional and local levels. The Plan is also a prime input by the Commonwealth to the development of water management policy and actions at the national and interstate levels. The Plan's selection of recommended alternatives was based on an assessment of basinwide and State concerns. These recommended alternatives may not be the most expedient or easiest solutions to each local problem. Because water is a shared resource, whose use and conservation affects the citizens, economy and environment of entire watersheds and the Commonwealth, the State Water Plan has attempted to identify those alternatives which best address the problems and interests of the whole basin and region.

It should be further emphasized that a prime purpose of the Plan is to provide vital information regarding water resources availabilities and problems, for use by decision-makers in both the public and private sectors. The problems discussed in this chapter are based on projections of current trends. However, such trends may not be optimal, or even desirable. Based on information provided in this Plan, as well as other relevant factors, State, regional and local agencies and private citizens may adjust land use planning, regulatory policies and investment decisions in a manner which avoids or moderates projected problems. This Plan's data and analyses regarding water resources should be a major consideration in decisions regarding future population distributions, the location of major development, and selection of technologies and processes which involve water use. Future work on the State Water Plan, as part of the continuing planning process, will include periodic revision of projections based on updated information. It is also intended that an "alternative future" analysis be conducted in the continuing planning process, in order to provide more detailed information to public and private decision-makers regarding the implications of possible options in land use development patterns and the use of alternate technologies.

A. WATER USES

Water is used for a variety of purposes, generally classified in one of two categories, either *instream* uses or *withdrawal* uses. Instream uses, which utilize water in place in lakes and water courses, include navigation, swimming, boating, fish and wildlife habitat, water quality maintenance, hydropower, and general environmental and aesthetic values. Withdrawal water uses are those which require the prior removal of water from its source and include both consumptive and nonconsumptive uses, consumptive uses being those which preclude the return of some or all of the water to the source. This section deals primarily with withdrawal uses.

Parts 1 and 2 focus on uses which divert or withdraw surface and groundwaters. Part 1 includes a broad examination of withdrawal uses on both the watershed and subbasin levels; while Part 2 concentrates on existing and projected uses and problems of public water suppliers based on detailed analyses, and further discusses alternative and recommended solution concepts.

Part 3 examines consumptive and interbasin transfer withdrawal uses which may affect the availability of water for instream uses, particularly during periods of low streamflow. Alternative solutions for consumptive water use makeup are also discussed; however, no recommendations are made because more detailed studies are needed.

1. WATERSHED WATER USES AND REUSE

a. *Watershed Total Water Uses*

Withdrawal water uses have been divided into six categories for study purposes:

(1) Public water supply – Water which is sold to the public by water supply companies, water authorities or municipalities.

(2) Self-supplied industrial – Water withdrawn by either manufacturing or mineral industries from their privately owned sources or intakes.

(3) Self-supplied electric power generation – Water withdrawn for cooling purposes by electric generating facilities from their privately owned sources or intakes.

(4) Self-supplied agricultural – Water withdrawn by agricultural enterprises from privately owned sources or intakes and used for either irrigation or livestock operations (does not include domestic uses on farms).

(5) Self-supplied institutional – Water withdrawn from privately owned sources or intakes for use by institutions including schools, hospitals, correctional institutions and golf courses.

(6) Self-supplied domestic – Water withdrawn from privately owned sources (usually wells) for domestic use in private residences.

The total water use projections for all six categories of water use in Watersheds A through E and the subbasin totals are listed in Table 14 and Table 15 respectively. The tables list the total and consumptive water uses in 1970 and projected uses for the years 1980 and 1990. The consumptive water use is the summation of consumptive losses and interbasin and/or interwatershed transfer losses. It can be seen from the tables that interbasin transfer losses mainly result from public water supply uses. This is because of the spatial distribution of their sources and discharge points. Interbasin transfers may occur if a water supplier's sources are located in a different watershed than the discharge point of the sewage treatment facilities. The tables list the net effect of interbasin transfers, taking into account both the export and import of water. Under the interbasin transfer column in the tables, a positive figure indicates a loss of water from the watershed or subbasin, whereas a negative figure indicates a gain of water to the watershed or subbasin.

Table 14 lists the water uses for Watershed A, which is the Lackawanna River watershed. The area is mainly forested except for the urban areas and coal fields along the Lackawanna River. Population is concentrated in the Scranton, Pittston and Carbondale area. The total water use in 1970 was about 48 mgd, of which 91 percent was public water supply, 6 percent was self-supplied industrial and 3 percent included the remaining categories of water use. This use is projected to increase to 50.8 mgd by 1980 and 54.8 mgd by 1990. The total consumptive water use within the watershed was about 5.2 mgd in 1970 and is projected to be about 6.0 mgd in 1990. An interwatershed transfer does exist between Watershed A and Watershed B; however, because it occurs at the mouth of Watershed A and is within the Pennsylvania Gas and Water Company's system, the effect on other water users is negligible.

Watershed B, a portion of the Susquehanna River main stem, is primarily a forested area except for coal mining activity in the Wyoming Valley and the urban areas of Wilkes-Barre, Nanticoke and Dallas. The total water use in 1970, as shown in Table 14, was 174.6 mgd of which 69 percent was power generation, 26 percent was public water supply, 4 percent was self-supplied industrial and 1 percent included the remaining water use categories. This is projected to decrease to 117.5 mgd in 1980 and increase to 193.8 mgd by 1990 due to fluctuations in power generation requirements. These power generation fluctuations will result from the scheduled completion of the Susquehanna and Hanover Electric Generating Stations in the 1980's and the recent retirement of two units at the Hunlock Electric Generating Station. The total consumptive water use within the watershed was about 7.2 mgd in 1970 and is projected to be 7.6 mgd in 1980 and 44.1 mgd in 1990, again reflecting power generation facility additions after 1980.

Table 14 also lists the water uses for Watershed C, the Fishing Creek drainage. The headwaters of the watershed are forested while the southern part of the basin is a rural and agricultural area. Population is concentrated in the towns of Bloomsburg, Benton, Millville and Orangeville. Total water use in the area in 1970 was 3.3 mgd, of which 44 percent was public water supply, 29 percent was self-supplied agriculture, 19 percent was self-supplied domestic and 8 percent was self-supplied manufacturing. This use is projected to increase to 5.4 mgd by 1980 and 6.6 mgd by 1990. The total consumptive water use within the watershed was about 1.0 mgd in 1970 and is projected to increase to 3.8 mgd by 1990, due to an increase in irrigation requirements. Although an interwatershed transfer via the Bloomsburg Water Company exists, it does not affect other water users because it occurs at the mouth of the watershed, within the Bloomsburg service area.

Watershed D contains Nescopeck Creek, Briar Creek and a portion of the Susquehanna River main stem. The headwaters are mainly forested, while coal mining is active around the Hazleton area, and the downstream portion of the watershed is an agricultural and rural area. Population is concentrated in Berwick

Continued on page 41

Table 14

WATERSHED WATER USE TOTALS

Type Use	1970 Water Use (mgd[a]) Groundwater Withdrawal	Surface Water Withdrawal	Total Withdrawal	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	1980 Water Use (mgd[a]) Total Water Use	Consumptive Losses	Interbasin Transfer Losses	1990 Water Use (mgd[a]) Total Water Use	Consumptive Losses	Interbasin Transfer Losses
Watershed A												
1) Public Water Supply:	2.293	55.006	57.299	44.003	4.402	12.974	46.393	4.641	13.506	50.075	5.009	14.373
2) Self-Supplied Industry												
a) Mineral:	0.013	2.771	2.784	2.784	0.222	0.000	2.784	0.222	0.000	2.784	0.222	0.000
b) Manufacturing:	0.057	0.067	0.124	0.124	0.008	0.000	0.164	0.010	0.000	0.205	0.013	0.000
3) Self-Supplied Power[b]:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4) Self-Supplied Agriculture[c]												
a) Livestock:	0.088	0.056	0.144	0.144	0.108	0.000	0.151	0.113	0.000	0.167	0.125	0.000
b) Irrigation:	0.000	0.036	0.036	0.036	0.036	0.000	0.097	0.097	0.000	0.097	0.097	0.000
5) Other Self-Supplied												
a) Golf Course:	0.067	0.315	0.382	0.382	0.382	0.000	0.420	0.420	0.000	0.458	0.458	0.000
b) Institution:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6) Self-Supplied Domestic:	0.668	0.000	0.668	0.668	0.067	0.000	0.827	0.083	0.000	1.028	0.103	0.000
Totals:	3.186	58.251	61.437	48.151	5.225	12.974	50.836	5.586	13.506	54.814	6.027	14.373

[a]mgd: million gallons per day

[b]Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c]Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

Table 14 (Cont.)

WATERSHED WATER USE TOTALS

Type Use	1970 Water Use (mgd[a]) Groundwater Withdrawal	1970 Surface Water Withdrawal	1970 Total Withdrawal	1970 Total Water Use	1970 Consumptive Losses	1970 Interbasin Transfer Losses	1980 Water Use (mgd[a]) Total Water Use	1980 Consumptive Losses	1980 Interbasin Transfer Losses	1990 Water Use (mgd[a]) Total Water Use	1990 Consumptive Losses	1990 Interbasin Transfer Losses
Watershed B												
1) Public Water Supply:	0.985	29.940	30.925	44.821	4.482	−13.944	47.296	4.728	−14.600	51.035	5.108	−15.638
2) Self-Supplied Industry												
a) Mineral:	4.281	1.880	6.161	6.161	0.454	0.000	6.564	0.476	0.000	6.967	0.497	0.000
b) Manufacturing:	0.821	0.005	0.826	0.826	0.132	0.000	0.842	0.135	0.000	0.858	0.137	0.000
3) Self-Supplied Power[b]:	0.000	120.930	120.930	120.930	1.397	0.000	60.000	0.800	0.000	131.800	36.800	0.000
4) Self-Supplied Agriculture[c]												
a) Livestock:	0.054	0.021	0.075	0.075	0.056	0.000	0.096	0.073	0.000	0.118	0.088	0.000
b) Irrigation:	0.000	0.356	0.356	0.356	0.356	0.000	0.970	0.970	0.000	0.970	0.970	0.000
5) Other Self-Supplied												
a) Golf Course:	0.125	0.101	0.226	0.226	0.226	0.000	0.259	0.259	0.000	0.271	0.271	0.000
b) Institution:	0.199	0.000	0.199	0.199	0.020	0.000	0.218	0.022	0.000	0.226	0.023	0.000
6) Self-Supplied Domestic:	1.015	0.000	1.015	1.015	0.101	0.000	1.302	0.130	0.000	1.584	0.158	0.000
Totals:	7.480	153.233	160.713	174.609	7.224	−13.944	117.548	7.593	−14.600	193.829	44.052	−15.638

[a]mgd: million gallons per day

[b]Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c]Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

Table 14 (Cont.)

WATERSHED WATER USE TOTALS

Type Use	1970 Water Use (mgd[a])						1980 Water Use (mgd[a])			1990 Water Use (mgd[a])		
	Groundwater Withdrawal	Surface Water Withdrawal	Total Withdrawal	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses
Watershed C												
1) Public Water Supply:	0.117	3.098	3.215	1.480	0.148	1.735	1.715	0.172	1.996	1.953	0.196	2.250
2) Self-Supplied Industry												
a) Mineral:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
b) Manufacturing:	0.249	0.000	0.249	0.249	0.013	0.000	0.034	0.004	0.000	0.040	0.004	0.000
3) Self-Supplied Power[b]:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4) Self-Supplied Agriculture[c]:												
a) Livestock:	0.213	0.166	0.379	0.379	0.284	0.000	0.421	0.316	0.000	0.481	0.337	0.000
b) Irrigation:	0.000	0.569	0.569	0.569	0.569	0.000	2.406	2.406	0.000	3.111	3.111	0.000
5) Other Self-Supplied												
a) Golf Course:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
b) Institution:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6) Self-Supplied Domestic:	0.652	0.000	0.652	0.652	0.065	0.000	0.823	0.082	0.000	1.017	0.102	0.000
Totals:	1.231	3.833	5.064	3.329	1.079	1.735	5.399	2.980	1.996	6.602	3.750	2.250

[a]mgd: million gallons per day

[b]Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c]Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

Table 14 (Cont.)

WATERSHED WATER USE TOTALS

Type Use	1970 Water Use (mgd[a])						1980 Water Use (mgd[a])			1990 Water Use (mgd[a])		
	Groundwater Withdrawal	Surface Water Withdrawal	Total Withdrawal	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses
Watershed D												
1) Public Water Supply:	5.057	1.412	6.469	9.766	0.977	–5.033	10.739	1.077	–5.454	11.808	1.179	–5.938
2) Self-Supplied Industry												
a) Mineral:	4.208	0.542	4.750	4.750	0.304	0.000	4.903	0.372	0.000	5.056	0.380	0.000
b) Manufacturing:	0.971	0.825	1.796	1.796	0.244	0.000	1.792	0.249	0.000	2.053	0.298	0.000
3) Self-Supplied Power[b]:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4) Self-Supplied Agriculture[c]												
a) Livestock:	0.114	0.036	0.150	0.150	0.112	0.000	0.156	0.117	0.000	0.177	0.133	0.000
b) Irrigation:	0.133	1.253	1.386	1.386	1.386	0.000	3.676	3.676	0.000	3.676	3.676	0.000
5) Other Self-Supplied												
a) Golf Course:	0.025	0.426	0.451	0.451	0.451	0.000	0.496	0.496	0.000	0.541	0.541	0.000
b) Institution:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6) Self-Supplied Domestic:	0.807	0.000	0.807	0.807	0.081	0.000	1.052	0.105	0.000	1.285	0.129	0.000
Totals:	11.315	4.494	15.809	19.106	3.595	–5.033	22.814	6.092	–5.454	24.596	6.336	–5.938

[a]mgd: million gallons per day

[b]Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c]Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

Table 14 (Cont.)

WATERSHED WATER USE TOTALS

Type Use	1970 Water Use (mgd[a])						1980 Water Use (mgd[a])			1990 Water Use (mgd[a])		
	Groundwater Withdrawal	Surface Water Withdrawal	Total Withdrawal	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses
Watershed E												
1) Public Water Supply:	2.025	8.439	10.464	3.699	0.371	6.751	3.849	0.387	7.184	4.254	0.426	7.889
2) Self-Supplied Industry												
a) Mineral:	1.560	0.000	1.560	1.560	0.125	0.000	1.560	0.125	0.000	1.560	0.125	0.000
b) Manufacturing:	0.406	19.800	20.206	20.206	1.380	0.000	22.708	1.576	0.000	23.469	1.643	0.000
3) Self-Supplied Power[b]:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4) Self-Supplied Agriculture[c]												
a) Livestock:	0.187	0.138	0.325	0.325	0.244	0.000	0.423	0.317	0.000	0.487	0.365	0.000
b) Irrigation:	0.000	3.097	3.097	3.097	3.097	0.000	11.252	11.252	0.000	13.604	13.604	0.000
5) Other Self-Supplied												
a) Golf Course:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
b) Institution:	0.214	0.399	0.613	0.613	0.061	0.000	0.810	0.081	0.000	0.900	0.090	0.000
6) Self-Supplied Domestic:	0.922	0.000	0.922	0.922	0.092	0.000	1.108	0.111	0.000	1.343	0.134	0.000
Totals:	5.314	31.873	37.187	30.422	5.370	6.751	41.710	13.849	7.184	45.617	16.387	7.889

[a] mgd: million gallons per day

[b] Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c] Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

Table 15

SUBBASIN WATER USE TOTALS

Type Use	1970 Water Use (mgd[a])						1980 Water Use (mgd[a])			1990 Water Use (mgd[a])		
	Groundwater Withdrawal	Surface Water Withdrawal	Total Withdrawal	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses	Total Water Use	Consumptive Losses	Interbasin Transfer Losses
1) Public Water Supply:	10.477	97.895	108.372	103.769	10.380	2.483	109.992	11.005	2.632	119.125	11.918	2.936
2) Self-Supplied Industry												
a) Mineral:	10.062	5.192	15.255	15.255	1.165	0.000	15.811	1.195	0.000	16.367	1.224	0.000
b) Manufacturing:	2.504	20.697	23.201	23.201	1.757	0.000	25.540	1.974	0.000	26.625	2.095	0.000
3) Self-Supplied Power[b]:	0.000	120.930	120.930	120.930	1.397	0.000	60.000	0.800	0.000	131.800	36.800	0.000
4) Self-Supplied Agriculture[c]												
a) Livestock:	0.656	0.417	1.073	1.073	0.804	0.000	1.248	0.936	0.000	1.430	1.048	0.000
b) Irrigation:	0.133	5.311	5.444	5.444	5.444	0.000	18.401	18.401	0.000	21.458	21.458	0.000
5) Other Self-Supplied												
a) Golf Course:	0.217	0.842	1.059	1.059	1.059	0.000	1.175	1.175	0.000	1.270	1.270	0.000
b) Institution:	0.413	0.399	0.812	0.812	0.081	0.000	1.028	0.103	0.000	1.126	0.113	0.000
6) Self-Supplied Domestic:	4.064	0.000	4.064	4.064	0.406	0.000	5.112	0.511	0.000	6.257	0.626	0.000
Totals:	28.526	251.684	280.210	275.607	22.493	2.483	238.307	36.100	2.632	325.458	76.552	2.936

[a]mgd: million gallons per day

[b]Power projections are for thermoelectric power generation only and do not include hydroelectric water use. Thermoelectric power generation water withdrawals and total usages reflect plant requirements when operating at design capacity.

[c]Agricultural irrigation and livestock projections are preliminary estimates, not to be used for allocation or other regulation of water use.

along the river and the Hazleton and Freeland areas in the headwaters of the Nescopeck Creek drainage. Total water use in 1970, as shown in Table 14 was 19.1 mgd, of which 51 percent was public water supply, 34 percent was self-supplied manufacturing, 8 percent was self-supplied agriculture, 4 percent was self-supplied domestic and 3 percent was self-supplied golf courses. This use is projected to increase to 22.8 mgd by 1980 and 24.6 mgd by 1990. The total consumptive water use within this watershed in 1970 was 3.6 mgd, increasing to 6.3 mgd by 1990. A major import of water occurs in the headwaters of the Nescopeck Creek drainage within the Hazleton Water Authority System. Sources in the Lehigh River Basin provide approximately 3.5 mgd to the Hazleton System. This water is used and discharged into Black Creek through the sanitary sewer system. This interbasin transfer may increase if Hazleton develops additional sources in the Lehigh River Basin.

Table 14 shows the water demands for Watershed E which contains Catawissa Creek, Roaring Creek and a portion of the Susquehanna River main stem. The northeast part of the watershed is forested, although there is some coal mining being done at the headwaters of Catawissa Creek. The Roaring Creek drainage and areas adjacent to the Susquehanna River are mainly agricultural and rural. Population is concentrated in the towns of Catawissa, Northumberland, McAdoo, Ringtown and Danville. The total water use in 1970 was 30.4 mgd, of which 12 percent was public water supply, 72 percent was self-supplied industrial, 11 percent was self-supplied agriculture, 3 percent was self-supplied domestic and 2 percent was self-supplied institutional. This use is projected to increase to 41.7 mgd by 1980 and to 45.6 mgd by 1990. The total consumptive use within Watershed E was about 5.4 mgd in 1970 and is projected to be 13.8 mgd in 1980 and 16.4 mgd in 1990. This increase in consumptive water use is due almost entirely to increasing irrigation requirements. An additional depletive loss of about 6.0 mgd is a result of interbasin transfers of water from the Catawissa Creek watershed by Shenandoah Borough and from the Roaring Creek watershed by the Roaring Creek Water Company.

The total water use in Subbasin 5, as shown in Table 15, was about 275.6 mgd in 1970 and is projected to be 238.3 mgd in 1980 and 325.5 mgd in 1990. Consumptive water use, including interbasin transfers, was about 25 mgd in 1970 and is projected to increase to 38.7 mgd in 1980 and 79.5 mgd in 1990. This represents the highest consumptive use forecast in the Susquehanna Basin except for the main stem reach between Harrisburg and the Conowingo Pool. Future power requirements comprise the major portion of this demand.

b. *Use Intensity*

Figure 8 shows a comparison of total supply and total use at three gaging station locations in Subbasin 5. The supply is represented by a daily duration curve, which indicates the streamflow which is equalled or exceeded for any given percentage of time. These curves indicate not only the total flows available, but by their slopes also indicate the reliability of the flows. A flat duration curve would indicate a stream with very steady flows; whereas a steep duration curve applies to a flashy stream on which flows are exceptionally high during periods of rainfall but recede quickly as the weather clears. The ultimate example of a flashy stream would be an erosion gully in a field, which is dry most of the time and sustains flows only during a rain. Exceptionally steady streamflows occur in limestone areas where rainfall infiltrates to the groundwater rather than contributing heavily to runoff and where underground storage contributes heavily to streamflows during dry conditions, thus maintaining higher low flows. Streams draining larger areas also tend to have flatter duration curves because the effects of localized heavy rain or drought conditions are minimized by flows originating in other areas of the drainage basin.

By overlaying the line representing total water use above a gaging station upon the graph of the duration curve for that gaging station, it is possible to compare the supply and its reliability against the total use. Although this comparison is of limited hydrologic value, it does provide a visual indication of the intensity of water use upstream of the gaging station or the probability for water reuse to occur.

Reuse occurs when water returned to the stream by upstream users is used again by downstream users. The probability of this occurring is indicated by the percentage of time that total water use exceeds flow, as shown on the duration curve. An important consideration regarding reuse is potential degradation of water quality. Although many other factors affect water quality more directly, intensive use usually results in some degree of water quality degradation. Because the potential for degradation increases with reuse, effective water quality management becomes increasingly important with reuse to protect not only the stream itself, including instream uses, but also the downstream users.

For the three gaging stations included on Figure 8, use intensity is very low. The flow of the Susquehanna River entering Subbasin 5 exceeds even the projected 1990 total water use upstream of Wilkes-Barre 99 percent of the time. As the river flows out of the subbasin below Danville, total 1990 uses will be exceeded by the flow about 98 percent of the time. Total projected 1990 uses on Fishing Creek will be exceeded by the flows virtually all the time. The low intensity use of those streams is reflective of their natural scenic and recreational values.

2. PUBLIC WATER SUPPLY

a. *Problems*

Because public water supply is more complex than other water use categories, involving larger service areas and populations, public water supplier problems have been studied individually. Dependable yields have been estimated for all existing sources, including stream withdrawals, reservoirs, wells, and springs located in or nearby the subbasin. These estimates are based on

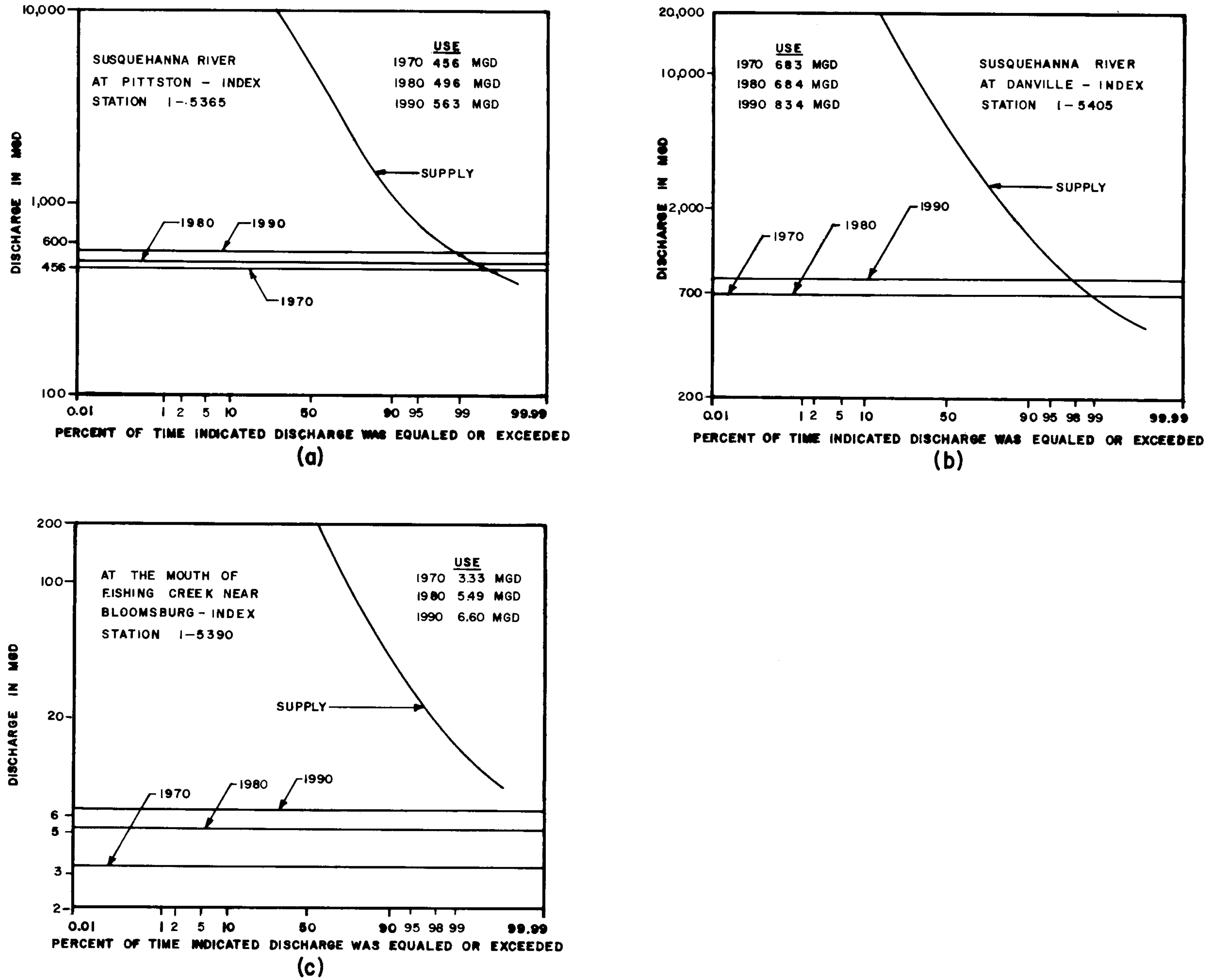


FIGURE 8. Comparisons of Supply and Use for Selected Drainage Areas

information contained in the reports B-12 "Low Flow Characteristics of Pennsylvania Streams",[25] B-7 "Long Duration Low Flow",[26] and "Planning Criteria for Determination of the Adequacy of Water Supply Sources"[27]. Projected uses for individual water suppliers were determined using projections of population and daily per capita uses. These projection methods are described in "Planning Principles". Finally, each water supplier which has its own sources was analyzed to identify existing or possible future yield, storage and, where applicable, allocation or filtration plant deficiencies.

A yield deficiency was identified when the required daily withdrawal (determined considering peak and average daily water use as well as total raw and treated water storage) exceeds the safe yield of all combined surface and groundwater sources of a particular supplier. Because safe yield is based upon long term drought conditions, a yield deficiency indicates a supplier's inability to provide for normal uses during the occurrence of a major drought.

A storage deficiency was identified when the average daily water use exceeds the total available treated storage. Treated water storage equal to one day's normal use is a minimum public safeguard in case of electrical or mechanical failures or in case of temporary pollution of the source.

A deficiency in filtration capacity was identified when the required daily withdrawal (determined from peak and average daily water use in addition to treated water storage) exceeds total filtration capacity. This indicates that the supplier cannot treat water at a rate equal to which it is being used. A deficiency in filtration plant capacity will, therefore, affect water use on a continuous, daily basis.

All public water suppliers using stream withdrawals as supply sources are required to obtain a water allocation permit from DER, which specifies a maximum allowable daily withdrawal from that surface source. An allocation deficiency was identified when the peak daily water use exceeds the allocation permit and indicates that the supplier cannot legally withdraw water at a rate equal to which it would be used on a peak use day.

It is important to recognize that a water supplier may face many other types of problems. Water quality problems may affect sources and have led to the failure of some suppliers in the past. Many water suppliers, particularly smaller suppliers (generally less than 1,000 customers) with limited revenues, are plagued with deteriorating systems, resulting in wasteful leakage and frequent service interruptions. Institutional problems of public water suppliers are discussed in the State Water Plan document "Water Laws and Institutional Arrangements".

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[25] L.V. Page and L.C. Shaw, *Water Resources Bulletin No. 12, Low Flow Characteristics of Pennsylvania Streams*, (Pennsylvania Department of Environmental Resources, 1977).

[26] Department of Environmental Resources, *Water Resources Bulletin No. 7, Long-Duration Low Flow of Pennsylvania Streams*, (December 1972).

[27] Department of Environmental Resources, *Planning Principles, SWP-1*, (March 1975), Appendix A-2.

Fifty-eight public water suppliers associated with Subbasin 5 are listed by watershed in Table 16, with their locations and relative number of customers shown on Figure 9. Fifty-four of the suppliers have both their sources and service areas located within Subbasin 5. The remaining four suppliers (Honey Brook Water Company, Keystone Water Company-Northumberland District, Freeland Municipal Authority, and Pennsylvania Gas and Water Company) have portions of their service areas and/or sources located in either Subbasin 2, Subbasin 3 or Subbasin 10. Twelve other public water suppliers located principally outside of the subbasin have a portion of their service areas and/or sources within Subbasin 5. The net amount of water transferred out of the subbasin in 1970 by these sixteen water suppliers was only about 2.5 mgd or approximately two percent of the total 1970 public water supply withdrawal in Subbasin 5. The Pennsylvania Gas and Water Company, one of the largest investor-owned utilities in the state, provides water to a major portion of Lackawanna and Luzerne Counties and to minor areas in Susquehanna and Wayne Counties. Of the total public water supply usage in Subbasin 5, about 84 percent was distributed by the Pennsylvania Gas and Water Company in 1970.

Table 16 lists existing sources and existing and projected deficiencies of 55 water suppliers in Subbasin 5 which have their own sources of supply. Suppliers which purchase 100 percent of their water from another supplier are not analyzed. Their existing and projected uses are considered as part of that other supplier's uses. The Mocanaqua Water Company purchases water from Shickshinny Water Company, while Trucksville and Anne Hall Water Companies purchase from the Pennsylvania Gas and Water Company.

Six water suppliers show no quantitative deficiencies to the year 2020 in dependable yield, water allocation, storage and filtration plant capacity. The other water suppliers show a deficiency at the present or in the future in one or more of the items examined. Five companies have an immediate yield problem as presented in Table 16 and on Figure 10. Eighteen companies are projected to have yield deficiencies by the year 1990, and 30 suppliers will fall into this category by the year 2020.

At the present, only the Bloomsburg and Shickshinny Water Companies have allocation deficiencies, with the exception that the Moscow Water Company needs an allocation on its existing source, LaTouche Creek, because it has never obtained one. According to current projections, Danville Borough and the Pennsylvania Gas and Water Company will have allocation deficiencies by 1990. By 1990, Pennsylvania Gas and Water Company will have a yield as well as an allocation deficiency because increased allocations cannot be supported by the dependable yield of their existing surface sources. Twenty-six water suppliers have immediate storage deficiencies, while 31 and 37 suppliers are identified as having problems by 1990 and 2020, respectively.

Only one water supplier, Pennsylvania Gas and Water Company, currently has insufficient filtration plant capacity. However, the company has long-range plans to upgrade filtration capacity on their existing sources to

Table 16

PUBLIC WATER SUPPLY STATISTICS

Legend (See Figure 9)	Water Supplier	Estimated Population Served (1970)	Total System GPCD[a] (1970)	Residential GPCD (1970)	Average Daily Water Use (mgd[b]) 1970	1990	2020	Existing Sources	Yield (mgd)
	Watershed A								
1	Stanton Water Company	135	60	59	0.008	0.021	0.027	2 wells	0.122
2	Anna Hall Water Company	270	60	60	0.016	0.041	0.063	1 well, 1 spring, purchases from Pa. Gas & Water Company	
3	Chinchilla Water Company	270	40	36	0.010	0.028	0.044	2 wells	0.069
4	Pennsylvania Gas and Water Company	427,879	204	76	87.606	107.30	121.89	18 wells, 34 surface water sources with 69 reservoirs & diversion structures	96.460
5	Elmbrook Public Service	97	60	54	0.005	0.047	0.076	2 wells	0.168
6	Olwen Heights Water Service	415	44	40	0.018	0.050	0.083	3 wells	0.255
7	Poco Spring Water Company	180	60	54	0.010	0.069	0.111	2 wells	0.182
8	Moscow Water Company	772	132	112	0.102	0.117	0.145	La Touche Creek	0.032
	Watershed B								
9	Rhodes Terrace Water Company	–	–	–	–	0.005	0.009	1 well	0.072
10	Warden Place Water Company	–	–	–	–	0.007	0.011	2 wells	0.144
11	Whitebread Water Company	52	231	208	0.011	0.014	0.020	1 well	0.086
12	Harveys Lake Water Company	86	58	52	0.004	0.008	0.026	1 well	0.026
13	Village Water Company	44	60	54	0.002	0.007	0.013	1 well	0.033
14	Oakhill Water Supply Company	444	109	98	0.048	0.069	0.094	3 wells	0.279
15	Valley View Park Water Company	60	44	40	0.002	0.056	0.093	1 well	0.115
16	Dallas Water Company	4,292	91	64	0.388	0.830	1.796	6 wells	0.697
17	Overbrook Water Company	219	57	51	0.012	0.019	0.033	3 wells	0.101
18	Homesite Water Company	60	52	45	0.003	0.007	0.013	1 well	0.020
19	Hillcrest Water Company	132	52	41	0.006	0.010	0.018	1 well	0.043
20	Shavertown-Kingston Township Water Company	316	55	43	0.017	0.030	0.056	3 wells	0.023
21	William A. Still Estate Water Company	211	52	52	0.010	0.019	0.036	Purchases from Shavertown Water Company	
22	Shavertown Water Company	2,423	57	35	0.138	0.238	0.447	7 wells	0.563
23	Trucksville Water Company	1,106	84	84	0.093	0.159	0.286	Purchases from Pa. Gas & Water Company	
24	Meadow Crest Water Company	737	96	85	0.070	0.120	0.212	3 wells	0.164
25	Garbush Water Company	–	–	–	–	0.006	0.011	2 wells	0.114
26	Midway Manor Water Company	263	64	58	0.016	0.048	0.082	1 well	0.245
27	Harris Hill Acres Water Company	53	71	64	0.003	0.006	0.011	1 well	0.012
28	Brown Manor Water Company	53	57	57	0.003	0.005	0.009	1 well	0.144
29	John Fielding Water Company	137	50	50	0.006	0.020	0.037	1 well	0.034
30	Shickshinny Water Company	1,832	105	98	0.261	0.261	0.275	Little Shickshinny Creek	0.124
31	Mocanaqua Water Company	1,151	60	57	0.069	0.085	0.106	Purchases from Shickshinny Water Company	
32	Indian Springs Water Company	150	64	64	0.009	0.018	0.034	1 spring	0.103
33	Citizens Water Company	203	40	39	0.008	0.010	0.013	1 well, 4 springs	0.042
	Watershed C								
34	Benton Water Supply Company	1,022	57	46	0.058	0.097	0.154	1 well	0.200
35	Millville Municipal Authority	672	61	60	0.040	0.089	0.124	2 wells	0.100
36	Orangeville Borough Water Service	431	45	43	0.019	0.029	0.045	1 well, 7 springs	0.054
37	Bloomsburg Water Company	14,768	210	48	3.098	2.730	3.665	Fishing Creek	9.080

[a]GPCD: Gallons per capita per day

[b]mgd: Million gallons per day

[c]N/A: Not applicable

Yield Deficiency (mgd) 1970	Yield Deficiency (mgd) 1990	Yield Deficiency (mgd) 2020	Total Water Allocation[c] (mgd)	Allocation Deficiency (mgd) 1970	Allocation Deficiency (mgd) 1990	Allocation Deficiency (mgd) 2020	Treated/Total Water Storage (mg)	Treated Storage Deficiency (mg) 1970	Treated Storage Deficiency (mg) 1990	Treated Storage Deficiency (mg) 2020	Filtration Plant Capacity (mgd)	Filtration Plant Capacity Deficiency (mgd) 1970	Filtration Plant Capacity Deficiency (mgd) 1990	Filtration Plant Capacity Deficiency (mgd) 2020
0	0	0	N/A	N/A	N/A	N/A	0.002/0.002	0.006	0.019	0.025	N/A	N/A	N/A	N/A
0	0.004	0.045	N/A	N/A	N/A	N/A	0.007/0.007	0.003	0.021	0.037	N/A	N/A	N/A	N/A
0	10.84	25.43	135.0	0	24.88	46.62	6.79/21,502	0	0	0	29.0	102.9	135.7	161.9
0	0	.014	N/A	N/A	N/A	N/A	0.004/0.004	0.002	0.043	0.072	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.002/0.002	0.016	0.048	0.081	N/A	N/A	N/A	N/A
0	0	0.111	N/A	N/A	N/A	N/A	0.008/0.008	0.002	0.061	0.103	N/A	N/A	N/A	N/A
0.105	0.139	0.199	0	0.204	0.234	0.290	0/0.500	0.102	0.117	0.145	N/A	N/A	N/A	N/A
–	0	0	N/A	N/A	N/A	N/A	0.005/0.005	–	0	0.004	N/A	N/A	N/A	N/A
–	0	0	N/A	N/A	N/A	N/A	0.007/0.007	–	0	0.004	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.001/0.001	0.010	0.013	0.019	N/A	N/A	N/A	N/A
0	0	0.027	N/A	N/A	N/A	N/A	0.075/0.075	0	0	0	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.001/0.001	0.001	0.006	0.012	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.006/0.006	0.042	0.063	0.088	N/A	N/A	N/A	N/A
0	0.019	0.108	N/A	N/A	N/A	N/A	0.001/0.001	0.001	0.055	0.092	N/A	N/A	N/A	N/A
0.192	1.295	3.613	N/A	N/A	N/A	N/A	0.601/0.601	0	0.229	1.195	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.019/0.019	0	0	0.014	N/A	N/A	N/A	N/A
0	0	0.011	N/A	N/A	N/A	N/A	0.006/0.006	0	0.001	0.007	N/A	N/A	N/A	N/A
0	0	0.004	N/A	N/A	N/A	N/A	0.002/0.002	0.004	0.008	0.016	N/A	N/A	N/A	N/A
0	0.051	0.118	N/A	N/A	N/A	N/A	0.008/0.008	0.009	0.022	0.049	N/A	N/A	N/A	N/A
0	0	0.197	N/A	N/A	N/A	N/A	0.012/0.012	0.126	0.226	0.435	N/A	N/A	N/A	N/A
0.017	0.129	0.353	N/A	N/A	N/A	N/A	0.083/0.083	0.065	0.037	0.129	N/A	N/A	N/A	N/A
–	0	0	N/A	N/A	N/A	N/A	0.005/0.005	–	0.001	0.006	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.003/0.003	0.013	0.045	0.079	N/A	N/A	N/A	N/A
0	0.005	0.019	N/A	N/A	N/A	N/A	0.001/0.001	0.002	0.005	0.010	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.010/0.010	0	0	0	N/A	N/A	N/A	N/A
0	0.014	0.055	N/A	N/A	N/A	N/A	0.001/0.001	0.006	0.019	0.036	N/A	N/A	N/A	N/A
0.286	0.286	0.313	0.450	0.030	0.030	0.056	0.250/0.750	0.011	0.011	0.025	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.220/0.220	0	0	0	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.018/0.018	0	0	0	N/A	N/A	N/A	N/A
0	0.033	0.170	N/A	N/A	N/A	N/A	0.064/0.064	0	0.033	0.090	N/A	N/A	N/A	N/A
0	0.101	0.193	N/A	N/A	N/A	N/A	0.150/0.150	0	0	0	N/A	N/A	N/A	N/A
0	0	0.042	N/A	N/A	N/A	N/A	0.113/0.113	0	0	0	N/A	N/A	N/A	N/A
0	0	0	5.0	0.100	0	1.033	6.50/6.50	0	0	0	5.00	0	0	0.717

Table 16 (Cont.)

PUBLIC WATER SUPPLY STATISTICS

Legend (See Figure 9)	Water Supplier	Estimated Population Served (1970)	Total System GPCD[a] (1970)	Residential GPCD (1970)	Average Daily Water Use (mgd[b]) 1970	1990	2020	Existing Sources	Yield (mgd)
	Watershed D								
38	Scenic Knolls Water Authority	159	63	63	0.010	0.020	0.029	3 wells	0.030
39	Mifflin Township Water	–	–	–	–	0.092	0.173	2 wells	0.194
40	Keystone Water Company; Berwick District	16,982	237	57	4.030	3.894	5.051	3 wells, Glen Brook Reservoir on Briar Creek	6.479
41	Williams & Son Water Company	75	50	45	0.003	0.009	0.016	1 spring	0.020
42	Freeland Municipal Authority	6,102	45	30	0.274	0.401	0.540	9 wells	0.370
43	Conyngham Water Company	1,556	59	54	0.092	0.173	0.298	5 wells	0.248
44	Hazleton Water Authority; Lattimer Division	378	60	48	0.022	0.034	0.051	1 well	0.144
45	Hazleton Water Authority; Ebervale Division	610	60	48	0.036	0.053	0.083	2 wells, 1 reservoir	0.316
46	Hazleton Water Authority; Derringer Division	209	60	48	0.012	0.018	0.024	1 well	0.043
47	Hazleton Water Authority; Tomhickon Division	101	60	48	0.006	0.013	0.025	1 well	0.036
	Watershed E								
48	Danville Borough	6,176	301	260	1.859	2.487	2.733	Susquehanna River	478.0
49	Mahoning Township Sewer & Water Authority	1,286	82	78	0.105	0.236	0.419	3 wells	0.307
50	Hillside Estates; Thomas Ernst	76	60	60	0.004	0.006	0.009	2 wells	0.360
51	Catawissa Borough Municipal Authority	1,701	104	68	0.176	0.227	0.305	3 wells, 3 springs	0.270
52	Wonderview Development Water Company	53	57	51	0.003	0.013	0.029	3 wells	0.187
53	Nuremberg Water Company	486	60	52	0.029	0.046	0.073	3 wells	0.167
54	Oneida Water Company	319	60	57	0.019	0.035	0.054	3 wells	0.302
55	Beaver Brook Water Company	232	43	37	0.010	0.014	0.023	2 wells	0.094
56	Honey Brook Water Company	6,133	154	137	0.943	1.049	1.293	1 well, Honey Brook Reservoir, Reservoir #8 on Hunkydory Creek	1.894
57	Keystone Water Company; Northumberland District	4,571	88	40	0.401	0.558	0.801	3 wells, 1 spring, Johnson Run	0.675
58	Ringtown Borough Water Department	909	41	37	0.037	0.062	0.093	1 spring	0.120
	State Correctional Institute Dallas	782	255	–	0.199	0.226	0.244	2 wells	0.333
	Danville State Hospital	2,307	173	–	0.399	0.458	0.560	Purchases from Borough of Danville	
	Geisinger Medical Center	541	396	–	0.214	0.379	0.492	3 wells, 1 spring	0.304

[a]GPCD: Gallons per capita per day
[b]mgd: Million gallons per day
[c]N/A: Not applicable

83 mgd. The Company will need additional filtration on new sources unless future demands are significantly reduced by conservation measures. Bloomsburg Water Company will have a filtration plant deficiency by 2020.

b. *Solution Alternatives*

Public water supply deficiencies may be overcome or relieved by either improved management of existing resources or, when necessary, new development. Pennsylvania's past enjoyment of abundant and dependable supplies of water has instilled in the public's mind an epicurean-like philosophy of convenience through wasteful water use without due regard to either environmental or in some cases social or economic effects. As increasing societal pressures on water supplies approach the limits of this finite resource, many Commonwealth water users will begin to realize the importance of water conservation practices. The costs to society, both monetary and environmental, of continued unnecessary or questionable development of water resources are becoming more difficult to bear as time passes. Until recently, many water

Yield Deficiency (mgd) 1970	Yield Deficiency (mgd) 1990	Yield Deficiency (mgd) 2020	Total Water Allocation[c] (mgd)	Allocation Deficiency (mgd) 1970	Allocation Deficiency (mgd) 1990	Allocation Deficiency (mgd) 2020	Treated/Total Water Storage (mg)	Treated Storage Deficiency (mg) 1970	Treated Storage Deficiency (mg) 1990	Treated Storage Deficiency (mg) 2020	Filtration Plant Capacity (mgd)	Filtration Plant Capacity Deficiency (mgd) 1970	Filtration Plant Capacity Deficiency (mgd) 1990	Filtration Plant Capacity Deficiency (mgd) 2020
0	0.018	0.042	N/A	N/A	N/A	N/A	0.005/0.005	0.005	0.015	0.024	N/A	N/A	N/A	N/A
–	0	0.195	N/A	N/A	N/A	N/A	0.305/0.305	–	0	0	N/A	N/A	N/A	N/A
0	0	0	4.000	0	0	0	0.085/73.085	3.945	3.809	4.966	N/A	N/A	N/A	N/A
0	0.002	0.018	N/A	N/A	N/A	N/A	0	0.003	0.009	0.016	N/A	N/A	N/A	N/A
0.033	0.167	0.375	N/A	N/A	N/A	N/A	1.250/1.250	0	0	0	N/A	N/A	N/A	N/A
0	0.153	0.467	N/A	N/A	N/A	N/A	0.236/0.236	0	0	0.062	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.100/0.100	0	0	0	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0/0.340	0.036	0.053	0.083	N/A	N/A	N/A	N/A
0	0	0.008	N/A	N/A	N/A	N/A	0.066/0.066	0	0	0	N/A	N/A	N/A	N/A
0	0	0.024	N/A	N/A	N/A	N/A	0.015/0.015	0	0	0.010	N/A	N/A	N/A	N/A
0	0	0	4.0	0	0.974	1.466	3.700/3.700	0	0	0	6.000	0	0	0
0	0.165	0.548	N/A	N/A	N/A	N/A	0.300/0.300	0	0	0.119	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.002/0.002	0.002	0.004	0.007	N/A	N/A	N/A	N/A
0	0.057	0.178	N/A	N/A	N/A	N/A	0.530/0.530	0	0	0	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.065/0.065	0	0	0	N/A	N/A	N/A	N/A
0	0	0.008	N/A	N/A	N/A	N/A	0.015/0.015	0.014	0.031	0.058	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.020/0.020	0	0.015	0.034	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0/5.500	0.010	0.014	0.023	N/A	N/A	N/A	N/A
0	0	0	1.380	0	0	0	0/156.0	0.943	1.049	1.293	N/A	N/A	N/A	N/A
0	0	0.310	0.950	0	0	0	1.00/4.800	0	0	0	N/A	N/A	N/A	N/A
0	0	0	N/A	N/A	N/A	N/A	0.500/0.500	0	0	0	N/A	N/A	N/A	N/A
0.015	0.083	0.131	N/A	N/A	N/A	N/A	0.850/0.850	0	0	0	N/A	N/A	N/A	N/A
0.049	0.359	0.572	N/A	N/A	N/A	N/A	0.500/0.500	0	0	0	N/A	N/A	N/A	N/A

conservation practices have been viewed as measures to be used only in emergency situations - during a drought, or while mechanical failures or floods or other natural events may temporarily shut down water supply systems either wholly or partially. Concerns other than convenience are now beginning to alter society's attitudes toward wanton abuse of the environment; as a result, resource conservation must be considered as the primary means of solving existing problems and avoiding future ones. Only when conservation has been utilized to the maximum extent practicable should further development of the resource be considered justified.

Although conservation has become a "household term" in the past few years, it is something whose practice cannot be limited to the household. In fact, many forms of significant water conservation do not apply to the household, but rather to industrial or power generation uses or even to the public water supply systems themselves. The costs of maintaining newly-mandated stream water quality standards are forcing industry to adopt recycling/reuse production techniques which demand less total water. Advances in industrial cooling technology have led to lower total water requirements, although this is offset somewhat by the resultant problem

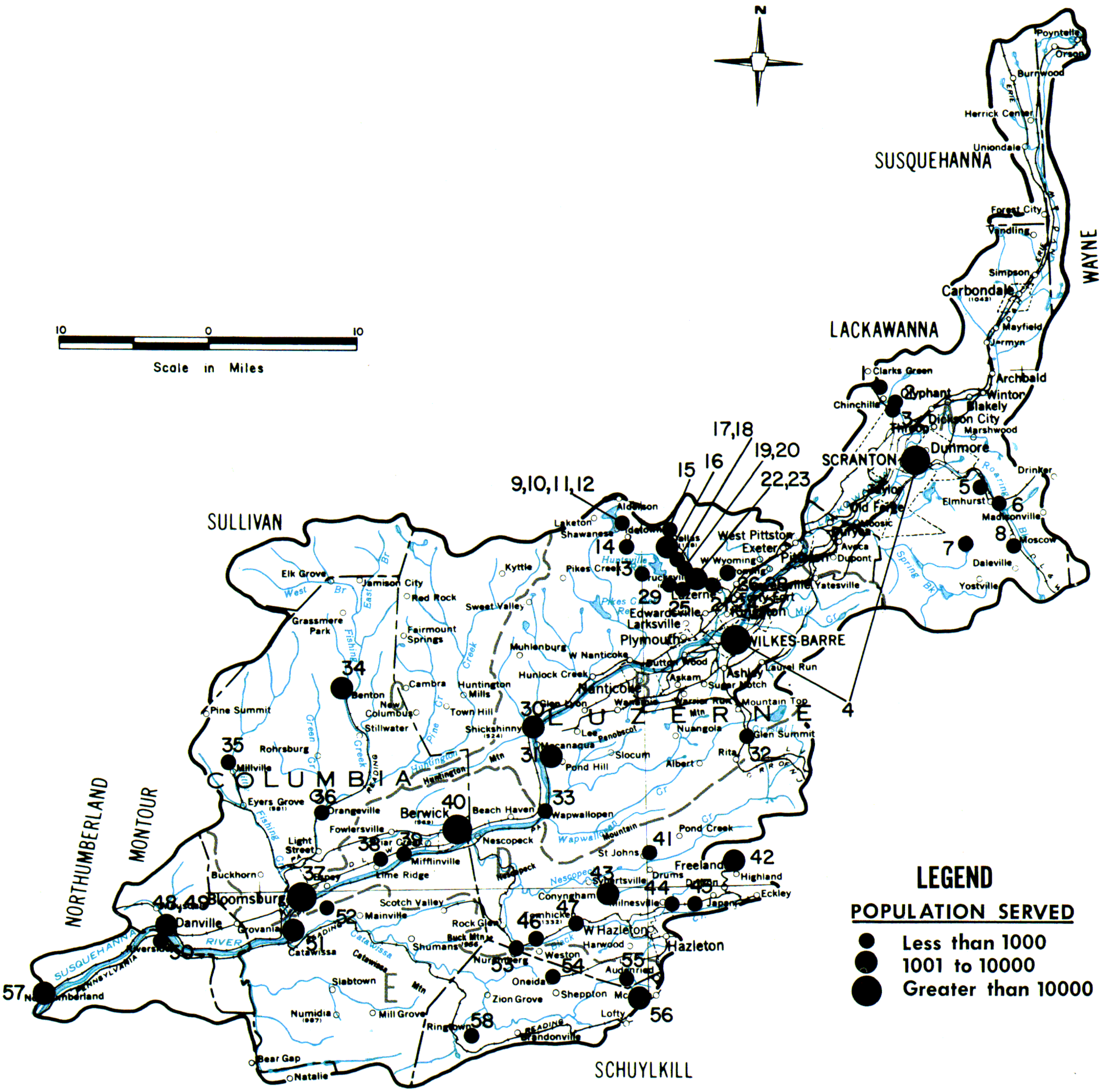

FIGURE 9. Location and Size of Public Water Suppliers

of increased evaporative loss, which is discussed in Part 3 of this section.

The major thrust of conservation as it relates to public water supply must be directed toward both the individual consumer and the supplier. Conservation education must be directed toward the consumer to enlighten him to both the importance of conservation and also the methods by which he can practice conservation. Measures which must be applied by the supplier to either conserve water directly or promote conservation by the consumer include:

(1) reduction of leakage and loss in the system

(2) adoption of conservation-promoting pricing policies

(3) rationing (primarily an emergency measure)

(4) the promotion of building codes which require the use of water-saving devices in new construction

(5) promotion of the use of water-saving devices by existing residential, commercial and industrial customers

(6) metering

(7) initiation of effective timber harvesting practices in water supply watersheds

Appendix B-1 provides a more detailed dicusssion of conservation techniques, particularly as they apply to the individual consumer.

The following alternatives have been considered as conceptual solutions to public water supply problems:

(1) Yield deficit
- (a) Management of Existing Resources
- (b) New Development
  - i. Stream withdrawal – taking water directly from a stream
  - ii. Surface raw water storage – reservoir
  - iii. Groundwater development – wells & springs

(2) Storage Deficit
- (a) Management of Existing Resources
- (b) Increase treated water storage (new development)

(3) Water Allocation Deficit
- (a) Management of Existing Resources
- (b) Increased Allocation

(4) Filtration Capacity Deficit
- (a) Management of Existing Resources
- (b) Increase Filtration Plant Capacity (expansion of existing facility or new development)

Management of existing resources includes the following measures:

(1) Reduction of demand through consumer conservation

(2) Metering (if not already being used)

(3) Purchasing from other suppliers which have excess supply (does not apply to storage deficit)

(4) Reduction of leakage and loss within the system

(5) Regionalization of water suppliers

Table 17 lists the present sources, projected short-term (1990) and long-term (2020) deficiencies, solution alternatives, and associated costs for those water suppliers which have been identified as having problems. The specific solution alternatives presented are the result of an examination of the conceptual solutions listed above, with regard to their feasibility for solving the identified problems. Conservation measures were examined in detail for suppliers whose residential gpcd[28] exceeds 50 or whose industrial usage is significant. Metering was considered where it was not already being used. Structural measures were outlined and examined for obvious, overwhelmingly negative characteristics, either economic, social or environmental; only feasible solutions were then listed in Table 17. In all cases, if regional, county or utility plans were available, they were screened to obtain locally developed solution concepts or recommendations. Costs for new project development were estimated on an annual basis, at 1976 price levels using a 5–1/4 percent interest rate amortized over the assumed life period of the structure. These costs are preliminary planning estimates only, developed for use in reviewing alternatives, and should not be used for project budgeting or design.

Any reservoir solution alternatives listed in Table 17 are also located on Figure 10. Environmental and social parameters for major potential structural solution alternatives are listed and evaluated in Table 18. A discussion of the impacts associated with the major recommended structural solutions is presented in Chapter VI.

c. *Recommendations*

The feasible solution alternatives were examined in greater detail in order to determine which alternative or combination of alternatives appeared most capable of solving a given problem, not only from the standpoint of that problem, but also with respect to the overall water resources scenario of the subbasin. Some alternatives were rejected in favor of others after consideration was given to physical resource and environmental restrictions, such as Scenic Rivers candidates or already-taxed groundwater aquifers or in some cases known social-political considerations. For

[28] gpcd – gallons per capita per day

Continued on page 76

Table 17

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Stanton Water Company (35937103)	2 wells 1990 SD = 0.019 2020 SD = 0.025	**1) Implement residential water conservation program** **2) Increase treated storage**
Chinchilla Water Company (35937105)	2 wells 1990 YD = 0.004 2020 YD = 0.045	**1) Metering** **2) Purchase water from Pa. Gas & Water Company** **3) Well development in the Susquehanna Gp. with groundwater treatment**
	1990 SD = 0.021 2020 SD = 0.037	**4) Increase treated storage**
Pa. Gas and Water Company (40001101) Existing Interconnection with Trucksville Water Company, Keystone Water Company; Abington District, Anna Hall Water Company	18 wells 34 surface sources 1990 YD = 13.99 2020 YD = 32.78 (Yield deficits above include proposed Back Mountain Regional System addition)	**1) Implement residential and industrial water conservation programs** **2) Metering** **3) Institute system-wide leakage and loss reduction program** 4) Intake on Susquehanna River with filtration plant 5) Small Dam #38–5 on the South Branch Tunkhannock Creek & intake with filtration plant 6) Well development in glacial outwash with groundwater treatment
	1990 AD = 24.88 2020 AD = 46.62	
	1990 FPD = 132.6 2020 FPD = 154.6	**7) Current company proposal to develop filtration plants on existing sources** **8) Additional filtration capacity on existing or potential sources**
Elmbrook Public Service (35935103)	2 wells 2020 YD = 0.014	**1) Implement residential water conservation program** **2) Well development in the Catskill Fm. with groundwater treatment**
	1990 SD = 0.043 2020 SD = 0.072	**3) Increase treated storage**

[a]Includes the following quantitative deficiencies only: YD - Yield deficiency (million gallons per day); SD - Storage deficiency (million gallons); FPD - Filtration plant deficiency (million gallons per day); AD - Allocation deficiency (million gallons per day).

[b]Storage alternatives apply to storage deficiencies only, and are supplemental to yield, allocation and filtration solution alternatives. **BOLDFACE** indicates recommended or preferred solution(s).

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				2) Should have at least 1 day treated storage capacity
0.020	2	0.030	2	
				1) Metering should solve 100% of 1990 & 24% of 2020 YD
0.007	1	0.011	2	
0.045	7	0.045	7	4) Should have at least 1 day treated storage capacity
0.065	2	0.065	2	
0.065	8	0.065	8	
0.030	2	0.040	3	
				2) Metering should solve 35% of 1990 and 17% of 2020 YD 3) Cost and demand reduction estimates not available
4.9	531	5.5	570	
–	–	–	–	
14.0	82	33.0	188	
14.0	564	33.0	985	
14.0	501	33.0	667	
14.0	564	33.0	985	
14.0	173	33.0	408	
14.0	229	33.0	394	
83.0	3,333	83.0	3,333	Allocation deficiency based on peak demand should not be used to determine future requirements as major water storage facilities are available for peak use
49.6	1,116	71.6	2,633	
				3) Should have at least 1 day treated storage capacity
		0.065	2	
		0.065	8	
0.050	3	0.080	4	

[c]Annual costs (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

Note: The 2020 design capacity includes the 1990 design capacity, and the long-term annual costs include the short-term annual costs unless otherwise noted in the remarks.

See Appendix B-2 for further explanation of columns.

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Olwen Heights Water Service Company (35935101)	3 wells 1990 SD = 0.048 2020 SD = 0.081	**1) Implement residential water conservation program** **2) Increase treated storage**
Poco-Spring Water Company (35935102)	2 wells 2020 YD = 0.111 1990 SD = 0.061 2020 SD = 0.103	**1) Implement residential water conservation program** **2) Metering** **3) Well development in the Catskill Fm. with groundwater treatment** **4) Increase treated storage**
Moscow Water Company (35931101)	Latouche Creek 1990 YD = 0.139 2020 YD = 0.199 1990 SD = 0.117 2020 SD = 0.145 1990 AD = 0.234 2020 AD = 0.290	**1) Implement residential water conservation program** **2) Metering** **3) Well development in the Catskill Fm. with groundwater treatment** 4) Purchase water from Pa. Gas & Water Company 5) Small Dam #37–9 on East Branch Roaring Brook Creek and intake with filtration plant 6) Small Dam #45–3 on Webster Creek and intake with filtration plant **7) Increase treated storage**
Rhodes Terrace Water Company (40974101)	1 well 2020 SD = 0.004	**1) Implement residential water conservation program** **2) Increase treated storage**
Warden Place Water Company (40974102)	2 wells 2020 SD = 0.004	**1) Implement residential water conservation program** **2) Increase treated storage**
Whitebread Water Company (40974103)	1 well 1990 SD = 0.013 2020 SD = 0.019	**1) Implement residential water conservation program** **2) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				2) Should have at least 1 day treated storage capacity
0.050	3	0.090	4	
				2) Metering should solve 26% of 2020 YD
		0.029	3	4) Should have at least 1 day
		0.111	4	treated storage capacity
		0.120	11	
0.070	4	0.110	5	
				2) Metering should solve 12% of 1990 and 12% of 2020 YD
				5) Present source to be used
0.017	2	0.023	3	as emergency system
0.139	5	0.199	7	6) Present source to be used
0.140	13	0.200	16	as emergency system
				7) Should have at least 1 day
0.140	15	0.200	22	treated storage capacity
0.235	119	0.235	119	
0.240	40	0.240	40	
0.235	47	0.235	47	
0.240	40	0.240	40	
0.120	5	0.150	6	
				Supplemental well development will satisfy this deficiency
				2) Should have at least 1 day treated storage capacity
		0.010	1	
				2) Should have at least 1 day treated storage capacity
		0.010	1	
				2) Should have at least 1 day treated storage capacity
0.020	2	0.020	2	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Harveys Lake Water Company (40974104)	1 well 2020 YD = 0.027	**1) Metering** **2) Purchase water from Pa. Gas and Water Company** 3) Well development in the Susquehanna Gp. with groundwater treatment
Village Water Company (40952102)	1 well 1990 SD = 0.006 2020 SD = 0.012	**1) Implement residential water conservation program** **2) Increase treated storage**
Oak Hill Water Company (40952101)	3 wells 1990 SD = 0.063 2020 SD = 0.088	**1) Implement residential water conservation program** **2) Increase treated storage**
Valley View Park Water Company (40931106)	1 well 1990 YD = 0.019 2020 YD = 0.108	**1) Metering** **2) Well development in the Susquehanna Gp. with groundwater treatment**
	1990 SD = 0.055 2020 SD = 0.092	**3) Increase treated storage**
Dallas Water Company (40809101)	6 wells 1990 YD = 1.295 2020 YD = 3.613	**1) Implement residential water conservation program** **2) Purchase water from Pa. Gas & Water Company** 3) Well development in the Susquehanna Gp. with groundwater treatment
	1990 SD = 0.229 2020 SD = 1.195	**4) Increase treated storage**
Overbrook Water Company (40931101)	3 wells 2020 SD = 0.014	**1) Increase treated storage**
Homesite Water Company (40809109)	1 well 2020 YD = 0.011	**1) Metering** **2) Purchase water from Pa. Gas & Water Company** 3) Well development in the Susquehanna Gp. with groundwater treatment
	1990 SD = 0.001 2020 SD = 0.007	**4) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				1) Metering should solve
		0.005	1	19% of 2020 YD
		0.027	4	2) Back Mountain Regional System
		0.065	2	
		0.065	8	
				2) Should have at least 1 day treated storage capacity
0.010	1	0.020	2	
				2) Should have at least 1 day treated storage capacity
0.070	4	0.090	5	
				1) Metering should solve 68%
0.013	3	0.022	3	of 1990 and 20% of 2020 YD
0.065	2	0.108	4	3) Should have at least 1 day
0.065	8	0.110	11	treated storage capacity
0.060	4	0.100	5	
				2) Back Mountain Regional System
				4) Should have at least 1 day
1.295	95	3.613	264	treated storage capacity
1.295	46	3.613	129	
1.300	51	3.620	98	
0.230	8	1.200	23	
				1) Should have at least 1 day
		0.020	2	treated storage capacity
				1) Metering should solve 27%
		0.003	1	of 2020 YD
		0.011	2	2) Back Mountain Regional System
		0.065	2	4) Should have at least 1 day
		0.065	8	treated storage capacity
0.010	1	0.010	1	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Hillcrest Water Company (40948108)	1 well 2020 YD = 0.004	**1) Metering** **2) Purchase water from Pa. Gas & Water Company** 3) Well development in the Susquehanna Gp. with groundwater treatment
	1990 SD = 0.008 2020 SD = 0.016	**4) Increase treated storage**
Shavertown-Kingston Twp. Water Company (40948107)	3 wells 1990 YD = 0.051 2020 YD = 0.118	**1) Metering** **2) Purchase water from Pa. Gas & Water Company** 3) Well development in the Susquehanna Gp. with groundwater treatment
	1990 SD = 0.022 2020 SD = 0.049	**4) Increase treated storage**
Shavertown Water Company (40948101) Existing Interconnection with William A. Still Estate	7 wells 2020 YD = 0.197	**1) Purchase water from Pa. Gas & Water Company** 2) Well development in the Susquehanna Gp. with groundwater treatment
	1990 SD = 0.226 2020 SD = 0.435	**3) Increase treated storage**
Meadowcrest Water Company (40948110)	3 wells 1990 YD = 0.129 2020 YD = 0.353	**1) Implement residential water conservation program** **2) Metering** **3) Purchase water from Pa. Gas & Water Company** 4) Well development in the Pocono Gp. with groundwater treatment
	1990 SD = 0.037 2020 SD = 0.129	**5) Increase treated storage**
Garbush Water Company (40945101)	2 wells 1990 SD = 0.001 2020 SD = 0.006	**1) Increase treated storage**
Midway Manor Water Supply Company (40948104)	1 well 1990 SD = 0.045 2020 SD = 0.079	**1) Implement residential water conservation program** **2) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				1) Metering should solve 100%
		0.004	1	of 2020 YD
		0.004	1	2) Back Mountain Regional
				System
		0.065	2	4) Should have at least 1 day
		0.065	8	treated storage capacity
0.010	1	0.020	2	
				1) Metering should solve 14%
0.007	1	0.014	2	of 1990 and 12% of 2020 YD
0.051	7	0.118	13	2) Back Mountain Regional
				System
0.065	2	0.118	4	4) Should have at least 1 day
0.065	8	0.120	11	treated storage capacity
0.030	2	0.050	3	
				1) Back Mountain Regional
		0.197	18	System
		0.197	7	3) Should have at least 1 day
		0.200	16	treated storage capacity
0.230	7	0.450	10	
				2) Metering should solve 22%
				of 1990 and 15% of 2020 YD
				3) Back Mountain Regional
0.029	3	0.052	4	System
0.129	12	0.353	32	5) Should have at least 1 day
				treated storage capacity
0.129	4	0.353	10	
0.130	12	0.360	23	
0.040	3	0.130	5	
				1) Should have at least 1 day
0.010	1	0.010	1	treated storage capacity
				2) Should have at least 1 day
				treated storage capacity
0.050	3	0.080	4	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Harris Hill Acres Water Company (40948113)	1 well 1990 YD = 0.005 2020 YD = 0.019	**1) Implement residential water conservation program** **2) Well development in the Susquehanna Gp. with groundwater treatment**
	1990 SD = 0.005 2020 SD = 0.010	**3) Increase treated storage**
John Fielding Water Company (40945102)	1 well 1990 YD = 0.014 2020 YD = 0.055	**1) Implement residential water conservation program** **2) Well development in the Susquehanna Gp. with groundwater treatment**
	1990 SD = 0.019 2020 SD = 0.036	**3) Increase treated storage**
Shickshinny Water Company (40965101) Existing interconnection with Mocanaqua Water Company	Little Shickshinny Creek 1990 YD = 0.286 2020 YD = 0.313	**1) Implement residential water conservation program** **2) Metering** **3) Well development in the Mauch Chunk Fm. with groundwater treatment** 4) Intake on Susquehanna River with filtration plant 5) Small Dam #08–8 on tributary to Shickshinny Creek and intake with filtration plant 6) Small Dam #08–9 on Little Shickshinny Creek and intake with filtration plant
	1990 SD = 0.011 2020 SD = 0.025 1990 AD = 0.030 2020 AD = 0.056	**7) Increase treated storage**
Benton Water Supply Company (19905101)	1 well 1990 YD = 0.033 2020 YD = 0.170	**1) Well development in glacial outwash with groundwater treatment** 2) Intake on Fishing Creek with filtration plant
	1990 SD = 0.033 2020 SD = 0.090	**3) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				3) Should have at least 1 day treated storage capacity
0.065	2	0.065	2	
0.065	8	0.065	8	
0.010	1	0.010	1	
				3) Should have at least 1 day treated storage capacity
0.065	2	0.065	2	
0.065	8	0.065	8	
0.020	2	0.040	3	
				2) Metering should solve 14% of 1990 and 2020 YD
				4) Present source to be used as emergency system
0.041	4	0.044	4	5) Present source to be used
0.286	8	0.313	9	as emergency system
0.290	20	0.320	21	6) Present source to be used
				as emergency system
0.437	6	0.437	6	7) Should have at least 1 day
0.450	60	0.450	60	treated storage capacity
0.437	77	0.437	77	
0.450	60	0.450	60	
0.437	46	0.437	46	
0.450	60	0.450	60	
0.012	1	0.025	2	
				Supplemental well development will satisfy this deficiency
				2) Present source to be used
0.288	4	0.288	4	as emergency system
0.040	6	0.170	14	3) Should have at least 1 day
				treated storage capacity
0.370	5	0.370	5	
0.400	57	0.400	57	
0.040	3	0.090	5	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Millville Municipal Authority (19923101)	2 wells 1990 YD = 0.101 2020 YD = 0.193	**1) Implement residential water conservation program** **2) Well development in the Hamilton Gp. with groundwater treatment** 3) Small Dam #36–12 on Little Fishing Creek and intake with filtration plant
Orangeville Borough Water Service (19928101)	1 well 7 springs 2020 YD = 0.042	**1) Well development in the Catskill Fm. with groundwater treatment** 2) Intake on Fishing Creek with filtration plant
Bloomsburg Water Company (19002101)	Fishing Creek 2020 AD = 1.033	**1) Implement industrial water conservation program** **2) Increased allocation on existing source**
	2020 FPD = 0.717	**3) Additional filtration capacity on existing source**
Scenic Knolls Water Company (19932101)	3 wells 1990 YD = 0.018 2020 YD = 0.042	**1) Implement residential water conservation program** **2) Metering** **3) Well Development in the Bloomsburg-McKenzie Fms. with groundwater treatment**
	1990 SD = 0.015 2020 SD = 0.025	**4) Increase treated storage**
Mifflin Township Water Authority (19922101)	2 wells 2020 YD = 0.195	**1) Implement residential water conservation program** **2) Well development in glacial outwash with groundwater treatment** 3) Intake on the Susquehanna River with filtration plant 4) Small Dam #08–11 on West Branch Blair Creek and intake with filtration plant 5) Small Dam #07–1 on Tenmile Run and intake with filtration plant

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				3) Present sources to be used as emergency system
0.101	13	0.193	25	
0.110	11	0.195	16	
0.199	162	0.199	162	
0.200	36	0.200	36	
				2) Present source to be used as emergency system
		0.065	2	
		0.065	8	
		0.096	3	
		0.100	23	
		1.033	N/A	
		0.720	26	
				2) Metering should solve 28% of 1990 and 17% of 2020 YD
0.005	1	0.007	1	4) Should have at least 1 day treated storage capacity
0.029	2	0.042	3	
0.029	6	0.050	7	
0.020	2	0.030	2	
				3) Present sources to be used as emergency system 4) Present sources to be used as emergency system
		0.288	4	
		0.200	16	5) Present sources to be used as emergency system
		0.390	6	
		0.400	56	
		0.390	55	
		0.400	56	
		0.390	53	
		0.400	56	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Keystone Water Company; Berwick District (19001101)	3 wells,Glen Brook Reservoir on Briar Creek 1990 SD = 3.809 2020 SD = 4.966	**1) Implement industrial water conservation program** **2) Institute system-wide leakage and loss reduction program** **3) Increase treated storage**
Williams and Son Water Company (40927101)	1 spring 1990 YD = 0.002 2020 YD = 0.018	**1) Metering** **2) Well development in the Mauch Chunk Fm. with groundwater treatment** 3) Purchase water from Hazleton City Authority
	1990 SD = 0.009 2020 SD = 0.016	**4) Increase treated storage**
Borough of Freeland Municipal Authority (40815101) Existing interconnection with Hazleton City Authority	9 wells 1990 YD = 0.167 2020 YD = 0.375	**1) Well development in the Mauch Chunk Fm. with groundwater treatment** 2) Intake on Pond Creek with filtration plant 3) Intake on Nescopeck Creek with filtration plant 4) Purchase water from Hazleton City Authority
Conyngham Water Company (40928101)	5 wells 1990 YD = 0.153 2020 YD = 0.467	**1) Implement residential water conservation program** **2) Well development in the Mauch Chunk Fm. with groundwater treatment** **3) Purchase water from Hazleton City Authority** 4) Purchase water from Hazleton City Authority 5) Small Dam #35–1 on tributary to Long Run and intake with filtration plant
	2020 SD = 0.062	**6) Increase treated storage**
Hazleton Water Authority;Ebervale Division (40940103)	2 wells,1 reservoir 1990 SD = 0.053 2020 SD = 0.083	**1) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				2) Cost and demand reduction
				estimates not available
				3) Should have at least 1 day
				treated storage capacity
–	–	–	–	
3.81	65	4.97	83	
				1) Metering should solve 100%
0.002	1	0.004	1	of 1990 and 22% of 2020 YD
0.094	3	0.094	3	3) Greater Hazleton Community
0.094	10	0.094	10	Authority, Alternative I
				4) Should have at least 1 day
0.018	18	0.018	18	treated storage capacity
0.010	1	0.020	2	
				2) Due to poor water quality
0.167	5	0.375	11	this source may require
0.170	14	0.380	24	additional treatment. Present
				sources to be used as emergency
0.745	27	0.745	27	system
0.750	120	0.750	120	3) Due to poor water quality
0.745	35	0.745	35	this source may require
0.750	120	0.750	120	additional treatment. Present
0.375	177	0.375	177	sources to be used as emergency
				system
				4) Greater Hazleton Community
				Authority, Alternative I
				3) Greater Hazleton Community
				Authority, Alternative II
				4) Greater Hazleton Community
0.153	4	0.467	13	Authority, Alternative I
0.160	14	0.470	27	5) Present sources to be used
				as emergency system
0.467	83	0.467	83	6) Should have at least 1 day
				treated storage capacity
0.467	150	0.467	150	
0.715	79	0.715	79	
0.750	84	0.750	84	
		0.070	4	
				1) Should have at least 1 day
0.060	3	0.090	4	treated storage capacity

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Hazleton Water Authority; Derringer Division (40925101)	1 well 2020 YD = 0.008	**1) Metering** **2) Well development in the Pottsville Fm. with groundwater treatment** 3) Intake on Black Creek with filtration plant
Hazleton Water Authority; Tomhicken Division (40967102)	1 well 2020 YD = 0.024	**1) Metering** **2) Well development in the Pottsville Fm. with groundwater treatment** 3) Intake on Black Creek with filtration plant
	2020 SD = 0.010	**4) Increase treated storage**
Borough of Danville (47801101) Existing interconnection with Mahoning Township Sewer and Water Authority	Susquehanna River 1990 AD = 0.974 2020 AD = 1.466	**1) Implement residential water conservation program** **2) Metering** **3) Increased allocation on existing source**
Mahoning Township Authority (47907101)	3 wells 1990 YD = 0.165 2020 YD = 0.548	**1) Implement residential water conservation program** **2) Metering** **3) Purchase water from Borough of Danville** **4) Well development in the Keyser-Tonoloway-Wills Creek Fms. with groundwater treatment** 5) Intake on the Susquehanna River with filtration plant
	2020 SD = 0.119	**6) Increase treated storage**
Hillside Estates; Thomas Ernst (49924202)	2 wells 1990 SD = 0.004 2020 SD = 0.007	**1) Implement residential water conservation program** **2) Increase treated storage**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				1) Metering should solve 63% of 2020 YD
		0.055	1	
		0.022	2	3) Due to poor water quality this source may require additional treatment. Present source to be used as emergency system
		0.022	4	
		0.051	3	
		0.050	21	
				1) Metering should solve 25% of 2020 YD
		0.006	1	
		0.024	2	3) Due to poor water quality this source may require additional treatment. Present source to be used as emergency system
		0.030	5	
		0.060	5	
		0.100	23	
		0.010	1	4) Should have at least 1 day treated storage capacity
–	17	–	17	
0.974	N/A	1.466	N/A	
				2) Metering should solve 28% of 1990 and 16% of 2020 YD
				5) Present sources to be used as emergency system
0.047	5	0.086	7	
0.170	16	0.550	40	6) Should have at least 1 day treated storage capacity
0.165	6	0.548	20	
0.170	14	0.550	30	
0.855	23	0.855	23	
0.860	92	0.860	92	
		0.120	5	
				2) Should have at least 1 day treated storage capacity
0.010	1	0.010	1	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
Municipal Authority of the Borough of Catawissa (19909101)	3 wells,3 springs 1990 YD = 0.056 2020 YD = 0.177	**1) Implement residential water conservation program** **2) Metering** **3) Well development in the Catskill Fm. with groundwater treatment** 4) Intake on Catawissa Creek with filtration plant 5) Small Dam #34–1 on tributary to Catawissa Creek and intake with filtration plant
Nuremberg Water Company (54943101)	3 wells 2020 YD = 0.008	**1) Well development in the Mauch Chunk Fm. with groundwater treatment**
	1990 SD = 0.031 2020 SD = 0.058	**2) Increase treated storage**
Oneida Water Company (54925101)	3 wells 1990 SD = 0.015 2020 SD = 0.034	**1) Implement residential water conservation program** **2) Increase treated storage**
Beaver Brook Water Company (40940101)	2 wells 1990 SD = 0.014 2020 SD = 0.023	**1) Increase treated storage**
Honey Brook Water Company (54809101)	1 well,Honey Brook Reservoir, Reservoir #8 on Hunkydory Creek 1990 SD = 1.049 2020 SD = 1.293	**1) Implement residential water conservation program** **2) Increase treated storage**
Keystone Water Company; Northumberland District (49806101)	3 wells,1 spring, Lithia Spring Creek (Johnson Run) 2020 YD = 0.310	**1) Institute system-wide leakage and loss reduction program** **2) Well Development in the Catskill Fm. with groundwater treatment** 3) Purchase water from the Municipal Authority of Sunbury 4) Intake on West Branch Susquehanna River with filtration plant 5) Small Dam #019–1 on Johnson Creek and intake with filtration plant

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				2) Metering should solve 59% of 1990 and 25% of 2020 YD
0.033	5	0.045	5	4) Due to poor water quality this source may require additional treatment. Present sources to be used as emergency system
0.065	2	0.177	6	
0.065	8	0.180	15	
0.448	6	0.448	6	5) Present sources to be used as emergency system
0.450	59	0.450	59	
0.448	156	0.448	156	
0.450	41	0.450	41	
				2) Should have at least 1 day treated storage capacity
		0.094	3	
		0.094	10	
0.040	3	0.060	4	
				2) Should have at least 1 day treated storage capacity
0.020	2	0.040	3	
0.020	2	0.030	2	1) Should have at least 1 day treated storage capacity
				2) Should have at least 1 day treated storage capacity
1.050	20	1.300	25	
				1) Cost and demand reduction estimates not available 4) Present sources to be used as emergency system
–	–	–	–	5) Present sources to be used as emergency system
		0.310	11	
		0.310	21	
		0.310	34	
		0.985	9	
		1.000	101	
		0.985	94	
		1.000	101	

Table 17 (Cont.)

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Public Water Supplier (DER Code)	Existing Source and Projected Deficiencies[a]	Solution Alternatives[b]
State Correctional Institution-Dallas (40945201)	2 wells 1990 YD = 0.083 2020 YD = 0.131	**1) Well development in the Susquehanna Gp. with groundwater treatment** 2) Small Dam #08–5 on tributary to Harveys Creek and intake with filtration plant
Geisinger Medical Center (47907202) Existing interconnection with Borough of Danville	3 wells,1 spring 1990 YD = 0.359 2020 YD = 0.572	**1) Purchase water from Borough of Danville** **2) Well development in the Hamilton Gp. with groundwater treatment**

[a,b,c]See footnotes on pages 50 and 51.

1990 Increased Capacity Requirement	1990 Annual Cost ($1,000)[c]	2020 Increased Capacity Requirement	2020 Annual Cost ($1,000)[c]	Remarks
				2) Present sources to be used
0.083	3	0.131	5	as emergency system
0.090	10	0.140	13	
0.464	32	0.464	32	
0.500	65	0.500	65	
				2) Insufficient aquifer yields
0.360	33	0.580	53	may prohibit additional
				well development
0.360	47	0.575	75	
0.360	23	0.580	31	

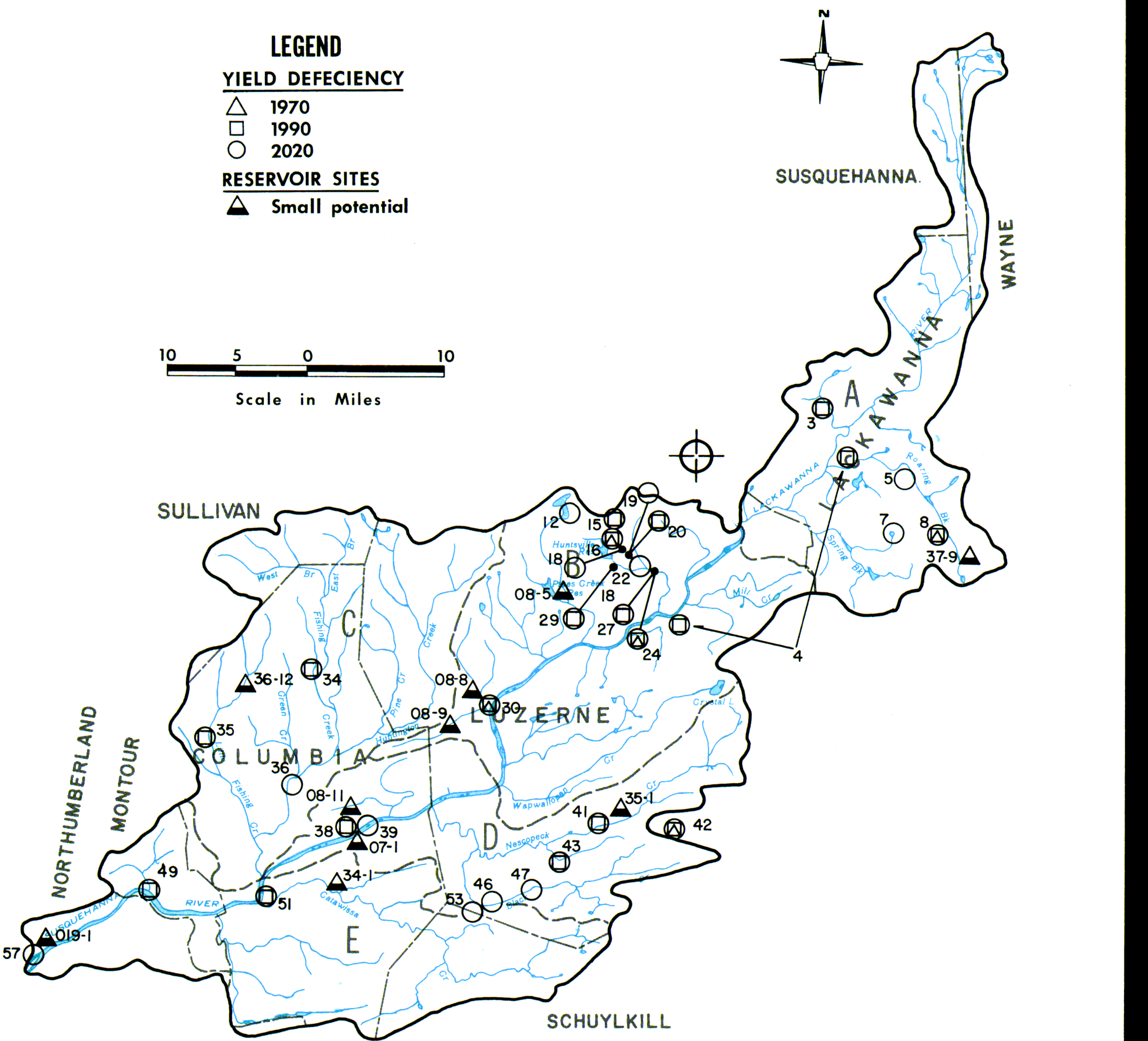

FIGURE 10. Water Supply Yield Deficiencies and Structural Solution Alternatives

Table 18

SCREENING ASSESSMENT OF WATER SUPPLY STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #37-9 on East Branch Roaring Brook	29.6 FC	28.0 FC 119.0 WS 154.0 WS/t	-Reduces flood damages -Provides storage capability for anticipated consumptive use makeup needs on Roaring Brook -Could provide storage for low flow augmentation needs -Could serve as a public water supply source for Moscow Water Company	-Loss of forestland -Alters habitat for fish and wildlife. -Would alter aquatic life	-Small potential reservoir #45–3 -Purchase water from Pa. Gas and Water Company -Well development	This project is recommended for further study. It is not the least costly alternative for water supply but warrants further study for flood control
Small Potential Reservoir #45-3 on Webster Creek		47.0 WS only 87.0 WS/t	-Could serve as a public water supply source for Moscow Water Company	-Loss of wetland area and forestland -Alters fish habitat and aquatic life	-Small potential reservoir #37–9 -Purchase water from Pa. Gas and Water Co. -Well development	Not Recommended This is not the least costly alternative
Small Potential Reservoir #38–5 on South Branch Tunkhannock Creek		501.0 WS only 1990-staged cost 1065.0 WS/t	-Provides storage capability for 67% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen -Could serve as a public water supply source for Pennsylvania Gas and Water Supply	-Relocation of 24–27 houses and 3 miles of roads and highways -Loss of farm, prime agriculture and forest land -Alters fish habitat on a trout stream -Alters aquatic life	-Well development -Water supply intake on the Susquehanna River	Not recommended This is not the least costly alternative
Small Potential Reservoir #08-8 on a Tributary to Shickshinny Creek		77.0 WS only 137.0 WS/t	-Could serve as a public water supply source for Shickshinny Water Company	-Loss of wetland area and forestland -Alters fish habitat and aquatic life	-Small potential reservoir #08-9 -Well development -Intake on the Susquehanna River	Not recommended This is not the least costly alternative

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 18 (Cont.)

SCREENING ASSESSMENT OF WATER SUPPLY STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #08-9 on Little Shickshinny Creek	1.5 FC	12.0 FC 46.0 WS 106.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Shickshinny Water Company	-Loss of forestland -Loss of wetland area -Would alter aquatic life -Minor relocation would include 1 school site	-Public water supply intake on Susquehanna River -Small potential reservoir #08-8 -Well development	Not Recommended This is not least costly alternative
Small Potential Reservoir #36-12 on Little Fishing Creek	4.1 FC	52.0 FC 162.0 WS 198.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Millville Municipal Authority	-Loss of farm, prime agriculture and forestland -Alters fish habitat on a trout stream -Would alter aquatic life -Wild and Scenic River Candidate Stream -Relocation of approximately 7–10 houses	-Well development	Not Recommended This is not the least costly alternative
Small Potential Reservoir #08-5 on East Fork Harvey Creek		32.0 WS only 97.0 WS/t	-Could serve as a public water supply source for the State Correctional Institution at Dallas	-Loss of forest and farm land -Alters fish habitat and aquatic life	-Well development	Not Recommended This is not the. least costly alternative
Small Potential Reservoir #08-11 on West Branch Briar Creek		55.0 WS only 2020 cost 111.0 WS/t	-Could serve as a public water supply source for the Mifflin Township Water Authority	-Loss of farm and prime agriculture land -Relocation of 7-10 houses a schoolhouse, 2 miles of railroad track and 1 mile of roadway -Alters fish habitat and aquatic life	-Small potential reservoir #07-1 -Well development -Intake on the Susquehanna River	Not recommended This is not the least costly alternative

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 18 (Cont.)

SCREENING ASSESSMENT OF WATER SUPPLY STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #07-1 on Tenmile Run		53.0 WS only 2020 cost 109.0 WS/t	-Could serve as a public water supply source for the Mifflin Township Water Authority	-Loss of farm and prime agriculture land -Relocation of 8-10 houses,1 mile of roadway, and a power transmission line -Alters fish habitat and aquatic life	-Small potential reservoir #08-11 -Well development -Intake on the Susquehanna River	Not Recommended This is not the least costly alternative
Small Potential Reservoir #35-1 on a Tributary to Long Run		79.0 WS only 163.0 WS/t	-Could serve as a public water supply source for Conyngham Water Company	-Loss of wetland area and forest land -Wild and Scenic River Candidate Stream -Alters fish habitat and aquatic life	-Purchase water from Hazleton City Authority -Well development	Not Recommended This is not the least costly alternative
Small Potential Reservoir #34-1 on a Tributary to Catawissa Creek	8.2 FC	38.9 FC 156.0 WS 197.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Catawissa Municipal Authority	-Loss of farm and prime agricultural land -Relocation of 4-6 houses -Would alter aquatic life	-Intake on Catawissa Creek -Well development	Not Recommended This is not the least costly alternative
Small Potential Reservoir #019-1 on Johnson Creek		94.0 WS only 195.0 WS/t	-Could serve as a public water supply source for Keystone Water Company; Northumberland District	-Loss of farm and forest land -Relocation of 8-10 houses and 1 mile of roadway -Alters fish habitat and aquatic life	-Purchase water from the Municipal Authority of Sunbury -Intake on West Branch Susquehanna River -Well development	Not Recommended This is not the least costly alternative

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 18 (Cont.)

SCREENING ASSESSMENT OF WATER SUPPLY STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Intake and treatment plant on Susquehanna River - Pa. Gas and Water Company		82.0 WS only 1990 staged cost 646.0 WS/t	-Could serve as a public water supply source for Pa. Gas and Water Company	-Alters fish habitat and aquatic life -Depletes stream flow for a distance of 12.7 miles between intake and discharge points -Wild and Scenic River Candidate Stream -Loss of wildlife habitat	-Small potential reservoir #38-5 -Well development	This alternative should be studied further if deficiencies still exist after the recommended conservation measures are fully implemented
Intake and Treatment plant on Susquehanna River - Shickshinny Water Company		6.0 WS 66.0 WS/t	-Could serve as a public water supply source for Shickshinny Water Company	-Wild and Scenic River Candidate Stream -Could alter aquatic life	-Small potential reservoirs #08-8 and #08-9 -Well development	Not Recommended This is not the least costly alternative
Intake and Treatment plant on Fishing Creek - Benton Water Company		5.0 WS 62.0 WS/t	-Could serve as a public water supply source for Benton Water Company	-Alters fish habitat on a trout stream -Wild and Scenic River Candidate Stream -Could alter aquatic life	-Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Fishing Creek - Orangeville Borough Water Service		3.0 WS - 2020 cost 26.0 WS/t	-Could serve as a public water supply source for Orangeville Borough Water Service	-Alters fish habitat on a trout stream -Wild and Scenic River Candidate Stream -Could alter aquatic life	-Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Susquehanna River -Mifflin Township Water Authority		6.0 WS- 2020 Cost 62.0 WS/t	-Could serve as a public water supply source for Mifflin Township Water Authority	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Small potential reservoirs #08-11 and #07-1 -Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Susquehanna River – Mahoning Township Authority		23.0 WS 115.0 WS/t	-Could serve as a public water supply source for Mahoning Township Authority	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Purchase water from Borough of Danville -Well development	Not recommended This is not the least costly alternative

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 18 (Cont.)

SCREENING ASSESSMENT OF WATER SUPPLY STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Intake and treatment plant on Pond Creek - Freeland Borough Municipal Authority		27.0 WS 147.0 WS/t	-Could serve as a public water supply source for Freeland Borough Municipal Authority	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Intake and treatment on Nescopeck Creek -Purchase water from Hazleton City Authority -Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Nescopeck Creek -Freeland Borough Municipal Authority		35.0 WS 155.0 WS/t	-Could serve as a public public water supply source for Freeland Borough Municipal Authority	-Wild and Scenic River Candidate Stream -Alters fish habitat on a trout stream -Could alter aquatic life	-Intake and treatment on Pond Creek -Purchase water from Hazleton City Authority -Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Black Creek - Hazleton Water Authority; Derringer Division		3.0 WS 2020 cost 24.0 WS/t	-Could serve as a public water supply source for Hazleton Water Authority; Derringer Division	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Black Creek - Hazleton Water Authority; Tomhicken Division		5.0 WS 2020 cost 28.0 WS/t	-Could serve as a public water supply source for Hazleton Water Authority; Tomhicken Division	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on Catawissa Creek - Catawissa Municipal Authority		6.0 WS 2020 cost 65.0 WS/t	-Could serve as a public water supply source for Catawissa Municipal Authority	-Could alter fish habitat and aquatic life	-Small potential reservoir #34-1 -Well development	Not Recommended This is not the least costly alternative
Intake and treatment plant on West Branch Susquehanna River - Keystone Water Company; Northumberland District		9.0 WS 2020 cost 110.0 WS/t	-Could serve as a public water supply source for Keystone Water Company; Northumberland District	-Wild and Scenic River Candidate Stream -Could alter fish habitat and aquatic life	-Purchase water from the Municipal Authority of Sunbury -Small potential reservoir #019-1 -Well development	Not Recommended This is not the least costly alternative

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

some problems two or more alternatives may appear equally satisfactory.

The alternatives which appear to most warrant further study for implementation are indicated by bold type in Table 17. In some cases, more than one total solution to a problem may be recommended if available information was not sufficient to determine the preference of one over the other. The recommendations include:

(1) It is strongly recommended that applicable conservation measures be applied by all suppliers whose residential gpcd exceeds 50 or whose industrial usage is significant. Those public water suppliers who are currently not metered or only partially metered should extend metering to all customers in order to help reduce water demands (See Table 17). These should be the initial means to alleviate existing or projected deficiencies.

(2) For the Pennsylvania Gas and Water Company, it is strongly recommended that meters be installed for all customers and that a system-wide analysis of leakage and loss reduction be conducted in order to more efficiently utilize the water resources they are tapping from the basin. At least a ten percent reduction in total demand could be realized by these two measures. In addition, a water conservation program is needed to reduce the company's residential gpcd from its present level of 76 to 50. Industrial customers should also be encouraged to conserve. A five percent reduction in total demand is achievable through these two measures. If yield deficiencies still exist after the above demand reduction measures are fully employed, a new source of supply will have to be developed by the company. Three viable alternatives, including a Susquehanna River intake, well field development and additional reservoir storage, should be studied in detail to determine the best option.

(3) Groundwater development will meet short-term (1990) and long-term (2020) yield deficiencies of 14 and 22 public water suppliers, respectively.

(4) Purchasing water will solve the 1990 and 2020 yield deficiencies of three public water suppliers. Chinchilla Water Company could purchase water from Pennsylvania Gas and Water Company; Conyngham Water Company's deficiencies could be eliminated by the purchase of water from the Hazleton City Authority and Mahoning Township Authority could purchase additional supplies from Danville Borough.

(5) Another solution alternative that is recommended is the Back Mountain regional system. Water would be provided by the Pennsylvania Gas and Water Company via its Huntsville source to the Greater Back Mountain Community Area, which includes seven public water suppliers with projected yield deficiencies. These companies currently utilize groundwater sources which are of low production and insufficient yield. Pennsylvania Gas and Water Company's Huntsville source should provide the needed source reliability for the Back Mountain Area. The companies that should be included in the Back Mountain regional system are:

*(a) Banks Water Company (Meadowcrest Water Company)
*(b) Dallas Water Company
*(c) Harvey's Lake Water Company
(d) High Point Water Association
*(e) Hillcrest Water Company
*(f) Homesite Water Company
(g) John Fielding Water Company
(h) Lakeview Terrace Water Company
(i) Maple Knoll Water Association
(j) Midway Manor Water Company
(k) Oak Hill Water Company
(l) Overbrook Water Company
(m) Rhodes Terrace Water Company
*(n) Shavertown Water Company
*(o) Shavertown-Kingston Township Water Company
(p) William A. Still Estate Water Company
(q) Trucksville Water Company
(r) Whitebread Water Company
(s) Warden Place Water Company

*Public water suppliers with projected yield deficiencies

In addition to the seven Back Mountain water suppliers that have projected yield deficiencies, the remaining 12 suppliers also utilize groundwater sources which are of low production.

(6) Increased treated water storage capacity is needed for 31 water suppliers by 1990 and for 37 water suppliers by 2020.

(7) A water allocation is needed for the Moscow Water Company's present source, LaTouche Creek. Also, according to current projections, the Bloomsburg Water Company and Danville Borough need increased allocations on their existing sources.

These recommendations are made as possible solutions to public water supply problems. Prior to actual construction of a project or implementation of a program, detailed studies of all environmental, social and economic factors must be completed to assure optimum benefits and results.

3. CONSUMPTIVE USE MAKEUP

a. *Problems*

The protection of water uses from future source depletion is a primary concern of water resources management. One facet of water resources management, which is important to the protection of both instream and withdrawal uses, is the careful management of consumptive water uses.

Consumptive water uses can be divided into two categories: (1) direct consumptive water - the quantity of water discharged to the atmosphere or incorporated in the product of a process such as vegetative growth, food processing or an industrial process, and (2) indirect consumptive water - the quantity of water transferred from a source watershed to another watershed and never returned, or water transferred from an upstream intake point to a downstream discharge point bypassing inbetween users.

Consumptive water use thus results in a depletion of natural streamflows downstream of the intake point. Although the effects of limited and in some cases even significant depletions may be negligible under normal streamflow conditions, the impacts on instream as well as downstream withdrawal uses can become critical during periods of low streamflow.

The Susquehanna River Basin Commission (SRBC), with regulatory powers over all water use in the basin, adopted a low flow policy on September 14, 1976. That policy, which was developed with considerable input from DER, requires that all future incremental consumptive uses be made up during periods when the streamflow is less than the total of the 7-day 10-year low flow (Q_{7-10}[29]) plus the consumptive use. The policy applies to all water users who use stream withdrawals as sources or who use groundwater aquifers hydraulically related to streamflows.

In order to adopt a policy by which water use can be specially managed during low flow conditions, it was necessary to first define some characteristic of streamflow which could be observed in order to identify when the low flow is occurring. Stream discharge is the obvious characteristic to monitor; and a discharge less than or equal to Q_{7-10} was adopted as the definition of low flow. The 7-day 10-year low flow is the average low flow for a period of seven consecutive days, which would occur on the average once every ten years. Although that low flow definition is the subject of continuing investigation, it was initially adopted by SRBC on the premise that it is generally high enough to protect water quality standards and instream ecological uses, while at the same time being low enough so that it would be economically, socially and environmentally possible to provide the makeup water necessary during critical drought periods. Until further research possibly leads to a more comprehensive guideline, the Q_{7-10} is the adopted low flow level which must be protected against depletion by incremental consumptive water use.

In compiling past, present and future consumptive water use information, it was recognized that while its impact on streamflows in the past was small, in the future, consumptive uses could cause significant instream problems during low flows. An objective was set stating that *existing* streamflows should be protected against the detrimental effects of consumptive use. As existing streamflow records already reflect past and present consumptive water uses, the regulation was written to address only new or increased consumptive uses which would occur after the adoption of the policy. The effective date of the SRBC regulation was made retroactive to January 23, 1971, the date that SRBC was legally formed. The analyses in this report assume a base year of 1970 and should provide an accurate assessment of incremental consumptive use for the SRBC regulation requirements. Incremental consumptive use in any year is defined as the difference between consumptive use in that year and consumptive use in the base year; in other words, past consumptive water uses are "grandfathered".

Because the objective of consumptive use makeup is to protect the low flow against further depletion by consumptive use, a "trigger point" must be defined to indicate at what time a user must begin to make up his incremental consumption. When the flow is at a value equal to Q_{7-10} plus the total consumptive use, the user would be depleting the flow below his taking point to exactly the Q_{7-10} level; therefore, a flow equal to Q_{7-10} plus the total consumptive use has been assigned as the trigger point to guarantee that consumptive withdrawal water uses never contribute to depletion of streamflows below Q_{7-10}.

It must be emphasized that consumptive use makeup is not intended to maintain Q_{7-10}; it is intended to maintain the natural flow when the streamflow drops below Q_{7-10}, whatever that natural flow may be. A user is never required to return more water to the stream than was withdrawn. The user must only replace the water that was consumed, beyond the base year consumptive level. All makeup water must, however, be provided either at or upstream of the withdrawal point.

The 1990 consumptive water uses (including public water supply, self-supplied industry, power, agriculture and golf courses) were analyzed to determine makeup requirements along eight streams and stream reaches in Subbasin 5 (See Figure 11). The needs listed in Table 19 represent the total daily incremental consumption based on projected water usage for the five categories of water users. In order not to underestimate the aggregate compensating reservoir storage requirements in this preliminary planning stage, projected consumptive water use data were uniformly increased by 25 percent, thereby increasing the required storage estimates presented by a comparable amount. This has the effect of an overall safety factor to recognize both a) the difficulty in precise projection of total consumptive use for the subbasin and b) possible inaccuracies in necessarily preliminary estimates of yields or makeup period durations.

[29]Average consecutive 7-day low flow having a 10-year return period or a 10 percent chance of occurrence each year.

Table 19

CONSUMPTIVE WATER USE MAKEUP NEEDS

Legend (See Figure 11)	Stream and (Watershed)	Public Water Supply[a]			Self-Supplied Industry[a]			Self-Supplied Power Cooling[a]		
		D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)	D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)	D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)
1	Roaring Brook (A)	0.012	0.015	1.3						
2	Lackawanna River (A)									
3	Abrams Creek (B)				0.019	0.024	1.5			
4	Susquehanna River (D, E)	0.04	0.05	2.8	0.30	0.38	19.6			
5	Susquehanna River (B)							35.4	44.3	3,850
6	Fishing Creek (C)	0.096	0.12	6.2						
7	Nescopeck Creek (D)									
8	Catawissa Creek (E)									
	Subbasin Total									

[a]D.C.U. - Daily Consumptive Use; D.M.S.R. - Daily Makeup Source Requirement; A.M.S.R. - Annual Makeup Storage Requirement; mgd - million gallons per day; mg - million gallons
[b]Includes all irrigation which is assumed to occur within two miles of the stream identified in Column 2.
[c]Includes all livestock, and the remainder of irrigation not assumed to occur within two miles of the streams identified in Column 2.

For the eight areas identified as having consumptive use makeup needs in 1990, the total need is about 53 mgd. Eighty-four percent of that total will be needed to maintain operation of the Susquehanna and Hanover Electric Generating stations when natural flows fall below the trigger point. Both of those stations are scheduled to begin operation in the 1980's. Agricultural irrigation will account for another 14 percent of the daily makeup need. The numbers show that 98 percent of the total daily makeup needs are for uses that are vital during dry periods.

b. *Solution Alternatives*

When streamflows drop below the trigger point, consumptive users must be prepared to protect the natural streamflow. In order to avoid any additional depletion of streamflows, those users will be faced with a decision to either temporarily curtail consumptive uses until streamflows recover or else provide makeup water to replace what is being consumed. While curtailment or reduction of consumptive use may be the most desirable solution environmentally, it is not socially or economically the most effective because electric power generation and agricultural irrigation account for nearly all the significant consumptive use in Subbasin 5.

Consumptive users who are unable to curtail use will need to employ makeup techniques. The means by which makeup requirements can be met may be categorized as follows:

(1) Improved management of Existing Resources

(a) Release from existing excess storage

Self-Supplied Irrigation[a,b]			Self-Supplied Agriculture[a,c] and Golf Courses			Total[a]		
D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)	D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)	D.C.U. (mgd)	D.M.S.R. (mgd)	A.M.S.R. (mg)
						0.012	0.015	1.3
0.010	0.013	3.0	0.063	0.08	12.5	0.073	0.09	15.5
						0.019	0.024	1.5
2.8	3.5	180	0.13	0.16	6.9	3.27	4.1	209
						35.4	44.3	3,850
1.2	1.5	84	0.033	0.04	2.4	1.33	1.66	93
			0.05	0.06	3.3	0.05	0.06	3.3
1.90	2.38	138				1.90	2.38	130.
						42.1	52.6	4,304

(b) Change in utilization of existing reservoirs

(c) Temporary modification of production techniques or output

(d) Effective use of alternate sources if more than one source is available.

(e) Development of more efficient water use technology.

(2) New Development

(a) Upstream reservoir storage

(b) Groundwater development

(c) Individual storage

(d) Others

Users may already have storage for normal water use purposes onsite or in-system. It may be possible for those which have excess storage to use part or all of that excess to provide the necessary makeup water. On a broader scale, changes in the utilization of existing reservoirs represent an alternative which deserves serious consideration. Many reservoirs already in existence could possibly be used more effectively. In most cases, consumptive use makeup releases would be compatible with design or authorized uses. Makeup releases would only be required on an infrequent basis on most streams and would most likely occur after the summer months and not interfere with recreational uses.

In the case of Federal dams, for which Congress originally provided authorization and/or appropriations, it would be necessary to obtain a reauthorization. This would be accomplished by first submitting to the responsible Federal agency a proposal for new use of the project. If it is determined that the proposed use is significantly different than presently authorized uses, then a request would be submitted to Congress for funding a reauthorization study. The study, which would include public hearings, would be similar to

Continued on page 95

Table 20

CONSUMPTIVE WATER USE MAKEUP SOLUTION ALTERNATIVES[a]

Legend (See Figure 11)	1	2	3	6
Beneficial Areas[b] and 1990 Projected Makeup Requirement[c] / Solution Alternative	Roaring Brook........A P.W.S.........0.015mgd/1.3mg Total[d]........1.3mg	Lackawanna River........A Golf........0.08mgd/12.5mg Irrigation........0.013mgd/3.0mg Total[d]........15.5mg	Abrahams Creek........B Industry........0.024mgd/1.5mg Total[d]........1.5mg	Fishing Creek........C P.W.S........0.12mgd/6.2mg Livestock........0.04mgd/2.4mg Irrigation........1.5mgd/84mg Total[d]........93mg
(COE) Stillwater Lake on Lackawanna River (multipurpose)		100% 15.5 mg		
(DER) Frances Slocum Dam on Abrahams Creek (multipurpose)			100% 1.5 mg	
Potential SCS Reservoir #PA.665 on Nescopeck Creek (multipurpose)				
Potential small Reservoir #37–9 on Roaring Brook (multipurpose)	100% 1.3 mg			
Potential small Reservoir #36–5 on Marsh Creek (multipurpose)				100% 93 mg
Potential small Reservoir #36–10 on Maple Run (multipurpose)				100% 93 mg

[a]Table entries list the percentage of the total need which could be satisfied by the listed alternative and the equivalent allocated storage required to meet that percentage of the need. See Appendix B-3 for more detailed description of this table.
[b]Stream or stream reaches on which consumptive water use will occur by 1990 and the associated watershed(s).
[c]Makeup required by each category of water use. Daily requirements are listed in million gallons per day (mgd) and storage requirements for low flow periods are listed in million gallons (mg).

7 Nescopeck Creek...D Livestock – Golf...0.06mgd/3.3mg Total[d]...3.3mg	8 Catawissa Creek...E Irrigation...2.38mgd/130mg Total[d]...130mgd	Total Annual Available Storage[e] (million gallons)	Satisfied 1990 Need[f] (million gallons)	Remarks
		See remarks	15.5	Use of existing reservoir requires further study for reauthorization of storage
		See remarks	1.5	Use of existing reservoir requires further study for reauthorization of storage
100% 3.3 mg		See remarks	3.3	Use of existing reservoir requires further study for reauthorization of storage
		322	1.3	
		210	93	
		316	93	

[d] Total Storage Requirement
[e] Total annual storage available for beneficial use. Does not include flood control storage.
[f] Summation of all needs which could be satisfied by the alternative identified in column 1.

Table 20 (Cont.)

CONSUMPTIVE WATER USE MAKEUP SOLUTION ALTERNATIVES[a]

Legend (See Figure 11)	1	2	3	6
Solution Alternative / Beneficial Areas[b] and 1990 Projected Makeup Requirement[c]	Roaring Brook ......A P.W.S. ......0.015mgd/1.3mg Total[d] 1.3mg	Lackawanna River ......A Golf ......0.08mgd/12.5mg Irrigation ......0.013mgd/3.0mg Total[d] 15.5mg	Abrahams Creek ......B Industry ......0.024mgd/1.5mg Total[d] 1.5mg	Fishing Creek ......C P.W.S. ......0.12mgd/6.2mg Livestock ......0.04mgd/2.4mg Irrigation ......1.5mgd/84mg Total[d] 93mg
Potential small Reservoir #36–4A on Huntington Creek (multipurpose)				100% 93 mg
Potential small Reservoir #34–5 on tributary to Little Catawissa Creek (single-purpose)				
Groundwater development	100% 1.3 mg	100% 15.5 mg	100% 1.5 mg	
Individual storage	100% 1.3 mg	100% 15.5 mg	100% 1.5 mg	100% 93 mg

[a]Table entries list the percentage of the total need which could be satisfied by the listed alternative and the equivalent allocated storage required to meet that percentage of the need. See Appendix B-3 for more detailed description of this table.
[b]Stream or stream reaches on which consumptive water use will occur by 1990 and the associated watershed(s).
[c]Makeup required by each category of water use. Daily requirements are listed in million gallons per day (mgd) and storage requirements for low flow periods are listed in million gallons (mg).

7	8			
Nescopeck Creek....D Livestock – Golf....0.06mgd/3.3mg Total[d]....3.3mg	Catawissa Creek....E Irrigation....2.38mgd/130mg Total[d]....130mgd	Total Annual Available Storage[e] (million gallons)	Satisfied 1990 Need[f] (million gallons)	Remarks
		815	93	
	100% 130 mg	556	130	
100% 3.3 mg	100% 130 mg	Not Applicable	151.6	
100% 3.3 mg	100% 130 mg	See remarks	244.6	Sites to be determined by user

[d]Total Storage Requirement
[e]Total annual storage available for beneficial use. Does not include flood control storage.
[f]Summation of all needs which could be satisfied by the alternative identified in column 1.

Table 20 (Cont.)

CONSUMPTIVE WATER USE MAKEUP SOLUTION ALTERNATIVES[a]

Legend (See Figure 11)	4	5		
Solution Alternative / Beneficial Areas[b] and 1990 Projected Makeup Requirement[c]	Susquehanna River .... D,E P.W.S. .... 0.05mgd/2.8mg Industry .... 0.38mgd/19.6mg Livestock – Golf .... 0.16mgd/6.9mg Irrigation .... 3.5mgd/180mg Total[d] 209mg	Susquehanna River .... B Power .... 44.3mgd/3850mg Total[d] 3850mg	Upstream Users In Subbasin 4 – Total[d] 123mg	Downstream Users In Subbasin 7 – Total[d] 7,607mg
(COE) Tioga-Hammond Lakes on Tioga River and Crooked Creek (multipurpose)	50% 104.5 mg	50% 1,925 mg	83% 102 mg	
(COE) Cowanesque Lake on Cowanesque River (multipurpose)	50% 104.5 mg	50% 1,925 mg	83% 102 mg	
Potential (COE) Great Bend Reservoir on Susquehanna River (multipurpose)	100% 209 mg	100% 3,850 mg	83% 102 mg	38% 2924 mg
Potential (COE) Towanda Reservoir Site on Towanda Creek (multipurpose)	100% 209 mg	100% 3,850 mg	87% 107 mg	38% 3041 mg
Potential small Reservoir #010–12 on Gardner Creek (multipurpose)	100% 209 mg			
Potential small Reservoir #010–15 on Buttermilk Creek (multipurpose)	100% 209 mg			

[a]Table entries list the percentage of the total need which could be satisfied by the listed alternative and the equivalent allocated storage required to meet that percentage of the need. See Appendix B-3 for more detailed description of this table.
[b]Stream or stream reaches on which consumptive water use will occur by 1990 and the associated watershed(s).
[c]Makeup required by each category of water use. Daily requirements are listed in million gallons per day (mgd) and storage requirements for low flow periods are listed in million gallons (mg).

Downstream Users In Subbasin 6 – Total[d] 448mg	Total Annual Available Storage[e] (million gallons)	Satisfied 1990 Need[f] (million gallons)	Remarks
	See remarks	2,132	Use of existing reservoir requires further study for reauthorization of storage
	See remarks	2,132	Use of existing reservoir requires further study for reauthorization of storage
	See remarks	7,085	Potential available storage not known
26% 117 mg	See remarks	7,207	Potential available storage not known
	261	209	
	345	209	

[d]Total Storage Requirement
[e]Total annual storage available for beneficial use. Does not include flood control storage.
[f]Summation of all needs which could be satisfied by the alternative identified in column 1.

Table 20 (Cont.)

CONSUMPTIVE WATER USE MAKEUP SOLUTION ALTERNATIVES[a]

Legend (See Figure 11)	4	5		
Beneficial Areas[b] and 1990 Projected Makeup Requirement[c] / Solution Alternative	Susquehanna River .... D,E P.W.S. .... 0.05mgd/2.8mg Industry .... 0.38mgd/19.6mg Livestock – Golf .... 0.16mgd/6.9mg Irrigation .... 3.5mgd/180mg Total[d] 209mg	Susquehanna River .... B Power .... 44.3mgd/3850mg Total[d] 3850mg	Upstream Users In Subbasin 4 – Total[d] 123mg	Downstream Users In Subbasin 7 – Total[d] 7,607mg
Potential small Reservoir #07–3A on Wapwallopen Creek (single-purpose)		35% 1,362 mg		
Potential small Reservoir #07–8 on Little Wapwallopen Creek (single-purpose)		27% 1,048 mg		
Potential small Reservoir #08–4 on Harvey Creek (multipurpose)		31% 1,202 mg		
Potential small Reservoir #38–5 on South Branch Tunkhannock Creek (multipurpose)		49% 1,876 mg		
Potential small Reservoir #010–2 on Meshoppen Creek (single-purpose)		25% 957 mg		
Individual storage	100% 209 mg	100% 3,850 mg		

[a]Table entries list the percentage of the total need which could be satisfied by the listed alternative and the equivalent allocated storage required to meet that percentage of the need. See Appendix B-3 for more detailed description of this table.
[b]Stream or stream reaches on which consumptive water use will occur by 1990 and the associated watershed(s).
[c]Makeup required by each category of water use. Daily requirements are listed in million gallons per day (mgd) and storage requirements for low flow periods are listed in million gallons (mg).

Downstream Users In Subbasin 6 – Total[d] 448mg

Total Annual Available Storage[e] (million gallons)	Satisfied 1990 Need[f] (million gallons)	Remarks
1,362	1,362	
1,048	1,048	
1,202	1,202	
1,876	1,876	
957	957	
See remarks	4,059	Sites to be determined by user

[d]Total Storage Requirement
[e]Total annual storage available for beneficial use. Does not include flood control storage.
[f]Summation of all needs which could be satisfied by the alternative identified in column 1.

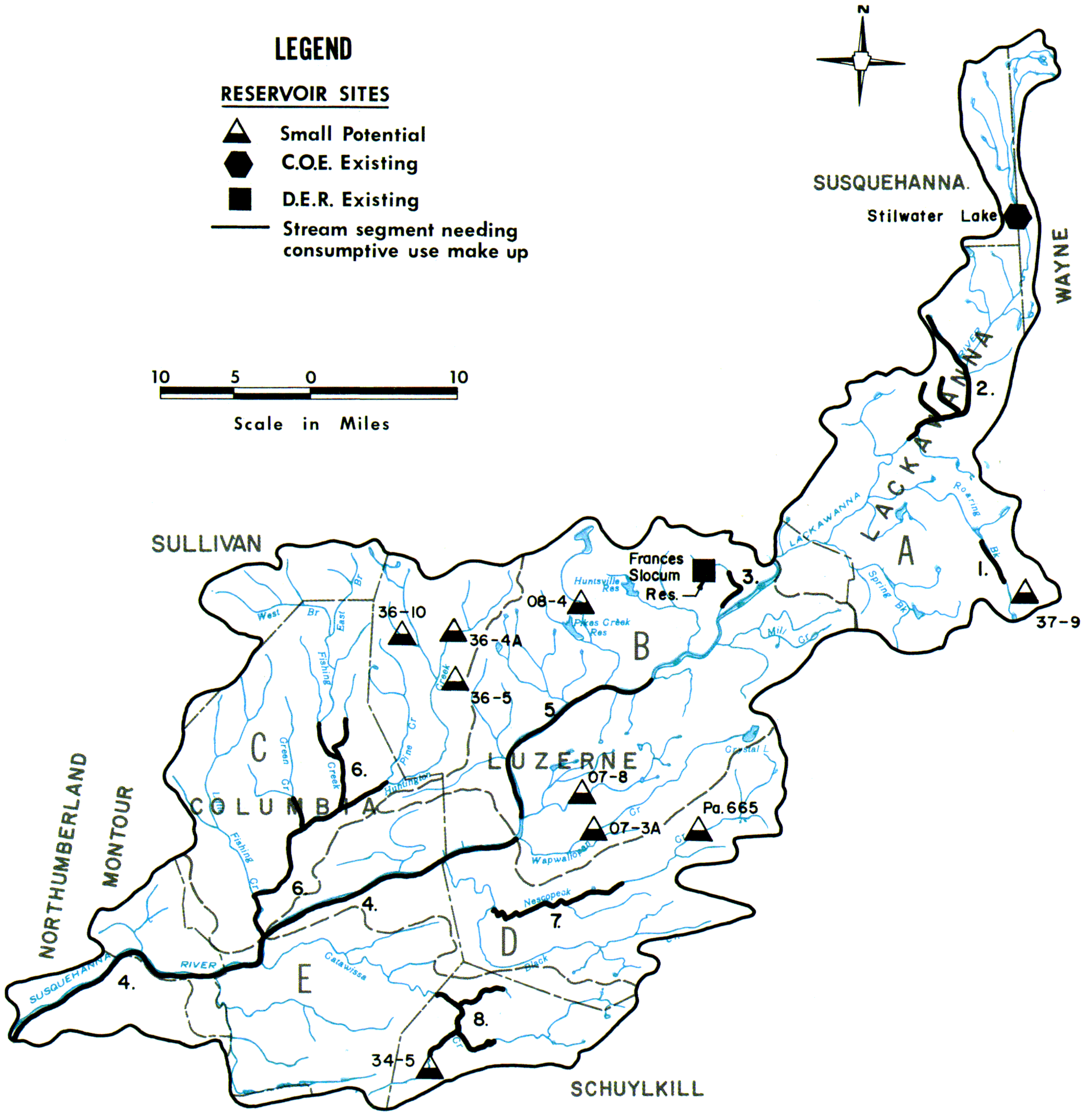

FIGURE 11. Consumptive Use Makeup Streams and Structural Solution Alternatives

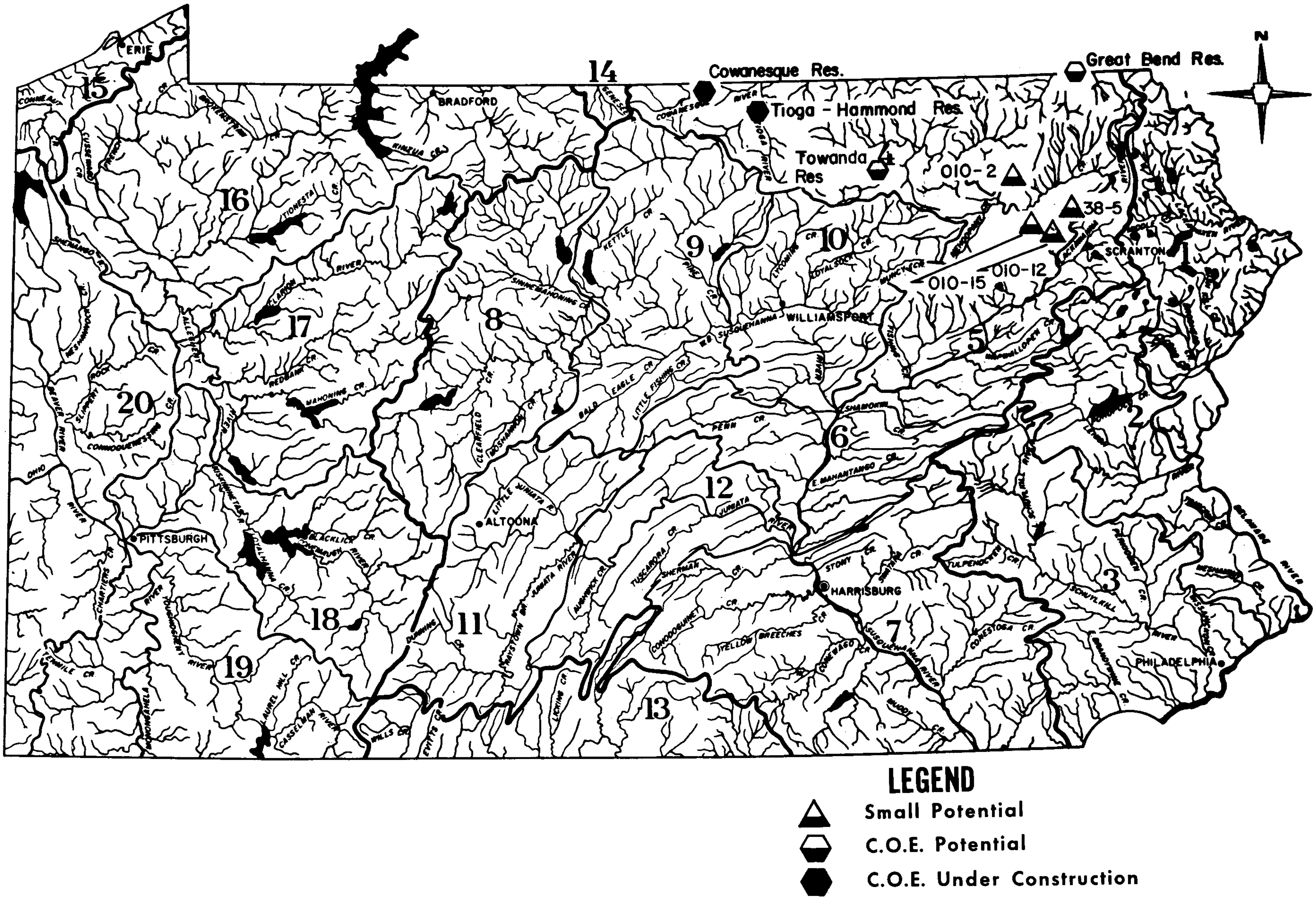

FIGURE 12. Extra-Basin Consumptive Use Makeup Structural Solution Alternatives

Table 21

SCREENING ASSESSMENT OF CONSUMPTIVE USE MAKEUP STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Potential COE Great Bend Reservoir Site on the Susquehanna River	9,991 FC only	16,869 FC only				
-AT THE SITE			-Enhances recreational potential of area	-Substantial relocation in Pa. communities of Oakland, Susquehanna and Lanesboro -Loss of existing farm, prime agriculture and forest land -Alters habitat for fish and wildlife -Alters fish production -Alters aquatic life -Inundation of Indian Village Site at Oghquaga, New York	-Potential COE Towanda Reservoir -Other small potential reservoirs for consumptive use makeup or low flow augmentation capability -Nonstructural flood control measures	This project is not recommended. -Not economically feasible -Major relocation necessary -Major adverse environmental impact
-DOWNSTREAM EFFECTS			-Reduces flood damages downstream of dam -Provides storage to meet anticipated consumptive use makeup needs on the Susquehanna River above its confluence with the W.Br.Susquehanna River -Could provide storage for low flow augmentation needs -Improve water quality during low flow periods	-Could encourage more development or encroachment on the flood plain -Modifies fish production and movement	-Local structural flood control alternatives -Possible reauthorization of use for consumptive use makeup capability at: (1) Stillwater Lake (2) Francis Slocum Dam (3) Small Dam PA-665 (4) Tioga-Hammond Lakes (5) Cowanesque Lake	

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 21 (Cont.)

SCREENING ASSESSMENT OF CONSUMPTIVE USE MAKEUP STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Potential COE Towanda Reservoir Site on Towanda Creek	1,530 FC only	2,129 FC only			-Potential COE Great Bend Reservoir -Other small potential reservoirs for consumptive use makeup or low flow augmentation capability -Possible reauthorization of use for consumptive use makeup capability at (1) Stillwater Lake (2) Francis Slocum D (3) Small Dam PA-665 (4) Tioga-Hammond Lakes (5) Cowanesque Lake -Nonstructural flood control measures	This project is recommended for further study which would include an investigation of all uses that could be incorporated in the project
-AT THE SITE			-Enhances recreational potential of area	-Relocation necessary in communities of West Franklin, Sayees Corners, Woodruff Corners and Leroy -Loss of existing farm, prime agricultural and forest land -Alters habitat for fish and wildlife -Alters aquatic life		
-DOWNSTREAM EFFECTS			-Reduces flood damages downstream of dam -Provides storage to meet anticipated consumptive use makeup needs on the Susquehanna River above its confluence with the W.Br. Susquehanna River -Could provide storage for low flow augmentation needs -Improve water quality during low flow periods	-Recreational development in and around the site would adversely affect the natural state of the area -Could encourage further development of the flood plain -Modifies fish production and movement		

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 21 (Cont.)

SCREENING ASSESSMENT OF CONSUMPTIVE USE MAKEUP STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #37-9 on East Branch Roaring Brook	29.6 FC	28.0 FC 119.0 WS 159.0 WS/t	-Reduces flood damages -Provides storage capability for anticipated consumptive use makeup needs on Roaring Brook -Could provide storage for low flow augmentation needs -Could serve as a public water supply source for Moscow Water Supply Company	-Loss of forestland -Alters habitat for fish and wildlife -Would alter aquatic life		
Small Potential Reservoir #010-12 on Gardner Creek			-Provides storage to meet anticipated consumptive use makeup needs on the Susquehanna River from Wapwallopen to Sunbury	-Loss of farm and forest land -Alters fish habitat on a trout stream -Would alter aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend, and Towanda -Small reservoir #010-15	
Small Potential Reservoir #010-15 on Buttermilk Creek			-Provides storage capability for anticipated consumptive use makeup needs on the Susquehanna River from Wapwallopen to Sunbury	-Relocation of 20-25 houses and 5 miles of roads and highways -Loss of farm, prime agriculture and forest land -Alters fish habitat and aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend, and Towanda -Small reservoir #010-12	
Small Potential Reservoir #07-3A on Wapwallopen Creek			-Provides storage capability for 49% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen	-Relocation of 18-20 houses, a Boy Scout Camp and 2 miles of roads and highways -Loss of farm and forest land -Wild and Scenic River Candidate Stream -Alters fish habitat and aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend, and Towanda -Other small potential reservoirs	

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 21 (Cont.)

SCREENING ASSESSMENT OF CONSUMPTIVE USE MAKEUP STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #08-4 on Harvey Creek			-Provides storage capability for 43% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen	-Relocation of 8-10 houses and 2 miles of roads and highways -Loss of forest and farm land -Alters fish habitat on a trout stream -Wild and Scenic River Candidate Stream -Alters aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend, and Towanda -Other small potential reservoirs	
Small Potential Reservoir #07-8 on Little Wapwallopen Creek			-Provides storage capability for 37% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen	-Loss of forest and farm land -Alters fish habitat on a trout stream -Alters aquatic life -Relocation of 1-3 houses and 1 mile of roads and highways	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend and Towanda -Other small potential reservoirs	
Small Potential Reservoir #38-5 on South Branch Tunkhannock Creek		501.0 WS only 1990 staged cost 1065.0 WS/t	-Provides storage capability for 67% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen -Could serve as a public water supply source for Pennsylvania Gas and Water Company	-Relocation of 24-27 houses and 3 miles of roads and highways -Loss of farm, prime agriculture and forest land -Alters fish habitat on a trout stream -Alters aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend and Towanda -Other small potential reservoirs	

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 21 (Cont.)

SCREENING ASSESSMENT OF CONSUMPTIVE USE MAKEUP STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #010-2 on Meshoppen Creek			-Provides storage capability for 34% of the anticipated consumptive use makeup needs on the Susquehanna River from the Lackawanna River to Wapwallopen	-Loss of forest, prime agriculture and farm land -Loss of wetland area -Alters fish habitat on a trout stream -Wild and Scenic River Candidate Stream -Alters aquatic life	-Major reservoirs including Tioga-Hammond, Cowanesque, Great Bend and Towanda -Other small potential reservoirs	
Small Potential Reservoir #36-5 on Marsh Creek			-Provides storage capability for anticipated consumptive use makeup needs on Fishing Creek	-Loss of forest and farm land -Loss of wetland area -Relocation of 4-5 houses and 1 mile of roadway -Alters fish habitat and aquatic life -Wild and Scenic River Candidate Stream	-Small potential reservoirs #36–10 and #36–4A	
Small Potential Reservoir #36-10 on Maple Run			-Provides storage capability for anticipated consumptive use makeup needs on Fishing Creek	-Loss of forest land -Wild and Scenic River Candidate Stream -Relocation of 2-3 houses -Alters fish habitat and aquatic life	-Small potential reservoirs #36-5 and #36–4A	
Small Potential Reservoir #36-4A on Huntington Creek			-Provides storage capability for anticipated consumptive use makeup needs on Fishing Creek	-Loss of forest land -Wild and Scenic River Candidate Stream -Alters fish habitat on a trout stream -Alters aquatic life	-Small potential reservoirs #36–5 and #36–10	
Small Potential Reservoir #34-5 on Little Catawissa Creek			-Provides storage capability for anticipated consumptive use makeup needs on Catawissa Creek	-Loss of forest and farm land -Alters fish habitat on a trout stream -Alters aquatic life		

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

a study conducted for original authorization. If the study results were favorable, then recommendations for reauthorization would be presented to Congress; and if approved by Congress, reauthorized uses would be instituted.

Temporary modifications of production techniques or output may be possible for some industrial users or possibly even agricultural irrigation users. Production of some product lines could be curtailed temporarily with emphasis shifted to other lines. Output could be reduced, with increased levels of production compensating later to achieve the same long-term production totals. Irrigators may alter their irrigation schedules to decrease the consumptive levels.

Many water users have more than one source of water. Industries may have surface or groundwater sources in addition to connections to public water supply systems. Interconnections also exist between public water suppliers. Some users have excess capacity through combinations of surface and groundwater sources. Alternative sources may allow these users to continue operations if low flow conditions do not affect all their sources concurrently.

If improved management of existing resources is insufficient to provide for makeup needs, then it will become necessary to consider new development of structural measures. Users may develop storage individually or collectively. Irrigators could construct ponds or dams on small watersheds. Industries and utilities could construct dams to provide storage or may be able to increase storage behind existing structures. Several users could jointly construct upstream reservoir storage or may purchase storage from public reservoirs upstream. Groundwater development may be a viable alternative for some users. Combinations of alternatives may be preferable or even necessary for other users.

Table 19 lists storage requirements which would be necessary to provide the daily consumptive use makeup during the critical duration period of the low flow if a user were to choose storage as a prefered alternative. The critical duration period was determined from historical streamflow records and equals the largest total number of days that streamflows were below $Q_{7\text{-}10}$ during any year of record. Storage was computed as the product of daily consumptive use multiplied by the number of days of critical duration. That product was then increased by a 25 percent safety factor as before.

Viable alternative solutions to the consumptive use makeup needs in Subbasin 5 are presented in Table 20. Existing or potential reservoirs which have been considered are mapped either on Figure 11 if located within the subbasin, or on Figure 12 if located upstream of the subbasin. Table 21 provides a quick examination of the economic, social and environmental factors associated with the structural solutions. Chapter VI presents a discussion of the physical, environmental and social implications of the major structural alternatives.

To briefly summarize Table 20, two potential Corps of Engineers reservoirs (Great Bend Reservoir and Towanda Reservoir) and 13 potential small reservoirs have been investigated along with groundwater development, individual storage, and releases from existing excess storage. The existing reservoirs that have been considered include three Corps of Engineers reservoirs (Tioga-Hammond Lakes, Cowanesque Lake, and Stillwater Lake), and the Pennsylvania Department of Environmental Resources' Frances Slocum Dam on Abrahams Creek.

B. FLOOD DAMAGE REDUCTION

Floods are natural occurrences that cause damages and loss of life, primarily as a result of man's use of, and encroachment upon, the floodplains. Because of this continued encroachment, flood damages have been increasing on a regular basis.

The State Water Plan has addressed the problems associated with riverine flooding. The damage figures utilized in the analyses are based on historical damages and do not consider damages which may result from future development. The Plan has not examined stormwater runoff on a community basis; however, it is recognized that the problems associated with stormwater runoff are becoming increasingly serious. Development actions such as the removal of vegetation and large scale resurfacing and drainage systems are increasing both the quantity and rate of runoff, resulting in many new localized flood problems, as well as exacerbating existing ones.

1. PROBLEMS

Subbasin 5 has experienced a significant amount of flood damage during the past half century. However, flooding conditions in many communities and stream reaches have been averted by structural measures provided by Federal and State government.

Major floods have occurred in this subbasin in 1936, 1942, 1955, 1968, 1969, 1972 and 1975. The largest amount of damage ever recorded in Watershed A was from the 1942 flood. In Watersheds B, C, D and E the largest amount of damage ever recorded was from the 1972 flood. As a result of previously saturated soils, the heavy rainfall in Tropical Storm Agnes caused unusually high flood stages. The 1972 flood resulted in the identification of three new damage centers in Watershed A, ten in Watershed B and ten in Watersheds C, D and E.

a. *Study Units, Flood Damage Centers and Reaches*

A damage center was identified wherever damages for one flood in a community totalled $25,000 or more at the 1969 price level ($45,000 or more at the 1976 price level). A damage reach was identified wherever the *average annual* flood damages per mile of stream length totalled $500 or more at the 1969 price level ($900 or more at the 1976 price level). Flood damage centers and reaches identified in these study units are listed in Tables 22, 23 and 24 and are shown on Figure 13. In all, 61 damage centers and 22 damage reaches have been identified in this subbasin.

Continued on page 102

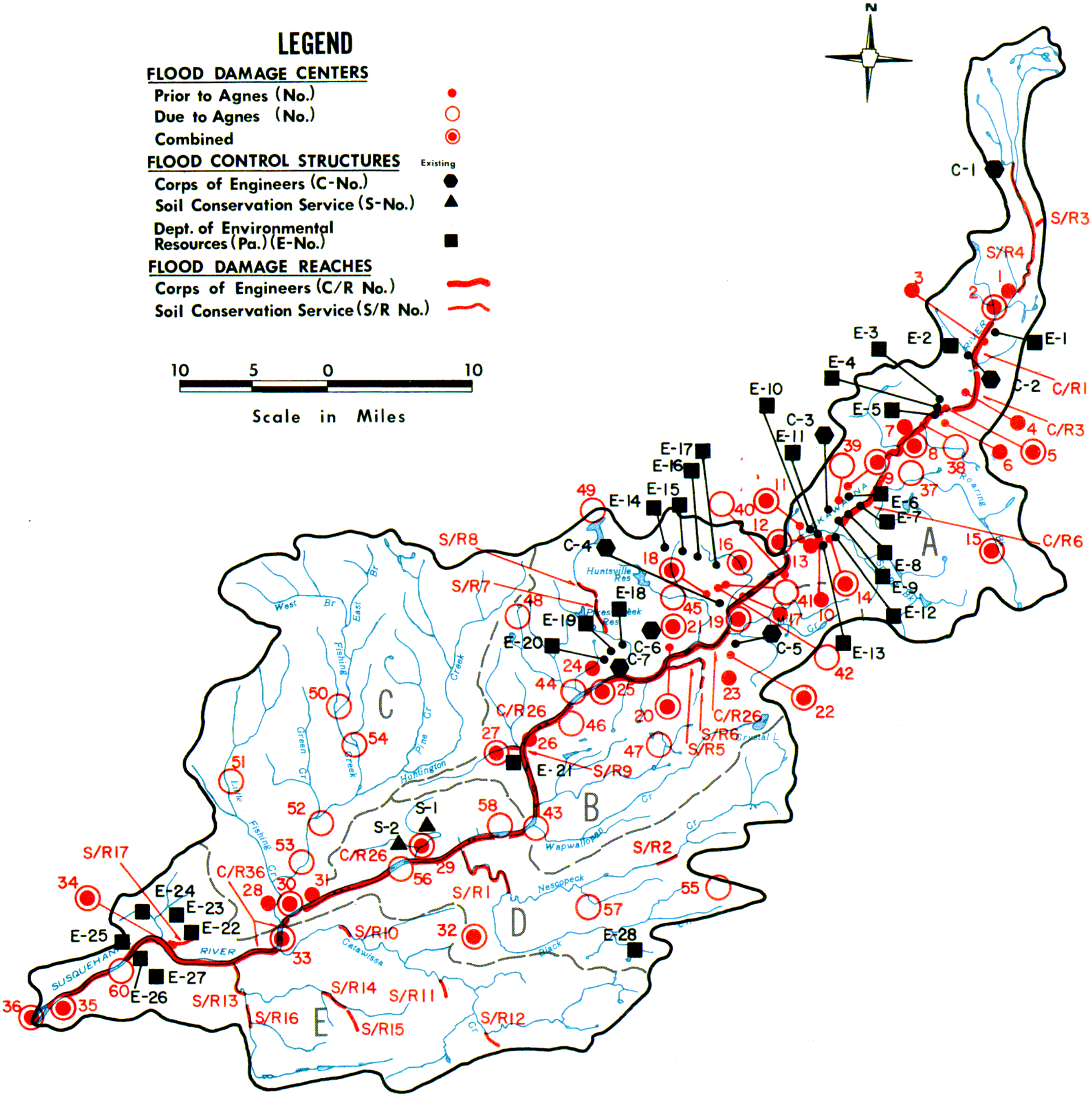

FIGURE 13. Flood Damage Areas and Flood Control Structures

Table 22

FLOOD DAMAGE CENTERS

Watershed	Legend (See Figure 13)	Damage Center – Stream	Highest Flood Damages Recorded Prior to 1969: Flood Date	Highest Flood Damages Recorded Prior to 1969: Damages[a] ($1,000)	"Agnes" 1972 Damages[b] ($1,000)
A	1	Simpson – Lackawanna River	5/42	1,124	
A	2	Carbondale City – Lackawanna River and Racket Brook	5/42	3,184	98
A	3	Mayfield Boro – Edgerton Creek	5/42	239	
A	4	Archbald Boro – Lackawanna River and White Oak Creek	5/42	1,271	
A	5	Blakely Boro – Hull Creek and Wildcat Creek	5/42	536	109
A	6	Olyphant Boro – Lackawanna River	5/42	3,964	
A	7	Dickson City Boro – Lackawanna River, Scott Creek, Miles Creek, and Elm Creek	5/42	2,123	
A	8	Throop Boro – Lackawanna River	8/55	103	154
A	9	Scranton City – Stafford Meadow Brook	8/55	1,216	
A	9	Scranton City – Roaring Brook	8/55	17,702	
A	9	Scranton City – Lackawanna River	5/42	7,946	5,624
A	10	Spike Island – Spring Brook	8/55	114	
A	11	Old Forge Boro – Lackawanna River	8/55	241	246
A	12	Duryea Boro – Lackawanna River	8/55	891	1,508
A	13	Belian Village – Spring Brook	8/55	277	
A	14	Moosic Boro – Lackawanna River and Spring Brook	8/55	2,746	310
A	15	Moscow Boro – Roaring Brook	8/55	791	81
A	37	Dunmore Boro – Roaring Brook			87
A	38	Dickson City Boro – Lackawanna River			96

[a] 1976 price level.

[b] Damages (1976 price level) are based on zip code areas which may not strictly coincide with municipal boundaries.

Table 22 (Cont.)

FLOOD DAMAGE CENTERS

Watershed	Legend (See Figure 13)	Damage Center – Stream	Highest Flood Damages Recorded Prior to 1969 Flood Date	Highest Flood Damages Recorded Prior to 1969 Damages[a] ($1,000)	"Agnes" 1972 Damages[b] ($1,000)
A	39	Taylor Boro – Lackawanna River			214
B	16	West Pittston Boro – Susquehanna River	3/36	58	17,448
B	17	Port Blanchard – Susquehanna River	3/36	282	
B	18	Swoyersville Boro & Forty Fort Boro – Susquehanna River	3/36	4,344	188,977
B	19	Plainsville – Susquehanna River	3/36	257	923
B	20	Plymouth Boro – Susquehanna River	3/36	405	34,718
B	21	Kingston Boro & Edwardsville Boro – Susquehanna River	3/36	29,141	281,813
B	22	Wilkes-Barre City & Hanover Township – Susquehanna River	3/36	34,933	541,308
B	23	Ashley Boro – Solomen Creek and Sugar Notch Run	8/55	691	
B	24	West Nanticoke – Susquehanna River	3/36	1,506	
B	25	Nanticoke City – Susquehanna River and Forge Creek	8/55	183	7,769
B	26	Mocanaqua – Susquehanna River	3/36	127	
B	27	Shickshinny Boro – Susquehanna River	3/36	2,806	8,918
B	40	Pittston City – Susquehanna River			9,177
B	41	Exeter Boro – Susquehanna River			284
B	42	Wyoming Boro & West Wyoming Boro – Susquehanna River			9,935
B	43	Wapwallopen – Susquehanna River			331
B	44	Hunlock – Susquehanna River			1,533
B	45	Shavertown – Toby Creek			2,713

[a] 1976 price level.

[b] Damages (1976 price level) are based on zip code areas which may not strictly coincide with municipal boundaries.

Table 22 (Cont.)

FLOOD DAMAGE CENTERS

Watershed	Legend (See Figure 13)	Damage Center – Stream	Highest Flood Damages Recorded Prior to 1969 Flood Date	Highest Flood Damages Recorded Prior to 1969 Damages[a] ($1,000)	"Agnes" 1972 Damages[b] ($1,000)
B	46	Glenlyon – Susquehanna River			87
B	47	Nuangola Boro – Little Wapwallopen Creek			101
B	48	Sweet Valley – Tributary of Hunlock Creek			145
B	49	Harveys Lake Boro – Harveys Lake			1,091
C	28	Hemlock Township – Rishing Creek	3/36	87	
C	50	Benton Boro – Fishing Creek			246
C	51	Millville Boro – Little Fishing Creek			208
C	52	Orangeville Boro – Fishing Creek			784
C	53	Light Street – Fishing Creek			45
C	54	Stillwater Boro – Fishing Creek			96
D	29	Berwick Boro – East Br Briar Creek	8/55	214	3,658
D	30	Bloomsburg Boro – Susquehanna River	3/36	4,941	19,152
D	31	Espy – Susquehanna River	3/36	56	
D	32	Black Creek Township – Raccoon Creek and Black Creek	8/55	433	58
D	55	Hazleton City – Hazle Creek			2,272
D	56	Mifflinville – Susquehanna River			74
D	57	Conyngham Boro – Little Nescopeck Creek			427
D	58	Beach Haven – Susquehanna River			96
E	33	Catawissa Boro – Susquehanna River	3/36	139	4,597
E	34	Danville Boro – Susquehanna River	3/36	4,435	15,548

[a]1976 price level.

[b]Damages (1976 price level) are based on zip code areas which may not strictly coincide with municipal boundaries.

Table 22 (Cont.)

FLOOD DAMAGE CENTERS

Watershed	Legend (See Figure 13)	Damage Center – Stream	Highest Flood Damages Recorded Prior to 1969		"Agnes" 1972
			Flood Date	Damages[a] ($1,000)	Damages[b] ($1,000)
E	35	Northumberland Boro – Susquehanna River	3/36	463	4,549
E	36	Sunbury Island – Susquehanna River	3/36	215	2,367
E	60	Riverside Boro – Susquehanna River			1,303

[a]1976 price level.

[b]Damages (1976 price level) are based on zip code areas which may not strictly coincide with municipal boundaries.

Table 23

CORPS OF ENGINEERS IDENTIFIED DAMAGE REACHES

Watershed	Legend (See Figure 13)	Damage Center – Stream	Highest Flood Damages Recorded Prior to 1969		"Agnes" 1972
			Flood Date	Damages[a] ($1,000)	Damages[a] ($1,000)
A	C/R1	Simpson to Jermyn – Lackawanna River	5/42	1,379	
A	C/R3	Jermyn to Olyphant – Lackawanna River	5/42	1,399	
A	C/R6	Olyphant to Susquehanna River – Lackawanna River	5/42	3,873	
B,D	C/R26	Pittston to Bloomsburg – Susquehanna River	3/36	4,634	
E	C/R36	Bloomsburg to Sunbury – Susquehanna River	3/36	2,100	

[a]1976 Price Level

Table 24

SOIL CONSERVATION SERVICE IDENTIFIED DAMAGE REACHES

Watershed	Legend (See Figure 13)	Damage Reach – Stream	Average Annual Flood Damages ($1,000[a])
A	S/R4	Jermyn to Stillwater Dam - Lackawanna River	69.9
A	S/R3	Lackawanna River to South Branch - White Oak Creek	23.0
B	S/R5	Susquehanna River to Sugar Notch Run – Solomen Creek	4.2
B	S/R6	Sugar Notch Run to Pine Creek – Solomen Creek	12.5
B	S/R7	Huntsville Creek to Trout Brook – Toby Creek	4.2
B	S/R8	Trout Brook to Dallas – Toby Creek	2.2
B	S/R9	Susquehanna River to Little Shickshinny Creek – Shickshinny Creek	2.2
D	S/R1	Susquehanna River to Black Creek – Nescopeck Creek	16.7
D	S/R2	Long Run to Township Route 358 – Nescopeck Creek	29.1
E	S/R10	Catawissa Creek to Mainville – Tributary to Catawissa Creek	8.3
E	S/R11	Catawissa Creek to Township Route 443 – Crooked Run	37.5
E	S/R12	Catawissa Creek to Park Crest Fish and Game Club – Rattling Run	2.2
E	S/R13	Susquehanna River to Riegel Covered Bridge – Roaring Creek	6.3
E	S/R14	Slabtown to Lick Run – Roaring Creek	2.2
E	S/R15	Roaring Creek to Township Route 329 – Lick Run	4.2
E	S/R16	Roaring Creek to Mugser Run – South Branch Roaring Creek	4.2
E	S/R17	Susquehanna River to Headwaters – Sechler Run	39.6

[a] 1976 price level

After damage centers and reaches were identified, they were grouped into different watersheds based on their locations within the subbasin. A watershed or a group of watersheds was then used as a unit for studying basinwide flood damage reduction needs. According to similarities in watersheds and flood characteristics, three study units were delineated in this subbasin. These study units are: 1) Watershed A, the Lackawanna River Basin, 2) Watershed B, the Susquehanna River Basin from the Lackawanna River to Wapwallopen Creek and 3) Watersheds C, D and E, the Susquehanna River Basin from Wapwallopen Creek to the West Branch Susquehanna River including the Fishing Creek, the Nescopeck Creek and the Catawissa Creek Basins.

The Department of Environmental Resources regularly receives requests from government officials or citizens seeking assistance in connection with a specific flood problem in their community. Usually these communities have been identified in a State or Federal flood damage inventory and, therefore, are already identified as damage centers. However, there are exceptions. Documented flood damage surveys and inventories are generally expensive and difficult to conduct. As a result, a local problem may not be identified as a damage center. Those communities are listed in Table 26 as a *Special DER Study Area.*

b. *Existing Flood Damage Reduction Measures*

Flood damage reduction measures can be either structural or nonstructural. Structural measures including reservoirs, levees, floodwalls and channel modifications are currently being used to reduce flood damages in this subbasin. Flood control structures, both existing and under construction, are shown on Figure 13 and listed in Appendices C-1, C-2 and C-3.

The Corps of Engineers has nine completed flood control projects, two projects under construction and one proposed project which benefit or will benefit the subbasin through the reduction of its flood damages. Levee projects have been completed in Scranton City, Swoyersville and Forty Fort Boroughs, Wilkes-Barre City and Hanover Township, Kingston and Edwardsville Boroughs and Plymouth Borough. Stillwater Lake and Aylesworth Creek Lake provide benefits to damage centers and reaches along the Lackawanna River and the Susquehanna River. Arkport Dam and Almond Lake located in New York State, and Tioga-Hammond and Cowanesque Lakes under construction in Watershed A of Subbasin 4 are reducing or will reduce damages along the main stem of the Susquehanna River.

The Department of Environmental Resources has completed flood control projects which have reduced damages in Mayfield, Olyphant and Dickson City Boroughs, Scranton City, and Duryea, Moosic, Plymouth, Wyoming, West Wyoming, Blakely, Mocanaqua and Danville Boroughs. New projects or additions to existing projects are under construction in Duryea, Wyoming, West Wyoming and Danville Boroughs.

The Soil Conservation Service (SCS) is also carrying out flood damage reduction work in the subbasin. One completed flood prevention dam and one dam under construction on Briar Creek in Watershed D will continue to reduce flood damages in the Berwick Borough area.

It should be noted that these structural measures are not total solutions to the flooding problem. A combination of increased runoff and more damage-prone investment in flood hazard areas erodes the effectiveness of structural measures. Flood protection projects are designed to protect a community against a certain design flood stage. If a flood occurs which exceeds the design criteria, flood damages will again occur. Another problem arises when the community fails to undertake effective stormwater planning and management. The results of such inaction may become obvious during periods of heavy rainfall.

c. *Residual Annual Damages*

Historical flood damage events and the frequency of their occurrence have been analyzed to develop the flood damage and frequency curves shown on Figure 14. These curves may be used to determine average annual flood damages. A weighted average of the frequent small flood events with the less frequent but larger flood events would yield *natural annual* flood damages, or the average damages that would occur on a yearly basis in the absence of existing flood control projects.

Existing flood control projects reduce the natural annual damage. By subtracting the total annual flood control benefits of all existing projects from the natural annual damage, the *residual* annual damage or the present day flood control need of the study unit was determined. The results of those analyses are presented in Table 25.

In the future, the residual annual flood damages will certainly increase if present action is not taken to manage floodplain development. Areas that warrant immediate attention are areas that have projected population increases. From a flood control viewpoint, intelligent and proper management of this population development is absolutely essential for a community which may be concerned about reducing its flood damages.

d. *Flood Plain Information and Flood Warning System*

Nonstructural measures such as floodplain regulation or flood proofing require adequate flood plain information. Another nonstructural measure, flood forecasting, requires a timely and accurate flood forecasting and warning system. A final measure, flood insurance, which is designed to reduce the financial impact of a flood, also requires floodplain delineation. At this time, the availability of this information is limited. The status of floodplain information prepared or under preparation by the U. S. Army Corps of Engineers and the floodplain mapping effort completed by the U. S. Geological Survey (U.S.G.S.) are listed in Appendices C-4 and C-5. Currently, the U.S.G.S. in cooperation with the State is mapping the damage centers and reaches within the State.

Another effort, currently being conducted by the U. S. Department of Housing and Urban Develop-

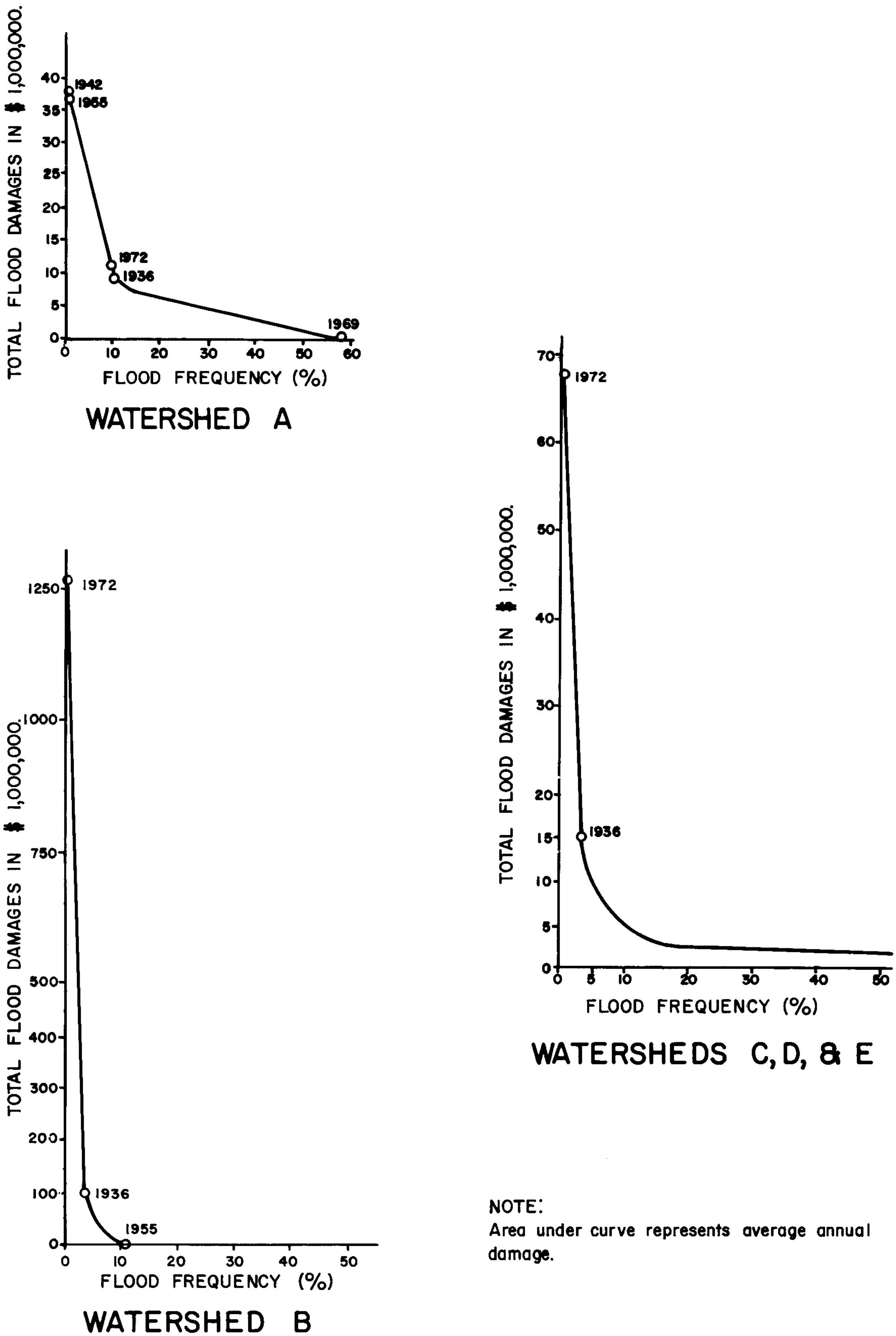

FIGURE 14. Flood Damage and Frequency Curves

Table 25

STUDY UNIT DAMAGES AND BENEFITS[a]

Study Unit	Drainage Area (Sq.Mi.)	Total Natural Annual Damages[b] ($1,000)	Total Annual Benefits of Existing Projects ($1,000)	Total Residual Annual Damages ($1,000)
Watershed A	348	4,809	2,787	2,022
Watershed B	401	38,638	36,070	2,568
Watersheds C,D,E	1,010	4,049	3,387	662

[a]Based on tangible damages only. All dollar figures are listed at 1976 price level.

[b]Average annual damage without any flood protection measures.

ment (HUD), is known as a Type 15 Flood Insurance Study. This study has been or will be completed for those communities which have qualified for flood insurance (See Table 26) under the National Flood Insurance Program. Contained in the study will be the identification of flood hazard areas, the development of flood frequency data, and the computation and mapping of proposed floodway data. The Susquehanna River Basin Commission, the U.S. Army Corps of Engineers, the Soil Conservation Service, and various consulting engineering firms are involved with the completed or ongoing studies. Because of their detailed information, these HUD studies should be used in place of any other mapping. A list of completed HUD studies is provided in Appendix C-6.

The Pennsylvania Department of Community Affairs is the State coordinative agency for Federal Flood Insurance and urban development programs. It provides advisory and financial assistance to municipalities in implementing and administering various municipal programs related to floodplain management. It has adopted regulations concerning flood-proofing of buildings in State-assisted redevelopment projects.

2. ALTERNATIVE SOLUTIONS TO EXISTING FLOOD DAMAGE PROBLEMS

Alternative measures were examined as possible means of reducing the flood damage threat to existing floodplain development. Future development on the floodplain should comply strictly with effective floodplain management objectives and regulations, and in no case should future development be used as justification for funding flood protection measures. The measures investigated for flood damage reduction are as follows:

a. Nonstructural Measures (Managing existing resources)

(1) Floodplain regulation promotes proper management of and control over the type of development that occurs in the flood plain.

(2) Flood insurance lessens economic burden on floodplain occupants and leads to reduction of future damage potential.

(3) Permanent flood proofing aids floodplain occupants and reduces future damage potential in areas where major structural solutions are not feasible.

(4) Flood forecasting provides time for warning and response in order to save life and property damage.

b. Structural Measures (New development)

(1) Levee and/or Floodwall

(2) Channel Modification

(3) Reservoirs, including small potential and Corps of Engineers potential reservoir sites.

The principles, advantages and disadvantages of these measures are discussed in "Planning Principles". It must be emphasized that the measures listed above may be investigated and utilized individually or in combination. Indeed, a combination of several measures may furnish the most desirable solution.

One nonstructural measure which is applicable in all small stream watersheds is the Self-Help Flood Forecasting and Warning System. This system, designed to issue flood forecasts to flood-prone communities, utilizes the following information:

a. Precipitation – type, amount and intensity

b. Runoff rate

c. Measured streamflow

d. Flood crest travel time

The National Weather Service and the Susquehanna River Basin Commission have assisted some communities in

Continued on page 126

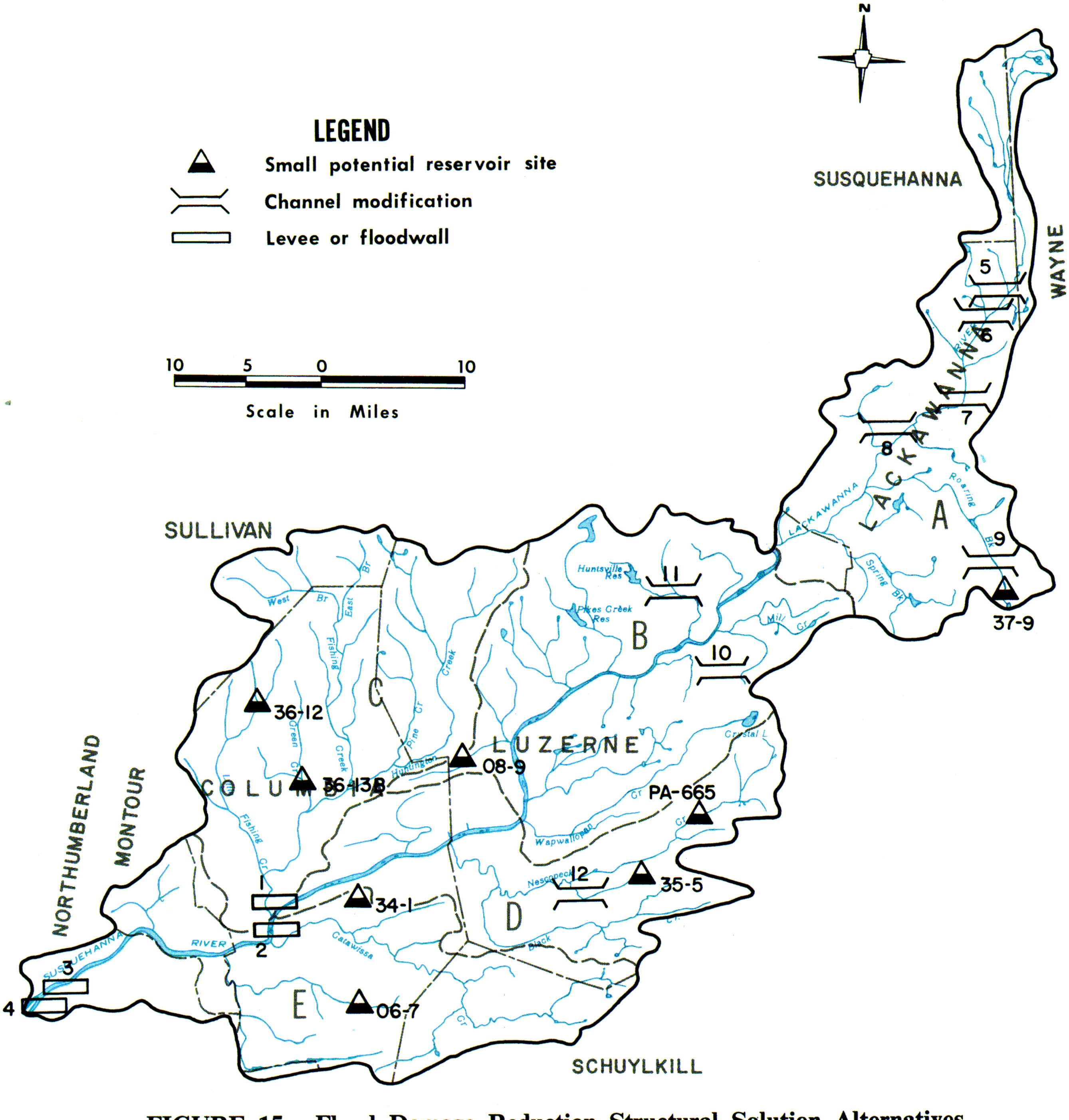

FIGURE 15. Flood Damage Reduction Structural Solution Alternatives

Table 26

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit A

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
1	Simpson (Lackawanna River)	33		48.7	◆	◆		
2	Carbondale City (Lackawanna River & Racket Brook)	33		183.4	◆	◆	◆	
3	Mayfield Boro (Edgerton Creek)	98(1)		0.5	◆	◆	◆	
4	Archbald Boro (Lackawanna River & White Oak Creek)	33		55.0	◆	◆	◆	
5	Blakely Boro (Hull Creek & Wildcat Creek)	98(3)		0.5	◆	◆	◆	
6	Olyphant Boro (Lackawanna River)	43(4)		179.7	◆	◆	◆	

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
	43.5					
	163.6					
						(1) The flood protection project for Mayfield was built in two units including work on the Lackawanna River and two local tributaries, Hosey and Powderly Creeks. Detailed information given in Appendix C-3.
(2)	49.1					(2) Completed DER flood control study on tributary.
						(3) In addition to channel improvement made in conjunction with the Lackawanna River Improvement Project (1957), DER completed a flood control project for Hull Creek in 1975. See Appendix C-3.
(5)						(4) Completed DER project consisting mainly of channel improvement and spoil dikes which were constructed by the Department as a feature of the Lackawanna River Improvement Project in 1957. See Appendix C-3. (5) Scattered damages – local flood protection not feasible.

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit A

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Percentage Reduction In Natural Annual Damages Due to: Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Nonstructural Measures: Eligible for Flood Insurance[c]	Nonstructural Measures: Permanent Flood Proofing	Nonstructural Measures: Flood Forecasting
7	Dickson City Boro (Lackawanna River, Scott Creek, Miles Creek & Elm Creek)	33[(6)]		118.4	◆	◆		
38	Dickson City Boro (Lackawanna River)	33		4.2[(8)]	◆	◆		
8	Throop Boro (Lackawanna River)	33		11.2	◆	◆		
9	Scranton City (Stafford Meadow Brook)	74[(9)]		31.0	◆	◆	◆	
9	Scranton City (Roaring Brook)	48[(11)]		636.0	◆	◆		
9	Scranton City (Lackawanna River)	96[(13)]		0.5	◆	◆		
10	Spike Island (Spring Brook)			7.4	◆	◆		
11	Old Forge Boro (Lackawanna River)	33		21.2	◆	◆	◆	◆

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
(7)	105.6					(6) In addition to the improved earth channel and spoil dikes constructed in conjunction with the Lackawanna River Improvement Project in 1957, the project at Dickson City included a diversion channel for Old Dam Creek. (7) A flood control feasibility study was recently conducted for Scott Creek and showed that a structural solution was not feasible.
						(8) See Damage Center 7 for additional damages.
	(10)					(9) A DER project consisting of a concrete channel for Stafford Meadow Brook was completed in 1965. See Appendix C-3 (E8). (10) An active study is in progress on a small tributary to Stafford Meadow Brook in the vicinity of Meadow Avenue.
(12)						(11) Completed DER projects E6 & E7. See Appendix C-3 for detailed information. (12) Scattered damages – further local flood protection not feasible.
						(13) Completed COE and DER projects C3 and E9 – See Appendices C-2 and C-3.
	(14)					(14) Project proposed and construction funds requested.

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit A		Percentage Reduction In Natural Annual Damages Due to:			Nonstructural Measures			
Legend (See Figure 13)	Damage Center or Reach (Stream)	Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
12	Duryea Boro (Lackawanna River)	62[15]		59.2	◆	◆		◆
13	Belian Village (Spring Brook)			17.9	◆	◆		
14	Moosic Boro (Lackawanna River & Spring Brook)	59[17]		80.4	◆	◆	◆	
15	Moscow Boro (Roaring Brook)			56.3	◆	◆	◆	
37	Dunmore Boro (Roaring Brook)			5.6	◆	◆		
39	Taylor Boro (Lackawanna River)	33		9.2	◆	◆		
C/R1	Simpson to Jermyn (Lackawanna River)	62[19]		36.0	◆	◆		
C/R3	Jermyn to Olyphant (Lackawanna River)	33		71.1	◆	◆		
C/R6	Olyphant to Susquehanna River (Lackawanna River)	33		297.4	◆	◆		
S/R4	Jermyn to Stillwater Dam (Lackawanna River)	33		69.9	◆			
S/R3	Lackawanna River to South Branch (White Oak Creek)			23.0	◆	◆	◆	

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]						
			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
						(15) Completed DER projects E10 and E11 – See Appendix C-3 for further information.
	(16)					(16) Project proposed and construction funds requested.
						(17) Completed DER projects E12 and E13 – See Appendix C-3 for further information.
	52.2	29.6(18)				(18) Small Reservoir #37–9
						(19) Completed DER projects – See Appendix C-3 for information.

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit B		Percentage Reduction In Natural Annual Damages Due to:			Nonstructural Measures			
Legend (See Figure 13)	Damage Center or Reach (Stream)	Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Funded Proposed Projects
16	West Pittston Boro (Susquehanna River)	91		58.1[e]	◆	◆		◆
17	Port Blanchard (Susquehanna River)	91		0.9	◆	◆		◆
18	Swoyersville Boro-Forty Fort Boro (Susquehanna River)	93(20)		494.5[e]	◆	◆		◆
19	Plainsville (Susquehanna River)	91		4.0	◆	◆		◆
20	Plymouth Boro (Susquehanna River)	98(22)		19.9[e]	◆	◆		◆
21	Kingston Boro-Edwardsville Boro (Susquehanna River)	95(24)		607.6[e]	◆	◆		◆
22	Wilkes-Barre City & Hanover Township (Susquehanna River)	94(25)		1,047.4[e]	◆	◆		◆

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]: Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Corps of Engineers Potential Reservoir Sites: Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
			58.0	29.1	58.0	
			0.9	0.5	0.9	
(21)			493.0	247.3	493.0	(20) In addition to the Susquehanna River levee constructed by the Corps of Engineers (See Appendix C-2), this Department is currently designing a flood protection project for Wade Run. (21) Corps of Engineers Wyoming Valley Study.
			4.0	2.0	4.0	
(21)	(23)		19.9	10.0	19.9	(22) Existing flood control facilities consist of a levee and pumping stations constructed by the Corps in 1948 and debris dams on Browns and Wadham Creeks constructed in 1959. As part of a Wadham Creek project a small tributary, Duffy Run, was diverted into the Wadham Creek Basin. (23) A concrete channel is planned between the Wadham Creek debris dam and the Corps' levee. Funding for the proposed Wadham Creek project is requested.
(21)			607.6	303.8	607.6	(24) Completed Corps of Engineers' project – See Appendix C-2.
(21)			1,047.4	523.7	1,047.4	(25) Completed Corps of Engineers project – See Appendix C-2.

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit B

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Percentage Reduction In Natural Annual Damages Due to: Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Nonstructural Measures: Eligible for Flood Insurance[c]	Nonstructural Measures: Permanent Flood Proofing	Nonstructural Measures: Flood Forecasting
23	Ashley Boro (Solomon Creek & Sugar Notch Run)			28.8	◆	◆	◆	
24	West Nanticoke (Susquehanna River)	91		5.1[e]	◆	◆		◆
25	Nanticoke City (Susquehanna River & Forge Creek)	91		26.8[e]	◆	◆		◆
26	Mocanaqua (Susquehanna River)	98[(26)]		0.1	◆	◆		◆
27	Shickshinny Boro (Susquehanna River)	91		38.9[e]	◆	◆		◆
40	Pittston City (Susquehanna River)	91		30.6	◆	◆		◆
41	Exeter Boro (Susquehanna River)	91		0.9	◆	◆		◆
42	Wyoming Boro & West Wyoming Boro (Susquehanna River)	97[(28)]		10.1[e]	◆	◆		◆
43	Wapwallopen (Susquehanna River)	91		1.1	◆	◆		◆
44	Hunlock (Susquehanna River)	91		5.1	◆	◆		◆
45	Shavertown (Toby Creek)			98.8	◆	◆	◆	
46	Glenlyon (Susquehanna River)	88		0.4	◆	◆		◆

[a] All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b] Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
	23.3					
			5.0	2.6	5.0	
			26.7	13.4	26.7	
			0.1	0.1	0.1	(26) Completed DER project (E21) – See Appendix C-3.
			38.9	19.5	38.9	
			30.4	15.3	30.4	
	(27)		0.9	0.5	0.9	(27) Project in DER Bureau of Design on Hicks Creek.
			10.1	5.1	10.1	(28) Completed DER projects (E14, E15, E16, E17) – See Appendix C-3.
			1.1	0.6	1.1	
			5.1	2.6	5.1	
	80.0					
			0.4	0.2	0.4	

[c] Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d] Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e] Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit B

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
47	Nuangola Boro (Little Wapwallopen Creek)			3.6	◆	◆	◆	
48	Sweet Valley (Tributary to Hunlock Creek)			5.2	◆	◆	◆	
49	Harveys Lake Boro (Harveys Lake)			39.8	◆	◆	◆	
C/R26	Pittston to Bloomsburg (Susquehanna River)	91		15.4	◆			◆
S/R5	Susquehanna River to Sugar Notch Run (Solomon Creek)			4.2	◆	◆	◆	
S/R6	Sugar Notch Run to Pine Creek (Solomon Creek)			12.5	◆	◆	◆	
S/R7	Huntsville Creek to Trout Brook (Toby Creek)			4.2	◆	◆		
S/R8	Trout Brook to Dallas (Toby Creek)			2.2	◆	◆		
S/R9	Susquehanna River to Little Shickshinny Creek (Shickshinny Creek)			2.2	◆	◆	◆	

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
(29)						(29) Project in DER Bureau of Design
			15.4	7.7	15.4	
		1.5(30)				(30) Small Reservoir #08–9

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit C, D, E

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
28	Hemlock Township (Fishing Creek)			4.9	◆	◆	◆	
29	Berwick Boro (East Br. Briar Creek)	83(31)		37.5	◆	◆	◆	
30	Bloomsburg Boro (Susquehanna River)	93		92.1[e]	◆	◆	◆	◆
31	Espy (Susquehanna River)	94		0.2	◆	◆		◆
32	Black Creek Township (Raccoon Creek & Black Creek)			28.1	◆	◆	◆	
33	Catawissa Boro (Susquehanna River)	93		18.1[e]	◆	◆	◆	◆
34	Danville Boro (Susquehanna River)	95(35)		55.4[e]	◆	◆		◆
35	Northumberland Boro (Susquehanna River)	93		19.2	◆	◆		◆

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
[32]						[31] Completed SCS projects (S1 & S2) See Appendix C-1. [32] Scattered damages – local flood protection not feasible.
67.7			92.1	46.1	92.1	
			0.2	0.1	0.2	
[33]						[33] Scattered damages – local flood protection not feasible.
[34]			18.1	9.1	18.1	[34] Active study – Division of Water Resources Projects.
[36]			54.8	27.7	54.8	[35] Existing DER projects at Danville consist of a channel improvement project for Mahoning Creek completed in 1968 and levee work along the Susquehanna River. A flood control levee rehabilitation project is currently under construction along the Susquehanna River. [36] An extention of the Susquehanna River levee and Mahoning Creek floodwall is currently under design. Funds are requested for additional levee work along Mahoning Creek and a pumping station and dam on Sechler Run.
14.0			19.2	9.6	19.2	

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.
[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit C, D, E

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
36	Sunbury Island (Susquehanna River)	93		10.0	◆	◆		◆
50	Benton Boro (Fishing Creek)			14.1	◆	◆	◆	
51	Millville Boro (Little Fishing Creek)			11.9	◆	◆	◆	
52	Orangeville Boro (Fishing Creek)			44.9	◆	◆		
53	Light Street (Fishing Creek)			2.5	◆	◆		
C/R36	Bloomsburg to Sunbury (Susquehanna River)	93		8.0	◆	◆		◆
S/R1	Susquehanna River to Black Creek (Nescopeck Creek)			16.7	◆	◆		
S/R2	Long Run to Township Route 358 (Nescopeck Creek)			29.1	◆	◆		
S/R10	Catawissa Creek to Mainville (Tributary to Catawissa Creek)			8.3	◆			
S/R11	Catawissa Creek to Township Route 443 (Crooked Run)			37.5	◆	◆		
S/R12	Catawissa Creek to Park Crest Fish and Game Club (Rattling Run)			2.2	◆	◆		

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
7.2			10.0	5.0	10.0	
		4.1[37]				[37] Small Reservoir #36–12
[38]		31.6[39]				[38] Scattered damages – local flood protection not feasible. [39] Small Reservoir #36–13B
			7.9	4.0	7.9	
		23.0[40]				[40] Small Reservoir PA-665
		1.2[41]				[41] Small Reservoir #34–1

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.
[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Study Unit C, D, E

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
S/R13	Susquehanna River to Riegel Covered Bridge (Roaring Creek)			6.3	◆	◆		
S/R14	Slabtown to Lick Run (Roaring Creek)			2.2	◆	◆		
S/R15	Roaring Creek to Township Route 329 (Lick Run)			4.2	◆	◆		
S/R16	Roaring Creek to Mugser Run (South Br. Roaring Creek)			39.6	◆	◆		
S/R17	Susquehanna River to Headwaters (Sechler Run)			4.2	◆	◆		
54	Stillwater Boro (Fishing Creek)			5.4	◆	◆	◆	
55	Hazleton City (Hazle Creek)			130.0	◆	◆	◆	
56	Mifflinville (Susquehanna River)	91		0.4	◆	◆		◆
57	Conyngham Boro (Little Nescopeck Creek)			24.4	◆	◆	◆	
58	Beach Haven (Susquehanna River)	93		0.4	◆	◆		◆
60	Riverside Boro (Susquehanna River)	93		5.1	◆	◆	◆	◆

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that floodplain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. *Indicates that floodplain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]			Corps of Engineers Potential Reservoir Sites			
Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
		0.9[(42)]				(42) Small Reservoir #06–7
[(43)]						(43) Scattered damages – local flood protection not feasible.
			0.4	0.2	0.4	
	22.6	13.9[(44)]				(44) Small Reservoir #35–5
			0.4	0.2	0.4	
			5.1	2.6	5.1	

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

Table 26 (Cont.)

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES[a]

Legend (See Figure 13)	Damage Center or Reach (Stream)	Percentage Reduction In Natural Annual Damages Due to: Existing Projects or Projects Under Construction	Funded Proposed Projects	Residual Annual Damages ($1,000)	Nonstructural Measures: Flood Plain Regulation[b]	Eligible for Flood Insurance[c]	Permanent Flood Proofing	Flood Forecasting
	SPECIAL DER STUDY AREAS							
	Jessup Borough (Sterry Creek)			(45)				
	Luzerne Borough (Toby Creek)			(46)				
	Larksville Borough (Boston Creek)			(47)				
	Nanticoke City (South Br. Newport Creek)			(48)				
	Scranton City (Meadow Brook)			(49)				
	Old Forge Borough (St. Johns Creek)			(50)				
	Wilkes-Barre City (Spring Run – Downstream of Empire Street)			(51)				

[a]All numbers are DER estimates unless otherwise noted. See Appendix C-7 for more detailed explanation of this table.

[b]Applies to all damage centers and reaches, more particularly to future than existing development; however, flood plain mapping is required for effective implementation. Indicates that flood plain mapping has been completed by U.S.G.S., the U.S. Army Corps of Engineers, the Susquehanna River Basin Commission or a consulting firm. Indicates that flood plain mapping has not been completed.

Structural Measures (Estimated Average Annual Benefit)[d]: Levee or Floodwall	Channel Modification	Small Potential Reservoir Site	Corps of Engineers Potential Reservoir Sites: Great Bend Reservoir	Towanda Reservoir	Combined Effects of Corps of Engineers Potential Reservoirs	Remarks
						(45) DER flood control feasibility study in progress
						(46) DER flood control feasibility study in progress
						(47) DER flood control feasibility study in progress
						(48) DER flood control feasibility study in progress
						(49) DER study completed
						(50) DER study completed and a project is proposed
						(51) DER project in design

[c]Does not serve to reduce existing flood hazard, but rather lessens the economic burden of flooding on flood plain occupants. Land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future flood plain development. Indicates eligibility as of December, 1977.

[d]Average annual benefits in thousand dollars (1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[e]Residual annual damage may be reduced because of an existing or a proposed Disaster Urban Renewal Project.

assembling this information into a useful format. When a threat of flooding occurs, local officials will have the ability to issue a flood warning. As the name "Self-Help" implies, the success of this system depends upon the willingness of the local people to get involved during an emergency situation and help themselves.

All the nonstructural and structural concepts were investigated for each damage center or damage reach in an attempt to identify possible flood damage reduction alternatives. However, in an initial screening evaluation, certain structural alternatives were eliminated because of major economic, physical, social or environmental restraints. The remaining alternatives are listed in Table 26. The table lists the damage centers and reaches identified in this subbasin, the damage reduction due to existing and funded proposed structures as a percentage of natural annual damage, the residual annual damage (or current annual damage), and nonstructural and structural measures. For structural measures, the table also lists the estimated average annual benefit for a damage center or a damage reach. The entry of each column on this table is further explained in Appendix C-7.

The structural measures investigated to reduce the residual annual flood damages in the damage centers and reaches are listed in Table 27. The table lists the information related to location, purpose, flood control beneficial area, estimated total annual flood control benefit and cost of a potential project. The structural alternatives investigated for this subbasin are shown on Figure 15 and Figure 16. Those located within this subbasin are shown on Figure 15, and those which are located upstream of this subbasin are shown on Figure 16. As shown in Table 27 and on Figures 15 and 16, four levees and/or floodwalls, eight channel modifications, eight small potential reservoirs and two Corps of Engineers potential reservoir sites have been considered for reducing the residual annual damages in this subbasin. The environmental and social impacts of the structural alternatives are listed in Table 28, and the impacts of the major structural alternatives are discussed in Chapter VI.

3. RECOMMENDATIONS

The flood control measures were examined in greater detail in order to determine those which appeared most capable of solving or reducing the flood control problems. Those alternatives which appear to warrant further study for possible implementation are indicated by bold face type in Table 27. The recommendations include:

a. Nonstructural measures including floodplain regulation, flood insurance, permanent flood proofing and flood forecasting are strongly recommended for the damage centers and reaches listed in Table 26. In addition, relocation of flood-prone activities and acquisition of lands or easements to assure flood-compatible development are suggested for investigation at the damage center level. In all small stream watersheds, the Self-Help Flood Forecasting and Warning System is recommended. It is imperative that every community undertake an effective stormwater planning and management program.

b. The early completion of the Corps of Engineers Tioga-Hammond Lakes and Cowanesque Lake Projects currently under construction are recommended. These projects will reduce damages along the main stem of the Susquehanna River.

c. The potential Corps of Engineers reservoir site, Towanda Reservoir, is recommended for further study. The analysis should contain all multipurpose aspects including flood control, recreation, low flow augmentation, consumptive use makeup and hydroelectric power generation. If the reservoir were constructed, it would be located 1.5 miles upstream of the town of Franklindale on Towanda Creek. In addition to mitigating flood damages in 28 damage centers and reaches along the Susquehanna River within this subbasin, Towanda Reservoir would also help to reduce flood damages upstream in Subbasin 4.

e. Two local channel modification projects are suggested for further study at Moscow and Conyngham Boroughs. The study at Moscow should determine whether the small dam, #37-9, or a channel modification, or both in combination would best meet the needs of the Borough. Early completion of the projects under construction in Duryea, Danville, Wyoming and West Wyoming Boroughs is recommended.

d. Two small potential reservoirs would aid in mitigating flood damages. The first site, numbered #37–9 and located on Roaring Brook, would reduce flood damages in Moscow Borough in Watershed A. The second site, numbered PA-665 and located on Nescopeck Creek, would reduce damages on Reach S/R 2 in study unit C/D/E. Land acquisition is currently underway at this site.

These recommendations are made as possible solutions to the identified flood control problems. The costs shown in the tables are preliminary planning estimates only, developed for use in reviewing alternatives, and should not be used for project budgeting or design. Prior to actual construction of a project or implementation of a program, detailed studies of all environmental, social and economic factors must be completed to assure optimum benefits and results.

Continued on page 137

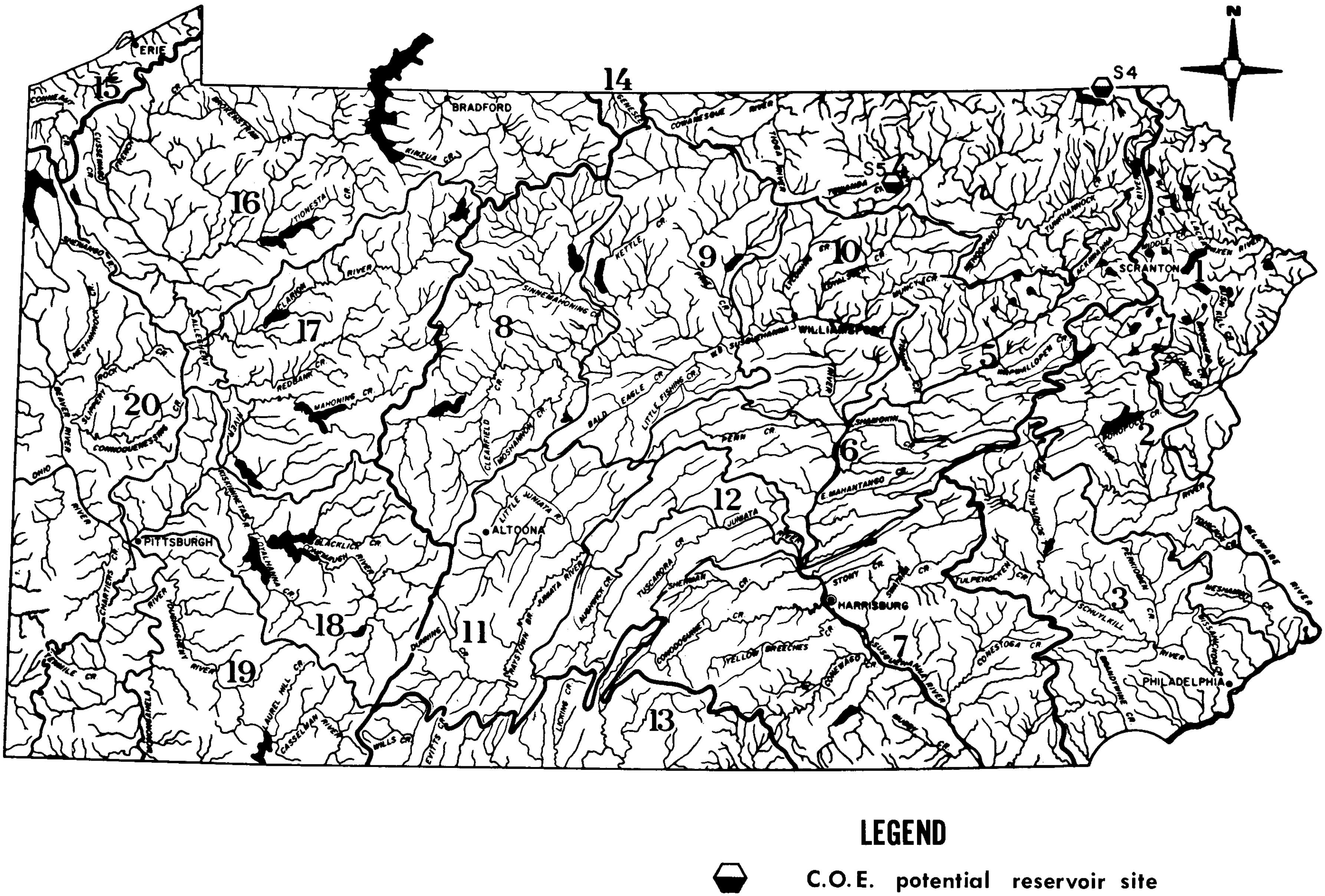

FIGURE 16. Extra-Basin Flood Damage Reduction Structural Solution Alternatives

Table 27

SUMMARY OF ALTERNATIVE STRUCTURAL SOLUTIONS

Legend (See Figures 15 and 16)	Project Name	Location	Purpose	Flood Control Beneficial Area (See Table 26)	Estimated Total Annual Benefits[a]	Preliminary Total Annual Cost[a]	Remarks
	LEVEE/FLOODWALL						
1	Bloomsburg Boro	Susquehanna River	Local Flood Protection	Center 30 – Bloomsburg Boro, in Study Unit CDE	67.7	761.1	Project not economically justified.
2	Catawissa Boro	Susquehanna River	Local Flood Protection	Center 33 – Catawissa Boro, in Study Unit CDE			Active study by DER – Division of Water Resources Projects
3	Northumberland Boro	Susquehanna River	Local Flood Protection	Center 35 – Northumberland Boro, in Study Unit CDE	14.0	133.3	Project not economically justified.
4	Sunbury Island	Susquehanna River	Local Flood Protection	Center 36 – Sunbury Island, in Study Unit CDE	7.2	138.3	Project not economically justified.
	CHANNEL MODIFICATIONS						
5	Simpson	Lackawanna River	Local Flood Protection	Center 1 – Simpson, in Study Unit A	43.5	111.4	Project not economically justified.
6	Carbondale City	Lackawanna River and Racket Brook	Local Flood Protection	Center 2 – Carbondale City, in Study Unit A	163.6	235.4	Project not economically justified.
7	Archbald Boro	Lackawanna River and White Oak Creek	Local Flood Protection	Center 4 – Archbald Boro, in Study Unit A	49.1	195.7	Project not economically justified.
8	Dickson City Boro	Scott, Elm, & Miles Creeks	Local Flood Protection	Center 7 – Dickson City Boro, in Study Unit A	105.6	318.6	Project not economically justified.
9	**Moscow Boro**	**Van Brunt Creek**	**Local Flood Protection**	**Center 15 – Moscow Boro, in Study Unit A**	**52.2**	**15.8**	**Project appears economically justified. Further study required.**
10	Ashley Boro	Solomon Creek and Sugar Notch Run	Local Flood Protection	Center 23 – Ashley Boro, in Study Unit B	23.3	106.1	Project not economically justified.

[a]All numbers are DER estimates unless otherwise noted. The annual benefits and costs (in thousand dollars, 1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[b]Includes benefits and costs applicable to New York State.

Note: **BOLD FACE** indicates projects which are recommended for construction or further study.

Table 27 (Cont.)

SUMMARY OF ALTERNATIVE STRUCTURAL SOLUTIONS

Legend (See Figures 15 and 16)	Project Name	Location	Purpose	Flood Control Beneficial Area (See Table 26)	Estimated Total Annual Benefits[a]	Preliminary Total Annual Cost[a]	Remarks
11	Shavertown	Toby Creek	Local Flood Protection	Center 45 – Shavertown, in Study Unit B	80.0	307.9	Project not economically justified.
12	**Conyngham Boro**	**Tributary to Little Nescopeck Creek**	**Local Flood Protection**	**Center 57 – Conyngham Boro, in Study Unit CDE**	**22.6**	**10.0**	**Project appears economically justified. Further study required.**
	SMALL POTENTIAL RESERVOIR SITES						
	#37–9	**East Branch Roaring Brook**	**Multipurpose**	**Center 15 – Moscow Boro, in Study Unit A**	**29.6**	**28.0**	**Project appears economically justified. Further study required. Cost information from the Soil Conservation Service.**
	#08–9	Little Shickshinny Creek	Multipurpose	Reach S/R9, in Study Unit B	1.5	12.0	Project not economically justified. Cost information from the Soil Conservation Service.
	#36–12	Little Fishing Creek	Multipurpose	Center 51 – Millville Boro, in Study Unit CDE	4.1	52.0	Project not economically justified. Cost information from the Soil Conservation Service.
	#36–13B	Green Creek	Flood Control	Center 52 – Orangeville Boro, in Study Unit CDE	31.6	93.6	Project not economically justified. Cost information from the Soil Conservation Service.
	#35–5	Little Nescopeck Creek	Flood Control	Center 57 – Conyngham Boro, in Study Unit CDE	13.9	39.3	Project not economically justified. Cost information from the Soil Conservation Service
	#34–1	Tributary of Catawissa Creek	Multipurpose	Reach S/R10, in Study Unit CDE	1.2	38.9	Project not economically justified. Cost information from the Soil Conservation Service.
	#06–7	Lick Run	Flood Control	Reach S/R15, in Study Unit CDE	0.9	9.5	Project not economically justified. Cost information from the Soil Conservation Service.
	PA-665	**Nescopeck Creek**	**Multipurpose**	**Reach S/R2, in Study Unit CDE**	**23.0**	**23.0**	**Project economically justified. Land acquisition in progress.**

[a]All numbers are DER estimates unless otherwise noted. The annual benefits and costs (in thousand dollars, 1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[b]Includes benefits and costs applicable to New York State.

Note: **BOLD FACE** indicates projects which are recommended for construction or further study.

Table 27 (Cont.)

SUMMARY OF ALTERNATIVE STRUCTURAL SOLUTIONS

Legend (See Figures 15 and 16)	Project Name	Location	Purpose	Flood Control Beneficial Area (See Table 26)	Estimated Total Annual Benefits[a]	Preliminary Total Annual Cost[a]	Remarks
	CORPS OF ENGINEERS POTENTIAL RESERVOIR SITES						
S4	Great Bend Reservoir	1.5 miles east of the town of Hallstead on Susquehanna River	Multipurpose	Subbasin 5			This project is not currently authorized by Congress. The cost information is from the Corps of Engineers, Baltimore District. The project does not appear to be economically feasible.
				Study Unit B – Benefits the Susquehanna River from the Lackawanna River to Wapwallopen	2,365		
				Study Unit CDE – Benefits the Susquehanna River from Wapwallopen to Sunbury	208		
				Subbasin 4	267		
				Subbasin 6	471		
				Subbasin 7	326		
				Total – Great Bend	9,991[b]	16,869[b]	
S5	**Towanda Reservoir**	**1.5 miles upstream of the town of Franklindale on Towanda Creek**	**Multipurpose**	**Subbasin 5**			**This project is not currently authorized by Congress. The cost information is from the Corps of Engineers, Baltimore District.**
				Study Unit B – Benefits the Susquehanna River from the Lackawanna River to Wapwallopen	**1,184**		
				Study Unit CDE – Benefits the Susquehanna River from Wapwallopen to Sunbury	**105**		**This project is suggested for further study. The analysis should contain all multipurpose aspects including flood control, recreation, low flow augmentation, consumptive use makeup and hydroelectric power generation.**
				Subbasin 4	**241**		
				Total – Towanda	**1,530**	**2,129**	

[a]All numbers are DER estimates unless otherwise noted. The annual benefits and costs (in thousand dollars, 1976 price level) are planning guidelines only, not to be used for project budgeting or design.

[b]Includes benefits and costs applicable to New York State.

Note: **BOLD FACE** indicates projects which are recommended for construction or further study.

Table 28

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Potential COE Great Bend Reservoir Site on the Susquehanna River	9,991 FC only	16,869 FC only				
-AT THE SITE			-Enhances recreational potential of area	-Substantial relocation in Pa. communities of Oakland, Susquehanna and Lanesboro -Loss of existing farm, prime agriculture and forest land -Alters habitat for fish and wildlife -Alters fish production -Alters aquatic life -Inundation of Indian Village Site at Oghquaga, New York	-Potential COE Towanda Reservoir -Other small potential reservoirs for consumptive use makeup or low augmentation capability -Nonstructural flood control measures	This project is not recommended. -Not economically feasible -Major relocation necessary -Major adverse environmental impact
-DOWNSTREAM EFFECTS			-Reduces flood damages downstream of dam -Provides storage to meet anticipated consumptive use makeup needs on the Susquehanna River above its confluence with the West Branch Susquehanna River -Could provide storage for low flow augmentation needs -Improve water quality during low flow periods	-Could encourage more development or encroachment on the flood plain -Modifies fish production and movement	-Local structural flood control alternatives -Possible reauthorization of use for consumptive use makeup capability at (1) Stillwater Lake (2) Francis Slocum Dam (3) Small Dam PA-665 (4) Tioga-Hammond Lakes (5) Cowanesque Lake	

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 28 (Cont.)

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Potential COE Towanda Reservoir Site on Towanda Creek	1,530 FC only	2,129 FC only			-Potential COE Great Bend Reservoir -Other small potential reservoirs for consumptive use makeup or low flow augmentation capability -Possible reauthorization of use for consumptive use makeup capability at 1) Stillwater Lake 2) Francis Slocum Dam 3) Small Dam PA-665 4) Tioga-Hammond Lakes (5) Cowanesque Lake -Nonstructural flood control measures	This project is recommended for further study which would include an investigation of all uses that could be incorporated in the project.
-AT THE SITE			-Enhances recreational potential of area	-Relocation necessary in communities of West Franklin, Sayees Corners, Woodruff Corners and Leroy -Loss of existing farm, prime agricultural and forest land -Alters habitat for fish and wildlife -Alters aquatic life		
-DOWNSTREAM EFFECTS			-Reduces flood damages downstream of dam -Provides storage to meet anticipated consumptive use makeup needs on the Susquehanna River above its confluence with the W.Br.Susquehanna River -Could provide storage for low flow augmentation needs -Improve water quality during low flow periods	-Recreational development in and around the site would adversely affect the natural state of the area -Could encourage further development of the flood plain -Modifies fish production and movement		

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 28 (Cont.)

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #37-9 on East Branch Roaring Brook	29.6 FC	28.0 FC 119.0 WS 159.0 WS/t	-Reduces flood damages -Provides storage to meet anticipated consumptive use makeup needs on Roaring Brook -Could provide storage for low flow augmentation needs -Could serve as a public water supply source for Moscow Water Company	-Loss of forestland -Alters habitat for fish and wildlife -Would alter aquatic life	-Nonstructural flood control measures -Local channel modification project at Moscow	This project is recommended for further study
Small Potential Reservoir #08-9 on Little Shickshinny Creek	1.5 FC	12.0 FC 46.0 WS 106.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Shickshinny Water Company	-Loss of forestland -Loss of wetland area -Would alter aquatic life -Minor relocation would include 1 school site	-Nonstructural flood control measures	This project is not recommended.
Small Potential Reservoir #36-12 on Little Fishing Creek	4.1 FC	52.0 FC 162.0 WS 198.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Millville Municipal Authority	-Loss of farm, prime agriculture and forest land -Alters fish habitat on a trout stream -Would alter aquatic life -Wild and Scenic River Candidate Stream -Relocation of approximately 7–10 houses	-Nonstructural flood control measures	This project is not recommended.
Small Potential Reservoir #36-13B on Green Creek	31.6 FC only	93.6 FC only	-Reduces flood damages	-Major relocation including the Village of Rohrsburg -Wild and Scenic River Candidate Stream -Loss of farm, prime agriculture and forest land -Loss of vegetation and wildlife	-Nonstructural flood control measures	This project is not recommended.

[a]Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 28 (Cont.)

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Small Potential Reservoir #35-5 on Little Nescopeck Creek	13.9 FC only	39.3 FC only	-Reduces flood damages	-Loss of farm, prime agriculture and forest land -Wild and Scenic River Candidate Stream -Would alter aquatic life	-Local channel modification project at Conyngham -Nonstructural flood control measures	This project is not recommended
Small Potential Reservoir #34-1 on a Tributary to Catawissa Creek	8.2 FC	38.9 FC 156.0 WS 197.0 WS/t	-Reduces flood damages -Could serve as a public water supply source for Catawissa Municipal Authority	-Loss of farm and prime agricultural land -Relocation of 4-6 houses -Would alter aquatic life	-Nonstructural flood control measures	This project is not recommended
Small Potential Reservoir #06-7 on Lick Run	0.9 FC only	9.5 FC only	-Reduces flood damages	-Loss of farm land -Wild and Scenic River Candidate Stream -Would alter aquatic life	-Nonstructural flood control measures	This project is not recommended
Levee/Floodwall at Bloomsburg Boro on Susquehanna River	67.7	761.1	-Reduces flood damages for residential and commercial properties, roads, highways, and utilities	-Would alter aesthetic quality -Alters fish habitat -Wild and Scenic River Candidate Stream -Could encourage further development on the flood plain	-Major reservoir construction including Great Bend or Towanda -Nonstructural flood control measures	This project is not recommended
Levee/Floodwall at Catawissa Boro on Susquehanna River	Active DER Study		-Reduces flood damages for residential and commercial properties, roads, highways, and utilities	-Wild and Scenic River Candidate Stream -Would alter aesthetic quality -Alters fish habitat -Could encourage further development on the flood plain	-Major reservoir construction including Great Bend or Towanda -Nonstructural flood control measures	Active Study by DER in progress

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 28 (Cont.)

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Levee at Northumberland Boro on Susquehanna River	14.0	133.3	-Reduces flood damages in urbanized area including residential and commercial properties.	-Would alter aesthetic quality -Wild and Scenic River Candidate Stream -Could encourage further development on the flood plain	-Major reservoir construction including Great Bend or Towanda -Nonstructural flood control measures	This project is not recommended
Levee at Sunbury Island on Susquehanna River	7.2	138.3	-Reduces flood damages in urbanized area including residential and commercial properties	-Would alter aesthetic quality -Alters fish habitat -Wild and Scenic River Candidate Stream -Could encourage further development on the flood plain	-Major reservoir construction including Great Bend or Towanda -Nonstructural flood control measures	This project is not recommended
Channel Modification at Simpson on Lackawanna River	43.5	111.4	-Reduces flood damages in residential and commercial properties	-Would alter aesthetic quality -Wild and Scenic River Candidate Stream	-Nonstructural flood control measures	This project is not recommended
Channel Modification at Carbondale City on the Lackawanna River and Racket Brook	163.6	235.4	-Reduces flood damages in urbanized area including residential and commercial properties and roadways	-Wild and Scenic River Candidate Stream -Alters fish habitat	-Nonstructural flood control measures	This project is not recommended
Channel Modification at Archbald Boro on the Lackawanna River and White Oak Creek	49.1	195.7	-Reduces flood damages in urbanized area including residential and commercial properties and roadways	-Wild and Scenic River Candidate Stream -Alters fish habitat	-Nonstructural flood control measures	This project is not recommended
Channel Modification at Dickson City Boro on Scott, Elm, and Miles Creek	105.6	318.6	-Reduces flood damages in urbanized area including residential and commercial properties and roadways	-Alters fish habitat	-Nonstructural flood control measures	This project is not recommended

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

Table 28 (Cont.)

SCREENING ASSESSMENT OF FLOOD DAMAGE REDUCTION STRUCTURAL SOLUTION ALTERNATIVES

Alternative	Preliminary Estimate of Annual Benefit[a] ($1,000)	Preliminary Estimate of Annual Cost[a] ($1,000)	Major Beneficial Impacts	Major Adverse Impacts	Alternatives to This Proposal	Remarks
Channel Modification at Moscow Boro on Van Brunt Creek	52.2	15.8	-Reduces flood damages in residential and commercial properties	-Alters fish habitat	-Small potential reservoir #37-9 -Nonstructural flood control measures	This project is recommended for further study
Channel Modification at Ashley Boro on Solomon Creek and Sugar Notch Run	23.3	106.1	-Reduces flood damages in residential and commercial properties	-Alters fish habitat -Would alter aesthetic quality	-Nonstructural flood control measures	This project is not recommended
Channel Modification at Shavertown on Toby Creek	80.0	307.9	-Reduces flood damages in residential and commercial properties	-Would alter aesthetic quality -Alters fish habitat	-Nonstructural flood control measures	This project is not recommended
Channel Modification at Conyngham Boro on a Tributary to Little Nescopeck Creek	22.6	10.0	-Reduces flood damages in residential and commercial properties	-Would alter aesthetic quality -Alters fish habitat	-Small potential reservoir #35-5 -Nonstructural flood control measures	This project is recommended for further study

[a] Annual costs and benefits (1976 price level) are planning guidelines only, not to be used for project budgeting or design.
WS - Water Supply
WS/t - Water supply including treatment costs
FC - Flood Control

C. WATER-RELATED OUTDOOR RECREATION

Pennsylvania's recreational needs were examined in the State Recreation Plan (formerly the State Comprehensive Outdoor Recreation Plan – SCORP), which was developed by the Governor's Office of State Planning and Development in conjunction with an Interagency Recreation Planning Committee[30] and published in report form in July 1976. Whereas the State Recreation Plan studied 19 outdoor recreation activities, the State Water Plan is addressing only those outdoor recreation activities which are water-related; swimming, boating and fishing. Picnicking is also included because of its common association with many other activities, in particular boating and swimming, and also because the picnicking experience itself is enhanced by the proximity of water. State Water Plan recreation analyses were performed using data developed for the State Recreation Plan; however, the methods of analysis were developed separately because of the need to determine facilities usage directly at the watershed level.

Recreational opportunity may be derived from many sources including Federal, State and locally operated and maintained facilities, in addition to privately owned profit and nonprofit facilities. Water resources projects, particularly dams, usually offer excellent opportunities to develop associated recreation facilities. Floodplain management which results in relocation of development away from the floodplain provides new open space areas which can be used for recreational purposes with minimal risk of expensive losses due to future flooding.

Although this Plan does not propose the use of recreation as justification for water resources development, it is recognized that water resources management and structural development frequently provide excellent opportunity for associated recreational development or for enhancement of recreational experiences. Neither the data nor the methods of analysis used for this study were intended to determine recreational *demands* or *needs* in the traditional sense, but rather the attempt was to determine where existing or future potential recreational participation is sufficient to justify the development of additional recreational facilities. Where there is shown to be such justification, recreation should be included in other project planning and design. The discussion that follows is structured to follow the traditional *demand/supply* concept. The total potential recreational participation is discussed first in the context of "demands". Then existing facilities are examined as "supplies". The *residual* participation potential is then presented, representing the resultant "need" and finally the State share of that "need" is discussed. Again it must be emphasized that the residual potentials and State shares are *not* true needs but rather an indication of how many additional recreational facilities would be likely to be used if they were provided in conjunction with water resources projects or programs.

[30]Departments of Community Affairs, Education, Environmental Resources, Public Welfare and Transportation in addition to the Pennsylvania Fish, Game, and Historical and Museum Commissions.

1. *Total Participation Potential*

Participation potential is a measure of the public's willingness or desire to participate in given recreational activities. Information developed for the State Recreation Plan indicates what percentages of Pennsylvania's citizens have an interest in the various activities studied and how frequently they participate in those activities, on a regional basis. From that information in conjunction with existing and projected county populations, total participation potential was assessed for each county in terms of seasonal activity-days. An activity-day represents one person's participation in an activity during one day; and *seasonal* activity-days indicate the total number of activity-days which would occur during the 13-week summer recreational season. Table 29 lists the participation potential for the five counties in Subbasin 5, although those numbers reflect a reduction from the total potential to account for the percentage of participation which normally occurs in privately restricted facilities such as those in backyards.

In examining those numbers, it should be understood that participation desires vary according to the availability and quality of facilities, the amount of leisure time available, income levels and other factors. The State Recreation Plan studies measured varying levels of participation depending upon different assumptions regarding those influencing factors. The minimum levels of participation determined by that study were used in this study, so in reality, participation potentials could be higher than those listed in the table.

2. *Existing Facility Supply*

Existing recreational facilities were inventoried for the State Recreation Plan in 1974. The total number of facility units in each county and watershed in Subbasin 5 are listed in Table 30 and the center column of Table 31, respectively. The supply totals include Federal, State and local, as well as private profit and nonprofit facilities which are available for public use.

Existing and proposed State parks are mapped on Figure 17. A corresponding listing of those parks is provided in Table 32. Archbald Pothole provides picnicking in Watershed A; Frances Slocum offers picnicking, boating and fishing opportunities in Watershed B. Ricketts Glen additionally provides camping and swimming in Watershed C, while Shikellamy Marina offers picnicking, fishing and boating opportunities in Watershed E.

Cold- and warm-water fishing streams are shown on Figure 6 in the previous section entitled Fish, Waterfowl and Furbearer Resources. Fishing and boating lakes greater than ten acres, as well as fishing and boating access areas, are shown on Figure 17 and listed in Tables 33 and 34. Fishing opportunity in a watershed is determined by either the presence of fish, water area or access, whichever is the limiting factor. Table 35 summarizes the fishing mileage and acreage by county. These numbers represent the physical presence of fishable water but do not imply any ready access.

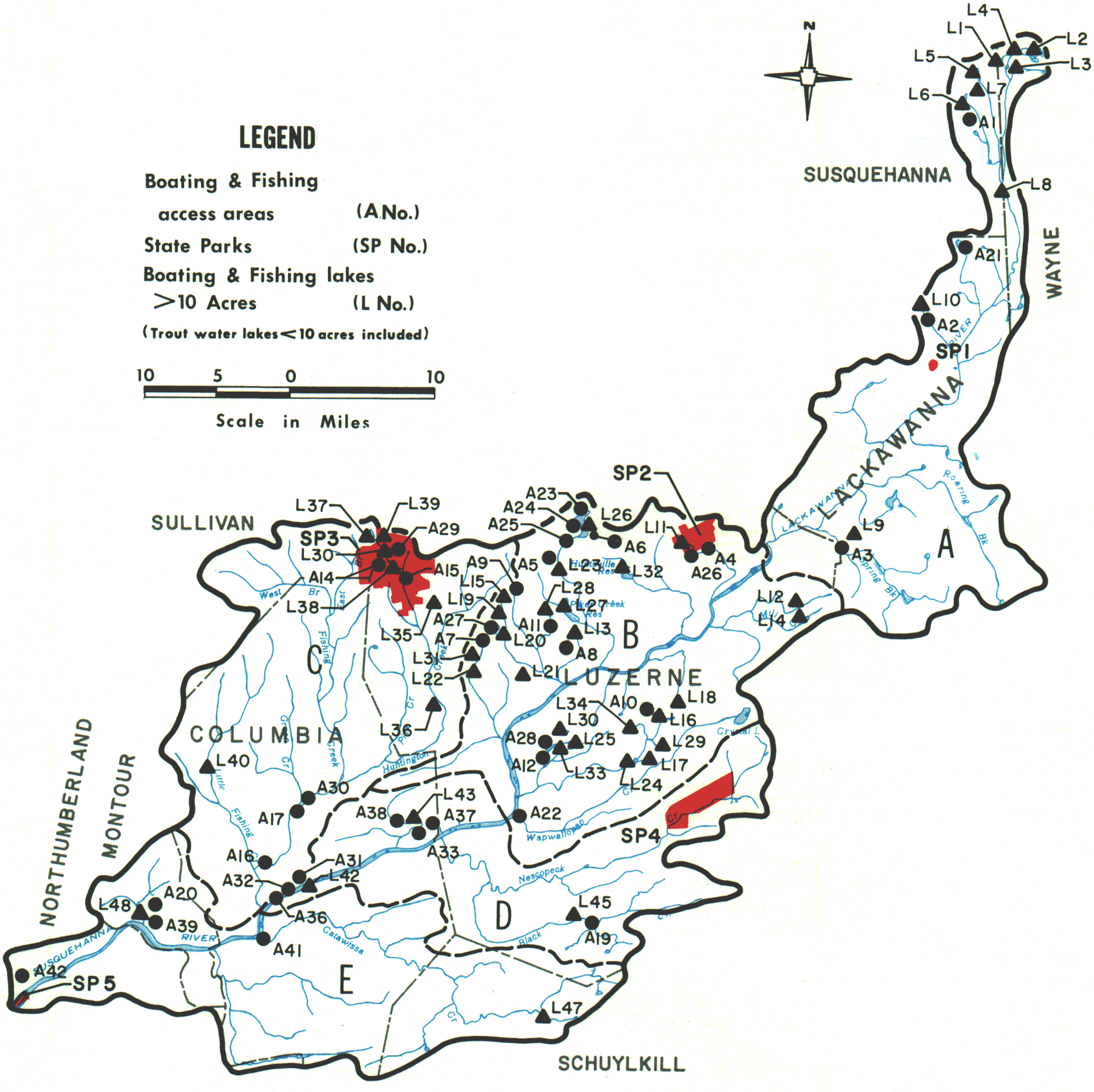

FIGURE 17. Recreation Areas and Facilities

Table 29

TOTAL RECREATIONAL PARTICIPATION POTENTIAL[a] BY COUNTY

Activity	County	Seasonal Activity-days (1,000's) 1970	1990	2020
Picnic	Luzerne	1,461	1,534	1,670
	Lackawanna	998	1,067	1,193
	Columbia	249	273	311
	Montour	75	74	82
Swim	Luzerne	6,839	7,818	9,378
	Lackawanna	4,671	5,437	6,699
	Columbia	1,083	1,304	1,624
	Montour	327	356	431
Boat	Luzerne	655	863	1,124
	Lackawanna	447	600	803
	Columbia	103	195	232
	Montour	31	39	52
Fish	Luzerne	1,502	1,784	2,106
	Lackawanna	1,026	1,240	1,505
	Columbia	245	298	365
	Montour	74	81	97

[a]Participation potentials listed are the activity-days that would result from the populations of the identified counties; they do not relate to the potential of the recreational resources in the counties.

Table 30

EXISTING RECREATION FACILITY UNITS BY COUNTY (1974)

County	Picnic Tables	Beach (Linear feet)	Pool (Square feet)	Power Boating (Acres)	Nonpower Boating (Acres)	Fishing (Man-days per year)
Luzerne	2,393	700	97,000	2,395.6	2,947.0	1,957,303
Columbia	643	1,000	31,000	5,481.6	5,481.6	686,555
Montour	1,250	8,700	172,000	962.0	998.4	960,324
Lackawanna	2,554	1,600	184,000	894.0	926.0	1,460,938

Figure 18 shows boatable streams as delineated by the Pennsylvania Fish Commission. Stream and lake acreages by county are listed in Table 30. Again these numbers do not imply any ready access. Any body of water suitable for both fishing and boating is included in both Tables 30 and 35.

3. *Residual Participation Potential*

The residual participation potential is the amount by which total participation potential exceeds the participation capacity of existing facility units. It is a measure of the quantity of additional facilities which would be likely to be used if they were developed. The 1970, 1990 and 2020 potential participations expressed in terms of facility units for the watersheds in Subbasin 5 are listed in the left three columns of Table 31.

Residual participation potentials are also listed in Table 31. They were computed as the difference between the total participation potential and the existing facility units. The absence of a residual potential entry in the table indicates that existing facilities exceed the number needed to accommodate the total participation desires if the facilities were used in a manner conforming to standards. Any number in the residual column indicates how many additional facility units would potentially be used if provided in the watershed, again assuming that their use would conform to regional standards, and also that access to and quality of the

Continued on page 147

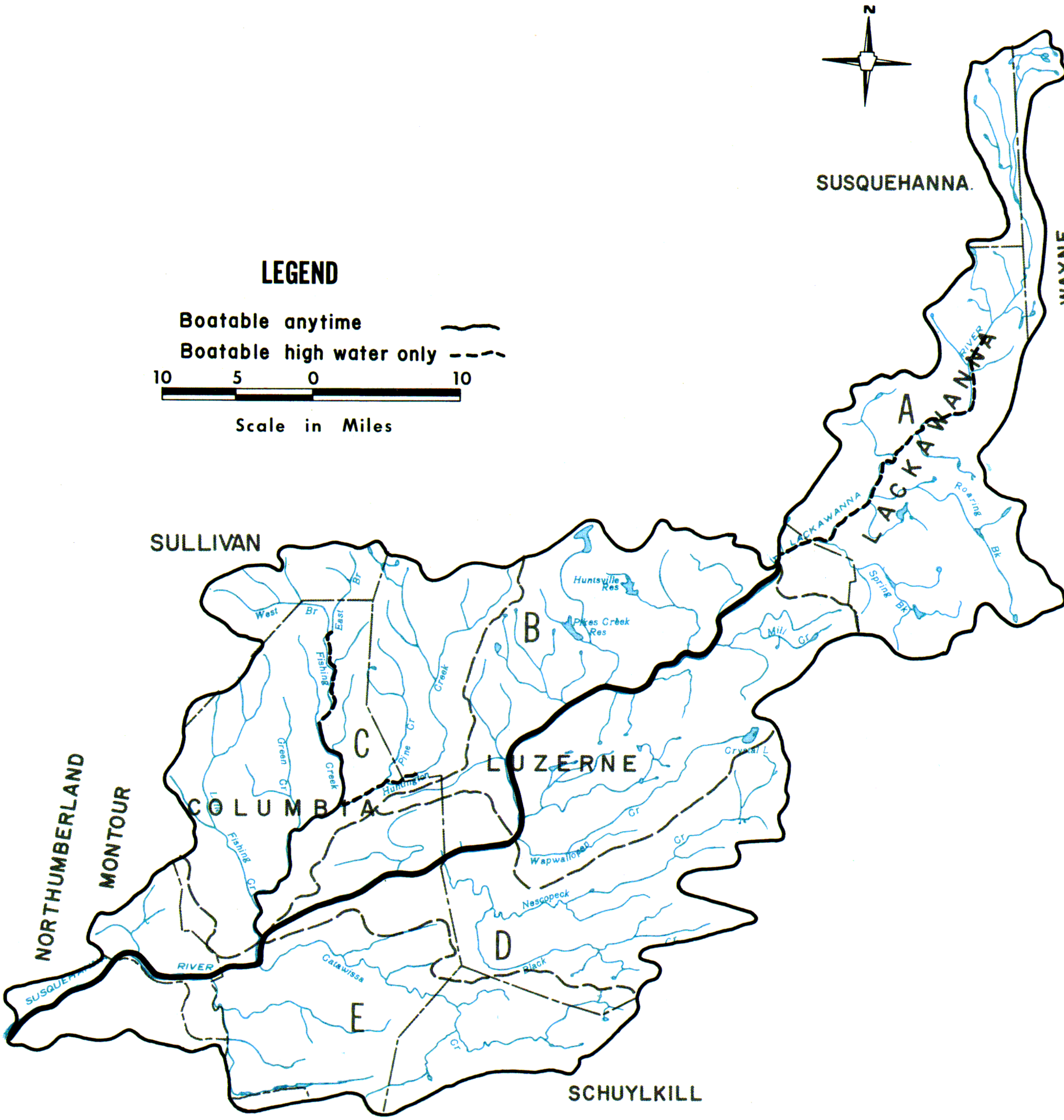

FIGURE 18. Boatable Streams

Table 31

TOTAL AND RESIDUAL PARTICIPATION POTENTIAL[a]

Activity Units	Watershed	Total Participation Potential 1970	1990	2020	Existing Facility Units	Residual Participation Potential 1970	1990	2020	State Share Residual Potential 1970	1990	2020
Picnic Tables (10's)	A	198	255	313	158	40	97	155	13	32	52
	B	218	335	390	127	91	208	263	30	69	88
	C	69	96	123	79		17	44		6	15
	D	53	73	93	56		17	37		6	12
	E	125	149	181	68	57	81	113	19	27	38
Beach Linear feet (100's)	A	1	2	2	84						
	B	2	3	3		2	3	3	2	3	3
	C	10	15	17	17						
	D										
	E	1	1	1	1						
Pool Square feet (1,000's)	A	169	179	215	164		15	51		2	5
	B	125	225	262	75	50	150	187	5	15	19
	C	6	10	11	7		3	4			
	D	32	49	56	34		15	22		2	2
	E	23	30	34	22		8	12			1
Power Boating Acres	A	735	1,049	1,649	246	489	803	1,403	489	489	1,403
	B	1,715	3,150	3,623	1,152	563	1,998	2,471	563	1,998	2,471
	C	141	184	220	141		44	79		44	79
	D	3,081	4,880	5,845	4,639		241	1,206		241	4,639
	E	2,753	4,208	5,105	4,271			834			4,271
Nonpower Boating Acres	A	382	619	709	270	112	349	439	112	349	112
	B	787	1,362	1,505	1,509						
	C	122	216	277	575						
	D	887	1,526	1,816	4,271						
	E	834	1,426	1,695	4,448						

[a]Participation potentials listed are a function of population rather than physical resources. Residual potentials indicate the number of additional facilities which would be likely to be used if developed.

Table 31 (Cont.)

TOTAL AND RESIDUAL PARTICIPATION POTENTIAL[a]

Activity Units	Watershed	Total Participation Potential 1970	Total Participation Potential 1990	Total Participation Potential 2020	Existing Facility Units	Residual Participation Potential 1970	Residual Participation Potential 1990	Residual Participation Potential 2020	State Share Residual Potential 1970	State Share Residual Potential 1990	State Share Residual Potential 2020
Fishing Man-days/Year (1,000's)	A	443	634	710	591		43	119		43	119
	B	774	1,120	1,164	1,143			21			21
	C	98	145	176	324						
	D	346	492	662	1,014						
	E	159	219	252	312						

[a]Participation potentials listed are a function of population rather than physical resources. Residual potentials indicate the number of additional facilities which would be likely to be used if developed.

Table 32

STATE PARKS

Watershed	Legend (See Figure 17)	State Park	Land Area (Acres)	Water Area (Acres)	Total Area (Acres)	Facilities[a] Existing (1974)	Facilities[a] Proposed	Remarks
A	SP1	Archbald Pothole	150	0	150	A		
B	SP2	Francis Slocum	841	165	1,006	A,C,E	B,C	
C	SP3	Ricketts Glen	8,621	254	8,793	A,B,C,D,E		Also in SB #4
D	SP4	Nescopeck	2,981		2,981		A,B,C,D,E	
E	SP5	Shikellamy Marina	47	0[b]	47	A,D,E		Also in SB #6

[a]Facility Codes: A - Picnicking, B - Camping, C - Swimming, D - Boating, E - Fishing

[b]Marina utilizes pool water behind Sunbury inflatable recreation dam.

Table 33

EXISTING FISHING AND BOATING LAKES

Watershed	Legend (See Figure 17)	Lake	Stream	County	Recreational Area (Acres)	Ownership	Remarks
A	L1	Dunn Lake	E. Br. Lackawanna River	Susquehanna	94	private	posted
A	L2	Bone Pond	E. Br. Lackawanna River	Wayne	38	private	
A	L3	Independent Lake	E. Br. Lackawanna River	Wayne	30	private	
A	L4	Five-mile Pond	E. Br. Lackawanna River	Wayne	48	private	
A	L5	Renobe Lake	W. Br. Lackawanna River	Susquehanna	30	private	posted
A	L6	Fiddle Lake	W. Br. Lackawanna River	Susquehanna	63	private	posted
A	L7	Hathaway Lake	W. Br. Lackawanna River	Susquehanna	31	private	posted
A	L8	Stillwater Res.	Lackawanna River	Susquehanna	82	Federal	posted
A	L9	Rocky Glen Pond	Trib. Covey Creek	Lackawanna	37	Rocky Glen Park	
A	L10	Heart Lake	Rush Brook	Lackawanna	30	private	
B	L11	Frances Slocum	Abraham Creek	Luzerne	165	DER	
B	L12	Harlow Pond	Gardners Creek	Luzerne	14	private	
B	L13	Moon Lake		Luzerne	47		boating
B	L14	Mill Creek Reservoir	Mill Creek	Luzerne	80	private	posted
B	L15	North Lake	Hunlock Creek	Luzerne	40	private	boating,posted
B	L16	Naungola Lake	Laurel Lakes	Luzerne	98	private	boating,posted
B	L17	Blytheburn Lake	L. Wapwallopen Creek	Luzerne	40	private	boating
B	L18	Boyle Pond	L. Wapwallopen Creek	Luzerne	24	private	posted
B	L19	Grassy Pond	Sylvan Lake	Luzerne	14	private-profit	boating
B	L20	Sylvan Lake	Hunlock Creek	Luzerne	80	private	boating,posted
B	L21	Sunset Lake	W.Br. Hunlock Creek	Luzerne	5	private	boating,posted
B	L22	Shickshinny Lake	Shickshinny Creek	Luzerne	140	private	boating,posted
B	L23	Bryants Pond	Harvey Creek	Luzerne	25	SFC	boating
B	L24	Andy Pond		Luzerne	34	private	
B	L25	Cranberry Pond	Lily Lake	Luzerne	15	private	
B	L26	Harveys Lake	E.Fk. Harvey Creek	Luzerne	659	Comm. of Pa.	boating,posted
B	L27	Pikes Creek Reservoir	Harvey Creek	Luzerne	385	private	posted
B	L28	Lake Silkworth	Hunlock Creek	Luzerne	28	private	posted,boating
B	L29	Ice Ponds	L.Wapwallopen Creek	Luzerne	45	private	
B	L30	Lielar Lake	Unnamed Stream	Luzerne	36	private	

Source: Pennsylvania Fish Commission

Table 33 (Cont.)

EXISTING FISHING AND BOATING LAKES

Watershed	Legend (See Figure 17)	Lake	Stream	County	Recreational Area (Acres)	Ownership	Remarks
B	L31	Hidden Lake	Shickshinny Lake	Luzerne	18	private	boating,posted
B	L32	Huntsville Reservoir	Huntsville Creek	Luzerne	360	private	posted
B	L33	Lily Lake	Pond Creek	Luzerne	160	PFC	boating
B	L34	Mud Pond	Pond Creek	Luzerne	18	private	posted
C	L35	Blair Pond	Huntingdon Creek	Luzerne	12	private	
C	L36	Lake Pinecrest	Pine Creek	Luzerne	52	private	
C	L37	Ganoga Lake	Kitchen Creek	Sullivan	60	private	posted
C	L38	Lake Rose	Kitchen Creek	Luzerne	50	PFC	
C	L39	Lake Jean	Kitchen Creek	Luzerne	245	DER	boating
C	L40	Millville Lake	Fishing Creek	Columbia	3	private	
C	L41	Jonestown Dam	Fishing Creek	Columbia	15	private	
D	L42	Espy Pond	N.Br. Susquehanna River	Columbia	15	private	
D	L43	Briar Creek Lake	Briar Creek	Columbia	51	PFC	
D	L44	Town Park Lagoon	Neals Run	Columbia	4		
D	L45	Lake Irena	Black Creek	Luzerne	14	Greater Hazleton Com.Park Corp	
E	L46	Dugout Dam	N.Br. Susquehanna River	North'd	4	private	
E	L47	Pumping Station Reservoir	Catawissa Creek	Schuylkill	9	private	
E	L48	Lawrence Ice Dam	Mahoning Creek	Montour	15	private	
E	L49	Narrows Lake	N.Br. Susquehanna River	Columbia	15	utilities	

Source: Pennsylvania Fish Commission

Table 34

EXISTING FISHING AND BOATING ACCESS AREAS

Watershed	Legend (See Figure 17)	Access	County	Stream or Water Body	Ownership	Remarks
A	A1	Fiddle Lake	Susquehanna	Fiddle Lake Creek		
A	A2	Heart Lake	Lackawanna	Rush Brook	private	
A	A3	Rocky Glenn Pond	Lackawanna	Covey Creek	private	
B	A4	Abrahams Creek	Luzerne	Abrahams Creek	DER	proposed
B	A5	Bryant's Pond	Luzerne	Harvey Creek	PFC easement	
B	A6	Harveys Lake	Luzerne	Harvey Creek	PFC[b]	To be constructed
B	A7	Sylvan Lake	Luzerne	Tributary to Hunlock Creek	PFC	
B	A8	Moon Lake	Luzerne		private	Luzerne County acquisition planned
B	A9	North Lake	Luzerne	Hunlock Creek	private	
B	A10	Lake Nuangola	Luzerne	Laurel Lakes	private	
B	A11	Lake Silkworth	Luzerne	Hunlock Creek	private	
B	A11	Lily Lake	Luzerne	Pond Creek	PFC	
C	A13	Red Rock	Luzerne	Maple Run	PFC	mooring
C	A14	Lake Jean	Luzerne	Kitchen Creek	DER	
C	A15	Lake Rose	Luzerne	Kitchen Creek	DER	
C	A16	Jonestown Dam	Columbia	Fishing Creek		
C	A17	Orangeville Dam	Columbia	Huntington Creek	PFC	
D	A18[a]	Briar Creek Run Dam	Columbia	Briar Creek	PFC	To be constructed
D	A19	Lake Irena	Luzerne	Black Creek	Hazel Township	
E	A20	Lawrence Ice Dam	Montour	Mahoning Creek	private	
A	A21	Crystal Lake – Dundoff	Lackawanna	Fall Brook		fee
B	A22	Berwick Boat Club – Wapwallopen	Luzerne	Susquehanna River		fee
B	A23	Link's Landing – Northwest of Wilkes-Barre	Luzerne	Harveys Lake	private	fee
B	A24	Sunset Marina – Northwest	Luzerne	Harveys Lake		fee

[a]Not shown on Figure.

[b]Pennsylvania Fish Commission.

Source: OSPD, State Recreation Plan facilities inventory.

Table 34

EXISTING FISHING AND BOATING ACCESS AREAS

Watershed	Legend (See Figure 17)	Access	County	Stream or Water Body	Ownership	Remarks
		of Wilkes-Barre				
B	A25	PFC Access Area – Northwest of Wilkes-Barre	Luzerne	Harveys Lake	PFC	
B	A26	Frances Slocum State Park – Wyoming	Luzerne	Frances Slocum Dam	DER	Boat rentals, no motors
B	A27	PFC Access Area – 1–1/2 mi. South of Sweet Valley	Luzerne	Sylvan Lake	private	15 HP limit
B	A28	Lily Lake Access	Luzerne	Lily Lake	PFC	Sanitary facility, small electric boats only
C	A29	Lake Jean Access	Luzerne	Lake Jean	DER	
C	A30	Old Orangeville Dam	Columbia	Huntington Creek	PFC	
D	A31	Susquehanna Boat Club – Epsy	Columbia	Susquehanna River		fee
D	A32	Bloomsburg Airport landing	Columbia	Susquehanna River		
D	A33	Berwick Boat Ramp	Columbia	Susquehanna River		
D	A34[a]	Town Marine Access	Columbia	Susquehanna River	private	
D	A35[a]	VFW Access	Columbia	Susquehanna River	private	
D	A36	Bloomsburg Access	Columbia	Susquehanna River		
D	A37	Berwick Access	Columbia	Susquehanna River		
D	A38	Briar Creek Lake Access	Columbia	Briar Creek Lake	PFC	Electric motors only
E	A39	Danville Boat Club	Montour	Susquehanna River	private nonprofit	Parking fee
E	A40[a]	North Branch Boat Club Access	North'd	Susquehanna River	private nonprofit	
E	A41	Catawissa Landing	Columbia	Susquehanna River		
E	A42	Shikellamy Marina	North'd	Susquehanna River	DER	

[a]Not shown on Figure.

[b]Pennsylvania Fish Commission.

Source: OSPD, State Recreation Plan facilities inventory.

Table 35

EXISTING FISHING SUPPLY

County	Stream (Miles)	Lake (Acres)
Luzerne	399.8	4,397.0
Lackawanna	100.0	2,567.7
Columbia	158.0	118.0
Montour	21.0	171.0

Source: Pennsylvania Fish Commission

facilities is sufficient to ensure that recreationists would travel to the facilities from distances which conform to the travel-time standards for the activities studied. It should again be emphasized that the residual potentials presented in the table represent conservative estimates, according to State Recreation Plan results.

4. *State Responsibility*

Pennsylvania has invested heavily in outdoor recreation over the past 15 years. In many areas, facilities for selected activities have been developed to nearly the maximum of which the resource is capable. Most forms of outdoor recreation involve a specific use of land or water; consequently, recreation finds itself competing for both land and water surface area against many other forms of incompatible use. The avenues through which the State can directly provide water-related outdoor recreation opportunity are limited primarily to State or Federal water resources projects and their environs, to State parks and, to a lesser degree, State forest picnic areas. Responsibility for all these lies primarily with the Department of Environmental Resources.

It is not expected that the State will provide additional facilities to accommodate all of the residual recreational participation potential. As stated previously, there are many sources of recreation facilities, the State being one of them. State-owned or operated facilities currently account for approximately the following percentages of facilities usage:

a. picnicking – approximately 33 percent
b. pool swimming – approximately 10 percent
c. beach swimming, power and nonpower boating, and fishing – nearly 100 percent

Although the State provides only about 60 percent of existing fishing and boating access facilities, State Water Plan analyses are concerned with the future development of additional potential fishing or boating surface areas, which can only be accomplished by construction of lakes and will, therefore, be wholly accessible to the State for recreational development. The percentages shown reflect present usages and are not policy; they may vary in the future. The last two columns in Table 31 list the share of residual participation potential for which the State may be likely to provide additional facilities based on those percentages. Picnicking and power boating appear as the activities which most justify additional development by the State. Pool swimming facilities will be justified in Watershed B by 1990; however, swimming pools are primarily a local responsibility.

5. *Recommendations*

Additional picnic site development should be pursued at the local level to provide for the needs throughout the subbasin. Additional development of picnicking facilities by the State is inhibited by the near capacity development of the existing State parks in the area. Picnicking facilities included in the proposed Nescopeck State Park, however, would provide additional opportunity in Watershed D. Swimming pool development should be considered at the local level in Watersheds A, B and D, as future growth may justify.

The power boating potential of this, as well as adjacent subbasins, should be considered in the recreation planning associated with preliminary design or proposed construction or modification of any of the following projects: Prompton, Great Bend, Nescopeck or Francis E. Walter. Power boating is a recreational activity of increasing popularity and demand, although resources for future development of power boating opportunity are limited statewide. Where demands cannot be satisfied by additional development, they may need to be solved by future shifts in recreation patterns away from power toward nonpower boating. The State should continue to expand boating and fishing access wherever possible to better provide for growth in both activities.

It is strongly recommended that recreational development or enhancement be considered as an integral part of any local floodplain management projects and programs. It is also recommended that the subbasin's recreation potential be justly considered in the formulation of plans for any State, regional or local water resources development activities; however, this report does not propose the use of recreation as a sole factor for the justification of water resources projects.

D. WILD AND SCENIC RIVERS

The Commonwealth's policy is to protect and enhance those river segments representative of Pennsylvania's natural and cultural river heritage for the purposes of environmental protection and the general recreational enjoyment and educational benefit of the public. Toward this end the Governor signed into law in December 1972, Act No. 283, which authorized the establishment of the Pennsylvania Scenic Rivers System.

The Scenic Rivers Act established four classifications into which candidate streams could be assigned:

1. Wild river areas – those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with

watersheds or shorelines essentially primitive and waters unpolluted.

2. Scenic river areas – those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and undeveloped, but accessible in places by roads.

3. Recreational rivers – those rivers or sections of rivers that are readily accessible, that may have some development along their shorelines and may have undergone some impoundment or diversion in the past.

4. Modified recreational rivers – those rivers or sections of rivers in which the flow may be regulated by control devices located upstream. Low dams are permitted in the reach so long as they do not increase the river beyond bank-full width. These reaches are used for human activities which do not substantially interfere with public use of the streams or the enjoyment of their surroundings.

Using this classification system, the Department of Environmental Resources[31] compiled and published in July 1975 the "Pennsylvania Scenic Rivers Inventory"[32]. That inventory is a listing of all candidate streams which were recommended for future study to determine their eligibility for inclusion by law in the Scenic Rivers System. Since it was recognized that the completion of such detailed studies statewide would require many years, possibly several decades, the candidate streams were further categorized according to relative priority as assigned by the Wild and Scenic Rivers Task Force. These priority assignments were based on the stream's recognition as having national, statewide or primarily local significance. Under the first priority, or those with statewide and in some cases even national significance, the streams were subdivided into three subgroups (A, B, and C). First priority group "A" streams are those which have most immediate need for protection and urgent need for additional study.

The streams or stream segments in Subbasin 5 which have been nominated for inclusion in the Scenic Rivers System are listed in Table 36 according to priority ranking. Priorities were assigned to stream segments regardless of their classifications; consequently, several classifications may appear within a priority group. The same stream segments are mapped on Figure 19. Seven stream segments have been nominated from this area in the three priority groups with one of the nominations, the Susquehanna River, falling in the Priority 1 group.

[31]The Department of Environmental Resources is the agency mandated by The General Assembly to administer the Pennsylvania Scenic Rivers Program.

[32]Pennsylvania Department of Environmental Resources, *Pennsylvania Scenic Rivers Inventory*, (December, 1975).

While responsibility for development of management programs to protect the Commonwealth's designated stream segments lies with the Scenic Rivers Program, the development of these management programs requires close coordination with the State Water Plan. The State Water Plan will not address management of the candidate streams as wild and scenic rivers; however, those stream nominations have been and will continue to be accounted for in all management schemes devised to solve the water resources problems presented in this report. Until a candidate stream becomes a legally adopted component of the Pennsylvania Scenic Rivers System, its nomination must be treated as an environmental constraint to any structural solution identified within the candidate segment. This does not represent a moratorium on development within the candidate segment, but does indicate a need for special emphasis on the examination of all factors when considering a possible structure within the area. After legal adoption, mandated restrictions on development within the segment would apply to any recommended structural solutions to water resources problems and would be strictly adhered to by the State Water Plan.

Future coordination between the State Water Plan and the Scenic Rivers Program is required to insure that State Water Plan decisions account for any stream segments which may be nominated at future dates. The Scenic Rivers Program will provide annual updates of the Scenic Rivers Inventory so that streams which meet eligibility requirements in the future are not forgotten or ignored and so that existing classifications and priorities may be reviewed.

E. WATER QUALITY

The following information was derived primarily from the Comprehensive Water Quality Management Planning (COWAMP) program. More detailed information on the problems and their solutions discussed herein can be found in the individual COWAMP study area reports.

A major problem in determining the quality of subbasin streams is the sparse distribution of quantitative sampling locations. Although there may be considerable information regarding water quality in a given stream, the geographical distribution of the monitoring stations limits the ability to derive general conclusions regarding water quality throughout the subbasin.

Figure 20 shows the location of stream reaches having a degraded water quality. Degraded reaches were determined by the Pennsylvania Department of Environmental Resources (DER) and the Pennsylvania Fish Commission. DER aquatic biologists considered a stream seriously degraded if it did not possess a diverse population of invertebrates and if the majority of invertebrates found were pollution tolerant species. Other indications of poor stream quality include low pH and dissolved oxygen values, high iron values, and the presence of acidity. Fish Commission personnel based their evaluation of degradation on the presence of a low

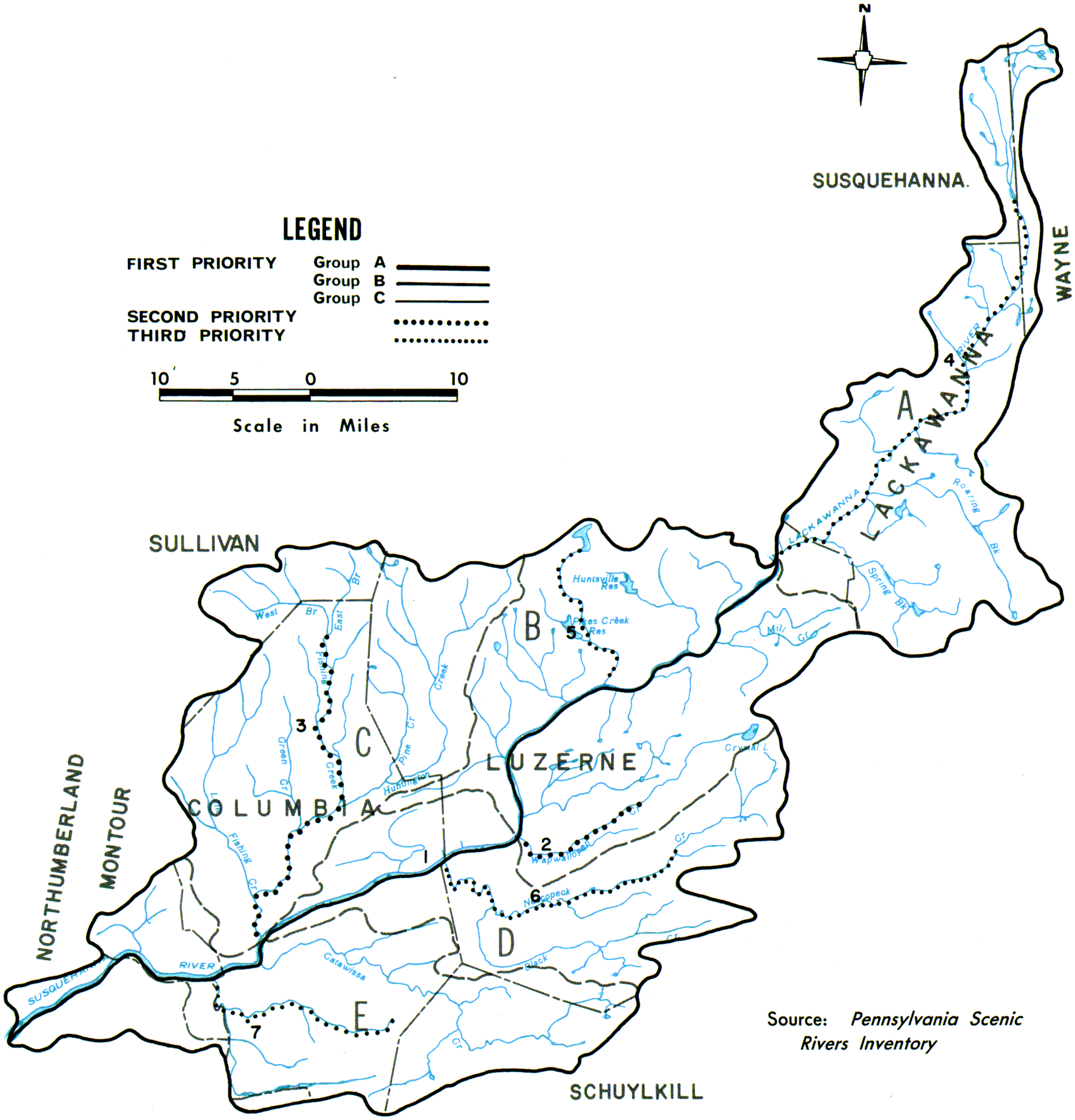

FIGURE 19. Pennsylvania Scenic Rivers Candidates

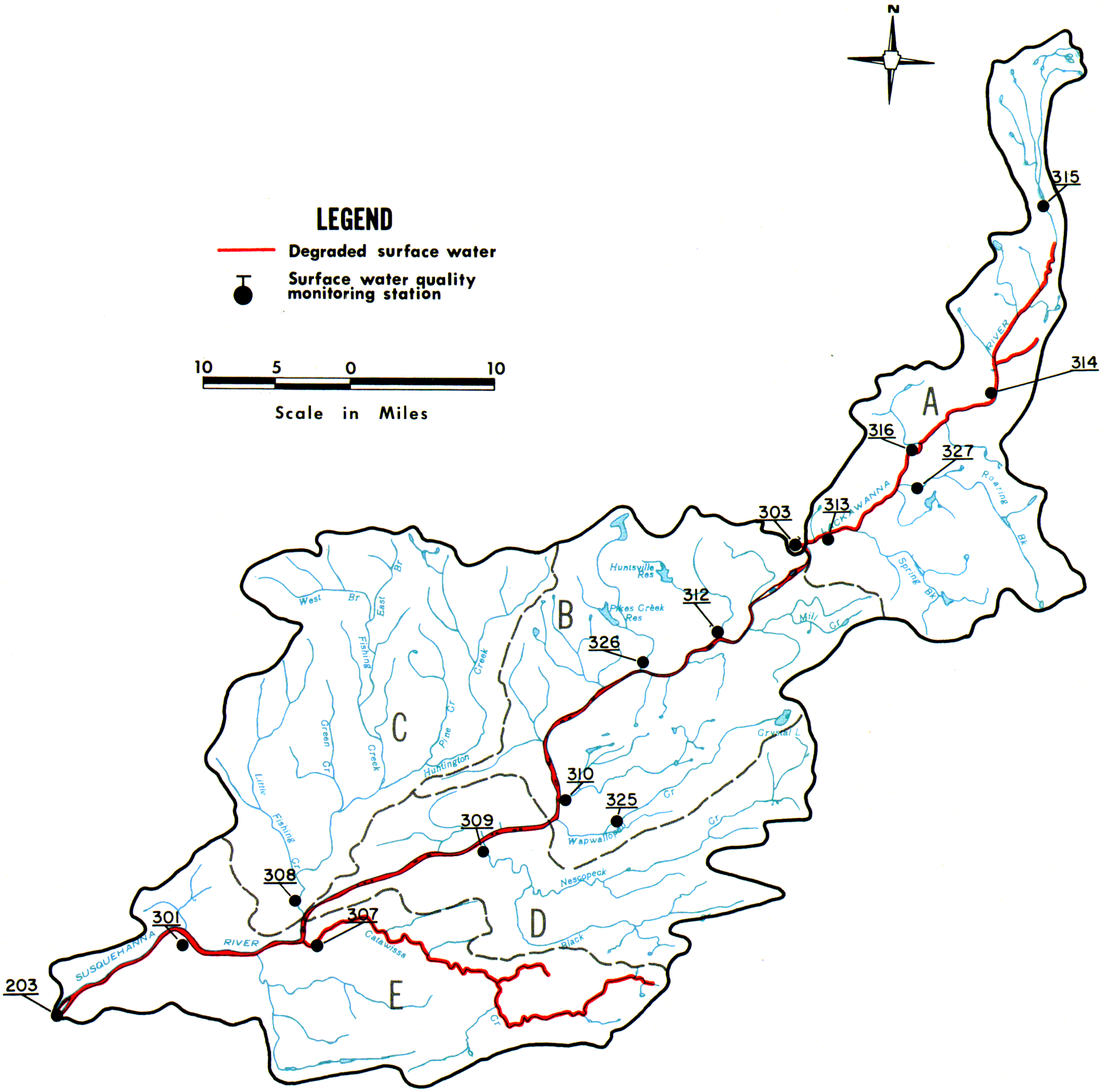

FIGURE 20. Water Quality

Table 36

PENNSYLVANIA SCENIC RIVERS CANDIDATES[a]

Legend (See Figure 19)	Stream Name	Priority Group	Proposed Segment Limits	Approx. Segment Length (miles)	Proposed Class	Water Quality
1	Susquehanna River	1-B	Lackawanna River - Sunbury	52	S,R	3,2
2	Wapwallopen Creek	2	Near Interstate 81 - Susquehanna River	11	W	1
3	Fishing Creek	2	Headwaters - Susquehanna River	30	R	1
4	Lackawanna River	3	Stillwater Reservoir - Susquehanna River	32	MR	1,2,3
5	Harvey Creek	3	Harveys Lake - Susquehanna River	13	S	1
6	Nescopeck Creek	3	Headwaters - Susquehanna River	29	S	1
7	Roaring Creek	3	Headwaters - Susquehanna River	18	R	1

[a]For explanation of columns see Appendix D-1.

population of game fish in the presence of industrial, municipal, or acid mine drainage discharges.

Figure 20 also shows the location of DER water quality monitoring stations, while Table 37 contains a summary of analytical results from selected stations. Further information on the monitoring station data and the aquatic biologists' reports is available from DER's Bureau of Water Quality Management. Monitoring samples are collected under a variety of conditions and are not designed to provide detailed knowledge of water quality in a number of stream reaches or the daily variations of quality. However, they do provide an overall view of the water quality over an extended period of time.

The aquatic biologists' reports describe the biological condition of a stream during the sampling period. They include information on the variety and number of biological species, limited chemical analyses, and a qualitative description of the stream condition. The biological reports provide information regarding a given stream's biological condition produced by events occurring over a period of time. In contrast, the chemical analyses of the samples collected at the monitoring stations reflect water quality only at the time of sampling.

Groundwater presents a much less dynamic picture than a normal surface stream does. In a frequently pumped well, water quality would change over a much longer period than that of a surface stream. Thus, data values for a groundwater station are less dependent on sampling frequency than those collected from a surface stream. Nevertheless, there can be a considerable variation of sampling results from a given aquifer due primarily to monitoring a number of wells at various depths in that aquifer. Also, a given aquifer can possess a wide range of water quality because of variations in the infiltrated soil and strata.

In order to quantitatively evaluate the quality of a given stream, certain stream criteria must be examined. Values of specific water quality criteria established by the Commonwealth are contained in Chapter 93 of DER's "Rules and Regulations". In most

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Table 37

WATER QUALITY MONITORING STATION[a] SUMMARY RESULTS

Parameter	Units	Minimum	Maximum	Mean	Years of Record
Station No. 303					
Stream: Susquehanna River					
Location: Coxton Railroad Bridge in Exeter Township, Luzerne County					
Temperature	°F	32.9	73.4	51.7	1971–1974
Dissolved Oxygen	mg/l	8.0	12.3	10.011	1971–1974
pH	S.U.	6.90	9.10	7.40	1971–1074
Total Dissolved Solids	mg/l	168	168	168	1972
Ammonia Nitrogen	mg/l	0.150	0.500	0.267	1972–1974
Iron, Total	g/kl	200	2,250	972.222	1971–1974
Total Coliform	MPN/100 ml	9,968	9,968	9,968	1971
Station No. 309					
Stream: Nescopeck Creek					
Location: Bridge on L.R. 40017 in Nescopeck Township, Luzerne County					
Temperature	°F	40.1	69.8	53.2	1971–1974
Dissolved Oxygen	mg/l	8.0	15.0	10.589	1971–1974
pH	S.U.	4.20	7.60	5.657	1971–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.100	0.800	0.358	1972–1974
Iron, Total	g/kl	100	3,000	1,415.714	1971–1974
Total Coliform	MPN/100 ml	60	60	60	1971
Station No. 310					
Stream: Wapwallopen Creek					
Location: Bridge on State Route 239 in Conyngham Township, Luzerne County					
Temperature	°F	35.6	69.8	55	1971–1974
Dissolved Oxygen	mg/l	8.5	12.0	10.790	1971–1974
pH	S.U.	6.10	7.30	6.822	1971–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.020	4.399	0.438	1972–1974
Iron, Total	g/kl	10	900	184.375	1971–1974
Total Coliform	MPN/100 ml	–	–	–	–

[a]See Figure 20 for location of monitoring stations.

Source: Pennsylvania Comprehensive Water Quality Management Plan (COWAMP) study area reports.

Table 37 (Cont.)

WATER QUALITY MONITORING STATION[a] SUMMARY RESULTS

Parameter	Units	Minimum	Maximum	Mean	Years of Record
Station No. 312					
Stream: Toby Creek					
Location: Grove Street Bridge in Pringle Borough, Luzerne County					
Temperature	°F	33.8	69.8	48.2	1971–1973
Dissolved Oxygen	mg/l	8.0	12.8	10.587	1971–1973
pH	S.U.	6.50	8.25	7.108	1971–1973
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.010	0.400	0.192	1972–1973
Iron, Total	g/kl	40	1,400	530	1971–1973
Total Coliform	MPN/100 ml	14,440	14,440	14,440	1971
Station No. 313					
Stream: Lackawanna River					
Location: Bridge Street Bridge in Old Forge Borough, Lackawanna County					
Temperature	°F	34.7	68	44.6	1971–1973
Dissolved Oxygen	mg/l	9.2	11.9	10.767	1971–1973
pH	S.U.	6.70	7.10	6.925	1971–1972
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.300	1.000	0.650	1972–1973
Iron, Total	ug/l	130	2,600	1,200	1971–1973
Total Coliform	MPN/100 ml	–	–	–	–
Station No. 314					
Stream: Lackawanna River					
Location: Ridge Street Bridge in Archbald Borough, Lackawanna County					
Temperature	°F	32.9	230.9	74	1971–1974
Dissolved Oxygen	mg/l	5.3	110.1	21.037	1971–1974
pH	S.U.	6.20	6.80	6.330	1971–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.070	0.700	0.338	1972–1974
Iron, Total	ug/l	520	1,300	536.587	1971–1974
Total Coliform	MPN/100 ml	5,938	5,938	5,938	1971
Station No. 315					
Stream: Lackawanna River					
Location: State Route 171 Bridge in Clifford Township, Susquehanna County					
Temperature	°F	32.9	71.6	51.9	1971–1974
Dissolved Oxygen	mg/l	8.7	12.3	10.533	1971–1974
pH	S.U.	6.70	7.90	7.350	1971–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.030	0.300	0.100	1972–1974
Iron, Total	g/kl	70	1,260	408.750	1971–1974
Total Coliform	MPN/100 ml	1,905	1,905	1,905	1971

[a]See Figure 20 for location of monitoring stations.

Source: Pennsylvania Comprehensive Water Quality Management Plan (COWAMP) study area reports.

Table 37 (Cont.)

WATER QUALITY MONITORING STATION[a] SUMMARY RESULTS

Parameter	Units	Minimum	Maximum	Mean	Years of Record
Station No. 316					
Stream: Leggetts Creek					
Location: Near Main Street Bridge in Scranton, Lackawanna County					
Temperature	°F	32.2	68	52.8	1971–1974
Dissolved Oxygen	mg/l	8.5	14.6	10.700	1971–1974
pH	S.U.	6.80	7.70	7.233	1971–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.040	1.799	0.349	1972–1974
Iron, Total	g/kl	90	1,340	378.125	1971–1974
Total Coliform	MPN/100 ml	–	–	–	–
Station No. 325					
Stream: Wapwallopen Creek					
Location: Bridge on L.R. 4022 in Donance Township, Luzerne County					
Temperature	°F	37.4	62.6	46.1	1972–1974
Dissolved Oxygen	mg/l	11.0	13.0	11.667	1972–1974
pH	S.U.	5.90	6.80	6.400	1972–1974
Total Dissolved Solids	mg/l	78	78	78	1973
Ammonia Nitrogen	mg/l	0.050	0.170	0.100	1972–1974
Iron, Total	g/kl	140	4,850	1,460.000	1972.1974
Total Coliform	MPN/100 ml	–	–	–	–
Station No. 326					
Stream: Harveys Creek					
Location: U.S. Route 11 Bridge in Nanticoke Township, Luzerne County					
Temperature	°F	37.4	73.4	54.8	1972–1974
Dissolved Oxygen	mg/l	7.3	15.0	10.775	1972–1974
pH	S.U.	6.30	7.70	7.017	1972–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.040	0.210	0.088	1972–1974
Iron, Total	g/kl	100	10,000	1,919.166	1972–1974
Total Coliform	MPN/100 ml	–	–	–	–
Station No. 327					
Stream: Roaring Brook					
Location: Cedar Avenue Bridge in Scranton, Lackawanna County					
Temperature	°F	33.8	66.2	48.7	1972–1974
Dissolved Oxygen	mg/l	9.1	11.8	10.483	1972–1974
pH	S.U.	1.30	7.20	5.033	1972–1974
Total Dissolved Solids	mg/l	–	–	–	–
Ammonia Nitrogen	mg/l	0.030	1.399	0.222	1972–1974
Iron, Total	g/kl	120	1,180	451.666	1972–1974
Total Coliform	MPN/100 ml	–	–	–	–

[a]See Figure 20 for location of monitoring stations.

Source: Pennsylvania Comprehensive Water Quality Management Plan (COWAMP) study area reports.

cases, more than one criterion has been established for each constituent to reflect permissible variations, depending on water use.

Chapter 93 also contains streams having a conservation area water use classification. A recently recommended revision to the definition of conservation area is as follows:

> A stream or watershed which has excellent quality waters or environmental or other features that require special water quality protection, including waters or watersheds which constitute an outstanding National, State or local resource. Waters in conservation areas are usually of better quality than numerical water quality criteria that are established to protect stream uses.

Subbasin streams or watersheds having a conservation area[33] classification are listed in Table 38.

To aid in the understanding of the following discussion, a glossary of water quality terms, a table listing chemical constituents in groundwater and their effects on water use, and a brief list of various pollutants and their effects are found in Appendices E-1 through E-3. Surface water quality in each watershed is discussed first, followed by groundwater quality.

The Susquehanna River, which drains Subbasin 5, suffers from several water quality problems. These include excessive sedimentation, acid mine drainage, domestic waste discharge, and industrial waste discharges.

The Lackawanna River, draining Watershed A, is adversely affected by acid mine drainage as evidenced by high iron concentrations at each of the four monitoring stations located on the river. The lower two miles of the Lackawanna River, from the Old Forge area to the Susquehanna River, is severely polluted by mine drainage. This reach receives approximately 121,000 pounds per day of acid, or 90 percent of the river's total acid load. Planned and completed mine drainage abatement projects on tributaries to the Lackawanna River will alleviate some of the pollution problem and result in a 23-mile reach of the river being improved between Carbondale and Old Forge. Many waste banks and silt ponds are being removed for coal reprocessing and use in subsidence control flushing projects.

In addition to being degraded by acid mine drainage, the Lackawanna River is polluted by domestic sewage, combined sewer overflows, and industrial wastes, along with coal silt sedimentation from coal waste banks and silt ponds. Much of the combined sewer overflow occurs in the Scranton-Dunmore area during periods of wet weather. Pollution from domestic sewage is scattered and originates primarily with malfunctioning on-lot sewage disposal systems. During low flow conditions, the river develops odor problems due to the volume of domestic and industrial waste discharges being greater than the amount the river can naturally assimilate.

Streams in Watershed B are seriously affected by both acid mine drainage and organic wastes from municipal sewage treatment plants and industrial discharges. Completion of proposed mine drainage abatement projects in the Solomon Creek, Mill Creek, Nanticoke Creek, and Warrior Run watersheds will alleviate much of the acid problem in this region during low flow. Big Wapwallopen Creek is degraded by both domestic and industrial wastes, while Harvey, Hemlock, and Toby Creeks are degraded by domestic waste discharges. In addition to organic pollution caused by domestic wastes, Black Creek suffers from excessive sedimentation.

The Fishing Creek watershed has few water quality problems. A 1973 aquatic biologist's report on Spruce Run and Little Fishing Creek indicates that the lower reaches of Spruce Run had been degraded due to an acid spill of unknown origin. No other significant water quality problems have been reported in Watershed C.

Watershed D is divided into two major regions by the Susquehanna River. The northern region is dominated by the drainage of Briar Creek, while the southern portion is drained by a series of small tributaries of the Susquehanna River. Although no major water quality problems have been reported in the watershed, the presence of pesticides in Neals Run, a small tributary of the Susquehanna River, has been reported by DER aquatic biologists.

The major water quality problem in Watershed E is that caused by discharge of acid mine drainage to the two major streams, Catawissa and Tomhickon Creeks, which are being evaluated by DER for possible mine drainage treatment projects. In 1972 and 1973, aquatic biologist investigations revealed a mineral acidity value of 104 mg/l in Catawissa Creek and pH values ranging from 3.6 to 4.0. Limited aquatic communities dominated by acid-tolerant macroinvertebrates were observed in the stream.

A pH value of 4.9 and an iron concentration of 3.2 mg/l were recorded for Tomhickon Creek. Near its confluence with Little Tomhickon Creek, Tomhickon Creek was devoid of aquatic life, a condition thought to be caused by large quantities of coal silt in the streambed.

As indicated by Table 39, groundwater above the coal limits in the Lackawanna and Wyoming Valleys is generally of good quality. However, upon entering the acid-forming coal-bearing structure, it becomes totally degraded. In additon, over 50 incidents of groundwater pollution have occurred in the subbasin. Most of these are due to man's activities.

Man-made pollution sources can be a serious threat to the groundwater resources. A variety of noxious and sometimes toxic substances enter the ground, eventually reach the groundwater reservoirs, and travel along the groundwater flow pattern to points of discharge. Various sources of contamination include septic tanks in unsuitable soils, landfills, oil tank leaks, seepage from industrial waste treatment or storage lagoons, pipeline breaks, and salt storage.

[33]Public hearings have recently been held by DER's Bureau of Water Quality Management for the purpose of accepting testimony on proposed water quality standards revisions. These revisions include the replacement of the *Conservation Area* stream designation with a new *High Quality Waters* category, as well as the addition of a new *Exceptional Value Waters* designation. The Pennsylvania Fish Commission's Wilderness Trout Streams have been recommended as *Exceptional Value Waters.*

Table 38

CONSERVATION AREAS

1. Fishing Creek Basin

    a. Fishing Creek Basin from PA Route 118 to source

2. Harvey Creek Basin

    a. Harvey Creek Basin from and including Pikes Creek to source

3. Huntington Creek Basin

    a. Huntington Creek Basin from and including Kitchen Creek to source

4. Lackawanna River Basin

    a. Spring Brook Basin from northeast extension of Pennsylvania Turnpike bridge to source

    b. Stafford Meadow Brook Basin

    c. Grassey Island Creek Basin

5. Nescopeck Creek Basin

    a. Nescopeck Creek Basin from Route 309 bridge to source

6. Roaring Creek Basin

    a. South Branch Roaring Creek Basin

7. Shickshinny Creek Basin

    a. Little Shickshinny Creek Basin from mouth to source

F. EROSION AND SEDIMENTATION

Sediment is generally regarded as the greatest pollutant by volume in the waters of the Commonwealth. Because of this, participants in earthmoving activities are required to develop and follow an erosion and sedimentation plan designed to prevent accelerated runoff and erosion. When an area to be disturbed is over 25 acres, they are required to file the plan with DER and obtain a permit prior to commencing the activity. Farmers are exempt from the permitting requirement. However, they must still have a workable plan.

Sediment has several adverse impacts. One of the more widepsread of these is its deleterious effect on the aquatic ecosystem. In addition, sediment can decrease the capacity of reservoirs through siltation and also cause clogging of filters in public water supply systems. Although sediment is produced by soil loss from streambanks, roadsides, gullies, and sheet and rill erosion[34], only sheet and rill erosion will be discussed here quantitatively.

[34]For a detailed methodology on determining soil loss by sheet and rill erosion see Appendix F-1.

The rate of sheet and rill erosion, and consequently the amount of sediment being produced, is significantly influenced by land use. Much of the state's land is used for agriculture or forests. Thus, on the basis of land area, cropland and pasture are potentially large contributors of sediment, with cropland being the major contributor. Due to the extensive area they cover, forests are also potentially large sources.

Of the subbasin's 258,896 acres in agriculture, 87 percent is used as cropland, with one-fourth of this being in row crops, which have the highest soil loss potential of all crops. In this subbasin, cropland has an average annual soil loss rate of 7.2 tons per acre and a gross loss of 1,604,000 tons (See Appendix F-2, Tables 1 and 2).

Only a portion of this gross loss is transported into the subbasin's streams, while the remainder is deposited as colluvium at the base of slopes and in swales. However, over a period of years this colluvium moves in stages to the stream system due to further erosion and soil creep. The amount of eroded material transported from the subbasin by water is the subbasin's sediment yield. For Subbasin 5 this averages 382,000 tons of soil per year (See

Continued on page 160

Table 39

GROUNDWATER QUALITY BY AQUIFER

Geologic Age Aquifer	Dissolved Solids (mg/l) No. of Samples	Range	Median	Hardness – $CaCO_3$(mg/l) No. of Samples	Range	Median	Alkalinity – $CaCO_3$(mg/l) No. of Samples	Range	Median
Pleistocene									
Unconsolidated desposits	25	18 – 972	174	29	4 – 280	81	25	7 – 235	36
Pennsylvanian									
Post-Pottsville Formations	2	20 – 39	–	5	12 – 44	26	2	7 – 10	–
Pottsville Group	9	11 – 584	135	9	9 – 388	84	1	43 –	
Mississippian									
Pocono Group	11	21 – 487	70	14	9 – 173	54	11	4 – 130	35
Mauch Chunk Formation	7	19 – 261	100	11	9 – 170	51	10	11 – 98	36
Devonian									
Oswayo Formation	3	162 – 501	188	3	10 – 150	34	3	69 – 139	118
Catskill Formation	24	44 – 648	107	16	8 – 185	85	30	6 – 182	49
Marine Beds	8	35 – 3,155	228	9	22 – 298	140	7	15 – 230	99
Hamilton Group (Mahantango and Marcellus Formations)	10	99 – 523	198	15	34 – 410	86	11	11 – 279	102
Onondaga Formation	3	102 – 282	158	6	93 – 250	150	4	100 – 180	115
Old Port Formation	3	253 – 514	279	5	164 – 456	247	4	180 – 205	197
Silurian									
Keyser Formation	2	186 – 278	232	3	160 – 216	190	3	144 – 170	249
Tonoloway Formation	11	152 – 660	280	12	96 – 400	207	9	56 – 355	150
Wills Creek Formation	6	83 – 1,019	271	10	72 – 1,700	242	8	47 – 243	112
Bloomsburg Formation	5	71 – 300	125	10	34 – 1,400	95	8	20 – 253	99
Clinton Group	3	14 – 56	22	7	9 – 46	14	5	3 – 13	6

Source: Pennsylvania Water Quality Management Plan (COWAMP) study area reports.

Table 39 (Cont.)

GROUNDWATER QUALITY BY AQUIFER

Geologic Age Aquifer	Iron – FE (mg/l) No. of Samples	Range	Median	Manganese – Mn (mg/l) No. of Samples	Range	Median	Chloride – Cl (mg/l) No. of Samples	Range	Median
Pleistocene									
Unconsolidated deposits	27	<0.01 – 56.00	0.25	11	0.00 – 11.00	0.04	30	1 – 465	9
Pennsylvanian									
Post-Pottsville Formations	5	0.00 – 0.30	0.11	2	0.05 – 33	–	5	1 – 8	3
Pottsville Group	9	0.00 – 28.00	2.60	1	0.08 –	–	9	0 – 58	3
Mississippian									
Pocono Group	14	0.00 – 12.00	0.30	5	0.00 – 0.58	0.01	15	0 – 197	4
Mauch Chunk Formation	10	0.07 – 0.33	0.12	5	0.00 – 0.10	1.00	10	1 – 50	2
Devonian									
Oswayo Formation	3	0.18 – 4.50	2.90	3	0.03 – 0.15	0.04	3	24 – 210	27
Catskill Formation	27	0.00 – 24.00	0.12	18	0.00 – 2.90	0.03	29	1 – 300	14
Marine Beds	6	0.09 – 2.60	0.70	4	0.06 – 2.10	0.29	9	1 – 1,820	24
Hamilton Group (Mahantango and Marcellus Formations)	10	0.12 – 16.00	0.40	5	0.03 – 0.24	0.04	15	1 – 172	2
Onondaga Formation	5	0.00 – 0.20	–	0	– –	–	6	1 – 244	15
Old Port Formation	3	0.28 – 6.60	0.54	2	0.04 – 0.35	–	5	1 – 39	9
Silurian									
Keyser Formation	3	0.00 – 0.40	0.12	2	0.00 – 0.01	–	3	2 – 11	9
Tonoloway Formation	10	0.00 – 0.43	0.05	2	0.00 – 0.04	–	12	1 – 290	7
Wills Creek Formation	7	0.00 – 0.87	0.16	2	0.05 – 0.20	–	10	1 – 175	4
Bloomsburg Formation	8	0.02 – 1.80	0.38	4	0.00 – 0.08	0.01	10	2 – 136	9
Clinton Group	4	0.00 – 0.11	0.03	1	0.02 – –	–	7	0 – 3	1

Source: Pennsylvania Water Quality Management Plan (COWAMP) study area reports.

Table 39 (Cont.)

GROUNDWATER QUALITY BY AQUIFER

Geologic Age Aquifer	Nitrate – N (mg/l) No. of Samples	Range	Median	Sulfate – SO_4(mg/l) No. of Samples	Range	Median	pH (units) No. of Samples	Range	Median
Pleistocene									
Unconsolidated deposits	29	0.0 – 7.3	0.8	24	0 – 46	12	19	5.5 – 7.2	6.6
Pennsylvanian									
Post-Pottsville Formations	4	0.2 – 8.6	1.0	4	6 – 42	19	3	5.0 – 5.6	5.1
Pottsville Group	8	0.0 – 1.3	0.0	8	2 – 345	14	2	4.7 – 7.1	–
Mississippian									
Pocono Group	12	0.0 – 1.0	0.3	14	3 – 67	7	7	6.4 – 1.9	7.7
Mauch Chunk Formation	11	0.0 – 9.3	0.7	10	0 – 66	6	7	5.4 – 7.8	6.7
Devonian									
Oswayo Formation	3	0.0 – 0.7	0.0	3	5 – 18	13	3	7.8 – 8.4	8.2
Catskill Formation	30	0.0 – 4.1	0.2	27	0 – 61	10	24	5.3 – 8.4	7.3
Marine Beds	8	0.0 – 4.5	0.0	8	2 – 88	10	4	7.1 – 7.4	7.3
Hamilton Group (Mahantango and Marcellus Formations)	14	0.0 – 0.7	0.1	15	2 – 165	20	5	7.5 – 8.5	8.0
Onondaga Formation	6	0.0 – 8.0	3.2	3	12 – 65	13	4	7.3 – 7.6	7.4
Old Port Formation	5	0.0 – 2.2	0.3	5	15 – 220	67	2	6.8 –	–
Silurian									
Keyser Formation	3	0.3 – 9.9	2.4	2	21 – 33	–	3	7.5 – 7.6	7.5
Tonoloway Formation	10	0.1 – 6.4	2.0	9	10 – 67	38	5	6.9 – 7.8	7.2
Wills Creek Formation	8	0.0 – 16.0	0.3	7	3 – 1,464	144	5	6.2 – 7.3	6.9
Bloomsburg Formation	9	0.1 – 7.7	1.0	9	1 – 1,266	12	6	6.1 – 8.1	7.5
Clinton Group	7	0.0 – 0.7	0.0	5	2 – 4	4	3	6.4 – 7.0	6.4

Source: Pennsylvania Water Quality Management Plan (COWAMP) study area reports.

Appendix F-2, Table 3), but may be significantly higher or lower depending upon rainfall characteristics and subsequent streamflow.

As stated previously, sheet and rill erosion are not the only mechanisms of soil loss. Gully and bank erosion are also responsible for a considerable amount of soil removal. In addition, soil loss and sediment yield are not equivalent. Sediment yield is the amount of soil actually transported from a watershed or subbasin by water, while soil loss is simply the removal of soil particles from their point of origin. Therefore, Table 2 (Appendix F-2) will show a greater amount of gross soil loss for the subbasin than is listed as sediment yield in Table 3 (Appendix F-2).

The soil loss from cropland may be reduced by the use of conservation practices such as minimum tillage, strip-cropping, contour farming, crop rotations, and the installation of sod waterways and diversion terraces. However, since a farm is an individual management unit, the methods used to control erosion must be part of the farming operation and will be influenced by the owner's economic limitations. Erosion control measures and practices must be selected, designed and installed to meet the situation on individual farms, with soil loss being reduced to feasible and acceptable levels. It should be noted that agricultural erosion control involves both environmental and economic common sense. Erosion control protects the farmer's investment in crops, fertilizers and the soil, while at the same time improving water quality in the Commonwealth's streams. For the most part, agricultural erosion control practices are more a matter of good crop rotations, cultural practices and tillage activity control than expensive investment in physical facilities.

As indicated in Table 40, approximately seven percent of the subbasin's cropland is in Capability Classes V through VIII. Capability groupings indicate, in a general way, the suitability of soils for most kinds of field crops, and are made according to the limitations of the soils when used in this capacity. Land in Classes I through IV is suited for cultivation and other uses, while land in Classes V through VIII is generally not suited for cultivation and should be limited as to its use. Thus, over 16,000 acres of existing cropland in the subbasin is not suitable for use as cropland and should be converted to less intensive uses to reduce erosion to acceptable levels.

A second component of agricultural land use is pasture. This has an average annual soil loss rate of 4.4 tons per acre and an average annual gross loss of 461,000 tons. In comparison to cropland, the potential for sediment pollution from pasture is low. However, heavy grazing on the steeper slopes, which are generally used for pasture, and in small areas close to streams greatly increases the erodibility of pasture land.

Approximately 25 percent or 8,922 acres of the subbasin's pastureland is in the least desirable capability classes. Although this land is generally suited for pasture, special care must be taken to insure that proper management is used to prevent excessive erosion.

Forestland, comprising 56 percent of the subbasin's total land area, is normally very resistant to erosion. However, disturbances, either natural or man-made, to a forest ecosystem can create conditions with a large pollution potential. For example, fire can destroy both the vegetative cover and the organic material covering the forest floor, thus severely reducing the forest's erosion resistant nature. Improper road and skid trail location during timber harvesting can also have a similar detrimental effect. Normally, though, the effects of these disturbances last only for part of one growing season or until the natural succession of lesser vegetation takes place.

Additional activities contributing significant amounts of sediment to the Commonwealth's streams include construction and mining. Grading and excavation for construction projects expose soil that is then easily eroded and provides the potential for the production of significant amounts of sediment. Construction activities having the potential for contributing large amounts of sediment include the development of industrial parks, shopping centers, residential areas, dams and pipelines, in addition to highway construction. Contractors engaged in these activities are required by DER to prepare erosion and sedimentation plans as discussed previously.

Erosion from construction sites can be restricted through numerous techniques ranging from selecting the proper season for construction to the building of engineering works. Basically, these techniques include (1) reducing the area and duration of exposure of soils to erosion, (2) covering exposed soils with mulch or vegetation, (3) mechanically reducing the rates of storm runoff, (4) trapping sediment carried by the storm runoff, and (5) planning land clearing operations to coincide with periods of minimum rainfall.

One of the sources of sediment from current surface mining operations is from activities associated with haul roads. Problems from this source can be expected, especially after major storms. However, the primary source of sediment is backfilled areas immediately after replacement of topsoil and prior to establishment of an adequate vegetative cover. These and other sediment sources associated with surface mining can be held to a minimum by effective erosion and sedimentation control measures.

Surface mining techniques, as practiced in Pennsylvania, help to minimize the amount of bare ground exposed at any one time, and therefore, the amount of erosion. The major methods of surface mining practiced here are Contour Mining, also called the Box Cut Method, and the Block Cut Method of Mining.

The Department of Environmental Resources, through the Federal "Surface Mining Control and Reclamation Act of 1977", the Commonwealth's "Surface Mining Conservation & Reclamation Act", and the "Clean Streams Law", is responsible for regulating sedimentation from surface mining operations. Under these laws, all mined areas are to be reclaimed in accordance with conditions of the permits, with failure to comply resulting in forfeiture of bond and loss of operation privileges. The Department of Environmental Resources also has a program for initiating the reclamation of previously mined areas. This program

Table 40

LAND CAPABILITY CLASSES

Land Use	Acres	Capability Class (Percent) I	II	III	IV	V	VI	VII	VIII	I – IV	V – VIII
Cropland	222,773	3.7	49.0	28.6	11.4	0.0	5.1	2.2	0.0	92.7	7.3
Pasture	36,123	1.0	26.9	26.8	20.6	0.0	16.0	8.7	0.0	75.3	24.7
Forest	628,893	0.2	9.7	10.1	13.4	0.3	43.2	20.9	2.2	33.4	66.6

DEFINITIONS OF LAND CAPABILITY CLASSES

Land Suited for Cultivation and Other Uses

Class I Soils have few limitations that restrict their use.

Class II Soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III Soils have severe limitations that reduce the choice of plants, or require special conservation tactics, or both.

Class IV Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Land Limited In Use – Generally Not Suited for Cultivation

Class V Soils subject to little or no erosion but have other limitations such as rocks, impractical to remove, that limit their use largely to pasture, woodland, or wildlife food and cover.

Class VI Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woodland, or wildlife food and cover.

Class VII Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII Soils and land forms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife or water supply; or to aesthetic purposes.

Source: U.S. Department of Agriculture, Soil Conservation Service

specifically addresses surface reclamation and acid mine drainage abatement from abandoned surface mines with a reduction in erosion resulting.

Specific erosion and sedimentation control practices that are adaptable to various sites and situations can be found in the "Directory of Soil Erosion and Sedimentation Control Practices" published by the Pennsylvania Department of Environmental Resources. These practices include both vegetative methods such as seeding and mulching, and structural methods such as constructing sediment traps and interceptor channels. In addition, simply minimizing the amount of disturbed and impervious areas results in significant decreases in erosion and sedimentation.

VI. PRINCIPAL PHYSICAL CHARACTERISTICS AND ENVIRONMENTAL AND SOCIAL IMPACTS OF STRUCTURAL ALTERNATIVES

Many water resources projects have been examined as possible solutions to existing or future problems in Subbasin 5. In some cases, projects located outside the subbasin have been studied. While considerable staff effort was devoted to the investigation of alternatives and professional engineering judgment was applied during that effort, these important behind-the-scenes activities are not afforded any degree of visibility or exposure to the reader of this report. Specific project or program proposals were rejected before they even reached the "alternative" stage, because of overwhelmingly negative economic, environmental, social or physical constraints, if it was obvious that more acceptable alternatives were available.

This chapter provides a description of the basic characteristics and impacts which were considered in the examination of alternative structural solutions to the problems in this subbasin. The discussion includes: 1) all potential multipurpose Corps of Engineers projects which were considered in this subbasin study, 2) all alternatives which were considered for consumptive water use makeup, and 3) the alternatives which were *recommended* for flood control or public water supply.

The consideration and analyses of impacts only deals with those which are direct; there is no discussion of impacts which may be considered secondary or tertiary, such as development pressures which may follow the construction of a major project, or economic or social benefits which may accrue as a result of the direct benefits.

A. POTENTIAL MULTIPURPOSE CORPS OF ENGINEERS PROJECTS

Two multipurpose projects were included in the study of alternatives for this subbasin. Both projects have been investigated in previous Corps of Engineers studies. They were first proposed in the *Susquehanna River Basin Study* of 1970 and were later subjected to more detailed study in the *Susquehanna River Basin Flood Control Review Study Reservoir Systems Analysis* of 1976. The Corps has terminated further study on the Great Bend project, which would be located in Great Bend Township in Susquehanna County, and would inundate lands extending into New York State. The potential Towanda project, on Towanda Creek in Bradford County, has been recommended for further study for flood control, water supply, hydropower and recreation. Both of these potential projects are located in Subbasin 4.

1. GREAT BEND RESERVOIR

The Corps of Engineers potential Great Bend Reservoir site is located on the Susquehanna River approximately 1.5 miles east of the town of Hallstead in Susquehanna County. Possible multipurpose aspects of the impoundment include flood control, recreation, water supply and hydropower. The 160-foot high dam would be an earthfill structure and would control runoff from a drainage area of 2,018 square miles. At a maximum pool elevation of 1,015 feet, the total storage would be 1,300,000 acre-feet with a flood control storage capability of 310,000 acre-feet. The remaining storage of 990,000 acre-feet would be allocated to recreation, water supply and hydropower. The estimated construction cost of the project would be approximately $296 million. The environmental and social aspects of this proposal have been considered from two different viewpoints: 1) at the damsite and lake area, and 2) downstream of the damsite.

a. *At The Damsite*

Environmental and social considerations of this dam would include inundation of farm, open and forestland in addition to residential, commercial and industrial properties. Over 530 homes, 20 commercial establishments, 2 cemeteries, 2 churches and an airplane landing strip would be the minimum amount of relocation required in the three Pennsylvania communities of Oakland, Susquehanna and Lanesboro. Relocation of approximately six miles of State Route 171, five miles of State Route 92 and 13 miles of railroad track, including one railroad yard, would also be necessary. Additional relocation of similar facilities would occur in New York State. Sand and gravel operations would be seriously impaired. Vegetation and wildlife would be permanently displaced from the lake area. Project-occasioned soil erosion and resulting stream siltation may have adverse effects on surface water quality and aquatic life. Strict control during construction would be required to minimize such conditions.

b. *Downstream Of The Damsite*

Flood control benefits from this reservoir would be realized in downstream communities located along the Susquehanna River. Including benefits accrued in New York State, the average annual flood control benefits are estimated at approximately $10 million. The dam would provide protection for residential, commercial and industrial properties in addition to roads and highways, churches, schools, water treatment plants and sewage treatment facilities. Sand and gravel operations would be provided some relief from high water situations. Benefits from the consumptive use makeup capability of the reservoir should also be recognized. Great Bend Reservoir would be able to provide sufficient storage to satisfy the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River, from the dam downstream to the West Branch Susquehanna River. In addition to these multipurpose aspects, additional storage for low flow augmentation could be provided. By augmenting flows, water quality downstream of the reservoir would be improved.

A complete analysis of the recreation and hydropower capabilities of this project has not been performed.

2. TOWANDA RESERVOIR

The Corps of Engineers potential Towanda Reservoir site is located on Towanda Creek approximately 1.5 miles upstream of the town of Franklindale in Bradford County. Mulitpurpose aspects of the impoundment include flood control, consumptive use makeup and recreation. The 133-foot high dam would be an earthfill structure and would control runoff from a drainage area of 115 square miles. At a maximum pool elevation of 1,032 feet, the total storage would be 125,000 acre-feet with a flood control storage capability of 29,000 acre-feet, and the remaining storage of 97,000 acre-feet allocated to recreation and consumptive use makeup. In addition, the impoundment would inundate approximately 2,727 acres and would have a shoreline of 27 miles. The estimated construction cost of the project would be approximately $40 million. The environmental and social aspects of this proposal have been considered from two different viewpoints: 1) at the damsite and lake area, and 2) downstream of the damsite.

a. *At The Damsite*

Environmental and social considerations of this dam would include the permanent inundation by the conservation pool of approximately 2,092 acres of farm, prime agricultural and open land located in the bottom lands and forestland on the steeper hillsides. An additional area of about 635 acres would be inundated during full pool storage. At full pool storage elevation, approximately 135 residences including scattered farms, homes, schools and churches in and around the communities of West Franklin, Sayres Corners, Woodruff Corners and Leroy would be relocated. Relocation of some sections of State Routes 414 and 514, as well as some secondary roads, would be necessary. Vegetation and wildlife would be permanently displaced from the lake area. However, this could be partially offset by adequate watershed management to mitigate this displacement. The reservoir would affect some of the gravel pit operations located within the lake area. In addition, some of the surrounding land use may be affected as the result of potential recreational development. Project-occasioned soil erosion and resulting stream siltation may have adverse effects on surface water quality and aquatic life. Strict control during construction would be required to minimize such conditions.

The major benefits attributable to Towanda Reservoir would be recreational in nature. It is expected that most of the recreational development would occur on the northern shores of the reservoir because of the steeper hillsides on the southern sectors. Full service recreation facilities would contain boat launches, camping areas, picnic areas and a swimming area. Benefits would accrue from annual visitation of persons utilizing these facilities.

b. *Downstream Of The Damsite*

Flood control benefits from this reservoir would be realized in downstream communities located along Towanda Creek and the Susquehanna River. The average annual flood control benefits are estimated at approximately $1.5 million. The dam would provide protection for residential, commercial and industrial properties in addition to roads and highways, churches, schools, water treatment plants and sewage treatment facilities. Sand and gravel operations would be provided some relief from high water situations. Benefits from the consumptive use makeup capability of the reservoir should also be recognized. Towanda Reservoir would be able to provide sufficient storage to satisfy the anticipated consumptive water use makeup needs during low flow periods on Towanda Creek and the Susquehanna River from Towanda Creek to the West Branch Susquehanna River. In addition to these multipurpose aspects, additional storage for low flow augmentation could be provided. By augmenting flows, water quality downstream of the reservoir would be improved.

B. POTENTIAL CONSUMPTIVE USE MAKEUP ALTERNATIVES

Consumptive water use makeup is a serious problem facing the Commonwealth if instream and existing withdrawal uses are to be protected in the future. No recommendations are made for solutions to the projected consumptive use makeup problems in Subbasin 5, because further study of the identified alternatives is necessary to assess their remedial characteristics in conjunction with any individual solutions which consumptive users may choose to adopt. The following discussion includes all the alternative structures which were considered in this study.

1. *Small Potential Reservoir #36–5*

The small potential reservoir #36-5 located on Marsh Creek approximately 2.9 miles upstream of the Huntington-Ross Township line in Ross Township, Luzerne County, could serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 42-foot high dam would be an earthfill structure and would control runoff from a drainage area of 2.2 square miles. The dam, as proposed, would have a total storage of 1,750 acre-feet with a beneficial use storage of 1,320 acre-feet, provisional floodwater storage of 386 acre-feet and a sediment pool of 44 acre-feet. The estimated construction cost of the project would be $1.5 million. The relocation of approximately five houses and one mile of roadway would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 75 acres of forest and wetland and 60 acres of agricultural land. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. Fishing Creek is listed in Pennsylvania's Scenic Rivers Inventory as a candidate stream with a recreation classification from its headwaters to the Susquehanna River. Because Marsh Creek is a tributary to Fishing Creek, the same recreation classification may be applicable. Therefore, future impoundment structures may be restricted. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the entire reach of Fishing Creek.

2. *Small Potential Reservoir #36–10*

The small potential reservoir #36-10 located on Maple Run approximately 1,000 feet upstream of the Village of Mossville in Fairmount Township, Luzerne County, could serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 30-foot high dam would be an earthfill structure and would control runoff from a drainage area of 3.0 square miles. The dam, as proposed, would have a total storage of 2,590 acre-feet with a beneficial storage of 2,000 acre-feet, provisional floodwater storage of 560 acre-feet and a sediment pool of 30 acre-feet. The estimated construction cost of the project would be $1.62 million. The relocation of approximately three houses would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 196 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream could have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. Fishing Creek is listed in Pennsylvania's Scenic Rivers Inventory as a candidate stream with a recreation classification from its headwaters to the Susquehanna River. Because Maple Run is a tributary to Fishing Creek, the same recreation classification may be applicable. Therefore, future impoundment structures may be restricted. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the entire reach of Fishing Creek.

3. *Small Potential Reservoir #36–4A*

The small potential reservoir #36-4A located on Huntington Creek approximately 4,000 feet upstream of the Fairmount-Ross Township line in Ross Township, Luzerne County, could serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 84-foot high dam would be an earthfill structure and would control runoff from a drainage area of 9.1 square miles. The dam, as proposed, would have a beneficial use storage of 5,030 acre-feet and a sediment pool of 85 acre-feet. The estimated construction cost of the project would be $5.4 million. There would not be any relocation of houses involved with construction of this project. The dam, when at full storage capacity, would inundate approximately 158 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. Project-occasioned soil erosion and resulting stream siltation would have some minor effects on surface water quality. Fishing Creek is listed in Pennsylvania's Scenic Rivers Inventory as a candidate stream with a recreation classification from its headwaters to the Susquehanna River. Because Huntington Creek is a tributary to Fishing Creek, the same recreation classification may be applicable. Therefore, future impoundment structures may be restricted. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the entire reach of Fishing Creek.

4. *Small Potential Reservoir #34–5*

The small potential reservoir #34–5 located on Little Catawissa Creek approximately 1/2 mile upstream of Ringtown Borough, Schuylkill County, could serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 66-foot high dam would be an earthfill structure and would control runoff from a drainage area of 6.0 square miles. The dam, as proposed, would have a total storage of 4,825 acre-feet with a beneficial storage of 3,500 acre-feet, provisional floodwater storage of 1,100 acre-feet and a sediment pool of 225 acre-feet. The estimated construction cost of the project would be $3.2 million. The relocation of approximately two houses and

1/2 mile of local roadways would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 180 acres of forestland and 20 acres of agricultural land. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists this section of Little Catawissa Creek as a trout stream. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the entire reach of Catawissa Creek.

5. *Small Potential Reservoir #010–12*

The small potential reservoir #010–12 located in Subbasin 4 on Gardner Creek approximately 1,500 feet upstream of the Village of Milwaukee in Newton Township, Lackawanna County, would serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 70-foot high dam would be an earthfill structure and would control runoff from a drainage area of 9.3 square miles. The dam, as proposed, would have a total storage of 3,050 acre-feet with beneficial use storage of 1,413 acre-feet, provisional floodwater storage of 1,490 acre-feet and a sediment pool of 147 acre-feet. The estimated construction cost of the project would be $1.1 million. The relocation of 1 to 3 houses would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 100 acres of agricultural land and 20 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists this stretch of Gardner Creek as a trout stream. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from Wapwallopen to Sunbury.

6. *Small Potential Reservoir #010–15*

The small potential reservoir #010–15 located in Subbasin 4 on Buttermilk Creek approximately 0.5 miles upstream of the Village of Falls in Falls Township, Wyoming County, would serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 75-foot high dam would be an earthfill structure and would control runoff from a drainage area of 20.2 square miles. The dam, as proposed, would have a total storage of 5,350 acre-feet with beneficial use storage of 1,864 acre-feet, provisional floodwater storage of 3,230 acre-feet and a sediment pool of 256 acre-feet. The estimated construction cost of the project would be $1.35 million. The relocation of 20–25 houses and approximately five miles of roads and highways would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 200 acres of agricultural land and 60 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream may have some adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from Wapwallopen to Sunbury.

7. *Small Potential Reservoir #07–3A*

The small potential reservoir #07–3A located on Wapwallopen Creek approximately 1.5 miles upstream of the Village of Camp Keller in Hollenbach and Dorrance Townships, Luzerne County, would serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 85-foot high dam would be an earthfill structure and would control runoff from a drainage area of 33.4 square miles. The dam, as proposed, would have a beneficial use storage of 6,745 acre-feet and a sediment pool of 255 acre-feet. The estimated construction cost of the project would be $4.2 million. The relocation of 18–20 houses, one boy scout camp, and approximately two miles of roads and highways would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 100 acres of agricultural land and 100 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream would have some adverse effects on fishing and aquatic life. This section of Wapwallopen Creek is listed as a candidate stream in Pennsylvania's Scenic Rivers Inventory. The proposed wild classification would prohibit any future impoundment construction. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy 49 percent of the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from the Lackawanna River to Wapwallopen.

8. *Small Potential Reservoir #07–8*

The small potential reservoir #07–8 located on Little Wapwallopen Creek approximately 300 feet upstream of the Dorrance-Conyngham Township line in Dorrance Township, Luzerne County, would serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 90-foot high dam would be an earthfill structure and would control runoff from a drainage area of 24.0 square miles. The dam, as proposed, would have a beneficial use storage of 5,078 acre-feet and a sediment pool of 182 acre-feet. The estimated construction cost of the project would be $2.45 million. The relocation of 1–3 houses and approximately one mile of roads and highways would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 176 acres of forestland and 40 acres of agricultural land. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists this section of Little Wapwallopen Creek as a trout stream. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. Project-occasioned soil erosion and resulting stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy 37 percent of the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from the Lackawanna River to Wapwallopen.

9. *Small Potential Reservoir #08–4*

The small potential reservoir #08–4 located on Harvey Creek approximately 0.9 miles upstream of the Lehman-Jackson Township line in Lehman Township, Luzerne County, would serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 55-foot high dam would be an earthfill structure and would control runoff from a drainage area of 19.9 square miles. The dam, as proposed, would have a total storage of 10,244 acre-feet with a beneficial use storage of 7,406 acre-feet, provisional floodwater storage of 2,665 acre-feet and a sediment pool of 173 acre-feet. The estimated construction cost of the project would be $2.2 million. The relocation of 8–10 houses and approximately two miles of roads and highways would be necessary if the proposed dam were built. The dam, when at full storage capacity, would inundate approximately 420 acres of forestland and 45 acres of agricultural land. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists Harvey Creek as a trout stream beginning at a point immediately downstream of this proposed site. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. Harvey Creek is listed as a candidate stream in Pennsylvania's Scenic Rivers Inventory. The proposed scenic classification would prohibit any future impoundment construction. The reservoir could affect some of the surrounding land use as a result of possible recreational development. Project-occasioned soil erosion and resulting stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy 43 percent of the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from the Lackawanna River to Wapwallopen.

10. *Small Potential Reservoir #38–5*

The small potential reservoir #38–5 located in Subbasin 4 on South Branch Tunkhannock Creek approximately 0.65 miles upstream of State Route 407 in Benton Township, Lackawanna County, would serve as a multipurpose structure. The 80-foot high dam would be an earthfill structure and would control runoff from a drainage area of 37.3 square miles. The dam, as proposed, would have a total storage of 15,400 acre-feet with a beneficial use storage of 9,005 acre-feet, provisional floodwater storage of 5,975 acre-feet and a sediment pool of 420 acre-feet. The estimated construction cost of the project would be $3.9 million. The relocation of approximately 24–27 houses, and three miles of roads and highways including a portion of State Route 438 would be necessary if the proposed dam were built. Possible relocation may also be required for an existing telephone line and an existing power transmission line. The dam, when at full storage capacity, would inundate approximately 330 acres of open and agricultural land and 80 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists this section of South Branch Tunkhannock Creek as a trout stream. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fish and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. During construction, soil erosion and stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy 67 percent of the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from the Lackawanna River to Wapwallopen. This dam was also analyzed as a public water supply source for the Pennsylvania Gas and Water Company. However, the economic analysis indicates that this alternative is not the least costly alternative for this company and, therefore, it is not recommended as a water supply source at this time.

11. *Small Potential Reservoir #010–2*

The small potential reservoir #010–2 is located in Subbasin 4 on Meshoppen Creek approximately 4.1 miles upstream of the Susquehanna-Wyoming County line in Springville and Dimock Townships, Susquehanna County. The reservoir could serve as a multipurpose structure. However, consumptive use makeup benefits have been the focus of analyses at this time. When the need arises for consumptive use makeup or other purposes, a detailed feasibility study should be made. The 43-foot high dam would be an earthfill structure and would control runoff from a drainage area of 31.8 square miles. The dam, as proposed, would have a beneficial use storage of 4,964 acre-feet and a sediment pool of 236 acre-feet. The estimated construction cost of the project would be $5.1 million. The relocation of approximately 10–12 houses, and three miles of roads and highways would be necessary if the proposed dam were built. Possible relocation may also be required for an existing pipeline crossing. The dam, when at full storage capacity, would inundate approximately 340 acres of forestland and wetland and 143 acres of agricultural land. The effects of this would include losses of vegetation and wildlife from the lake area. The Pennsylvania Fish Commission lists Meshoppen Creek as a trout stream. Therefore, the dam's obstruction to the free-flowing nature of the stream would have adverse effects on fishing and aquatic life. Meshoppen Creek is listed as a candidate stream in Pennsylvania's Scenic Rivers Inventory. The proposed scenic classification would prohibit any future impoundment construction. The reservoir could affect some of the surrounding land use as a result of possible recreational development. Project-occasioned soil erosion and resulting stream siltation would have some minor effects on surface water quality. The benefits from the consumptive use makeup capability of the reservoir are substantial. Sufficient storage is provided in order to satisfy 34 percent of the anticipated consumptive water use makeup needs during low flow periods along the Susquehanna River from the Lackawanna River to Wapwallopen.

C. PROJECTS RECOMMENDED FOR WATER SUPPLY OR FLOOD CONTROL

Numerous structural measures were examined as possible solutions to public water supply or flood damage problems in Subbasin 5. In the interest of brevity, only the following three structures, which are recommended for further study or construction, are discussed here. No discussion is presented for surface water intakes or additional groundwater development for public water supply or for alternatives which have not been recommended.

1. *Small Potential Reservoir #37-9*

The small potential reservoir #37-9 located on East Branch Roaring Brook approximately four miles upstream of Moscow Borough is recommended for further study as a multipurpose structure. The 46-foot high dam would be an earthfill structure and would control runoff from a drainage area of 5.2 square miles. The dam, as proposed, would have a total storage of 4,310 acre-feet with provisional floodwater storage of 1,000 acre-feet, beneficial storage of 3,300 acre-feet and a sediment pool of 10 acre-feet. The estimated construction cost of the project would be $1.95 million. There would not be any relocation of houses involved with construction of this proposal. The dam, when at full storage capacity, would inundate approximately 310 acres of forestland. The effects of this would include losses of vegetation and wildlife from the lake area. The dam's obstruction to the free-flowing nature of the stream could have some adverse effects on fishing and aquatic life. The reservoir could affect some of the surrounding land use as a result of possible recreational development. The downstream community of Moscow would receive substantial flood control benefits from this project. The dam would provide protection for residential and commercial properties in addition to roads and highways. Project-occasioned soil erosion and resulting stream siltation may have an adverse effect on surface water quality and aquatic life. Therefore, strict control during construction would be required to minimize such conditions. Benefits from the consumptive use makeup capability of the reservoir should also be recognized. Sufficient storage is provided in order to satisfy the anticipated consumptive water use makeup needs during low flow periods along Roaring Brook. In addition to the flood control and consumptive use makeup, this project was analyzed as a public water supply source for the Moscow Water Company. However, the economic analysis indicates that the least costly alternative for the company is groundwater development; and therefore, this reservoir #37-9 is not recommended as a water supply source at this time.

2. *Channel Modification at Moscow*

The potential structural solution recommended for further study to reduce flood damages at Moscow Borough would be located on Van Brunt Creek at a point immediately upstream of Roaring Brook. The project consists of a concrete channel approximately 200 feet long, 10 feet high by 15 feet wide. The estimated construction cost of the proposal is $262,000. The project would be beneficial to residential and commercial properties, including some benefit to the local road and highway system. Relocation of houses should not be necessary due to the nature of the project. Project-occasioned soil erosion and resulting stream siltation should have very minor effects on surface water quality and aquatic life. The Pennsylvania Fish Commission lists this section of Roaring Brook as a trout stream. Even though the project is located on a tributary, some adverse impacts on fishing may result on Roaring Brook.

3. *Channel Modification at Conyngham*

The potential structural solution recommeded for further study to reduce flood damages at Conyngham Borough would be located on a tributary to Little Nescopeck Creek. The project consists of a stream realignment with a concrete channel approximately 300 feet long, 10 feet wide by 7 feet high. The project would be beneficial to residential and commercial properties. Relocation of one house and one garage would be necessary because of the realignment. Project-occasioned soil erosion and resulting stream siltation should have very minor effects on surface water quality and aquatic life. There would be a possible adverse impact on aesthetic quality because of the alteration of the natural stream channel.

APPENDIX A

SOILS

Appendix A-1

CHARACTERISTICS OF SOILS

Soil Assn. Symbol	Soil Association Name	Percent of Each Soil in Assn.[a]	Percent of Each Assn. In the Subbasin	Dominant Slope (Percent)	Drainage Class[b]	Depth of Soil (Inches)	Hydrologic Group
Alb	Calvin	25	10.8	3–20	W	30	C
	Leck Kill	25		3–25	W	50	B
	Meckesville	10		3–15	W	70+	C
Ale	Meckesville	40	1.7	3–15	W	70+	C
	Albrights	20		3–15	MW	70+	C
A2e	Dekalb	40	7.4	3–35	W	30	C
	Laidig	20		3–20	W	70+	C
	Buchanan	5		3–25	MW	70+	C
A2f	Edgemont	30	4.1	3–20	W	60	B
	Hazelton	30		3–20	W	50	B
Dla	Oquaga	40	12.2	3–45	W	30	C
	Lordstown	30		3–30	W	30	C
Dlb	Oquaga	40	14.5	3–45	W	30	C
	Wellsboro	10		3–20	MW	60	C
	Morris	10		0–15	SWP	60	C
Dlc	Morris	30	18.1	0–15	SWP	60	C
	Wellsboro	20		3–20	MW	60	C
	Oquaga	10		3–45	W	30	C
Dld	Wellsboro	30	1.2	3–20	MW	60	C
	Morris	30		0–15	SWP	60	C
	Lackawanna	5		3–30	W	60	C
D2d	Hartleton	50	14.3	3–15	W	50	B
	Berks	10		8–30	W	30	C
	Watson	5		0–12	MW	70+	C
D2g	Swartswood	40	4.8	3–30	W	60	C
	Wurtsboro	20		3–25	MW	60	C
D2i	Volusia	40	1.9	0–15	SWP	60	C
	Mardin	15		3–20	MW	60	C
	Lordstown	15		3–20	W	30	C
Ela	Chenango	25	9.0	0–20	W	72+	A
	Howard	20		0–15	W	72+	B
	Pope	20		0–3	W	72+	B

[a]Percentages do not total 100 because of minor soils in each association.

[b]W - Well drained; MW - Moderately well drained; SWP - Somewhat poorly drained; P - Poorly drained

Source: Soil Conservation Service

APPENDIX B

WATER USE

Appendix B-1

WATER CONSERVATION

The Commonwealth enjoys a relatively abundant supply of water when compared to many other states in the Nation. During the past ten years, normal and above normal annual precipitation totals have provided many of Pennsylvania's water suppliers with the quantities of water needed to support growth in service populations, increased use of water-using household conveniences, and the general growth in per capita daily usages associated with the rising standard of living of a society largely unaccustomed to conserving resources.

Unfortunately, many suppliers have just been able to keep one step ahead of rising demands, by relying on existing streamflow or groundwater conditions during relatively good times. Thus, many of those suppliers have rendered themselves extremely vulnerable to the ill effects of even a mild drought. Several areas in the state would be subject to extreme social and economic disruption if a severe or prolonged drought were to occur at this time.

Because of the continually growing demands being placed upon this finite resource by an innovative society driven by the urge to attain a high standard of living, it is becoming increasingly important that, as more citizens are able to avail themselves of modern conveniences, they realize the water "pie", in a sense, is being shared by more people. Therefore, each person will be required to accept a smaller share.

By practicing effective conservation techniques it will be possible for more of society to enjoy the benefits of modern technology without placing any additional immediate demands upon the resource. It is strongly recommended that all water users in Pennsylvania strive to practice good conservation. Good conservation can accomplish the following:

1. Buy time for planners to formulate detailed studies which would determine the adequacy of system facilities and existing sources.
2. Delay the need for expansion of both water supply facilities and sewage treatment plants. Highly successful conservation campaigns may even eliminate any need for expansion, which would eliminate possible degradation of the environment associated with new development.
3. Save water – This is the major area in which the general public can really get involved. By saving water, one can also reduce energy consumption and, therefore, realize not only a monetary reward for himself but also the companies involved in supplying the water. Energy utilized in supplying water is consumed in treatment processes, transmission of water in both untreated and treated form and in heating processes. Because power plants are major water users, any reduction in power requirements will result in even further reduction of water use.

Conservation measures are generally not emphasized to any great degree unless an emergency such as a drought or a flood arises. During periods of drought, water supplies become critically low. During periods of flooding, water is plentiful but often is unsafe to drink. Existing supplies become contaminated, and treatment plants inundated with high waters are unable to treat the water. In either case, as potable water supplies decrease, water users may pass through three phases of cutbacks or curtailments. These are 1) voluntary water conservation, 2) mandatory water conservation and 3) mandatory water rationing. In order to comply with either Phase 1 or Phase 2, the water user must not only be willing to save but must know how to save. If water conservation is already being practiced, the user may find it much easier to adjust to further curtailment during an emergency situation. However, if the user has no idea about the best ways to conserve water, Phase 3 conditions could be imposed very early during a crisis. Therefore, it is imperative that water conservation be encouraged immediately.

Consider the following example of how water is used in a typical household, and how much water could be saved. Assume that one household, or a family of four people, uses 255 gallons of water per day (gpd). The initial usage breakdown is listed in Table 1. Also assume that this family wants to conserve water and decides to introduce two water-saving devices into their household. These devices, with a comparison of usage before and after installation, are as follows:

1. Maximum 3.0 gallon per minute (gpm) shower head.

   Present conventional system: 5 gpm x 4 minutes/day x 4 persons = 80 gpd.

   New system: 3 gpm x 4 minutes/day x 4 persons = 48 gpd. If this device were installed, a 12 percent savings would be made as noted in Table 1.
2. 3.5 gallons per flush water closet.

   Present conventional system: 5 gallons/flush x 5 flushes/day x 4 persons = 100 gpd.

   New system: 3.5 gallons/flush x 5 flushes/day x 4 persons = 70 gpd. If this device were installed, a 12 percent savings would be made as noted in Table 1.

A combination of these devices would result in a savings of 62 gpd, or a 24 percent reduction in total water use. Based on a system serving 1,000 people or 250 households, 566,000 gallons of water could be saved each year, if only

Table 1

TYPICAL HOUSEHOLD WATER USAGE AND POTENTIAL REDUCTION

	Initial Usage (gpd)	Usage With 3.0 GPM Shower Head (gpd)	Usage With 3.5 Gal./Flush Water Closet (gpd)
Toilet Flush	100	100	70
Bathing/Showers	80	48	80
Laundry	35	35	35
Kitchen	27	27	27
Lavatory	8	8	8
Utility Sink	5	5	5
Total	255	223	225
Total Savings		32	30
% Savings		12%	12%

10 percent of the customers would use these devices (See Table 2).

It should be emphasized that these figures are used only as an example. A household may be able to save more or less water than indicated in these tables, depending upon its present usage. However, the fact remains that water will be conserved. In certain communities, the new water closet may not be applicable because of potential sewer problems associated with decreased flows. Nevertheless, a water company should consider encouraging the installation of these devices wherever possible.

In addition to these devices, there are other water-saving devices which may be utilized. These would include faucet aerators, spray taps, flow control devices and toilet tank inserts. In general, installation of these devices is very easy and quite inexpensive.

There are many other areas throughout the house where water conservation could be practiced. The following list will point out just a few of these:

1. Repair any leaky faucets, connections, pipes or toilets. To check for toilet leaks, put a few drops of food coloring in the tank; then check to see if the coloring appears in the bowl.
2. Check for leaks between the water meter and the home. Turn off all water uses in the home; then observe the meter to see if it continues to register any water usage.
3. Do not use the toilet for trash disposal. Approximately 5 to 7 gallons of water are used per flush in a conventional toilet.
4. Do not wash dishes, shave, brush teeth, or wash hands utilizing an open faucet. Use a stopper as often as possible.
5. Take shorter showers. Use a timer and time your showers. Remember, the longer the shower, the more water used. If practical, turn off shower while soaping up.
6. Dislodge particles of dirt with a brush or wash cloth instead of using the force of the water.
7. Operate a washing machine or dishwasher only with a full load. If the washing machine has a suds saver, use it and save 16–19 gallons of water per load. Avoid long pre-wash and scrub cycles for automatic dishwashers.
8. Avoid using the garbage disposal on items that could be used for composting or disposed of in the garbage can.
9. Keep a container of drinking water cold in the refrigerator instead of allowing the water to run to obtain a cold drink.
10. Reuse washwater to water plants, lawns, gardens or even to wash cars.
11. Do not water the driveways/sidewalk along with the lawn or garden.
12. When watering the lawn or garden, do it in the early morning to reduce evaporation losses.

Table 2

TYPICAL ANNUAL WATER SAVINGS PER 1000 PERSONS (Million Gallons)

Percentage of Customers Using Water-Saving Devices	Savings Utilizing Device "A" (3 GPM Shower Head)	Savings Utilizing Device "B" (3.5 Gallon/Flush Water Closet)	Savings Utilizing "A" and "B"
10	0.292	0.274	0.566
20	0.584	0.548	1.132
30	0.876	0.821	1.697
40	1.168	1.095	2.263
50	1.460	1.369	2.829
60	1.752	1.643	3.395
70	2.044	1.916	3.960
80	2.336	2.190	4.526
90	2.628	2.464	5.092
100	2.920	2.738	5.658

Appendix B-2

PUBLIC WATER SUPPLY SOLUTION ALTERNATIVES

Table 17 in Chapter V lists the alternatives which were examined as solutions to public water supply deficiencies in Subbasin 5. The columns in Table 17 are explained here.

Column 1: Public Water Supplier Name and DER Numerical Code.

Column 2: List of present sources and projected deficiencies for 1990 and 2020. Deficiencies include yield, allocation, treatment plant (filtration) and storage deficiencies.

Column 3: List of solution alternatives which could serve to decrease or eliminate deficiencies. Increased storage alternatives apply only to storage deficiencies and will not help to solve other deficiencies. They are supplemental to yield, allocation and treatment solution alternatives.

Column 4: Increased capacity which would be required to provide for projected 1990 usages, measured against existing capacity.

Column 5: 1990 Annual Costs in 1976 dollars for alternatives listed in Column 3.

Column 6: Increased capacity which would be required to provide for projected 2020 usages, measured against existing capacity.

Column 7: 2020 Annual Costs in 1976 dollars for alternatives listed in Column 3.

Column 8: Remarks applicable to specific solution alternatives.

Appendix B-3

CONSUMPTIVE WATER USE MAKEUP SOLUTION ALTERNATIVES

Table 20 in Chapter V lists the alternatives which were examined as possible solutions to the consumptive water use makeup needs in Subbasin 5. The streams or stream reaches on which consumptive water uses should be made up are listed in that table along with the various solution alternatives investigated to satisfy those needs. The columns in that table are described here.

Row 1: The legend for each of the streams or stream reaches on which consumptive water use is required to be made up. (See Figure 11)

Column 1: The various solution alternatives such as potential reservoirs, existing reservoirs, groundwater development, individual storage, etc., investigated to satisfy the needs.

Row 2/Column 2 through Column 10: The streams or stream reaches on which the consumptive water uses are required to be made up. For each stream or stream reach, the table lists the associated watersheds, the need for each category of water use and the total need. The daily need is given in mgd and the storage required during low flow periods is given in mg. The needs in any upstream or downstream subbasin (whenever applicable) are given as total needs.

Column 11: The total annual storage in million gallons available for beneficial uses in potential reservoirs. (For multipurpose reservoirs the flood control storage is excluded.)

Column 12: The total needs in million gallons satisfied by a solution listed in Column 1. This is the summation of all the needs.

Column 13: Alternative remarks applicable to specific solution.

A consumptive water use makeup need, which is satisifed by a specific solution alternative is identified in the box corresponding to that need column and solution alternative row. The entries made in the box are the percentage of the need satisifed by that specific solution alternative and the equivalent storage allocated to meet, that need in million gallons. For example, if the entry is 100 percent, then the storage allocated will be equal to the total needs for that particular stream or stream reach.

APPENDIX C

FLOOD DAMAGE REDUCTION

Appendix C-1

SOIL CONSERVATION SERVICE PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
D	S1	Briar Creek PA 497	Completed (1969)	Multipurpose Flood Prevention	Dam		50			37		84	781	6,078	388	29
D	S2	Briar Creek PA 498	Under Construction	Flood Prevention	Dam		50			65	3	21.9	348.4	5,518	356	29

[a]1976 Price Level

[b]Total annual cost (1976 prive level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-2

CORPS OF ENGINEERS PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
A	C1	Stillwater Lake	Completed (9/1960)	Flood Control	Dam and Reservoir	36.80	100	1,700		77			11,657	15,961	923	See (c) & (e)
A	C2	Aylesworth Creek/Lake	Completed (11/1970)	Flood Control	Dam and Reservoir	6.20	100	1,270		90	3		1,700	3,468	195	See (d) & (e)
A	C3	Scranton	Completed (6/1969)	Flood Protection	Channel Improvement & Earth Levee		100	3,600		3				11,036	666	9

Appendix C-2 (Cont.)

CORPS OF ENGINEERS PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
B	C4	Susquehanna River Swoyersville-Forty Fort	Completed (6/1957)	Flood Protection	Levee		50	16,970						9,700	601	18
B	C5	Wilkes-Barre Hanover Twp.	Completed (1943)	Flood Protection	Levee & Pumping Stations		50	24,660	10					32,410	1,958	22
B	C6	Kingston-Edwardsville	Completed (8/1943)	Flood Protection	Earth Levee & Conduit		50	18,429	10		16.5			38,629	2,333	21
B	C7	Plymouth	Completed (5/1948)	Flood Protection	Levee & Pumping Stations		50	8,680	10					10,391	628	20
4A[f]		Cowanesque Lake	Under Construction	Flood Control Structure	Earthfill Structure	298.0	100	3,100		151			89,100	83,278	4,648	See (e)
4A[f]		Tioga-Hammond Lakes	Under Construction	Flood Control Structure	Earth & Rock fill with Concrete Spillway	280.0(T) 122.0(H)	100	2,590(T) 5,950(H)		140(T) 122(H)		1,640(T) 1,760(H)	105,000 (total)	140,094	6,661	See (e)
Out of State (N.Y.)		Arkport Dam Canisteo River	Completed 1953	Flood Control Structure	Earthfill with Concrete Spillway	30.5	100	1,200		113		192	7,950	7,468	420	See (e)
Out of State (N.Y.)		Almond Lake Canacadea Creek	Completed 1956	Flood Control Structure	Earthfill with Concrete Spillway	56.0	100	1,260		90		490	14,640	18,587	1,046	See (e)

[a] 1976 Price Level

[b] Total annual cost (1976 price level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

[c] 1,2,4,6,7,9,11,12,38,9,C/R1,C/R3,C/R6,S/R4,35,36,60

[d] 6,7,8,9,11,12,38,39,C/R3,C/R6,35,36,60

[e] 16,17,18,19,20,21,22,24,25,26,27,40,41,42,43,44,46,C/R26,30,31,33,34,56,58,C/R36

[f] The structure without a legend number is located in the watershed shown and is providing benefits to this subbasin.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-3

DEPARTMENT OF ENVIRONMENTAL RESOURCES PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
A	E1	Lackawanna River Powderly Cr. & Hosey Creek C35:7–101.1 Unit 1	Completed (8/1968)	Flood Protection	Channel Improvement & Levee		50	1,500		10				1,046	65	3,C/R1
A	E2	Lackawanna River Powderly Cr. & Hosey Creek C35:7–102.1 Unit 2	Completed (6/1969)	Flood Protection	Levee		50	500						58	4	3,C/R1
A	E3	Blakely Flood Project GSA 180–10.1	Completed (9/1975)	Flood Protection	Channel Improvement		50							1,303	81	5
A	E4	Lackawanna River C35:4	Completed (7/1957)	Flood Protection	Channel Improvement & Dikes		50	26,000						753	47	6
A	E5	Old Dam Creek C35:4	Completed (6/1960)	Flood Protection	Channel Improvement & Levee		50	545			2.5			22	2	7
A	E6	Roaring Brook C35:5 Unit 2	Completed (6/1961)	Flood Protection	Channel Improvement		50	2,619	55	13				2,994	85	9
A	E7	Roaring Brook C35:5 Unit 3	Completed (8/1958)	Flood Protection	Channel Improvement		50	1,925						56	4	9

[a] 1976 Price Level

[b] Total annual cost (1976 price level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-3 (Cont.)

DEPARTMENT OF ENVIRONMENTAL RESOURCES PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Flood Pool Surface Area (acres)	Diameter (feet)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Beneficial Area (See Figure 13)
A	E8	Stafford Meadow Brook C35:5 Unit 4	Completed (12/1965)	Flood Protection	Channel Improvement & Stilling Basin		50	1,365	24	10	2		1,211	74	9
A	E9	Lackawanna River C35:5 Unit 1	1)Completed (9/1960) 2)Completed (11/1961)	Flood Protection	Channel Improvement		50	12,600					1,587 54	98 4	9 9
A	E10	Lackawanna River Duryea C40:8	Completed (11/1967)	Flood Protection	Channel Improvement & Levee		50	5,000	200–240	10	3.5		787	49	12
A	E11	Lackawanna Duryea C40:8 E	Under Construction	Flood Protection	Levee		50						291	18	12
A	E12	Lackawanna River C35:6 Unit 1	Completed (11/1963)	Flood Protection	Levee		50	2,700	10				451	27	14
A	E13	Lackawanna River & Spring Run C35:6 Unit 2	Completed (10/1970)	Flood Protection	Channel Improvement		50	1,325	30	14			1,439	89	14
B	E14	Abrahams Creek C40:1	Completed (9/1962)	Flood Protection	Channel Improvement		50	4,800	30	6			127	7	42
B	E15	Abrahams Creek Francis Slocum Dam C40:1	Completed (7/1965)	Flood Control	Dam & Reservoir	6.10	50	810	20	51	275		791	49	42

[a] 1976 Price Level

[b] Total annual cost (1976 price level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-3 (Cont.)

DEPARTMENT OF ENVIRONMENTAL RESOURCES PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construc-tion Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
B	E16	Abrahams Creek GSA 180–18 (C40:1)	Completed (12/1973)	Flood Protection			50							1,044	65	42
B	E17	Abrahams Creek & Wade Run GSA 180–17 (C40:9)	Under Construction	Flood Protection			50							2,085	129	42
B	E18	Brown Creek C40:3 Unit 2	1)Completed (11/1959) 2)Completed (7/1967)	Flood Protection	Earthfill Dam & Conduit		50	900		23	10			1,381 13	85 2	20 20
B	E19	Wadham Creek & Duffey Run Unit 1	1)Completed (9/1959) 2)Completed (4/1961)	Flood Protection	Earthfill Dam & Channel Improvement		50	378	10	29	5			346 81	22 5	20 20
B	E20	Duffey Run Dam C40:3	Completed (9/1965)	Flood Control	Dam & Reservoir	0.25	50		10	14				103	7	20
B	E21	Turtle Creek C40:7	Completed (7/1963)	Flood Protection	Channel Improvement		50	809	8	8				366	24	26
E	E22	Sechler Run (Danville) C47:2–101.1	Completed (5/1970)	Flood Protection	Channel Improvement		50							252	16	34
E	E23	Schler Run Danville GSA 180–15 (C47:1)	Completed (5/1977)	Flood Protection			50							2,085	129	34

[a] 1976 Price Level

[b] Total annual cost (1976 price level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-3 (Cont.)

DEPARTMENT OF ENVIRONMENTAL RESOURCES PROJECTS

Watershed	Legend (See Figure 13)	Location	Status	Purpose	Type of Structure	Drainage Area (sq.mi.)	Design Life-time (years)	Length (ft.)	Width (feet)	Height or Depth (ft.)	Diameter (feet)	Flood Pool Surface Area (acres)	Flood Control Surface Area (Acres)	Total Construction Cost ($1,000)[a]	Total Annual Cost ($1,000)[b]	Beneficial Area (See Figure 13)
E	E24	Mahoning Creek Danville C47:1-103	Completed (11/1970)	Flood Protection	Channel Improvement		50	4,000						659	42	34
E	E25	Susquehanna River & Mahoning Creek Danville C47:1 Unit 2	Completed (7/1968)	Flood Protection	Channel Improvement		50	6,000	10					983	62	34
E	E26	Susquehanna River Danville C47:1 E	Under Construction	Flood Protection	Levee		50							965	60	34
E	E27	Susquehanna River Danville C47:1 A	Completed (4/1958)	Flood Protection	Levee		50	2,000	10	24				139	9	34
E	E28	Celebration Creek McAdoo	Completed	Flood Protection	Channel Improvement		50	varies						548	60	

[a] 1976 Price Level

[b] Total annual cost (1976 price level) consists of annual construction cost amortized at the rate of 5.25% over the respective life periods plus annual operation and maintenance cost.

Note: In some cases, for fiscal or other reasons, flood control projects are designed and constructed as two or more units; however, all units acting in tandem are required to achieve the design flood damage reduction. Units are listed separately.

Appendix C-4

FLOOD PLAIN INFORMATION REPORTS BY
U.S. ARMY CORPS OF ENGINEERS

Watershed	Report	Date Completed
A	Susquehanna River & Lackawanna River – Luzerne County	1972
B	Susquehanna River – Nanticoke - Luzerne County	–
B	Susquehanna River – Shickshinny - Luzerne County	1973
C	Susquehanna River, Fishing Creek & Little Fishing Creek – Columbia County	–
C	Huntingdon Creek – Columbia County	–
D	Susquehanna River, Briar Creek & Tenmile Run – Columbia County	–
D	Susquehanna River – Bloomsburg - Columbia County	2/1974
E	Susquehanna River & Catawissa Creek – Columbia County	–

Appendix C-5

FLOOD PRONE AREAS MAPPED BY
U.S. GEOLOGICAL SURVEY

Watershed	Stream(s)	U.S.G.S. Topographic Map	Date Completed
A	Lackawanna River	Pittston	1969
A	Fiddle Lake Creek	Clifford	1974
A	East Br. Lackawanna River & Lackawanna River	Forest City	1973
A	Lackawanna River	Waymart	1973
A	Lackawanna River	Carbondale	1973
A	Lackawanna River & Roaring Brook	Scranton	1973
A	Lackawanna River & Roaring Brook	Olyphant	1973
A	Lackawanna River & Spring Brook	Avoca	1973
A	Roaring Brook & Brunt Creek	Moscow	1973

Appendix C-5 (Cont.)

FLOOD PRONE AREAS MAPPED BY
U.S. GEOLOGICAL SURVEY

Watershed	Stream(s)	U.S.G.S. Topographic Map	Date Completed
B	Susquehanna River & Mill Creek	Pittston	1969
B	Harveys Lake, Harvey Creek, East Fork Harvey Creek, Bear Hollow, Fades & Pike Creeks	Harveys Lake	1973
B	Toby Creek & Susquehanna River	Kingston	1969
B	Susquehanna River, Shickshinny Creek & Reyburn Creek	Shickshinny	1973
B	Hunlock Creek, Susquehanna River, Newport Creek, South Branch & Harvey Creek	Nanticoke	1973
B	Wapwallopen Creek & Susquehanna River	Berwick	1972
B	Susquehanna River, Solomon Creek, Sugar Notch Run, Warrior Creek, Bow Creek & Big Wapwallopen Creek	Wilkes-Barre West	1974
B	Susquehanna River	Shickshinny	1973
B	Wapwallopen Creek, Little Wapwallopen Creek, & Pond Creek	Sybertsville	1973
B	Little Wapwallopen Creek, Big Wapwallopen Creek, Watering Run, & Balliet Run	Freeland	1974
C	Ore Run, Big Run, Sullivan Br. Fishing Creek, Pigeon Run, Herberly Run, West Br. Fishing Creek, Coles Creek, Ashelman Run, Brish Run, Pine Creek, Kitchen Creek, & East Br. Fishing Creek	Red Rock	1974
C	Spruce Run, Little Fishing Creek, Hemlock Creek, West Hemlock Creek & Frozen Run	Millville	1974
C	Fishing Creek, Green Creek, Little Green Creek & West Creek	Benton	1973
C	Fishing Creek, Pine Creek, Huntington Creek, Ashs West Br. & East Br. Raven Creek	Stillwater	1973
C	Little Fishing Creek, West Br. Run, Spruce Run	Lairdsville	1974

Appendix C-5 (Cont.)

FLOOD PRONE AREAS MAPPED BY
U.S. GEOLOGICAL SURVEY

Watershed	Stream(s)	U.S.G.S. Topographic Map	Date Completed
C	West Br. Fishing Creek, Painter Run, Elk Run, Fishing Creek & West Br. West Creek	Elk Grove	1974
C	Susquehanna River, Fishing Creek, Green Creek, Mud Run, & Little Fishing Creek	Bloomsburg	1973
D	Susquehanna River, Fishing Creek, & Huntington Creek	Mifflinville	1969
D	Susquehanna River, Nescopeck Creek, & Black Creek	Berwick	1972
D	Nescopeck Creek & Black Creek	Nuremberg	1973
D	Little Nescopeck Creek, Black Creek & Stony Creek	Conyngham	1974
D	Nescopeck Creek & Little Nescopeck Creek	Sybertsville	1974
D	Nescopeck Creek & Little Nescopeck Creek	Freeland	1974
E	Raccoon Creek, Sugarloaf Creek, Tomhicken Creek, Stony Run, Catawissa Creek, Little Catawissa Creek, Dark Run & Crooked Run	Nuremberg	1973
E	Little Catawissa Creek & Catawissa Creek	Shenandoah	1973
E	Messers Run	Delano	1974
E	Catawissa Creek	Conyngham	1974
E	Susquehanna River	Riverside	1972
E	Kase Run & Mahoning Creek	Millville	1974
E	Susquehanna River	Northumberland	1973
E	Catawissa Creek, Beaver Run, Mill Creek, & Roaring Creek	Shumans	1973
E	Susquehanna River, Roaring Creek, Mugser Run, Montour Run, Fishing Creek, Hemlock Creek, & Catawissa Creek	Catawissa	1973
E	Susquehanna River, Sechler Run, Roaring Creek, South Br. Roaring Creek & Mahoning Creek	Danville	1973

Appendix C-6

FLOOD INSURANCE STUDIES COMPLETED
FOR U.S. DEPARTMENT OF HOUSING AND
URBAN DEVELOPMENT FEDERAL
INSURANCE ADMINISTRATION[a]

Watershed	Location of Study
A	Clarks Green Borough
A/B	Pittston City
A	Jenkins Township
B	Wilkes-Barre City
B	Kingston Borough
B	Nanticoke City
B	Plymouth Borough
B	Edwardsville Borough
B	Exeter Borough
B	Forty-Fort Borough
B	Larksville Borough
B	Luzerne Borough
B	Swoyersville Borough
B	West Pittston Borough
B	West Wyoming Borough
B	Wyoming Borough
B/D	Bear Creek Township
B	Conyngham Township
B	Hanover Township
B	Jenkins Township
B	Plains Township
B	Plymouth Township
B	Pringle Borough
B	Shickshinny Borough
B	Sugar Notch Borough
B	Warrior Run Borough
C	Benton Borough
C	Benton Township
E	Danville Borough
E	Derry Township
E	Mahoning Township
E	Sunbury City
E	Northumberland Borough
E	Point Township
E	Ralpho Township
E	Riverside Borough
E	Upper Augusta Township
E	McAdoo Borough
E	Ringtown Borough

[a]Includes studies completed as of February, 1978.

Appendix C-7

FLOOD DAMAGE REDUCTION SOLUTION ALTERNATIVES

Table 26 in Chapter V lists the alternatives which were identified as possible solutions or partial solutions to existing flood damage problems in Subbasin 5. The columns in that table are described here.

Column 1: Legend No. of a damage center or reach (See Figure 13)

Column 2: Name of a damage center or reach and name of streams identified as causing the damage. For each damage center or reach, the first row identifies the name and the second row identifies the stream.

Column 3: Damage reduction due to existing or funded proposed structures expressed as a percentage of natural annual damage in a damage center or reach.

Column 4: Need expressed as residual annual damage (damage remaining after completion of existing flood control structures or those currently under construction) in thousands of dollars (1976 price level).

Column 5: Nonstructural Solution

A. Floodplain regulation: requires floodplain information, as well as workable and strong legislative action (more applicable to future than existing development).

B. Flood Insurance: does nothing to reduce flood hazard or damages, but rather lessens the economic burden of flooding on floodplain occupants. However, the land use regulations required to participate in HUD's National Flood Insurance Program will effectively reduce future damage potential and control future floodplain development.

C. Permanent Flood Proofing: applicable primarily to existing residential, industrial and commercial developments on the floodplain, where structural flood control measures cannot be economically justified.

D. Flood Forecasting: applicable only where upstream gaging is sufficient to provide accurate forecasts of flood stages downstream. Effective along the main stem of a river but not in headwater areas or small tributaries, where there is insufficient time for warning and response.

Column 6: Structural Solutions includes levees or flood walls, channel modifications and potential small and Corps of Engineers reservoir sites. The average annual benefit in thousand dollars (1976 price level) for each damage center or reach resulting from each alternative structural solution is shown.

Column 7: Any remarks applicable to specific solution alternatives.

APPENDIX D

WILD AND SCENIC RIVERS

Appendix D-1

PENNSYLVANIA SCENIC RIVERS CANDIDATES

Table 36 in Chapter V lists the streams and stream reaches which were identified in the *Pennsylvania Scenic Rivers Inventory* as candidates for wild, scenic or recreational designation by the General Assembly. The columns in that table are described here.

Column 1: Legend – Number code shown in this column corresponds with number code shown on Figure 19.

Column 2: Stream Name – Name of stream on which proposed segment is located.

Column 3: Priority Group – Waterways have been categorized into three priority groups. First priority waterways are considered to be of statewide, and in some instances, even national significance. Second and third priority waterways exhibit some outstanding values, yet not enough in quantity or quality to merit statewide recognition. These are primarily locally and regionally significant. First priority waterways have been further divided into three priority subgroups (A, B and C) based upon degrees of environmental quality, resource endangerment and recreational potential. First priority "A" group waterways are those which have the most urgent need for protection and immediate need for additional study. First priority "B" and "C" groups are of less than immediate concern; however, lower priority ratings should not be equated with a de-emphasized need for protection.

Column 4: Proposed Segment Limits – Upstream and downstream limits of the candidate segment.

Column 6: Proposed Class – Candidate segments have been designated according to the following classes:

W - Wild river areas—those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted.

S - Scenic river areas—those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and undeveloped but accessible in places by roads.

R - Recreational rivers—those rivers or sections of rivers that are readily accessible, that may have some development along their shorelines and that may have undergone some impoundment or diversion in the past.

MR - Modified recreational rivers-those rivers or sections of rivers in which the flow may be regulated by control devices located upstream. Low dams are permitted in the reach so long as they do not increase the river beyond bank-full width. These reaches are used for human activities which do not substantially interfere with public use of the streams or the enjoyment of their surroundings.

Column 7: Water Quality – As part of the scenic rivers inventory and evaluation process, the DER Bureau of Water Quality Management provided information related to the water quality of each nominated stream. All waterways have been placed in one of the following three groups:

Group 1 - Stream presently meets or exceeds state water quality standards.

Group 2 - Stream does not presently meet state water quality standards, but will within 10 years.

Group 3 - Stream does not presently meet state water quality standards, but will beyond 10 years.

APPENDIX E

WATER QUALITY

Appendix E-1

GLOSSARY OF WATER QUALITY TERMS

Acidity (Mineral)	–	The capacity of an aqueous media to neutralize a base; usually reported in mg/1 as $CaCO_3$.
Alkalinity	–	The capacity of an aqueous media to neutralize an acid; usually reported in terms of mg/1 as $CaCO_3$.
Ammonia-Nitrogen	–	A gas (NH_3) released by the microbiological decay of plant and animal proteins. Reported in the study as mg/1 of nitrogen.
Biochemical Oxygen Demand (BOD)	–	A measure of the quantity of oxygen used in the oxidation of organic matter by natural biological processes in a specified time under standard conditions. For the purposes of this report, all values are expressed as oxygen demand in mg/1 exerted over a period of five days.
Chlorides	–	A measure of the concentration of chloride ions, predominately Cl, expressed in this report as mg/1.
Dissolved Oxygen (DO)	–	A measure of the quantity of oxygen gas in solution; generally expressed in mg/1.
Hardness	–	A characteristic of water caused by divalent cations, primarily calcium and magnesium, that are capable of reacting with soap to form precipitates.
Nitrate-Nitrogen	–	The final decomposition product (NO_3) of the organic nitrogen compounds, expressed in this study as mg/1 of nitrogen.
pH	–	The reciprocal of the log of the hydrogen ion activity coefficient. It ranges from 0 (acidic) to 14 (basic) with neutral water having a value of 7.
Sulfate	–	The final decomposition product (SO_4) of organic sulfur compounds; generally occurs in areas affected by acid mine drainage and expressed in this report as mg/1.
Total Phosphorus	–	Primarily the total of the complexed forms of phosphorus, orthophosphate, polyphosphate, as well as organic phosphorus (P). In this report, concentrations of phosphorus compounds are expressed as mg/1 of phosphorus. Phosphorus compounds are normally found in domestic and agricultural wastewater and many forms of industrial wastewater.
Turbidity	–	A condition caused by the presence of suspended matter in water resulting in the scattering and absorption of light; generally expressed in Jackson Turbidity Units (JTU).

Appendix E-2

CHEMICAL CONSTITUENTS IN GROUNDWATER
AND THEIR CHARACTERISTIC EFFECTS ON WATER USE

Constituents	*Concentration*	*Characteristic Effects On Water Use*
Iron (Fe)	Less than 0.3 mg/1 in the eastern and southwestern sections of the Plateau regions; elsewhere on Plateau and throughout folded Appalachians, approximately half the formations yield groundwater with excessive concentrations.	More than 0.3 mg/1 stains laundry, utensils and fixtures reddish brown.
Manganese (Mn)	Commonly less than 0.05 mg/1, but as high as 0.29 mg/1 in the far northern Plateau, 0.19 mg/1 in the southwestern Plateau, and up to 0.26 in sections of the folded Appalachians.	Iron and manganese together should not exceed 0.3 mg/1. Concentrations of Mn in excess of 0.05 mg/1 may cause laundry stains and impair taste of beverages.
Sulfate (SO_4)	Rarely less than 1 mg/1 or more than 100 mg/1 commonly one to 20 mg/1.	Concentrations in regions are not high enough to cause trouble.
Chloride (Cl)	Seldom less than one mg/1 or more than 40 mg/1, commonly one to 20 mg/1.	Salty taste to water having more than a few hundred milligrams per liter.
Nitrate (NO_3)	Rarely more than 5.0 mg/1, commonly less than 1.0 mg/1.	Where concentration is greater than 4.5 mg/1, contamination from sewage may be suspected. Water of concentrations greater than 10 mg/1 may be harmful to babies.
Dissolved Solids	Total of all mineral matter rarely more than 300 mg/1, commonly 100 to 300 mg/1.	Water containing more than 1,000 mg/1 of dissolved solids is unsuitable for most purposes.
Hardness as equivalent $CaCO_3$	Rarely less than 10 mg/1 or more than 300 mg/1, commonly 70 to 300 mg/1.	Causes consumption of soap before lather will form. Hard water forms scale in boilers and hot water heaters. Water whose hardness is less than 60 mg/1 is considered soft; 61 to 120 mg/1, moderately hard; 121 to 180 mg/1, hard; more than 180 mg/1, very hard.

Appendix E-3

WATER POLLUTANTS

Municipal Wastewater

This normally consists of domestic wastewater plus nominal amounts of commercial and industrial wastewater. Following treatment, the remaining portions of organic matter and nutrients in the effluent are discharged to subbasin streams. These pollutants can produce depressed dissolved oxygen levels, promote algae growths that cause fish kills and create overall degradation of the aquatic environment. Where municipal wastewater is held in leaking lagoons or where inadequate septic systems or spray irrigation systems are used, the groundwater system may be polluted.

Industrial Wastewater

The types of materials processed during manufacturing determine the composition of this wastewater. Toxic compounds, organic matter and metals may be released and produce conditions deleterious to aquatic life and surface water quality. The groundwater system may also be polluted where leaking waste lagoons are used or where spray irrigation or septic systems are inadequate or malfunctioning.

Acid Mine Drainage

This is formed in both active and abandoned surface and deep coal mines when iron sulfide chemically reacts with water and oxygen. The reaction produces acid, sulfate and iron which commonly pollute both surface and groundwaters.

Urban Runoff Pollutants

These come from debris, animal wastes, fertilizers, fallout from air pollution, stockpiled materials, automobile wastes and other sources. Pollutants on impervious areas are washed off during the initial part of a storm, resulting in a high initial pollutant concentration that decreases as the storm progresses. Long intervals between storms will result in large amounts of pollutants collected on urban surfaces, with resultant higher concentrations of the pollutants during runoff. Where combined sewers are used, heavy storms often cause a large portion of the total waste load (municipal wastewater and urban runoff) to overflow or bypass the treatment processes, resulting in the passage of urban runoff and untreated wastewater to the subbasin streams.

Solid Waste Leachate

This is highly contaminated water contained in or associated with refuse disposal sites such as dumps and sanitary landfills. Leachate is produced when solid waste decomposes and the products are dissolved and carried with the water that infiltrates the landfill or dump. Once the disposal site reaches its water holding capacity, the leachate flows from it into the groundwater or nearby surface water. Municipal refuse leachate is highly variable in its chemical composition, but commonly shows high values for BOD, COD, iron, ammonia-nitrogen, chloride and sulfate.

Septic System Wastewater

On-lot disposal systems, commonly in the form of septic systems, currently serve the wastewater needs of most rural areas, many suburban single-family dwellings and some small industries. Effluent from these systems percolates through the soil, and a portion of the effluent, carrying those pollutants that have not been filtered out in the soil, eventually reaches the groundwater system. Given the proper soil thickness and soil properties, many pollutants are removed; however, certain dissolved solids may infiltrate to the local groundwater system.

Thermal Wastes

These may cause a significant increase in overall stream temperature and can seriously alter biological communities in the receiving streams. Thermal discharges can originate from nuclear and coal-fired power plants and from certain industrial processes.

Agricultural Runoff

This may carry sediment, fertilizers, animal wastes and pesticides into streams. Sediment problems in agricultural areas can be a problem especially when ground disturbance coincides with heavy rains. Fertilizer nutrients constitute a problem when the runoff carries them away before they can be used by the crops. Animal wastes can become a particular problem where animals are grouped in feedlots and poultry farms. Pesticides and insecticides can be a pollution hazard when precipitation occurs soon after their application.

APPENDIX F

EROSION AND SEDIMENTATION

Appendix F-1

METHODOLOGY

Erosion Rates

The rates of sheet and rill erosion for each of the 20 subbasins in the state were calculated using methods described in Technical Release No. 51 (Rev.), USDA, Soil Conservation Service. This publication outlines methods of using the Universal Soil-Loss Equation (USLE) to estimate soil loss for Soil Conservation Service projects such as watershed and river basin studies.

The complete USLE is A = RKLSCP where A is the computed loss in tons per acre; R is the rainfall factor; K is the soil-erodibility factor; L is the slope-length factor; S is the slope-gradient factor; C is the cropping management factor; and P is the erosion-control practice factor.

To determine the factors to be used in the USLE for each of the 20 subbasins, methods were devised to obtain average values for an entire subbasin. The following discussion is an explanation of how these factors were determined.

Rainfall Factor (R)

The average annual "R" factor values for each subbasin were obtained from Figure 1 of Technical Release No. 51 (TR-51).

Soil-Erodibility Factor (K)

The "K" factor values are assigned to named kinds of soil and are given in the Pennsylvania Technical Guide, Section III-B. The "General Soils Information", published earlier as part of the Pennsylvania Analytical Summary, lists each soil association and percent of each association in the subbasin. To obtain a "K" value for an entire subbasin, an average "K" value was computed for each soil association. The average "K" value for each soil association and the percent of each association in the individual subbasin were used to calculate a "weighted" average "K" value for the subbasin. These "K" values were then correlated with the "K" values for "forest soils" prepared by the Forest Service of the USDA.

Slope Length (L) and Slope Gradient (S)

The "weighted" average "S" factors for cropland, forest and pasture in each subbasin were computed by using land use percentage by capability class and the average slope assigned to each capability. An average slope was assigned to each capability class according to the following table.

Class	*Avg. Slope*	*Class*	*Avg. Slope*
I	2%	V	2%
II	5%	VI	20%
III	12%	VII	35%
IV	20%	VIII	15%

The "L" factor was determined based on the "weighted" average slope according to the following table.

Slope (%)	*Slope Length (Feet)*
0–10	400
11–19	300
20	200

For convenience in the application of these factors, they are combined into a single topographic factor (LS). The "LS" factor was obtained from Table 1, TR-51, using calculated "S" and corresponding "L" factors.

Crop Cover or Cropping Management Factor (C)

The "C" factor values for cropland in each subbasin were estimated based on cropping sequence and management. A theoretical crop rotation was determined for an entire subbasin by analysis of the percent of row crops, small grains and hayland in the subbasin. Using this theoretical crop rotation, "C" values were obtained from Table 6 of the Technical Guide, Section III-B.

The "C" factor values for forestland were assumed to be similar for the entire state. An average condition, that would represent the majority of forestland across the state, was determined to be tree canopy on 40 to 70 percent of the area and forest litter on 75 to 85 percent of the area. Assuming this average condition, a "C" value of 0.002 for forestland was obtained from Table 3 of TR-51.

The "C" factor values for pastureland were also assumed to be similar for the entire state. An average condition, that would represent the majority of the pastureland in the state, was determined to be trees, but no appreciable low brush, with canopy covering less than 25 percent of the area and 80 percent ground cover with up to two inches of litter and mostly broadleaf herbaceous plants. Assuming this average condition, a "C" value of 0.025 was obtained from Table 2 of TR-51.

Erosion-Control Practice Factor (P)

The "P" factor values for cropland were determined assuming contouring as an average condition across the state and using the appropriate value based on land slopes as given in the following table.

Land Slope (%)	*"P" Value*
2–7	0.5
8–12	0.6
13–18	0.8
19–24	0.9

The "P" factor values for forest and pastureland are by definition equal to 1.0.

Appendix F-2

SOIL LOSS AND SEDIMENT YIELD

Table 1

RATES OF AVERAGE ANNUAL SOIL LOSS FROM SHEET AND RILL EROSION[a]
(Tons Per Acre)

	Land Use		
Subbasin	Cropland	Forest[b]	Pasture and Other Land
1	3.0	0.2	3.7
2	12.2	0.2	3.7
3	15.3	0.2	5.2
4	4.2	0.8	2.7
5	7.2	0.8	4.4
6	10.0	0.8	5.3
7	7.3	0.8	4.8
8	8.4	0.3	3.7
9	6.1	0.8	3.6
10	5.8	0.8	4.0
11	6.1	0.3	4.6
12	11.6	0.8	4.1
13	7.1	0.5	3.8
14 & 16	7.5	0.4	2.9
15	3.5	0.2	3.0
17	3.9	0.3	4.2
18	3.8	0.3	5.2
19	6.5	0.3	5.4
20	3.8	0.3	5.4

[a]Soil Conservation Service draft report *Erosion and Sediment Pollution Potential*, 1976.

[b]U.S. Forest Service

Table 2

GROSS AVERAGE ANNUAL SOIL LOSS FROM SHEET AND RILL EROSION[a]
(Thousand Tons)

	Land Use			
Subbasin	Cropland	Forest[b]	Pasture And Other Land	Total Loss
1	446	160	515	1,121
2	3,185	117	348	3,650
3	6,247	108	1,268	7,623
4	2,060	1,506	1,027	4,593
5	1,604	565	461	2,630
6	2,412	528	379	3,319
7	8,494	889	1,736	11,119
8	693	465	268	1,426
9	898	1,193	211	2,302
10	1,219	730	381	2,330
11	1,362	265	436	2,063
12	2,387	576	315	3,278
13	1,789	413	458	2,660
14 & 16	1,312	681	710	2,703
15	333	35	230	598
17	1,017	613	589	2,219
18	1,132	359	1,266	2,757
19	1,921	492	1,933	4,346
20	1,648	397	2,146	4,191
Totals	40,159	10,092	14,677	64,928

[a]Soil Conservation Service draft report *Erosion and Sediment Pollution Potential*, 1976.

[b]U.S. Forest Service

Appendix F-2 (Cont.)

SOIL LOSS AND SEDIMENT YIELD

Table 3

SUBBASIN LAND USE AND SEDIMENT YIELD

Subbasin	Area (Sq.Mi.)	Land Use (%) Cropland	Pasture	Forest	Other	Average Annual Sediment Yield (1000 Tons)
1	1,816	13	6	64	17	273
2	1,943	21	2	46	31	491
3	2,708	24	7	28	41	722
4	3,286	23	12	53	12	630
5	1,759	20	3	56	21	382
6	1,448	26	4	57	13	327
7	4,157	44	7	32	17	1,017
8	2,631	5	1	85	9	295
9	2,539	9	2	84	5	287
10	1,809	18	3	66	13	219
11	1,943	18	4	61	17	174
12	1,462	22	4	66	8	138
13	1,584	25	7	54	14	319
14 & 16	4,573	13	5	62	20	460
15	511	29	6	36	29	37
17	2,931	14	3	64	19	512
18	2,393	20	5	53	22	436
19	2,736	17	8	48	27	485
20	3,080	21	10	37	32	533
State	45,309	20	5	55	20	7,737