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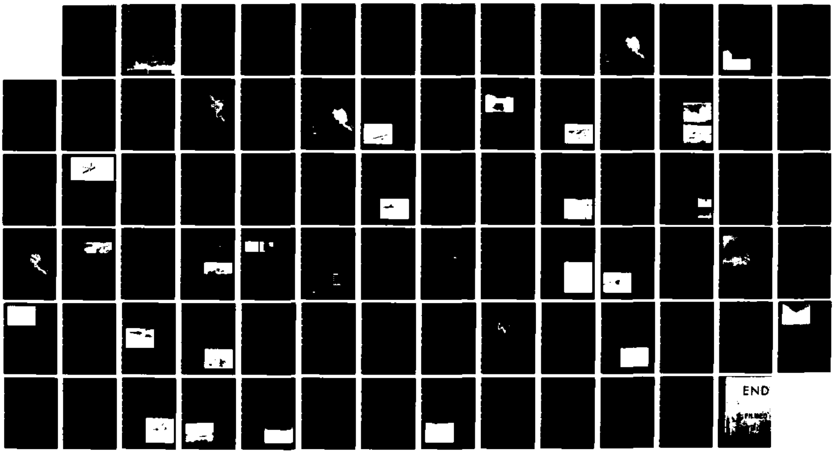

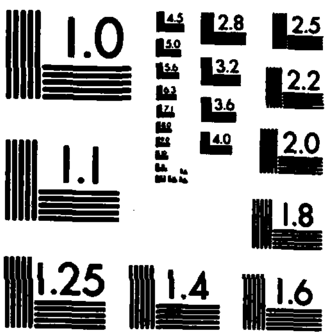

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Metropolitan Washington Area Water Supply Study

Main Report

Final/September 1983

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In response to the Water Resources Development Act of 1974, the Baltimore District of the U.S. Army Corps of Engineers conducted a comprehensive water supply analysis of the Metropolitan Washington Area (MWA). Severe water supply shortages had been forecast for the MWA and the study was undertaken to identify and evaluate alternative methods of alleviating future deficits. Initiated in 1976, the study was conducted in two phases over a 7-year period. The first, or early action phase, examined the most immediate water supply problems and proposed solutions that could be implemented locally. The second or long

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19. KEY WORDS (continued)

water shortage; reregulation; finished water interconnection; Occoquan Reservoir; Patuxent Reservoir; Potomac Estuary; Water Supply Coordination Agreement; Verona Lake

20. ABSTRACT (continued)

range phase included an analysis of the full spectrum of structural and nonstructural water supply alternatives. In addition to such traditional water supply alternatives as upstream reservoir storage, groundwater and conservation, the study also considered such innovative measures as wastewater reuse, raw and finished water interconnections between the major suppliers, the use of the upper Potomac Estuary, reregulation and water pricing. A key tool in the study was the development and use of a basin-specific model that was used to simulate the operation of all the MWA water supply systems and sources under various drought scenarios. As the study progressed, local interests used the technical findings of the Corps' study to make great strides toward a regional solution to their water supply problems. The Corps' study concluded that with the implementation of a series of regional cooperative management agreements, contracts, selected conservation measures, and the construction of one local storage project to be shared by all, severe water supply shortages could effectively be eliminated for the next 50 years. The Final Report of the study is comprised of eleven volumes which provide documentation of both the study process and the results of all the technical analyses conducted as part of the study.

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1715
BALTIMORE, MARYLAND 21203

Final Report September 1983

Metropolitan Washington D.C. Area Water Supply Study
Maryland, Virginia, And The District Of Columbia

Main Report

Syllabus

The Metropolitan Washington Area Water Supply Study was a comprehensive examination of the water supply problems facing Washington, D.C. and seven surrounding counties in Maryland and Virginia. Severe water supply shortages had been forecast for the Metropolitan Washington Area, and the study was undertaken to identify and evaluate alternative methods of alleviating future deficits.

The study was initiated in 1976 and was conducted in two distinct phases over the course of seven years. The first, or early-action phase, examined the most immediate water supply problems and proposed solutions that could be implemented locally. A ***Progress Report*** describing the results of the early-action phase was released mid-way through the study (August 1979). This document was published so that decisions concerning high priority water supply programs could be made as soon as possible. The second, or long-range phase, was completed in 1982 and included an analysis of the full spectrum of water supply alternatives available to the Metropolitan Washington Area. The present report contains a discussion of both the early-action and long-range phases of the study.

As the study progressed, non-Federal agencies and organizations made great strides toward a regional solution to their water supply problem. These efforts were aided in large part by the Corps of Engineers' work described in the accompanying report. The most significant of the accomplishments to solve the water supply problem included a contract to purchase all water supply storage in Bloomington Lake, an agreement to construct the Little Seneca Lake project for the benefit of all of the major water service areas, endorsement of water conservation programs, and a commitment to cooperatively manage the entire water supply system as a single regional resource. With the implementation and continued execution of these programs and several others not mentioned, the water supply shortages once forecast for the Metropolitan Washington Area should be effectively eliminated through the year 2030, at least for the major water supply utilities (Washington Aqueduct, Fairfax County Water Authority, and Washington Suburban Sanitary Commission). Some of the smaller utilities surrounding the metropolitan area still face potential shortages before the year 2030. The report suggests alternatives for their future consideration.

In light of the significant advances in regional cooperation among the major users, the region's recent commitment to certain high priority water supply programs, and the creation of local institutional mechanisms to implement these water supply programs, the District Engineer recommends that no additional water projects or programs be undertaken by the Corps of Engineers at this time. He does recommend, however, that the Corps' report be transmitted to Congress as an information document in response to the authorizing legislation, Public Law 93-251. The District Engineer also recommends that watershed protection measures and water quality monitoring programs be undertaken by the appropriate Federal, state, and local agencies to protect against the degradation of existing water supply sources.

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

MAIN REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

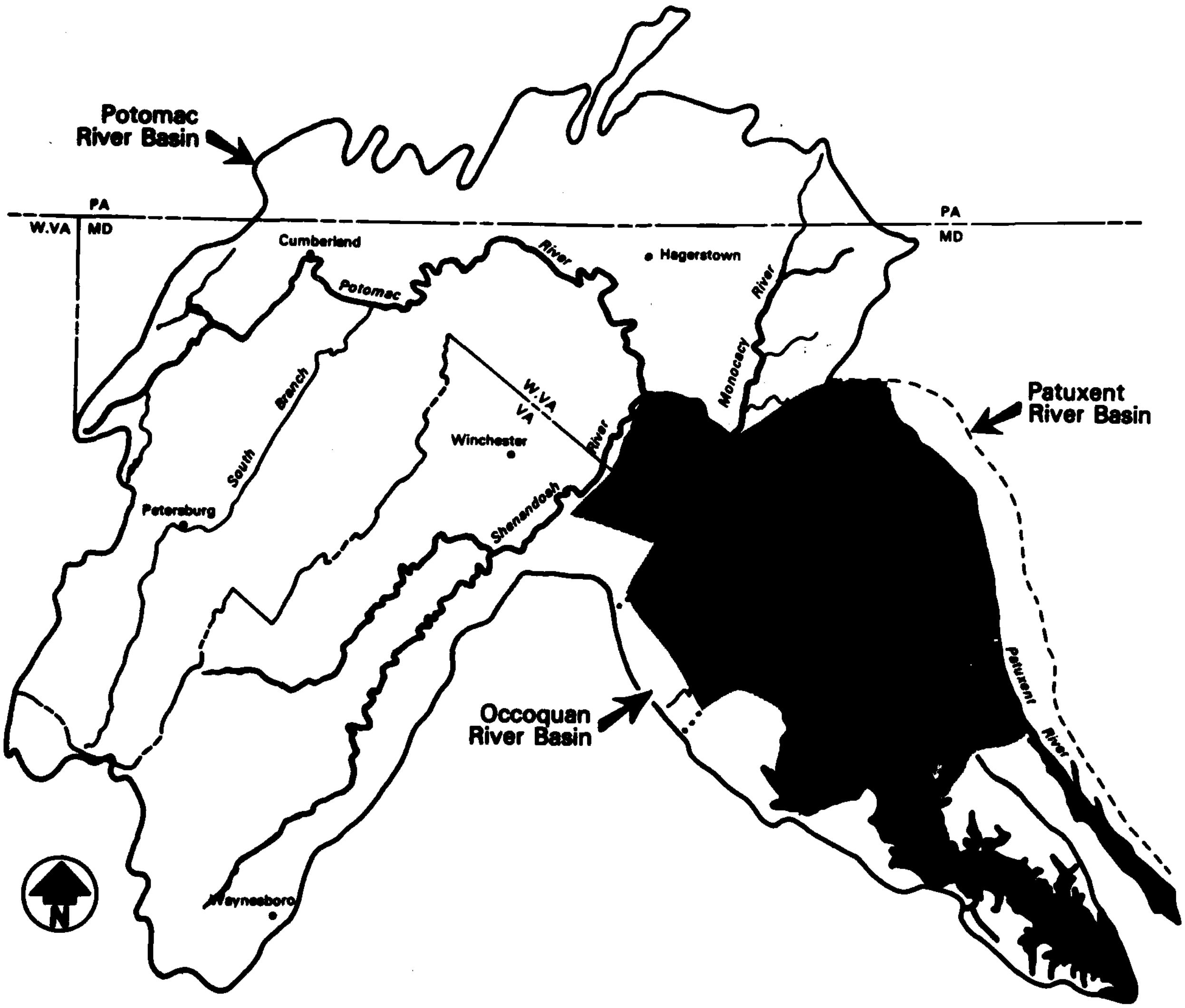
LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS (Cont'd)

LIST OF APPENDICES

Fig. 1-Location of Metropolitan Washington Area



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Metropolitan Washington Area (includes the following: Washington, DC; Montgomery, Prince Georges and Charles counties in MD; and Arlington, Fairfax, Prince William and Loudoun counties in VA).

Chapter I
Introduction

The nation's capital and surrounding counties in both Maryland and Virginia have been the subject of numerous water supply studies in recent years. Nearly all of these studies projected severe water shortages in future drought years unless specific actions were taken to reduce water demands, provide new supply sources, and/or better manage existing water supply systems. Despite these many investigations of the water supply situation, positive actions to ensure a dependable water supply for the Metropolitan Washington Area (MWA) for the next 50 years have only recently been initiated. This ***Metropolitan Washington Area Water Supply Study Report*** furnishes a comprehensive evaluation of the problems, needs, and opportunities associated with various water supply plans for the MWA.

As shown on Figure 1, the MWA was defined as the Washington, D.C. Standard Metropolitan Statistical Area and includes Montgomery, Prince Georges, and Charles Counties in Maryland; Arlington, Fairfax, Prince William, and Loudoun Counties in Virgina along with five independent cities; and the District of Columbia. These areas encompass about 3,000 square miles and rely primarily on the surface waters of the Potomac, Patuxent, and Occoquan River Basins as water supply sources. The MWA is served by 25 water supply systems, with the four largest systems (Washington Suburban Sanitary Commission [WSSC], Fairfax County Water Authority [FCWA], Rockville and Washington Aqueduct Division [Aqueduct]) providing almost 96 percent of the MWA's treated water supply. Information about the study area in general, and the major water service areas in particular, can be found in Chapter II.

Authority

The Metropolitan Washington Area Water Supply Study was authorized by Section 85(b)(1) of the Water Resources Development Act of 1974 (Public Law 93-251, 7 March 1974). This subsection, along with other subsections in Section 85, responded to earlier reports and recommendations transmitted to the U.S. Congress concerning water supply issues in the MWA. Figure 2 contains the complete citation of Section 85.

Section 85(b)(1) directed that a thorough investigation be made of the existing and future water supply needs of the MWA, and that recommendations be made to the U.S. Congress for satisfying such needs. In addition, Section 85(a) also authorized both the Verona Lake and Sixes Bridge reservoir projects for Phase I, Advanced Engineering and Design, by the Corps of Engineers. (Further study on the Verona project was terminated in 1977 when the Commonwealth of Virginia withdrew its previous support; the Sixes Bridge project was deauthorized by Public Law (PL) 97-128, 29 December 1981.) Section 85(b)(2) directed the Secretary of the Army to construct, operate, and evaluate an experimental project to test the feasibility of using the Potomac Estuary as a supplemental water supply source.

Finally, Section 85(b)(3) directed the Secretary of the Army to request the National Academy of Sciences-National Academy of Engineering (NAS-NAE) to review and provide written comment on the scientific basis for conclusions reached in both the Metropolitan Washington Area Water Supply Study and the Potomac Estuary Experimental Water Treatment Plant testing program.

Study Purpose and Scope

Given the study authorization in Section 85(b)(1), the purposes of the Metropolitan Washington Area Water Supply Study were to: (1) provide a comprehensive examination of applicable demand reduction and water supply measures; (2) formulate plans for satisfying regional water shortages; and (3) identify viable solutions for implementation, either by Federal or non-Federal entities. The planning horizon was defined to be the period between year 1980 and year 2030.

The level of detail developed in the following report is generally of feasibility scope and is intended to identify potential solutions. The report has not been prepared as a detailed authorization document that recommends specific projects for implementation. Systematic comparisons were made of various plans in terms of technical feasibility; economic, environmental, social, and cultural impacts; implementation arrangements; and public acceptability. Because of the large number of potential measures considered, the broad geographic nature of the study area, and the complexity of the existing systems, only the significant effects were evaluated. Sufficient detail was developed to allow a choice among a range of alternatives; however, detailed engineering, environmental, and design analyses necessary for authorization, construction, or implementation of a specific project were not conducted.

This feasibility study concentrated primarily on measures to increase supply, to reduce demand, or to better manage existing water supply resources. As such, a number of broad assumptions were made at the beginning of the study which were basic to the overall effort. These assumptions are listed below:

- The existing infrastructure consisting of water supply intakes, pumps, water treatment plants, and water distribution systems would be maintained, repaired, or replaced as necessary by the water utilities to function safely and efficiently throughout the planning period. Additionally, the distribution systems would be extended by the water

Fig. 2-Section 85, Water Resources Development Act of 1974, P.L. 93-251

FIGURE 2

SECTION 85
WATER RESOURCES DEVELOPMENT ACT OF 1974

" SEC. 85. (a) The projects for Verona Dam and Lake, Virginia, and for Sixes Bridge Dam and Lake, Maryland, are hereby authorized substantially in accordance with the recommendations of the Secretary of the Army in House Document Numbered 91-343 as modified by the recommendations of the Chief of Engineers in his report dated July 13, 1973, except that such authorization shall be limited to the phase I design memorandum of advanced engineering and design, at an estimated cost of $1,400,000.

(b) (1) Prior to any further authorization of such Sixes Bridge Dam Project, the Secretary of the Army, acting through the Chief of Engineers shall (A) make a full and complete investigation and study of the future water resources needs of the Washington metropolitan area, including but not limited to the adequacy of present water supply, nature of present and future uses, the effect water pricing policies and use restrictions may have on future demand, the feasibility of utilizing water from the Potomac estuary, all possible water impoundment sites, natural and recharged ground water supply, wastewater reclamation, and the effect such projects will have on fish, wildlife, and present beneficial uses, and shall provide recommendations based on such investigation and study for supplying such needs, and (B) report to the Congress the results of such investigation and study together with such recommendations. The study of measures to meet the water supply needs of the Washington metropolitan area shall be coordinated with the Northeastern United States water supply study authorized by the Act of October 27, 1965 (79 Stat. 1073).

(2) The Secretary of the Army, acting through the Chief of Engineers, shall undertake an investigation and study of the use of estuary waters to determine the feasibility of using such waters as a source of water supply and is authorized to construct, operate, and evaluate a pilot project on the Potomac estuary for the treatment of such waters at an estimated cost of $6,000,000. The Secretary of the Army, acting through the Chief of Engineers, shall report to the Congress on the results of such project within three years after commencement of operation of such project and such report shall include the results of two years testing at the pilot project for the treatment of water from the Potomac estuary.

(3) The Secretary of the Army, acting through the Chief of Engineers, shall request the National Academy of Sciences-National Academy of Engineering to review and by written report comment upon the scientific basis for the conclusions reached by the investigation and study of the future water resource needs of the Washington metropolitan area and the pilot project for the treatment of water from the Potomac estuary. Such review and written report shall be completed and submitted to the Congress within one year following the completion of both the Corps of Engineers report on the future water resource needs of the Washington metropolitan area and the report on the results derived from the pilot project for the treatment of water from the Potomac estuary. Completion of such review and written report by the National Academy of Sciences-National Academy of Engineering shall be a condition of further authorization of such Sixes Bridge Dam Project.

(4) The Secretary of the Army is authorized to enter into appropriate arrangements with the National Academy of Sciences-National Academy of Engineering for the purpose of this subsection.

(c) There is authorized $1,000,000 for the purposes of carrying out the provisions contained in paragraph (3) of subsection (b)."

Prospect Peak Overlook along the Potomac River

utilities to serve new customers.

• Water supply capabilities of existing sources (reservoirs and the Potomac River) would not diminish appreciably over the planning period. Adequate land use controls would be practiced to at least maintain the present water supply capabilities and water quality characteristics of existing sources. As a related item, consumptive water uses in the Potomac River Basin upstream of the MWA would be controlled, especially during droughts.

• Water in the Potomac River and reservoirs presently serving the MWA would continue to be of suitable quality, following treatment, for potable purposes throughout the planning period. Existing water treatment plants could respond to slight changes in raw water quality without large-scale structural modifications.

• Population in the MWA would follow the general demographic patterns (size, location, and concentration) as projected by the Metropolitan Washington Council of Governments (MWCOG).

• An institutional arrangement such as the Potomac Low Flow Allocation Agreement (LFAA) would provide for the equitable distribution of Potomac River water among all users during low flow periods.

Study Process and the Report

The Metropolitan Washington Area Water Supply Study was initiated in 1976 immediately following appropriation of funds by Congress. Recognizing the study's lengthy and complex nature at the outset, the Corps devised a two-phased program. The first phase addressed the immediate or short-range water supply problems with the primary goal being more efficient use of existing water supplies. A ***Progress Report*** was published in August 1979 which evaluated the short-range problems and solutions for the MWA's major water supply systems. Chapter III provides a summary of the ***Progress Report***. Chapter IV discusses the ongoing efforts by the local water utilities to implement some of the alternatives examined in the ***Progress Report***.

Between 1979 and 1982, the study concentrated on the second phase of the investigation dealing with potential long-range water supply problems. The goal of the study's second phase was primarily to determine the feasibility of providing additional sources of raw water. Additionally, a reformulation study of the Corps' existing Bloomington Lake project on the North Branch Potomac River was conducted during the seccond phase to determine the maximum water supply capability of the existing project. Reallocation of existing storage or regulation of the project in a manner different than was originally envisioned may be economically and environmentally preferable to constructing a new project if additional water supply is needed.

The results of the entire Metropolitan Washington Area Water Supply Study are presented in this report which consists of a ***Main Report*** and nine supporting technical appendices as shown in Table 1. The ***Main Report*** provides a summary of the investigations, documentation of the planning process, a statement of significant findings and conclusions, and the recommendations of the District Engineer. The purpose of the ***Main Report*** is to tie together the many diverse components of a complex seven-year study in a concise and understandable format. The nine supporting technical appendices contain the information supporting the findings which are summarized in the ***Main Report*** . The annexes to the various appendices provide detailed data or complete reports about specific topics discussed in the respective appendices. Appropriate references are made throughout the text of the ***Main Report*** to detailed discussions in the appendices and annexes.

Prior Corps Studies and Reports

The history of water resources development in the Potomac River Basin includes many Congressional authorizations for individual studies, projects, and planning reports, dating from the 1800's to the present. Several of these studies are significant as they document comprehensive basin planning efforts as well as individual projects for water resources management.

In July 1955, Congress authorized a study of the North Branch Potomac River for the purposes of flood control, low flow augmentation, and water quality control. The Bloomington Lake project was subsequently authorized by the Flood Control Act of 1962 as a result of this earlier study. Located in Garrett County, Maryland, and Mineral County, West Virginia, the project was completed for operational purposes in 1981. This is the only Federal water storage project serving the MWA, and it provides 30 billion gallons (92,000 acre-feet) of storage for water supply, water quality, and recreation purposes. Releases during drought periods increase the dependable flow of the Potomac River between the project and Washington, D.C.

In January 1956, a Congressional resolution was passed directing the Corps of Engineers to prepare "...a comprehensive plan for the control of floods and the development and conservation of the water and related resources of the basin, with emphasis on present and future needs for water supply and pollution abatement." This authority provided the basis for the comprehensive Potomac River Basin Study.

The Potomac River Basin Study, completed in February 1963, underwent many additional reviews and changes before being submitted to the Congress in 1970. In reviewing the Secretary of the Army's recommendations for two upstream reservoir projects (Verona and Sixes Bridge), a 1972 Congressional Conference Report recommended that the projects be reformulated. The results of the reformulation were summarized in a 1973 document entitled ***Potomac River Basin Water Supply - An Interim Report***. Three distinct recommendations were made: (1) the authorization and construction of the reformulated Sixes Bridge and Verona projects for the purposes of water supply, recreation, and stream enhancement; (2) the authorization and construction of a prototype advanced water treatment plant (1 million gallon per day [mgd] capacity) to test the feasibility of using the Potomac Estuary as a supplemental water supply source for the MWA; and (3) the continuation of studies to prepare plans for meeting the water supply demands of the MWA.

A parallel Corps of Engineers study entitled the Northeastern United States Water Supply (NEWS) Study, completed in draft form in 1975 and in final form in 1977, examined water supply development throughout the northeast. The NEWS Study identified the MWA as a region with potentially severe water supply problems, and proposed a series of general programs for possible solutions.

Both the 1973 ***Potomac River Basin Water Supply - An Interim Report*** and the 1975 draft ***Northeastern United States Water Supply Study Report*** deserve mention. Their findings and recommendations ultimately led to Section 85, Public Law 93-251, which authorized the present study. Additional details about recent studies, reports, and recommendations are contained in Appendix A -***Background Information and Problem Identification***.

Related Water Resource Projects and Activities

In addition to the major Federal studies for comprehensive planning in the Potomac Basin just mentioned, the Corps of Engineers has been involved in many other activities as well. Construction of a temporary Potomac Estuary Emergency Water Pumping Station (EEWPS), authorized by the Supplemental Appropriations Act of 1971, was completed by the Corps in 1979. It provides for a maximum withdrawal of 100 mgd of water from the upper Potomac Estuary for use during critical water supply emergencies and is to remain in place until such time as other means are available to supplement the water supply sources of the MWA. The Estuary water would be pumped to the Dalecarlia Reservoir for subsequent purification at the Dalecarlia and McMillan water treatment plants. To date, it has not been necessary to use the EEWPS, and it is presently planned to deactivate this facility after Little Seneca Lake is constructed.

Construction of the Potomac Estuary Experimental Water Treatment Plant (EEWTP), authorized by Section 85(b)(2) of P.L. 93-251, was completed in 1980. The project was a water treatment plant of advanced design, with a nominal capacity of 1 mgd, which tested the feasibility of using the Potomac Estuary as a supplemental water supply source during droughts. A complete report on the two-year testing program is being

TABLE 1
REPORT ORGANIZATION.*
METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

Appendix Letter	Appendix Title	Annex Number	Annex Title
	Main Report		
A	Background Information & Problem Identification		
B	Plan Formulation, Assessment, and Evaluation	B-I	Water Supply Coordination Agreement
		B-II	Little Seneca Lake Cost Sharing Agreement
		B-III	Savage Reservoir Operation and Maintenance Cost Sharing Agreement
C	Public Involvement	C-I	Metropolitan Washington Regional Water Supply Task Force
		C-II	Public Involvement Activities - Initial Study Phase
		C-III	Public Opinion Survey
		C-IV	Public Involvement Activities - Early Action Planning Phase
		C-V	Sample Water Forum Note
		C-VI	Public Involvement Activities - Long-Range Planning Phase
		C-VII	Citizens Task Force Resolutions
		C-VIII	Background Correspondence
		C-IX	Coordination with National Academy of Sciences - National Academy of Engineering
		C-X	Comments and Responses Concerning Draft Report
D	Supplies, Demands, and Deficits	D-I	Water Demand Growth Indicators by Service Areas
		D-II	Service Area Water Demand & Unit Use by Category (1976)
		D-III	Projected Baseline Water Demands (1980-2030)
		D-IV	Potomac River Low Flow Allocation Agreement
		D-V	Potomac River Environmental Flowby, Executive Summary
		D-VI	PRISM/COE Output, Long-Range Phase
E	Raw and Finished Water Interconnections and Reregulation	E-I	Special Investigation, Occoquan Interconnection Comparison
F	Structural Alternatives	F-I	Digitial Simulation of Groundwater Flow in Part of Southern Maryland
G	Non-Structural Studies	G-I	Metropolitan Washington Water Supply Emergency Agreement
		G-II	The Role of Pricing in Water Supply Planning for the Metropolitan Washington Area
		G-III	Examination of Water Quality and Potability
H	Bloomington Lake Reformulation Study	H-I	Background Information
		H-II	Water Quality Investigations
		H-III	PRISM Development and Application
		H-IV	Flood Control Analysis
		H-V	US Geological Survey Flow Loss and Travel Time Studies
		H-VI	Environmental, Social, Cultural, and Recreational Resorces
		H-VII	Design Details and Cost Estimates
		H-VIII	Drawdown Frequency and Yield Dependability Analyses
		H-IX	Bloomington Future Water Supply Storage Contract
		H-X	Novation Agreement
I	Outlying Service Areas		

*The Final Report for the Metropolitan Washington Area Water Supply Study consists of a ***Main Report***, nine supporting appendices, and various annexes as outlined above. The ***Main Report*** provides an overall summary of the seven-year investigation as well as the findings, conclusions, and recommendations of the District Engineer. The appendices document the technical investigations and analyses which are summarized in the ***Main Report***. The annexes provide detailed data or complete reports about individual topics contained in the respective appendices.

submitted by the Corps to Congress in direct response to the authorization. The findings and conclusions of the testing program are also documented in Appendix F - ***Structural Alternatives*** of this report because the Potomac Estuary is one possible source for future supplmental water supply.

The Potomac Low Flow Allocation Agreement (LFAA), signed in 1978 and modified in 1982, provides an equitable means of sharing all sources of supply so that no area would suffer disproportionate shortages during low flow periods. Signatories included the Department of the Army, the State of Maryland, the Commonwealth of Virginia, the District of Columbia, the Washington Suburban Sanitary Commission, and the Fairfax County Water Authority. The principal feature of the LFAA is a formula which would allocate a share of the Potomac River flow to each user on the basis of previously determined water use. While the LFAA does not furnish additional water, it does assure that the water resource is distributed equitably during low flow periods. Furthermore, adoption of the LFAA represented a significant step by the MWA water suppliers to address water shortages in a regional manner. Detailed discussion of the terms and application of the LFAA is contained in Annex D-IV of Appendix D - ***Supplies, Demands, and Deficits***.

Subsequent to the signing of the LFAA and in accordance with its provisions, the State of Maryland initiated a multi-agency study to determine an appropriate volume of flowby. Flowby was defined to be the flow remaining in the Potomac River, after water supply withdrawals, which would be necessary to maintain environmental conditions in the lower portion of the free-flowing Potomac River as well as the upper Potomac Estuary. Conceivably, full operation of all Potomac River water supply intakes, coupled with a drought, could result in withdrawal of all water from the Potomac River. In the past flowby values ranging from as low as zero to as high as 1200 million gallons per day (mgd) have been proposed. The State of Maryland's flowby study, completed in December 1981, contained two major recommendations. One recommendation addressed the free-flowing stretch of the Potomac River between Great Falls and Little Falls, just upstream of tidal influence. Specifically, when the flow at the Washington Aqueduct's Great Falls intake drops below 500 mgd, the Aqueduct should begin shifting its withdrawals to the Little Falls intake so that at least 300 mgd remains in the Potomac River throughout the reach. The second recommendation called for at least 100 mgd of fresh water to flow past the Little Falls intake and into the tidal Potomac Estuary during even the most severe droughts. Annex D-V contains the executive summary of Maryland's flowby study. These recommendations for minimum flowby levels were subsequently adopted by the signatories of the LFAA. Determination of the flowby levels furnished minimum environmental requirements to be considered along with essential human, industrial, and other domestic water supply needs.

In November 1979, a Section for Cooperative Water Supply Operations on the Potomac (CO-OP) was established by the Interstate Commission on the Potomac River Basin (ICPRB) under its Article III charter authority. The CO-OP Section is composed of ICPRB commissioners from the District of Columbia, Maryland, Virginia, and West Virginia and is supported by a technical advisory group comprised of representatives from the MWA's three major water utilities. The general purposes of the CO-OP are to assist in resolving MWA water supply isses, negotiating contracts and agreements for water supply, and developing regional regulation procedures for water supply reservoirs serving the MWA. The CO-OP Section has developed and is using a water supply simulation model to evaluate the effectiveness of various daily reservoir regulation strategies.

Study Participants and Coordination

A continuous effort was made to elicit public participation throughout the seven-year study. A public participation and coordination program was devised to assure that the study met the needs and desires of the agencies, organizations, and individuals responsible for water supply planning in the MWA. This program included activities such as public meetings, workshops, and meetings with local officials and other interested groups. Announcements, newsletters, and progress reports were also distributed at key points during the study.

Several committees were used to assist the Corps of Engineers in conducting the Metropolitan Washington Area Water Supply Study. At the beginning of the study in 1976, the Metropolitan Washington Council of Governments (MWCOG) was actively involved in water resources planning, primarily through its work on a Section 208 wastewater management plan for the region. The MWCOG Water Resources Planning Board provided policy review of the study's early stages, and the MWCOG Water Supply Advisory Committee provided technical review.

Following a series of workshops throughout suburban Maryland, northern Virginia, and the District of Columbia, the Corps established a Citizens Task Force (CTF) to furnish a non-technical viewpoint of the water supply planning process. This group was comprised of people with diverse backgrounds from the MWA as well as people from areas both upstream and downstream. The Corps also established a Federal-Interstate-State-Regional Advisory Committee (FISRAC) made up of MWA water supply experts to provide overall guidance and direction specifically for the Metropolitan Washington Area Water Supply Study. As a result of the findings contained in the Corps' August 1979 ***Progress Report***, members of the FISRAC created an independent group in January 1980 to initiate implementation of certain water supply projects and programs at the non-Federal level. This group was called the Metropolitan Washington Regional Water Supply Task Force (RTF) and was composed of area-wide political representatives. Recognizing that the cost for water supply development is traditionally a non-Federal responsibility anyway, the purpose of the group was to develop and obtain the necessary commitments to implement a regional water supply management strategy for the MWA. This group also worked closely with the CO-OP Section discussed in a previous paragraph.

As directed by Section 85(b)(3) of P.L. 93-251, the National Academy of Sciences - National Academy of

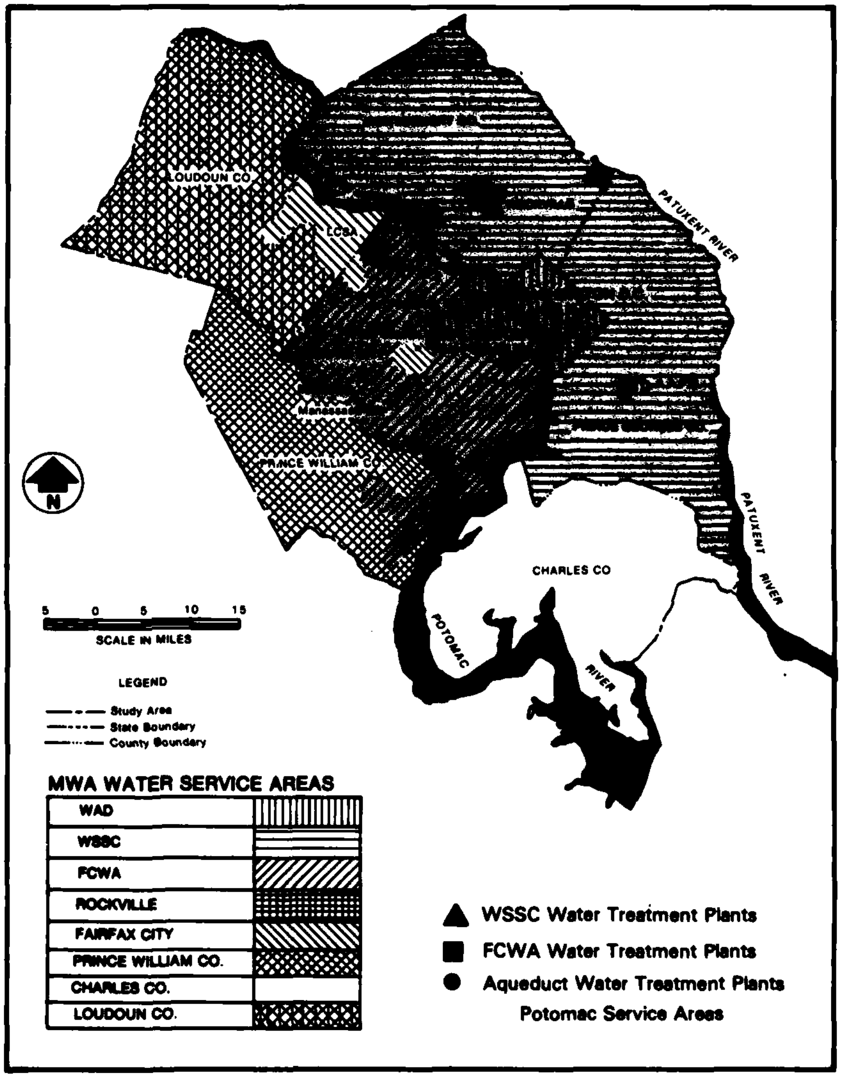
Engineering (NAS-NAE) assembled a committee "...to review and by written report comment upon the scientific basis for the conclusions reached by the investigation and study of the future water resource needs of the Washington metropolitan area..." This committee, composed of distinguished engineers and scientists, was formed in 1977. Members convened periodically throughout the study to review and comment on the study's progress. The committee is preparing a summary evaluation of the Corps' ***Final Report***. The committee plans to submit this evaluation directly to the U.S. Congress.

Participants during the study included: state, county, and local elected officials from Maryland, Virginia, and the District of Columbia; the Washington Suburban Sanitary Commission, the Fairfax County Water Authority, the Washington Aqueduct Division, and other smaller water utilities; state, county, and local planning and resource agencies; the Interstate Commission on the Potomac River Basin; the League of Women Voters; Federal agencies such as the U.S. Geological Survey (USGS) and the U.S. Fish and Wildlife Service (USFWL); and various other agencies, organizations, businesses, and individuals too numerous to mention in this summary document. The Corps of Engineers also participated on numerous committees and in many meetings where its expertise in water resources planning, and in particular its knowledge of the MWA's regional water supply situation, was requested.

More discussion of the public involvement program's objectives and accomplishments are provided in Chapter VII. Appendix C - ***Public Involvement*** provides a chronology of the public involvement program along with pertinent study correspondence. Appendix C also contains public comments and the Corps' responses concerning the draft report which was distributed for public review in March 1983.

Chapter II
Description of Study Area

Fig. 3-MWA Water Service Areas



The following sections summarize the existing and probable future setting in the Metropolitan Washington Area in the context of its resource base. Problems, needs, and opportunities are discussed, and National planning objectives are described along with the study planning objectives.

Major Water Supply Features

For the purposes of the Metropolitan Washington Area Water Supply Study, it was necessary to define two areas of study. The first area consisted of the MWA's "demand" area, or that region around the Nation's Capital which generates sizable water needs. The second area was the MWA's "supply" area, or those portions of surrounding river basins and watersheds which presently provide or could potentially furnish water to the MWA.

Demand Area

A brief description of the demand area was already given in Chapter I. As shown on Figure 3, the MWA was identified to include the following: the counties of Loudoun, Prince William, Fairfax, and Arlington and the independent cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park in Virginia; the counties of Montgomery, Prince Georges, and Charles in Maryland; and the District of Columbia. Within this large demand area, there are 25 independent water supply systems ranging in capacity from less than 1 mgd to several hundred mgd. The four Potomac water supply systems - the Washington Suburban Sanitary Commission (WSSC), the Fairfax County Water Authority (FCWA), the City of Rockville, and the Washington Aqueduct Division (Aqueduct) - furnish almost 96 percent of the MWA's treated water supply. These four water service areas shown on Figure 3 are the primary focus of this report.

Most of the non-Potomac service areas are located in Loudoun, Prince William, and Charles Counties surrounding the urban core. These outlying areas are typically comprised of many small systems which furnish water to individual towns or villages. Most of these systems rely solely on wells. The non-Potomac service areas were not examined in as great a detail as the four Potomac service areas; some reconnaissance level investigations were made, however, and these efforts are documented in Appendix I - *Outlying Service Areas*.

As shown on Figure 3, the WSSC serves Montgomery and Prince Georges Counties in Maryland. The primary water supply sources are the Potomac River and two reservoirs (Triadelphia and Rocky Gorge) on the Patuxent River along the northeastern edge of the MWA. The WSSC operates two water treatment plants -one on the Potomac River near Watts Branch and one on the Patuxent River near Rocky Gorge Reservoir. The FCWA serves the City of Alexandria, most of Fairfax County, and part of Prince William County. The FCWA relies on the Occoquan Reservoir and the Potomac River as its primary water supply sources, with water treatment plants downstream of the Occoquan Reservoir and near Lowes Island on the Potomac River. The Aqueduct is operated by the U.S. Army Corps of Engineers and serves the District of Columbia, Arlington County, Falls Church, and part of Fairfax County. The Aqueduct's only water supply source is the Potomac River, with intakes at both Great Falls and Little Falls. Water is treated at both the Dalecarlia and McMillan water treatment plants. A fourth and smaller water supply system, the City of Rockville, also uses the Potomac River as its sole water supply source. Figure 3 shows the general location of the major water service areas and their water treatment plants.

Figure 4 displays a schematic of the MWA's water supply system, showing (a) sources of raw water; (b) supply agencies which produce finished water; (c) a delineation of service areas; and (d) a definition of major jurisdictions served where service area geographical coverage is not obvious. The supply agencies shown on Figure 4 have treated and distributed over 500 mgd on many summer days during recent years.

In terms of potability, these water supply utilities produce treated water which satisfies the current drinking water regulations for the United States as promulgated by the U.S. Environmental Protection Agency (EPA). These standards are set forth in EPA's National Interim Primary Drinking Water Regulations and in EPA's National Secondary Drinking Water Regulations established pursuant to P.L. 93-523 - The Safe Drinking Water Act of 1974. The waters of the Potomac, Patuxent, and Occoquan Rivers, when treated at the existing MWA water treatment plants, are expected to provide a safe source of drinking water in future years as well.

Supply Area

Because of its location along the fall line between the Piedmont Plateau and the Coastal Plain, the MWA is in a position to use a number of water supply sources both inside and outside the immediate demand area. The most obvious supply area is the Potomac River Basin which currently provides about 70 percent of the MWA's water supply. As shown on Figure 5, the Potomac River drainage area upstream of the District of Columbia covers about 11,560 square miles and furnishes an average annual flow of 7,206 mgd. Summertime flow, however, has been observed as low as 388 mgd in September 1966.

Numerous surface water impoundments to serve the MWA have been proposed throughout the Potomac River Basin. But only Bloomington Lake on the North Branch Potomac River has been con-

Fig. 4-Schematic of the MWA Regional Water Supply

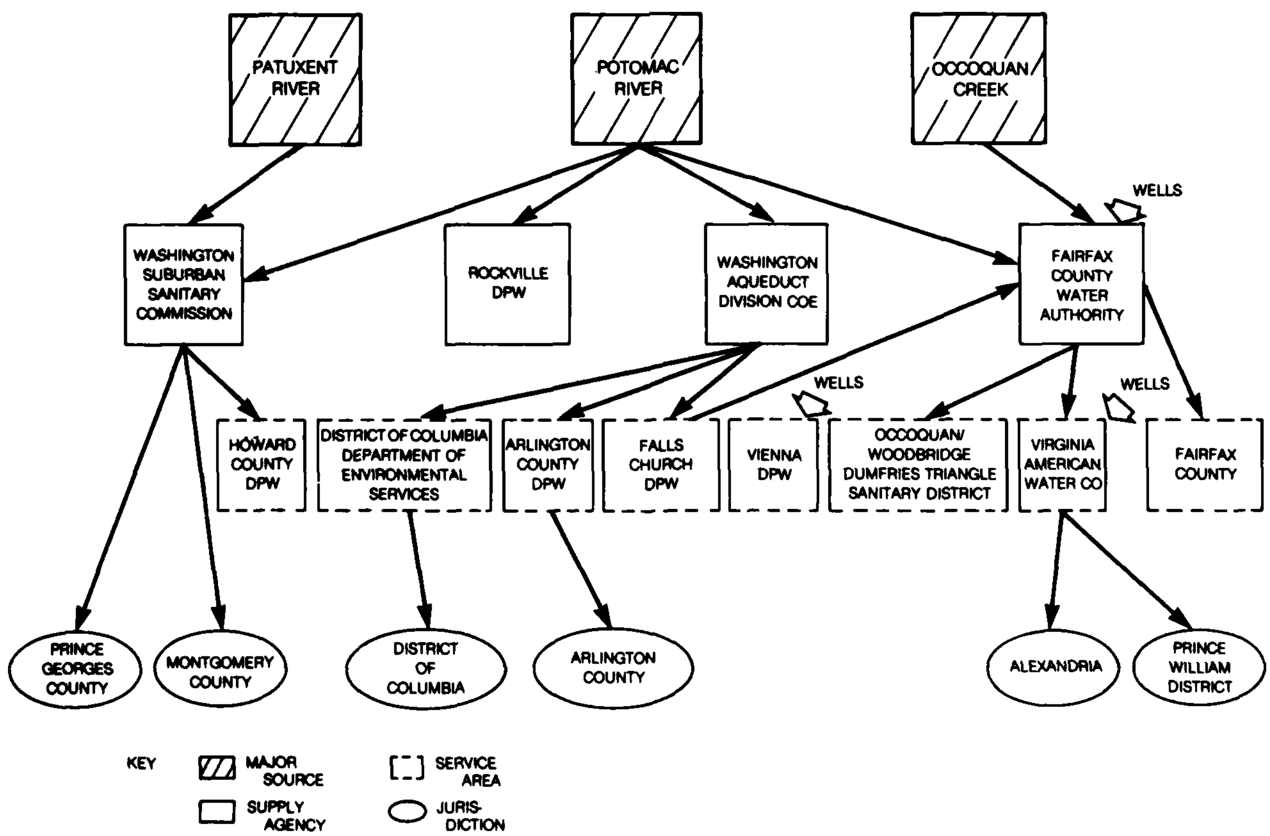
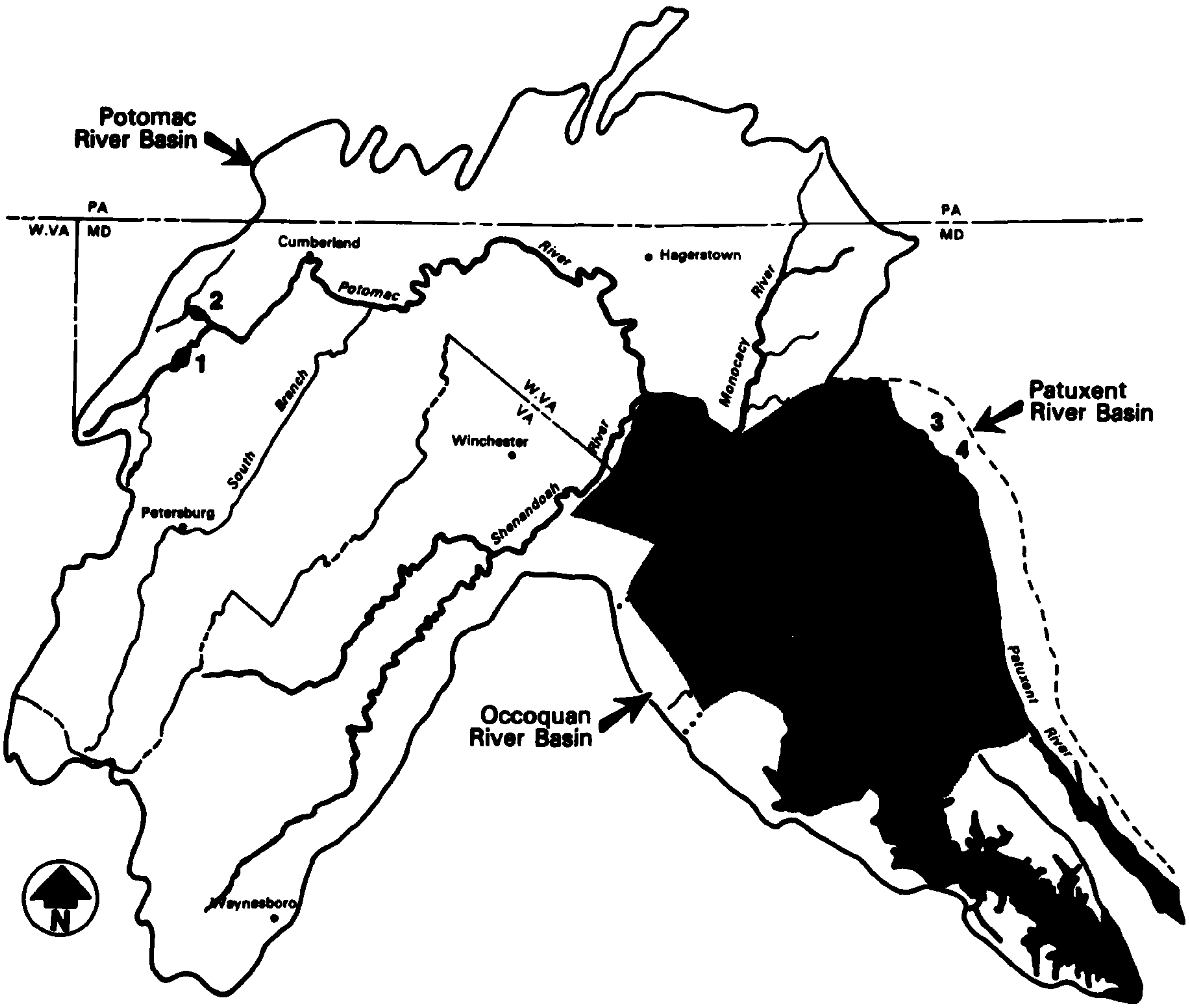


Fig. 5-Drainage Basins Affecting the Metropolitan Washington Area



Legend

Metropolitan Washington Area (Includes the following: Washington, DC; Montgomery, Prince Georges and Charles counties in MD; and Arlington, Fairfax, Prince William and Loudoun counties in VA).

1 Bloomington Reservoir
2 Savage Reservoir
3 Triadelphia Reservoir
4 Rocky Gorge Reservoir
5 Occoquan Reservoir

structed with downstream water supply as a specific purpose. Bloomington Lake presently contains about 13.4 billion gallons of water supply storage as part of a total 30.0 billion gallons of water conservation storage Appendix H - ***Bloomington Lake Reformulation Study*** provides additional details about the existing Bloomington Lake project as well as an examination of possible reallocation among project purposes to provide more water supply storage. A second project, the Savage River Reservoir, is also located in the North Branch Potomac River Basin. This project provides low flow augmentation and water quality control for areas immediately downstream near Luke, Maryland. The locations of both projects are shown on Figure 5; they are about 230 river miles upstream from the MWA water supply intakes.

A second supply area is the Patuxent River Basin upstream of Laurel, Maryland (see Figure 5). Runoff from a 132-square mile area is captured in two water supply reservoirs, Triadelphia and Rocky Gorge, which provide storage for the WSSC system. Total storage in the two reservoirs is about 10.1 billion gallons and provides for about 12 percent of the MWA's water needs.

A third supply area is the Occoquan Creek Basin along the southwestern edge of the MWA in Virginia as shown on Figure 5. A number of water supply impoundments are located in the Occoquan Creek Basin which has a total drainage area of about 570 square miles. The Occoquan Reservoir, located near the mouth of the Occoquan River, is the major impoundment in the Basin and provides about 10.3 billion gallons of water supply storage for the FCWA system. The Occoquan Reservoir furnishes water for about 14 percent of the MWA's needs.

Taken together, the surface waters of the Potomac, Occoquan, and Patuxent River Basins satisfy about 96 percent of the MWA's water needs. These three river basins thus constitute the primary study area for investigating existing and potential water supply alternatives for the MWA's needs. As described later in the ***Main Report***, the supply study area was further expanded to include the Potomac Estuary in the Washington, D.C. area (possible use of Estuary water) and the Atlantic Coastal Plain area of Southern Maryland (possible use of groundwater).

Existing and Future Without Conditions

Existing conditions are those physical, ecological, demographic, and economic characteristics of a region that are defined at the time of study. They form the basis for projecting the future conditions that would be expected in the absence of any water resources development plan. The following sections describe the existing and projected future "without conditions" of the MWA.

It should be noted that this chapter provides only an overview of the MWA's regional water supply situation. Computations showing actual water needs, in terms of quantity of water required, are contained in the following chapters. Chapter III discusses the "without condition" surpluses and shortages as calculated at the beginning of the early-action phase of study. Based on the findings of the early-action phase, certain actions to overcome the projected shortages were initiated by non-Federal entities as described in Chapter IV. Implementation of these projects and programs necessitated numerous revisions and modifications to the "without condition" such that surpluses and shortages were recomputed. The surpluses and shortages, as revised for the long-range phase, are discussed in Chapters IV and V.

Environmental Setting and Natural Resources

The following subsections provide an overview of the environmental setting and natural resource characteristics, concentrating mostly on the MWA demand area. More detailed information is provided in Appendix A -***Background Information and Problem Identification***.

Brighton Dam and Triadelphia Reservoir, Washington Suburban Sanitary Commission

Physiography

The MWA is situated within three physiographic provinces from east to west: the Atlantic Coastal Plain, the Piedmont Plateau, and the Blue Ridge. While the land surface in the MWA ranges from near mean sea level (msl) in the eastern portion to 1800 feet msl in the western portion, the majority of the MWA is gently rolling with elevations ranging from 200 to 600 feet msl. Surface area within the MWA covers about 3,000 square miles, including 200 square miles of water surface and 2,800 square miles of land surface. Upstream of the MWA, a large portion of the Potomac River Basin lies within the Appalachian Plateau and Ridge and Valley Provinces.

Climate

The climate of the MWA is generally temperate with seasonal extremes more pronounced in the northern and western suburbs than in the eastern tidewater sections of Charles County, Maryland, and Prince William County, Virginia. The summers are warm and humid, with the month of July exhibiting the highest mean temperature of about 78 degrees Farenheit (F). The winters in the MWA are generally mild, with the month of January having the lowest mean temperature of about 36 degrees F. The average frost-free season is about 200 days in the MWA. Average summer and winter temperatures are lower in the upstream portions of the Potomac River Basin, and the frost-free period drops to about 150 days in the westernmost portion of the Basin.

Precipitation within the MWA is not defined by particularly wet or dry seasons. In general, there is a greater abundance of precipitation during the period March through August than during the fall and winter. The average annual rainfall in the area is 40 inches and is distributed somewhat unevenly over the year, with the mean monthly precipitation ranging from 2.59 inches in January to 4.75 inches in August. These averages vary only slightly in the upstream portions of the Potomac River Basin west of the MWA.

Soil and Mineral Resources

The soils over the crystalline rocks of the Piedmont and the Blue Ridge cover approximately half of the MWA. These soils are shallow to deep loam, or silt loam on rolling to steep topography. The soils on the sandstone, shale, and conglomerate in western Montgomery County, Maryland, and parts of Fairfax and Loudoun Counties, Virginia, are shallow to moderately deep silt loams to sandy loams on gently rolling topography, with many areas that are nearly level and poorly drained.

The soils on limestones cover about 12 square miles in Loudoun County. These soils generally are moderately well to excessively drained, and range in texture from gravelly to rocky to silt loam. The soils on mixed crystalline rocks and coastal plain sediments cover a 42-square mile strip that extends from central Fairfax County, Virginia, into Arlington County, Virginia. These soils, which exhibit characteristics of both the Piedmont and Coastal Plain soils, are silty loams and loams that range from poorly drained to well drained and cover topography that ranges from level to steep.

The soils of the Coastal Plain sediments occur east of the fall line in Charles and Prince Georges Counties, Maryland, and in eastern Fairfax and Prince William Counties, Virginia. The soils vary from sandy to clayey and from poorly to excessively drained. The soils on alluvial terraces and floodplains are a result of previous and existing floodplains, respectively. Both alluvial terrace soils and floodplain soils are favorable for agriculture.

The distribution of mineral resources in the MWA is a direct consequence of the geology of the region. Sand and gravel, derived from the Coastal Plain formations, can be extracted from numerous pits along the eastern border of Montgomery County, Maryland; Fairfax and Prince William Counties, Virginia; and Prince Georges and Charles Counties, Maryland. Abundant clay resources extracted from shale and clay formations in the Coastal Plain section of the MWA have made brick a major local building material. Parts of the Piedmont Plateau and Blue Ridge Province are underlain with significant quantities of material suitable for crushed and building stone. It is expected that in the future, the demand for construction materials, particularly sand and gravel, will increase with any increase in population or development.

Terrestrial Resources

The woodlands of the MWA comprise part of the temperate deciduous forest biome known as the oak-deer-maple biome, whose chief characteristic is the predominance of trees with broad leaves that shed each autumn. The understory of small trees is also deciduous. The dominance of the oak-hickory-chestnut forest throughout most of the area has been diminished through lumbering, agriculture, and the death of the American chestnut from the chestnut blight. Since the blight of the American chestnut, the forests are becoming more populated with red oak, chestnut oak, and white oak. The southern Piedmont and Coastal Plain are still dominated by loblolly and shortleaf pine forests. The extreme western Potomac Basin in the more mountainous reaches shows the dominance of elms and basswood. There are about 50 deciduous shrubs and understory trees that are important in the forest, along with about 15 evergreen shrubs and a dozen vines. These subordinate species support a rich fauna of insects and spiders.

Important animals originally associated with the oak-hickory-chestnut forest were deer, elk, wolves, mountain lion, black bear, bobcat, gray fox, raccoon, fox squirrel, eastern chipmunk, white-footed mouse, pine vole, and short-tailed shrew. Since colonial days, the timber wolf, panther, elk, and American bison have entirely disappeared; however, the black bear and the bobcat are still found in the heavily timbered reaches of the Potomac River Basin in the Allegheny Mountains. A great number of nongame forest and river species now exist in the MWA environment.

Aquatic Resources

A review of the literature indicates that information on the aquatic vegetative resources of the non-tidal sections of the Potomac, Occoquan, and Patuxent Rivers is limited. Existing data, however, show that high planktonic production has occurred in the Potomac River. In the estuarine section of the Potomac River, fairly extensive data exist with regard to phytoplankton. As in most estuarine situations, conditions in the upper Potomac Estuary are conducive to the production of phytoplankton. Benthic algal primary production is generally reduced because of high turbidity. In the 1950's, 1960's and early 1970's, there were numerous noxious phytoplankton blooms of blue-green algae. Algal blooms are a typical symptom of eutrophic conditions. Aside from their undesirable aesthetic aspects, they can also cause large diurnal fluctuations in the dissolved oxygen content of the water and disrupt the food chain. Nutrient enrichment from agricultural and urban runoff basin-wide, and from wastewater treatment facilities in the upper Estuary, is considered to

South Branch Potomac River near Petersburg, WV

be the major factor causing the blooms. Since 1972, no major blooms have occurred, although the nutrient levels appear to have been high enough to support blooms.

Cold-water streams in the Potomac River Basin upstream from the MWA support limited populations of native brook trout that are supplemented by annual stocking of hatchery-reared trout. Smallmouth bass streams account for about 15,000 acres of the fishery resource in the Potomac River Basin, combining high natural productivity and aesthetic appeal. The South Fork of the Shenandoah River, the South Branch of the Potomac River, and the Cacapon River are among the finest bass streams in the United States. Catfish streams account for about 14,000 acres of the Potomac's 33,000 acres of fishery habitat above Great Falls. Rocky Gorge and Triadelphia, the two water supply reservoirs located on the Patuxent River, each provide 800 acres of pond-type habitat that support a wide variety of recreationally and non-recreationally important fish species. A stocking program for the two reservoirs exists for game species, notably bass, northern pike and catfish. Resident populations have been established but are relatively small. The Patuxent and Little Patuxent Rivers also provide considerable riffle type habitat for nest-building species. The Occoquan and related tributaries support a wide variety of game and nongame fish species. Habitat types vary from a pond (reservoir) effect in the Occoquan Bay to a fast flowing headwater habitat farther upstream (Bull Run and Little Bull Run). Recreational use of these areas is quite high, particularly in the Occoquan Reservoir. Channel cats, striped bass, and northern pike are currently stocked in sizable numbers. Recent creel census data indicate heavy angling pressure.

The Potomac River Estuary also supports a significant fishery, both in terms of anadromous and resident species. Sixty-four species of fish have been collected from the Estuary below Washington, D.C.; however, many of these are estuarine or marine and do not enter the upper Estuary. Fish within the Estuary may be either freshwater spawners, estuarine spawners include the totally freshwater species in the area, as well as many anadromous varieties. Significant spawning of yellow perch, alewife, blueback herring, and white perch occurs from the Wicomico River up to Little Falls. Estuarine species spawn and mature in higher salinity waters below the MWA. In general, the larvae of this group either remain in the area where they were hatched, or move upstream to the vicinity of the salt-freshwater interface. Significant species include the bay anchovy, salt marsh killifish, siversides, and tidewater silversides. Marine spawners are fish whose larvae hatch in the marine environment and show varying degrees of dependency on the upper Estuary. Of these, only the American eel and spot are known to move into the freshwater portion of the Estuary. The most important species utilizing the upper Estuary at some stage in their life history are the alewife, blueback herring, channel catfish, brown bullhead, white catfish, white perch, American eel, yellow perch, and the hogchoker.

Water Quality

As the Potomac River flows downstream, tributary streams contribute large quantities of water. The quality of the water of each tributary is influenced by variances in topography and discharges of wastewater effluent generated by domestic, industrial, and agricultural activities. For these reasons, the water quality of the Potomac River changes from one reach of the river to another in relation to the proximity of point and non-point pollutant discharges.

In the waterways of the North Branch Potomac River, the upper one-third is affected by acid mine drainage, originating from both active and abandoned coal mine operations. The middle and lower subreaches of the North Branch receive significant industrial and municipal discharges.

Water of better quality from large tributaries, including the South Branch and the Cacapon River, helps to improve the quality of the Potomac as it flows downstream. Dilution and self-purification make the water quality acceptable for the level and type of uses presently made of the river between Oldtown and Williamsport, Maryland. The population along this reach is relatively sparse. Surface runoff and wastewater from several small communities constitute the only known waste sources.

As the Potomac River flows toward the District of Columbia, residential, commercial, and industrial developments become more intense along most tributary streams causing a deterioration in water quality. Principal sources of bacteria appear to be surface drainage; erosion and sedimentation from urban runoff also cause some problems. With the exception of occasional taste and odor problems, though, the water in the Potomac River is generally considered to be of high quality and is suitable for potable purposes following proper treatment.

The water quality in the 40-mile reach of the upper Potomac Estuary is degraded by pollution from wastewater discharges and urban runoff. These pollutants originate from the MWA's population of almost three million. Further complications arise from the salinity level, which sometimes promotes sedimentation and retention of the sediment in the Estuary. In the lower Potomac Estuary, the water quality conditions are slightly improved. However, algal blooms, depleted oxygen at some depth, and high coliform counts have been noted on some occasions.

The water in the upper reach of the Patuxent River is clean and of good quality. The river receives little man-made pollution in this area primarily as a result of conscious decisions to protect the area with land uses such as parkland and low density development. The water is used as a water supply source by the Washington Suburban Sanitary Commission. Two reservoirs, Triadelphia and Rocky Gorge, are located on this section of the Patuxent River.

The middle reach of the river encompasses an area that has experienced rapid residential, industrial, and commercial growth. Wastewater discharge from a population of approximately 150,000 and associated industrial wastes are discharged into this reach of the river. The high pollution load and the sluggishness of the river water cause some pollution problems. About 15 miles of the upper Patuxent Estuary is filled with silt. The salinity fluctuates greatly with freshwater flow, tides, and winds. The estuary portion acts like a reservoir, retaining many of the pollutants that have been brought down the Patuxent River.

The water of the Occoquan Basin is generally of poorer quality than that of the Patuxent Basin. The Basin, which includes Bull Run, Cedar Run, Broad Run, as well as Occoquan Creek, suffers non-point source pollution from wastewater treatment plants in the past. However, in recent years the consolidation of several plants into one advanced wastewater treatment plant has improved this situation.

An indication of the water quality conditions in the Basin can be observed in the Occoquan Reservoir. The Occoquan Reservoir, which is located downstream from the majority of the urbanization, has exhibited eutrophic conditions due to excessive concentrations of nitrogen and phosphorus. Studies have shown that 50 to 60 percent of the total nutrient load discharge into the reservoir is derived from stormwater runoff from urban and agricultural land.

A regional non-point pollution management program has been formulated and implemented within the Occoquan Basin in an effort to reduce the pollution during stormwater events. However, since developmental pressures within the watershed are strong, the present water quality conditions are likely to continue for some time.

Rare and Endangered Species

Within the MWA, only two species are protected by law (Endangered Species Act of 1973; 16 U.S.C. 1531-1543): the southern bald eagle and the peregrine falcon. The Chesapeake Bay region is a nesting area for bald eagles, and they are dependent upon fish food sources from the Potomac River and the lower estuarine waters. Charles County, Maryland, has a breeding population of four or five pairs of eagles. Additionally, eagles frequent the shores of the Patuxent River during the period of January through July. The peregrine falcon is an occasional winter or migratory visitor.

Demographic Characteristics

Between 1960 and 1970, the MWA's total population increased from 2.1 million to 2.9 million for a 38 percent growth rate during the decade. This large percentage increase made the MWA the fastest growing large metropolitan area in the nation during the 1960's. The large increase was a result of several economic factors: (1) the post-World War II increase in government due to the introduction and administration of new programs; (2) the increased employment opportunities in the non-governmental sector; and (3) the location of the MWA at the southern end of the Northeast megalopolis.

By the mid-1970's, however, the growth trends had slowed considerably. The 1980 census data indicated a total population of about 3.1 million, for an approximate 5 percent growth rate for the decade of the 1970's. The slower growth rate in the 1970's can be attributed to several factors: (1) the economic recession of the

Wastewater Treatment Plant, Upper Occoquan Sewage Authority

mid-1970's and associated high interest rates discouraging migration (2) a slower growth rate in the Federal government establishment; (3) public opposition to proposed major development in the MWA; and (4) a slower growth rate nationwide.

Table 2 provides a listing of population by major jurisdiction according to the 1970 and 1980 U.S. Census showing regional totals of 2,911,000 and 3,060,000, respectively. Also shown in Table 2 is the projected population of the MWA for 1990, 2000, 2010, 2020, and 2030. (See Appendix D - ***Supplies, Demands, and Deficits*** for a detailed explanation of the population projections). By 2030, the end of the 50-year planning period used during the study, the MWA's total population is expected to reach about six million. These population projections are based on estimates by the Metropolitan Washington Council of Governments (MWCOG) Cooperative Forecasting Program for the next 20 years and extended by the Corps of Engineers to the year 2030 using growth rates obtained from the Bureau of Economic Analysis.

While the projections indicate that population is expected to increase in all of the counties and municipalities, the peripheral counties of Charles, Loudoun, and Prince William are especially susceptible to development pressures. The urban core communities including the District of Columbia, Arlington County, and the adjacent portions of Fairfax, Montgomery, and Prince Georges Counties, are already extensively developed and new development in these areas is expected to be minimal.

The 1980 Census estimated about 1.2 million households in the MWA for an average household size of about 2.6 persons. The household size, however, ranged from about 2 persons per household in Alexandria and Arlington County to well over 3 persons per household in Charles and Prince William Counties. Current projections reflect a slow trend toward smaller household size in the future, particularly in the urban core areas which have a high concentration of townhouses and apartments and fewer single-family detached homes.

Employment is expected to show a moderate rise from about 1.6 million jobs in 1980 to about 2.4 million jobs in the year 2000, according to MWCOG estimates. However, there will be a slow shift in employment distribution. The Federal government's share of total employment will decrease from about 25 percent in 1980 to about 20 percent in the year 2000. This percentage decrease for the Federal Sector will be more than offset by an increase in the employment share attributed to the Services Sector (increasing from 25 percent in 1980 to about 33 percent in 2000). The Manufacturing and Wholesale Sectors, normally the largest employer in established metropolitan areas, is estimated to provide only 5 or 6 percent of the jobs in the MWA because of the unique nature of the regional economy centered around the Federal government. Although the direct contribution of the Federal government to employment is projected to decline, its importance to the MWA's regional economy will not.

Problems, Needs, and Opportunities

Several noteworthy droughts have occurred in the MWA since streamflows were first recorded in the late 1800's. The two most severe droughts occurred in the early 1930's and mid-1960's. The worst droughts were caused by below average rainfall and snowfall over several years, resulting in lower streamflows and groundwater levels each succeeding summer. The months of lowest streamflow in the MWA are normally July through November, a time when water use is also at its greatest.

Because the MWA is highly dependent on the variable Potomac River flow (about 70 percent of the MWA's supply comes from the Potomac), the coincidence of low streamflow and large demand within the same time frame suggests the possibility of a water supply shortage. A shortage is defined as the amount by which demand exceeds supply. The possibility of shortage increases yearly as water supply use continues to grow with an expanding MWA population. The lowest observed flow in the Potomac River was 388 mgd on 12 September 1966. Daily withdrawals from the Potomac River for water supply purposes first exceeded this historical

TABLE 2-
POPULATION PROJECTIONS FOR THE MWA, 1970-2030 (1,000's)

	1970[1]	1980[1]	1990	2000	2010	2020	2030
POTOMAC USERS[2]							
District of Columbia	757	638	772	798	806	810	810
Montgomery County	523	579	717	792	851	909	952
Prince Georges County	662	665	934	1,101	1,262	1,397	1,506
Arlington County	174	153	183	193	191	190	187
Fairfax County	454	597	852	1,001	1,116	1,277	1,430
Alexandria	111	103	148	167	178	190	198
Falls Church	11	10	14	15	15	15	15
Sub-Total: Potomac	2,692	2,745	3,620	4,067	4,419	4,788	5,098
NON-POTOMAC USERS[3]							
Charles County	48	73	92	110	134	160	185
Loudoun County	37	57	109	150	218	305	411
Prince William County	95	145	211	261	337	423	516
Fairfax	23	19	22	24	24	24	23
Manassas	9	15	21	26	30	36	42
Manassas Park	7	6	10	12	16	18	21
Sub-Total: Non-Potomac	219	315	465	583	759	966	1,198
TOTAL	2,911	3,060	4,085	4,650	5,178	5,754	6,296

[1] Numbers for 1970 and 1980 are based on Decennial Census data contained in the 1980 Census of Population and Housing

[2] Estimates of population for the Potomac River Users are based on the Metropolitan Washington Council of Governments (MWCOG) Round I Population Forecasts to 1995 with extrapolations to the year 2030 by the Corps of Engineers using Bureau of Economic Analyses growth rates

[3] Estimates of population for the Non-Potomac Users are based on the MWCOG Round II Population Forecasts to the year 2000 Populations were extrapolated by the Corps of Engineers to the year 2030 using Bureau of Economic Analysis growth rates

low flow in 1971. Since then, daily withdrawals have exceeded this historical low flow nearly 100 times as water supply uses have slowly grown. With the recent completion of the Bloomington Lake project, the dependable flow in the Potomac River has increased somewhat. However, future water supply shortages could still be possible should low flows occur during periods of high seasonal water demands.

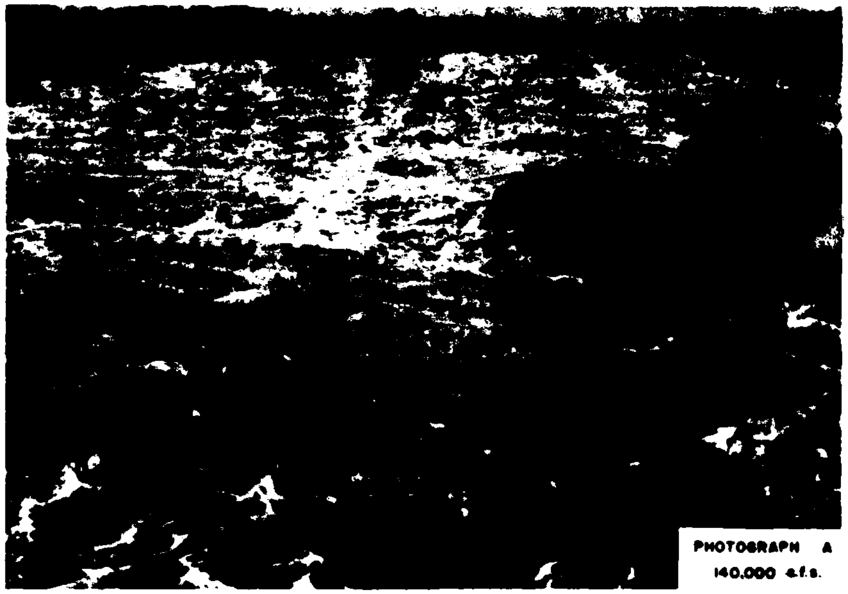
In identifying the exact magnitude of the water supply problem, the Corps performed two separate analyses. The first analysis was undertaken between 1977 and 1979 as part of the study's early-action phase. This analysis concentrated on defining future water supply shortages in terms of a ***rate*** of required flow in million gallons per day (mgd). For example, shortages were estimated as the difference between demand and a predefined flow condition such as the minimum seven-day average flow occurring once in one hundred years. While simplistic in its approach, this type of examination established a reasonable design condition for formulating early-action plans. The MWA's water supply problem, as defined for the early-action phase of study, is discussed in more detail in Chapter III of this report and in Appendix D - ***Supplies, Demands and Deficits***.

As a result of the early-action phase, several positive actions were taken by non-Federal interests to minimize potential water supply shortages. These actions, more fully described in Chapter IV, included adoption of a water conservation program, agreement to construct a new reservoir, more efficient management of existing supplies, purchase of Bloomington Lake's water supply storage, and a commitment to a regional agreement for coordinated reservoir operation. Thus, the "without condition," as originally defined for the early-action phase, had to be significantly revised for the long-range phase which was beginning in 1979. These revisions reflected the effects of the new projects, programs, and commitments being undertaken by the local water utilities.

Additionally, the approach to problem definition in the long-range phase was further modified to consider shortages in terms of a ***volume*** of required supply, in million gallons (mg), to compensate for the volumetric difference between demand and supply over historical droughts such as those occurring in the early 1930's or mid-1960's. A shortcoming of the early-action analysis was that the examination did not explicitly address ways of managing the volume of water stored in the MWA's existing reservoirs (Bloomington, Savage, Occoquan, and Patuxent) to optimize releases during a prolonged drought. Such an examination of the existing system's full capability in volumetric terms (mg) rather than flow rates (mgd) was accomplished during the long-range phase, and was the distinguishing factor between the problem definitions for the early-action and long-range phases of study. Although considerably more complex, the volume analysis provided a more accurate description of the water supply situation and potential water supply requirements. A more detailed description of the water supply problem, as redefined for the long-range phase, is contained in Chapter IV of the ***Main Report***.

Along with the investigation of water supply for the MWA's municipal needs, the MWA Water Supply Study also furnished an opportunity to examine the effects of different levels of flowby on supply availability. The signatories to the Potomac Low Flow Allocation Agreement have adopted 100 mgd as the minimum acceptable rate of flowby past Little Falls, and have also adopted a target value of 300 mgd between Great

Potomac River at Great Falls, High and Low Flows (140,000 cfs and 670 cfs respectively)



Falls and Little Falls. The U.S. Fish and Wildlife Service and others have suggested that higher flowby rates may be necessary to adequately protect and maintain the aquatic resources of the lower riverine and upper estuarine portions of the Potomac River. The present study examined the associated water supply requirements and the likely tradeoffs should higher flowby levels be desired; this examination is also summarized in Chapter IV of the ***Main Report***.

National Planning Objectives

Guidelines for the formulation and evaluation of plans of improvement for all Federal water and related land resources activities were contained in the Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources," established pursuant to Section 103 of the Water Resources Planning Act (P.L. 89-80). These Principles and Standards required that Federal and Federally-assisted water and land activities be planned toward achievement of National Economic Development (NED) and Environmental Quality (EQ) as national objectives. (Although later guidance has superceded the Principles and Standards, they are discussed here because they were in effect throughout both the early-action and long-range plan formulation phases.)

The components of the NED objective included:

- The value of increased outputs of goods and services resulting from a plan.
- The value of output resulting from external economies associated with a plan.

The components of the EQ objective included:

- Management, protection, enhancement, or creation of areas of natural beauty or human enjoyment.
- Management, preservation, and/or enhancement of especially valuable or outstanding archeological, historical, biological, or geological resources and ecological systems.
- Enhancement of quality aspects of water, land, and air by control of pollution or prevention of erosion and restoration of eroded areas.
- Avoiding irreversible commitments of resources to future needs.

In summary, the NED objective strived to achieve the most cost-effective solution from a National viewpoint while the EQ objective aimed for maximization of environmental benefits (and the least amount of adverse impacts) measured primarily in non-monetary units. In formulating alternative plans to maximize these National objectives, trade-offs naturally occur. These trade-offs were considered with reference to the "without condition". When final plans were developed, the impacts and trade-offs of each were then tabulated to aid decision-makers in selecting a program for further consideration.

Study Planning Objectives

Planning objectives are expressions of public and professional concerns about the future use of water and related land resources. They are derived through an analysis of the existing resource base and the expected future conditions within the study area. The purposes in defining planning objectives are to establish "targets" which guide the formulation of alternative plans and to enable evaluations of plan effectiveness. Planning objectives may sometimes conflict with each other, reflecting different perceptions of how the water resource should be managed in the future.

The objectives of the Metropolitan Washingtion Area Water Supply Study were developed through meetings, discussions, workshops, and correspondence with local individuals, governmental officials, water resource managers, the NAS-NAE committee, local planning agencies, citizens groups, and others in the study area. The NEWS Report also provided a valuable source of background information for identifying study planning objectives. From these varied sources, the following planning objectives were established for this study:

- Provide a water supply base of adequate quantity to meet essential municipal, industrial, commercial, and governmental needs.
- Provide a safe, reliable, potable water supply base of high quality.
- Use all existing water supply sources and facilities (including Bloomington) to the maximum extent practicable.
- Provide solutions within the MWA to the water shortage problem before constructing new projects outside the MWA.
- Employ water conservation measures to reduce the long-term trend of rising per capita water use.
- Use drought management techniques aimed at demand reduction rather than increased supply to overcome short-term peak deficits.
- Minimize the use of structural measures to satisfy future water needs.
- Minimize the adverse economic, environmental, and social effects of any water supply plan.
- Maintain or enhance stream conditions along the North Branch Potomac River through appropriate water quantity and quality releases from the combined Bloomington Lake and Savage Reservoir system.
- Maintain the existing level of flood damage protection already provided along the North Branch Potomac River.
- Maintain or enhance the aquatic environment in both the riverine and estuarine portions of the Potomac River by providing for flowby of sufficient quantity and suitable quality.
- Maintain or improve water-oriented recreation opportunities on water supply streams and reservoirs serving the MWA.
- Provide an institutional framework to promote cooperative management of all MWA water supply sources as a single regional resource.
- Equitably distribute the economic, environmental, and social costs and benefits of water supply plans.

Chapter III
Summary of Early-Action Progress Report

In August 1979, the Baltimore District Corps of Engineers published a report titled ***Metropolitan Washington Area Water Supply Study for the Potomac Water Users***. This report documented the work accomplished between 1976 and 1979 for the "early-action" phase of the study. The document was prepared as an interim or progress report at the approximate midpoint of the overall study so that immediate actions, if necessary, could proceed on high priority water supply plans without waiting for study completion several years later. This chapter provides a summary of the August 1979 ***Progress Report***.

Background

When the study was initiated in 1976, the MWA had witnessed over three decades of rapid population growth with accompanying increases in needs for dependable public water supply sources. A severe drought in 1966 had, in fact, dangerously tested the maximum water supply capabilities of the MWA systems. No significant projects had been added, however, even ten years later when the study was beginning. Thus, there was strong sentiment by all participants at the study outset to address the most immediate water supply needs as quickly as possible. The Corps of Engineers therefore devised a two-phased study program to first develop early-action plans to satisfy near-term water needs, and then to concentrate on long-range plans to meet water supply needs further into the future. Because of the expected length of the overall study, it was further decided to publish a ***Progress Report*** documenting the early-action phase. Actions to satisfy the near-term needs could then be initiated while studies of the long-range alternatives were continuing.

To identify the types of solutions to be considered in the early-action phase, the Corps of Engineers undertook an intensive program of public meetings, public workshops, committee meetings, and conferences as well as written correspondence. The results of the NEWS Study were used as the basis for these discussions. These public involvement activities helped to define the direction which the early-action phase was to take. Specifically, the study participants and general public felt that the early-action phase should: (1) examine only those projects having the greatest chance for implementation, preferably by local authorities, at an early date; (2) consider only proven technologies to reduce planning, design, and implementation time; (3) employ water conservation techniques to reduce demand before constructing additional facilities; (4) make maximum use of existing water supply facilities before building costly new projects; and (5) investigate projects within the MWA which could be implemented by local authorities, rather than proposing projects outside the MWA which might require significant regional or Federal involvement and cooperation.

As originally envisioned, then, the purpose of the early-action phase was to develop plans to satisfy needs up to about the year 2000 by making maximum use of existing or readily implementable water supply projects or programs. Plans to meet the water supply needs during the period 2000 to 2030 were to be developed in the long-range phase of study.

Detailed analyses of demand projections, water conservation capabilities, cooperative water resource management, and new local projects for the Potomac River users (Aqueduct, WSSC, FCWA, and Rockville) soon demonstrated, however, that the so-called "early-action" plans could be utilized to avert shortages much further into the future than previously anticipated. Thus, the approach to the ***Progress Report*** was revised to document the full capability of plans examined in the early-action phase for the Potomac River users. The following sections summarize the analyses and findings which were contained in the August 1979 ***Progress Report***.

Problem Definition

Projected water supply shortages in the MWA's four Potomac service areas are affected to a large degree by the variable flows in the Potomac River. To determine the magnitude of these shortages as they related to Potomac River flow, a range of low flow frequencies (or recurrence intervals) and durations was examined to define potential deficits for the early-action phase. A recurrence interval is defined as the average interval in years between the occurrence of low flow, in this case a low flow, of a specified magnitude and an equal or more severe low flow. For the early-action phase, USGS frequency curves were used to define the low flow frequency. Flow duration refers to the average length of time a given low flow would persist. Each flow duration was also associated with a particular recurrence interval.

The Corps of Engineers also devoted a considerable amount of effort to forecasting water use in future years by considering population, employment, and housing trends for each water service area. Water use was disaggregated into six major user categories (single family residential, multi-family residential, commercial/industrial, government/institutional, Federal government, and unaccounted for), and then a unit water use rate was developed based on the growth forecasts. Average annual water demands were projected for each water service area, aggregated for each benchmark year, and modified to reflect monthly patterns of water use. Within each month, the demands were further analyzed to estimate the maximum 7-day average and 1-day peak demands. Details of the procedure us-

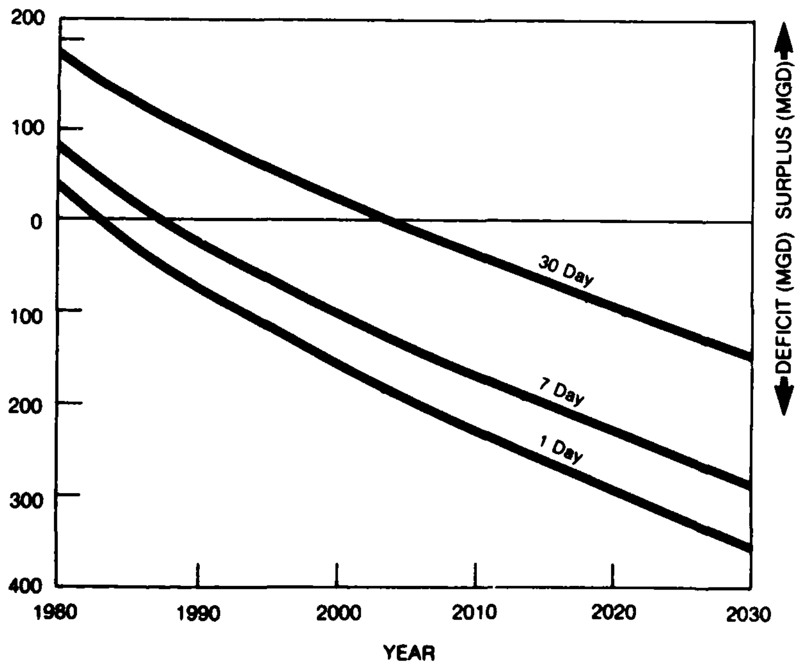
TABLE 3

REGIONAL SURPLUSES AND SHORTAGES FOR THE POTOMAC DEPENDENT USERS *

FREQUENCY	1980			1990			2000			2010			2020			2030		
	30	7	1	30	7	1	30	7	1	30	7	1	30	7	1	30	7	1
Once in 100 years	188	76	35	91	-30	-80	27	-100	-154	-27	-159	-217	-85	-223	-287	-135	-279	-346
Once in 50 years	247	129	85	150	23	-30	86	-47	-104	32	-106	-168	-26	-170	-237	-76	-226	-296
Once in 20 years	349	221	171	252	115	56	188	45	-18	134	-14	-82	76	-78	-151	26	-134	-210
Once in ten years	457	317	259	360	211	144	296	141	70	242	82	6	184	18	-63	134	-38	-122

*Assumptions: August supplies and demands
Baseline Conservation demands for WSSC, Aqueduct, FCWA, & Rockville
100 mgd flowby
135 mgd from Bloomington Lake
Occoquan treatment plant operating at 30, 7, and 1-day capacities of 84, 95, 112 mgd, respectively
Patuxent treatment plant operating at 30, 7, and 1-day capacities of 49, 55, 65 mgd, respectively

Fig. 6-Duration Sensitivity - Regional Surpluses and Shortages for Potomac River Users *

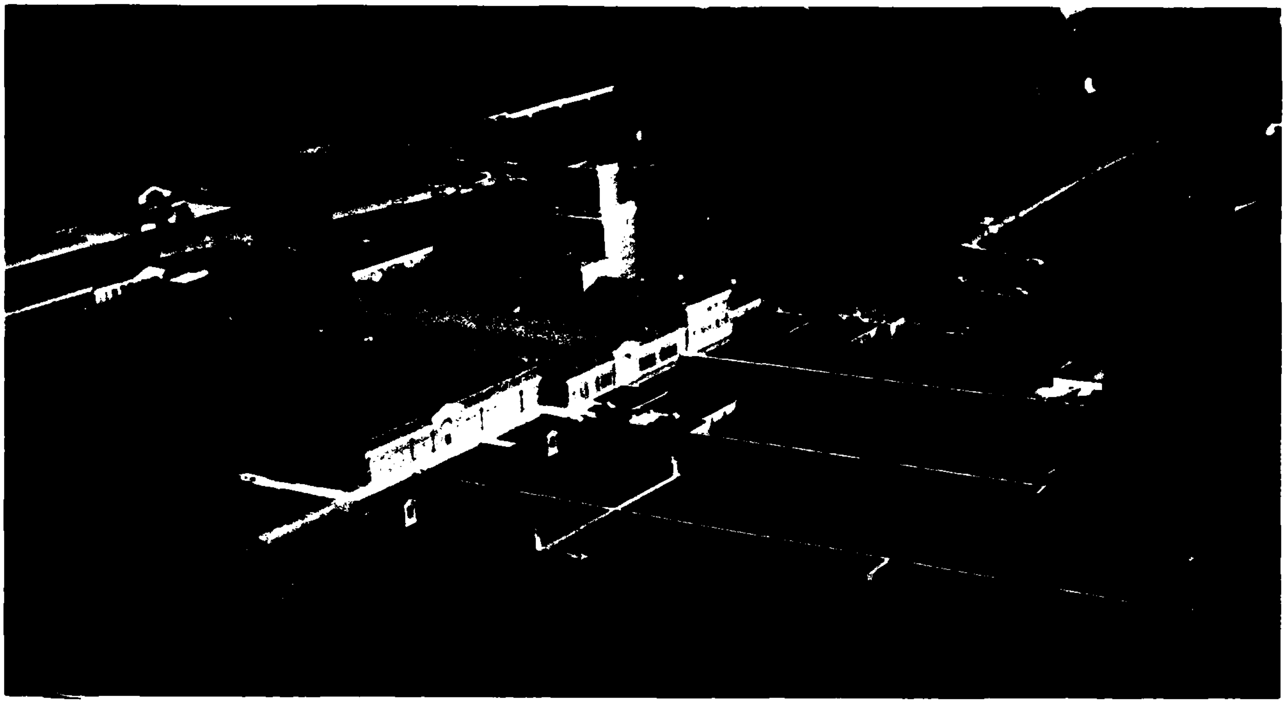


*** ASSUMPTIONS: August supplies and demands**
Baseline Conservation demands for WSSC, Aqueduct, FCWA, and Rockville
100 mgd flowby
135 mgd from Bloomington Lake
Occoquan treatment plant operating at 30, 7, and 1-day capacities of 84, 95, and 112 mgd, respectively
Patuxent treatment plant operating at 30, 7, and 1-day capacities of 49, 55, and 65 mgd, respectively
Once in 100-year drought

ed to forecast future water use within each service area are contained in Appendix D - ***Supplies, Demands, and Deficits*** and Appendix G - ***Non-Structural Studies***.

Based on work performed for the NEWS Study and confirmed by the early-action phase, water shortages (difference between demand and supply) in the MWA are usually at their greatest during the month of August. Shortages were, therefore, calculated for the month of August, using four recurrence intervals (once in 100 years, once in 50 years, once in 20 years, and once in 10 years) and three durations (30-day, 7-day, and 1-day). Maximum 1, 7, and 30-day water treatment plant capacities were obtained for the Patuxent and Occoquan facilities; Bloomington Lake was assumed to furnish a 135 mgd release throughout August; and an environmental flowby of 100 mgd was assumed to enter the Potomac Estuary. Table 3 lists the projected regional shortages by recurrence interval, duration, and benchmark year.

As expected, greater shortages would likely occur earlier in the planning period for shorter duration and less frequent events. For example, a once-in-100 year recurrence shortage was projected to occur as early as 1982 for a 1-day duration and as late as 2005 for a 30-day duration

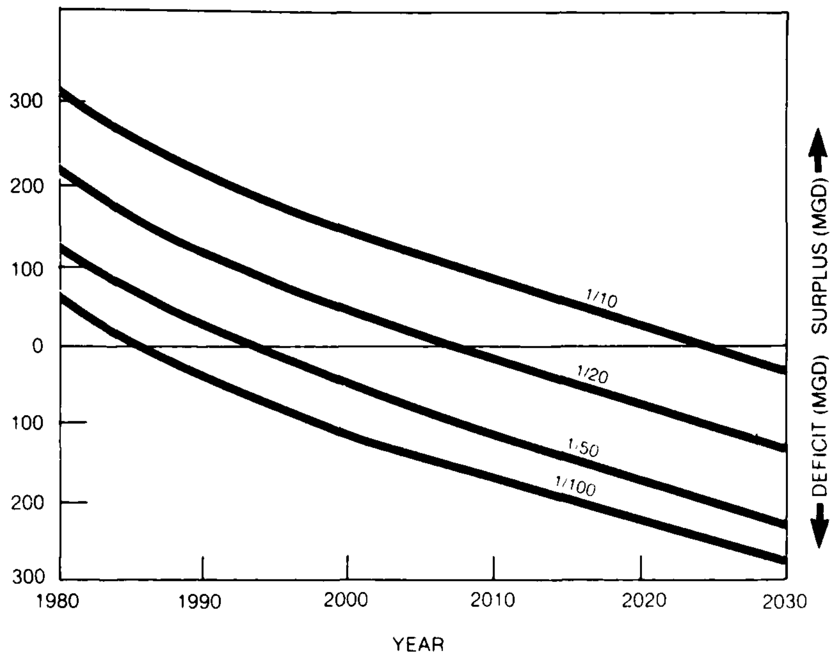


Dalecarlia Water Treatment Plant, Washington Aqueduct

(see Figure 6). Similarly, shortages could begin as early as 1986 and reach 279 mgd by the year 2030 for the 7-day, once-in-100 year probability. For the once-in-10 year frequency event of the same duration, shortages would not be expected until around 2022 and only reach about 38 mgd by the year 2030 (see Figure 7).

In comparing the projected surpluses and shortages, the water utilities reached a general consensus that the once-in-100 year, 7-day low flow condition should be used for planning purposes in the early-action phase. This decision was reached primarily for two reasons: (1) the estimated once-in-100 year, 7-day low flow in the Potomac River (401 mgd) roughly approximates the worst 7-day average low flow on record (404 mgd in September 1966); and (2) designing for peak one-day shortages is generally not cost-effective as the water utilities can use emergency drought management techniques to reduce water demands. As discussed later in this chapter, the water utilities also selected a specific level of water conservation to be implemented during the planning period. Table 4 provides a breakdown of water surpluses and shortages for the once-in-100 year, 7-day August design condition for those service areas using the Potomac River. These surpluses and deficits were calculated by applying the allocation

Fig. 7-Frequency Sensitivity - Regional Surpluses and Shortages for Potomac River Users *



* ASSUMPTIONS: August supplies and demands
Baseline Conservation demands for WSSC, Aqueduct, FCWA, and Rockville
100 mgd flowby
135 mgd from Bloomington Lake
Seven day duration
Occoquan treatment plant operating at 7-day capacity 95 mgd
Patuxent treatment plant operating at 7-day capacity 55 mgd

TABLE 4
EARLY-ACTION PHASE DESIGN CONDITION, SERVICE AREA SURPLUSES AND SHORTAGES * (MGD)

SERVICE AREA	1980	1990	2000	2010	2020	2030
WSSC	+26(+37)	-17(+5)	-44(-13)	-69(-35)	-95(-56)	-119(-75)
FCWA	+5(+11)	-10(0)	-24(-12)	-38(-22)	-55(-35)	-70(-47)
WAD	+44(+55)	-3(+16)	-31(-3)	-51(-22)	-71(-41)	-88(-57)
ROCKVILLE	+1(+2)	0(+1)	-1(0)	-1(0)	-2(-1)	-2(-1)
REGIONAL TOTAL	+76(+105)	-30(+22)	-110(-28)	-159(-79)	-223(-133)	-279(-180)

*Surpluses and shortages for individual service areas are based on application of the Potomac Low Flow Allocation Agreement, without the freeze provision. Calculations assumed 100 mgd flowby, 135 mgd from Bloomington, 1-in-100 year 7-day low flow in streams during August, Occoquan WTP operating at 95 mgd, and Patuxent WTP operating at 55 mgd. Numbers outside parentheses indicate projected shortages (-) or surpluses (+) with baseline demands; numbers inside parentheses indicate projected shortages or surpluses with Conservation Scenario 3 demands.

formula in the Potomac Low Flow Allocation Agreement. For convenience and later reference, surpluses and deficits are shown for both the baseline demands and as modified by the selected level of conservation (Conservation Scenario 3 - see later section for discussion and application). The surpluses and shortages in Table 4 were used as the "without condition" in formulating early-action plans.

Description of Components

As a result of the NEWS Study and the intensive public involvement program at the beginning of the MWA Study, five components were identified for detailed examination in the early-action phase. A component was defined as an individual mechanism or procedure that could reasonably be implemented, either independently or in combination with other components, to help satisfy a water supply shortage. The five components were: raw water interconnections, finished water interconnections, reregulation, local storage, and water conservation. Raw water interconnections, finished water interconnections, and reregulation were viewed as potential mechanisms to more evenly distribute available water within the region. Water use reduction through conservation could promote more efficient use of available water and decrease its unnecessary use. These components are described in the following sections.

Raw Water Interconnections

A raw water interconnection system is shown in schematic form on Figure 8. There are three basic features necessary for a raw water interconnection system: a river or stream source of water supply, an offstream reservoir, and a pipeline and pump connecting the two. The primary purpose of a raw water interconnection is to transfer water to storage or treatment facilities during periods of high streamflow so that more stored water would be available during low flow periods. This type of operation provides a potential mechanism to better utilize the existing water supply facilities. During the periods of excess flow in the river (in the case of the MWA, the Potomac), raw water could be withdrawn and transferred to an offstream reservoir or treatment plant via a pipeline. The excess water would be stored in the reservoir and used to supplement the major river source when natural flows are low, or it could be piped directly to a water treatment plant for treatment and distribution.

Several raw water interconnections were examined using either the Potomac or Shenandoah Rivers as major river sources and the Rocky Gorge, Triadelphia, Occoquan, or Beaverdam Reservoirs as storage sites. Based on engineering studies, impact analyses, and optimization techniques, two raw water interconnections were identified for further consideration in the plan formulation exercise. These two projects included one raw water interconnection between the Potomac River and the Rocky Gorge Reservoir for use by the Maryland suburbs and another interconnection between the Potomac River and the Occoquan Reservoir for use by the Virginia suburbs. Various sizes of pipelines capable of transferring 60 mgd to 180 mgd were investigated for each route. Details of the investigation are contained in Appendix E - ***Raw and Finished Water Interconnections and Reregulation***.

The following findings were derived from the analysis of raw water interconnections:

1. The operation of raw water interconnections would primarily affect those areas which depend upon the Potomac River as a water supply source.

2. Existing storage facilities in the WSSC and FCWA systems would be an integral part of the operation of raw water interconnections as they allow for storage of excess Potomac River flows and/or natural filling of the reservoirs.

3. Raw water interconnections between the Potomac River and either the Patuxent or Occoquan systems would be flexible in that they would take advantage of the capacity of existing treatment facilities at both ends of the pipelines. The ability to transfer water in both directions would also increase the efficiency of the overall system.

4. For raw water interconnections to operate effectively, some coordination and cooperation by Potomac users would be required to schedule withdrawals from the Potomac River.

5. Raw water interconnections would be expensive projects.

6. Raw water interconnections could cause disruption to the environment during construction. These impacts, however, would not be long-lasting.

7. Raw water interconnections would be energy-intensive projects when they are operating.

Finished Water Interconnections

A finished water interconnection between two adjacent distribution systems is shown in schematic form on Figure 9. The basic components are a set of independent finished water distribution systems (served by at least two distinct water treatment plants) and a pipeline connecting the two distribution systems. The primary purpose of a finished water interconnection is to avert local water shortages by linking together presently independent water supply systems. If a drought or other type of emergency (source contamination, power outage, pump failure, etc.) should occur in one distribution system, water could be made available from an adjacent distribution system through an interconnecting, reversible, finished water pipeline. Reversibility would allow for transfer of water in either direction during periods of need in either area.

There are presently a number of small (1 to 5 mgd) finished water interconnections which provide local suppliers with the capability to exchange treated water between systems. This analysis, however, also examined interconnections for the transfer of larger quantities of water between major lines of the water distribution systems. From a series of potential finished water interconnections, five were identified for detailed analysis: (1) between Dalecarlia (Aqueduct) and Montgomery Main Service (WSSC), 60 mgd; (2) between Arlington County (Aqueduct) and FCWA, 8 mgd; (3) between D.C. Low Service/Anacostia First High Service (Aqueduct) and Prince Georges Potomac Service (WSSC), 14 mgd; (4) between Arlington County (Aqueduct) and Pentagon Emergency Service (Aqueduct), 7 mgd; and (5) between Aqueduct and FCWA, 40 mgd. Detailed costs and impacts of the five pipelines are provided in Appendix E - ***Raw and Finished Water Interconnections and Reregulation***.

Based on the investigation of the finished water interconnections, the following observations were made:

1. Finished water interconnections could not provide additional supplies of water to the region; therefore, they would not reduce water supply deficits during severe widespread droughts.

Fig. 8-Representation of Raw Water Interconnection Operation

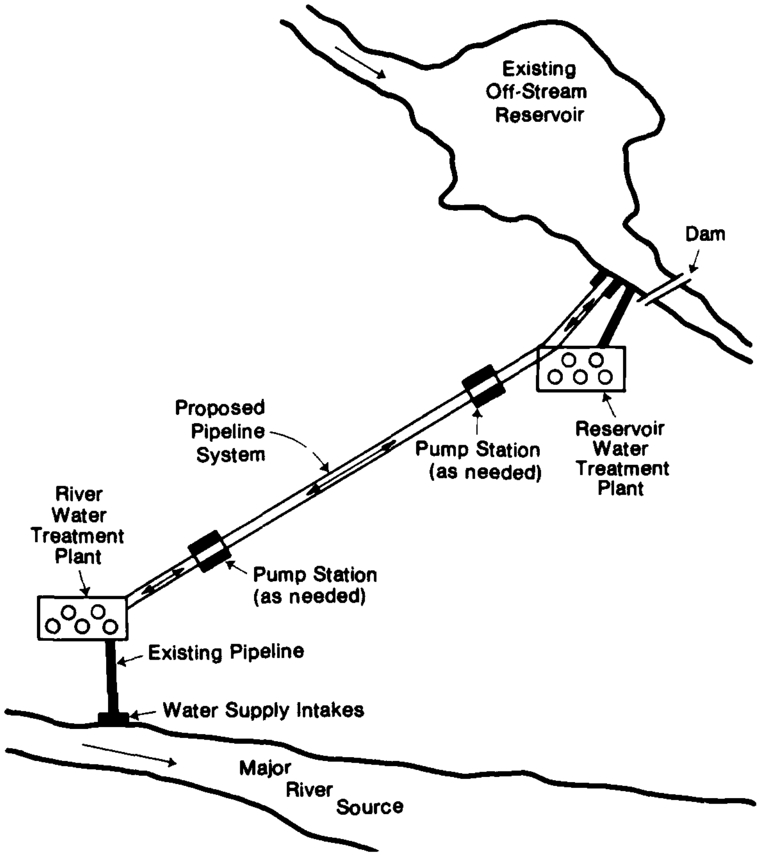


Fig. 9-Representation of Finished Water Interconnection Operation

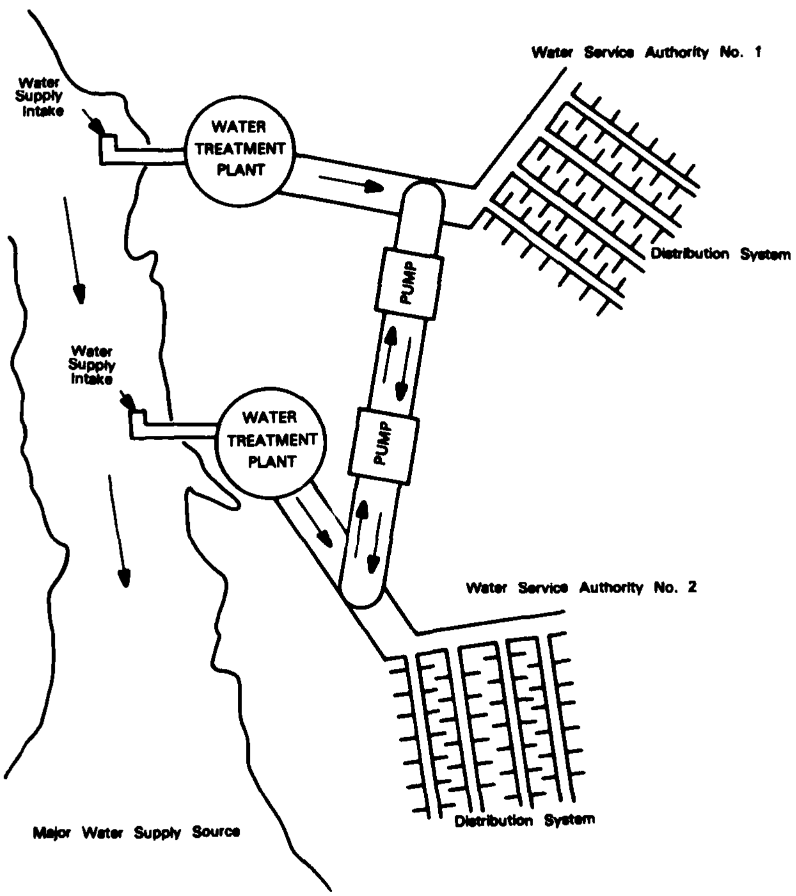


Fig. 10-Representation of Regulation (Intrasystem Transfer of Water)

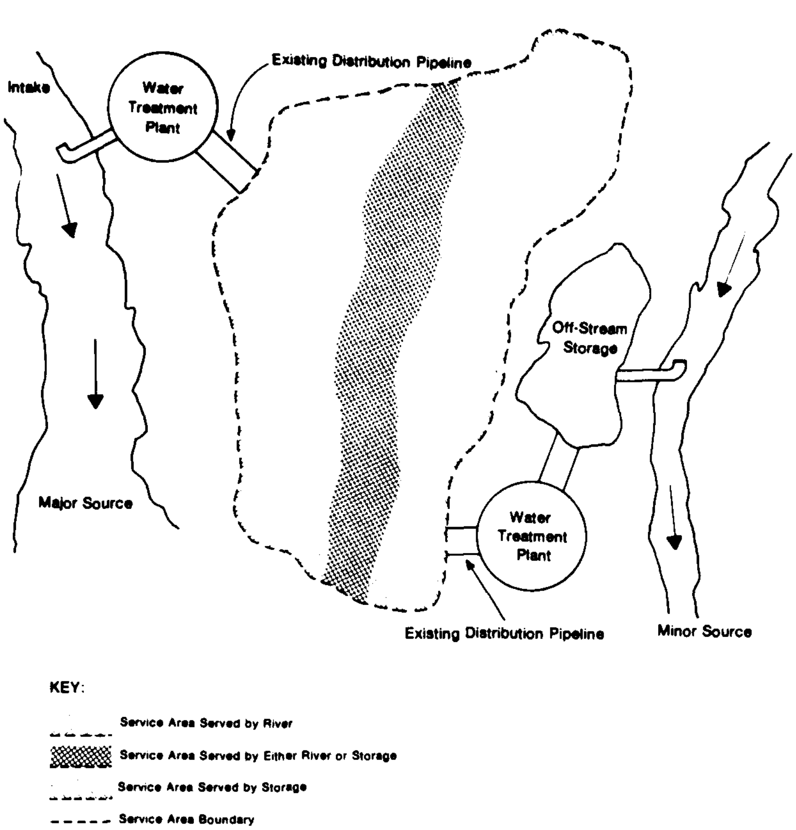
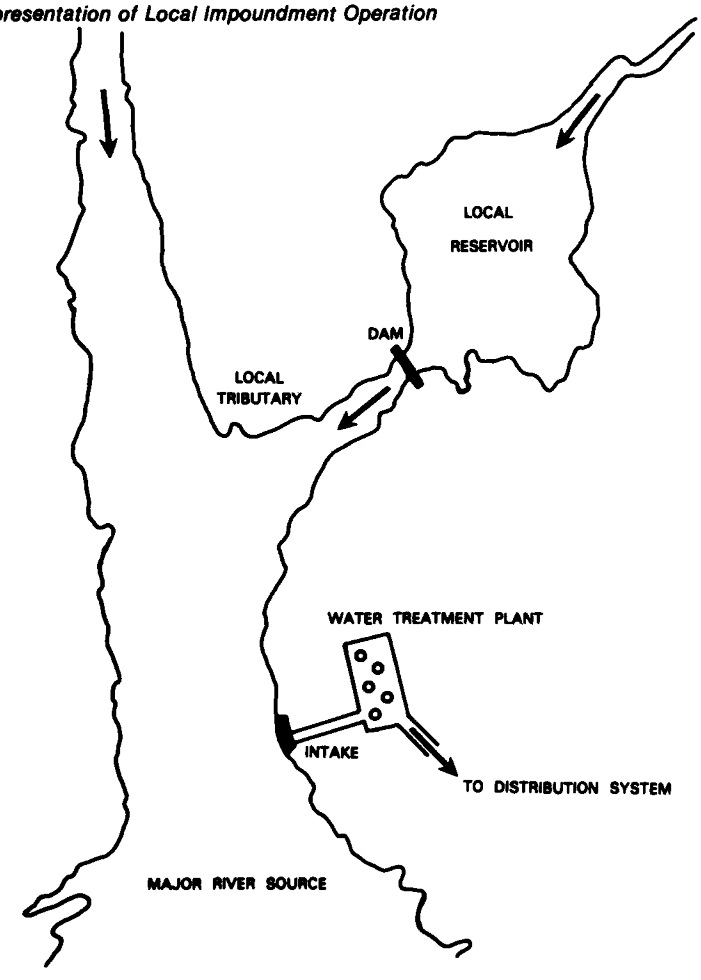


Fig. 11-Representation of Local Impoundment Operation



2. Finished water interconnections would, however, improve the "fail-safe" capability (emergency capacity) of the major service areas in the event of a failure in one part of the system. The Arlington County and Pentagon Emergency Service interconnection, for instance, would be desirable from national security and defense viewpoints.

3. Finished water interconnections would make use of total potential treatment capacity at the Aqueduct, thus deferring the need for completely new construction of additional treatment facilities by other suppliers (WSSC in particular). Cost savings may be possible.

4. Finished water interconnections may improve environmental quality of the Potomac River upstream of the Aqueduct Little Falls intakes by reducing the impacts associated with increased upstream withdrawals.

5. Finished water interconnections would require interagency agreement for purchase of water and construction of pipelines. In the case of the Dalecarlia and Montgomery Main Service interconnection, Congressional authorization would also be required.

Reregulation

Intrasystem transfer of water by reregulation involves distribution of the water within a given service area which is served by both a river and a reservoir source, and which has two independent water treatment plants. This mode of operation requires a flexible distribution system which can be served by either of two sources, and is depicted on Figure 10. During normal conditions, the service area is served largely from the river source, thereby conserving storage in the reservoir. During a low flow condition in the river, however, a greater area is served from the reservoir which decreases withdrawals from the river.

Within the MWA, both WSSC and FCWA presently have the capability to employ reregulation. By maximizing the use of the Potomac River and minimizing use of the Patuxent/Occoquan Reservoirs during non-drought periods, water can be "conserved" in the reservoirs. This would insure maximum reservoir capacity at the onset of drought conditions in the Potomac River when the reservoirs could be relied on more heavily. The

WSSC and FCWA (service areas with reservoirs) could then withdraw more water from storage during a drought, thus leaving more water in the Potomac River for the Aqueduct and Rockville which have no other source. The Potomac Low Flow Allocation Agreement employs the concept of reregulation as a fundamental basis for allocating Potomac River water among the users. Specific operating procedures to increase the MWA's dependable water supply yield through reregulation are discussed in Appendix E - ***Raw and Finished Water Interconnections and Reregulation***.

Findings of the reregulation analysis are listed below:

1. Reregulation within a service area would require at least two sources of supply - a reservoir source and a river source. Reregulation would allow for the maximum use of available storage by reducing withdrawals from the reservoirs during periods of non-critical flow and using excess water from the Potomac.

2. Reregulation would maximize use of existing facilities and would require a minimum amount of structural modification. For this reason, it would be a low cost alternative.

3. Reregulation would not be suited to meet needs during peak demand periods (1 or 7-day duration) since it saves small amounts of water over a long period of time.

4. Minimal environmental impacts would be expected as a result of reregulation during non-critical periods. During drought periods, more rapid drawdown in the reservoirs may occur.

5. During drought situations, reregulation would benefit Rockville and the Aqueduct which rely solely on the Potomac River for all of their available supply by reducing withdrawals through the FCWA and the WSSC Potomac intakes.

6. Regional cooperation among all Potomac River users would be necessary to obtain the full benefit of reregulation.

Local Storage

Local storage projects were defined as reservoirs within the boundaries of the MWA which could be used to augment one or more water supply systems. Normally, these local impoundments would be located on minor tributaries to the Potomac River, and could provide recreation benefits as well as water supply benefits. Figure 11 displays how a local storage project could be used to augment the MWA's water supply.

At the time of the early-action phase, three projects were being actively considered by local planning agencies. These projects included: the Little Seneca Lake project in Montgomery County, Maryland; a two to five-foot raising of the existing Occoquan Reservoir in Fairfax County; and the Cedar Run Reservoir project in Prince William County. Additional details about these projects are contained in Appendix D - ***Supplies, Demands, and Deficits*** and in Appendix F - ***Structural Alternatives***.

The following findings were noted concerning local storage projects:

1. Local storage projects could provide additional water on short notice to meet shortages.

2. A multi-purpose use could be achieved by local storage projects.

3. Impacts associated with local storage projects would be both immediate and long-lasting. Generally, these impacts would be local in nature.

4. Storage projects on Occoquan Creek and Cedar Run would provide direct benefits to the FCWA and Prince William service areas, respectively.

5. Little Seneca Lake could be implemented unilaterally; however, implementation of either the Cedar Run project or the Occoquan Reservoir raising would require agreements between FCWA and Prince William County.

Water Conservation

The fifth component examined during the early-action phase was non-structural in nature. Water conservation and demand reduction measures can be employed to more efficiently use existing water supplies and to decrease unnecessary use of water over time. Such measures may delay or negate the requirement for major structural projects. Some of the water conservation techniques which were examined included consumer education, metering, pressure reducing valves, and plumbing code regulations for water-saving devices. The study of water conservation measures was confined primarily to non-emergency techniques which could be implemented gradually over a number of years. Short-term emergency techniques were not addressed but are considered in the existing Water Supply Emergency Agreement (WSEA) developed by the MWCOG (see Annex G-1).

Five conservation programs or "scenarios" were developed to analyze the cost and effectiveness of different combinations of water conservation measures. As a basis for comparison, a baseline condition was developed which included no specific actions for water conservation other than those actions already being implemented. Each of the five conservation scenarios then considered methods to achieve increasing amounts of demand reduction. Regionally, the amount of water use reduction by 2030 ranged from 7 percent to 27 percent for Scenarios 1 and 5, respectively. Details of the water conservation scenarios are found in Appendix G - ***Non-Structural Studies***.

The pertinent findings of the water conservation analysis are listed below.

1. The conservation scenarios would be flexible and could be adopted in any one or all of the service areas.

2. Conservation could reduce demand in all service areas and could be combined with other water supply measures to satisfy the total demand. Conservation alone could not satisfy the water supply shortages identified in the region.

3. Of the scenarios examined, Conservation Scenario 5 was the most effective in terms of water demand reduction. The amount of demand reduction attributed to this scenario, however, was optimistic and would be questionable, as the scenario was based upon the highest estimate of effectiveness of each measure included in the scenario.

4. With the exception of Conservation Scenario 5, conservation measures could be implemented with relatively low capital cost; however, they may have an adverse impact upon utility revenues.

5. A conservation program could improve the regional wastewater situation by reducing the volume of projected wastewater flows to the treatment facilities.

6. The additional costs required to include pressure reducing valves and insulation in any scenario would be considerable. Only a relatively small decrease in water use would

be associated with these expenditures.

7. Residential water use could be significantly reduced by implementation of certain conservation measures.

Formulation of Early-Action Plans

Process

When the individual analyses of the five components were completed, an iterative formulation process was undertaken to combine the components into effective early-action plans. This iterative process provided for the systematic development, evaluation, and comparison of a range of early-action plans. The process provided for an increasing level of detail in each repetition as the range of possible plans was gradually narrowed. Such repetitions, or iterations, allowed decisions to be made sequentially at key points during the plan formulation process, both with regard to how the problem was defined and with regard to which plans should be examined in greater detail in the following iteration.

For the early-action phase, the iterative formulation process typically began with the development of various component combinations (plans) to meet given levels of MWA water shortage, followed by an estimate of costs and assessment of impacts. The plans and their associated costs and impacts were then reviewed by the various committees participating in the study. The committees offered suggestions for further refinements and modifications which became the basis for the next iteration of plan formulation. Three complete iterations of plan formulation were accomplished during the early-action phase, reducing the number of plans from 18 to 9 to 5. This process was fully documented in the August 1979 ***Progress Report***; the reader is referred to Appendix B - ***Plan Formulation, Assessment, and Evaluation*** for a summary of the various iterations. The following discussion describes the five final early-action plans.

Decisions and Assumptions

The repetitive formulation process required that several decisions and assumptions to be made before entering the third and final iteration. These decisions and assumptions had an important bearing on both the manner in which the water supply problem was defined and the approach to solving the problem. The important decisions and assumptions for the early-action phase, as determined by a consensus of study participants, are listed below. It is important to understand that these assumptions reflected the latest knowledge and conditions which prevailed at the time (1979).

1. The terms of the Potomac Low Flow Allocation Agreement should be applied when calculating individual service area shortages.

2. Until the State of Maryland completed the examination of environmental flowby in the Potomac River, 100 mgd would be used as a planning assumption.

3. The FCWA and WSSC Potomac River intakes should be assumed to be constructed. It should be further assumed that the water treatment plants would be expanded, as needed, to their maximum intake capacities (FCWA - 200 mgd, WSSC -400 mgd).

4. The plans should be designed to satisfy water shortages resulting from the predicted once-in-100 year, 7-day low flow condition in the Potomac River; the water utilities would use emergency drought management techniques to balance supplies and demands for peak shortages of less than a 7-day duration.

5. All plans, including the "without condition," should assume that the Occoquan Reservoir would be raised by two feet.

6. All plans, including the "without condition," should assume that FCWA and WSSC would practice reregulation to conserve water in the off-Potomac reservoirs during periods of adequate flow in the Potomac River.

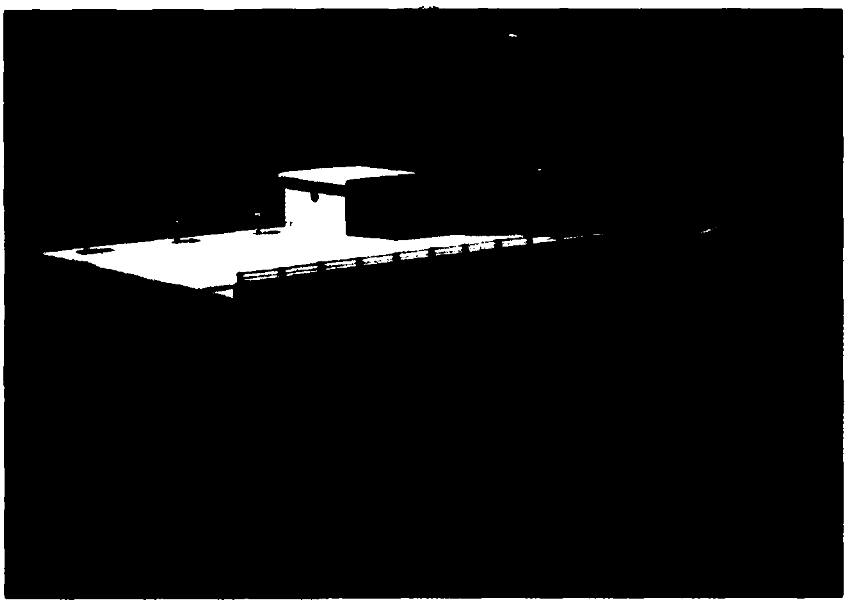
7. All action plans should consider the implementation of Conservation Scenario 3, which would reduce water use by about 11 percent by the year 2030. Table 4 listed the projected deficits both with and without the implementation of Conservation Scenario 3.

8. The Bloomington Lake project, then under construction, should be assumed to be completed and providing an additional 135 mgd to the Potomac River in the MWA. The cost of the unpurchased future water supply storage in Bloomington Lake should be apportioned to the different users.

9. Maximum average 7-day supplies available from the Patuxent and Occoquan Reservoir should be considered as 55 mgd and 95 mgd, respectively.

10. Three levels of cooperation should be investigated to demonstrate potential advantages or disadvantages to the MWA: (a) a "local" approach where each service are would provide a solution to meet its own problem; (b) a "subregional" approach where FCWA and WSSC would satisfy their own shortages plus a share of the Aqueduct's shortage; and (c) a "regional" approach where a project in one service area could be shared

Potomac River Water Supply Intake, Fairfax County Water Authority



to meet the needs of all of the Potomac water service areas.

It should again be emphasized that these assumptions and decisions applied only to the early-action phase of the study. As explained in a later chapter, the actions taken as a result of the early-action phase necessitated certain changes in the assumptions and approach to the long-range phase.

Early-Action Plans

The final product of the iterative formulation process in the early-action phase was a series of five plans generated from the components discussed earlier. These plans were formulated to satisfy the projected severe shortages in the Potomac water service areas (WSSC, FCWA, Aqueduct, and Rockville). Plan development for the outlying service areas not dependent on the Potomac River was deferred to the long-range portion of the study. Except for Plan 1 - Without Condition, all of the plans were designed to satisfy the once-in-100 year, 7-day combined shortage of 279 mgd for the Potomac water service areas in the year 2030 (see Table 4).

Table 5 provides a description of the five plans listing the plan features, the operational dates, the quantity of water supplied or demand reduced, the estimated first cost of construction, the estimated average annual cost (considering staging of projects), and the degree of regional cooperation required to implement and operate the plan. The action plans are arranged in ascending order of regionalization with the Local Plan (Plan 2) requiring little, if any, cooperation among the water supply utilities and the Regional Plans (Plans 4 and 5) requiring full cooperation. (The cost figures in Table 5 differ slightly from those contained in the earlier *Progress Report* as an error in the economic calculation has been corrected. This change did not affect the conclusion that regionalization would be cost effective.)

Plan 1—Without Condition Plan

This plan formed the basis for comparison with the four action plans. It projected the water supply conditions that would exist through the year 2030 in the absence of any plan to alter the management of water resources. It required no inter-jurisdictional cooperation other than to administer the Potomac Low Flow Allocation Agreement and area-wide emergency conservation programs. Given a once-in-100 year, minimum 7-day average August flow in the Potomac River, shortages could begin as early as 1986 and reach 279 mgd by 2030. The Without Condition Plan did include the new intakes by WSSC and FCWA, 100 mgd flowby to the Potomac Estuary, and 135 mgd from Bloomington Lake during the critical summer and fall months (it was assumed that some agency would purchase the then uncommitted future water supply storage in Bloomington Lake.).

Plan 2—Local Plan

This plan addressed the water supply problem by providing separate sources of water for each of the water service areas. Plan 2 assumed only minimal regional cooperation could be achieved. Components were sized to meet individual service area needs with all service areas requiring supplemental sources in 1994 (all jurisdictions would begin to face shortages in the same year because of the allocation formula in the Potomac Low Flow Allocation Agreement). Conservation Scenario 3 would reduce water demands in each of the service areas about 11 percent by 2030. The distinctive feature of Plan 2 was that water released from Bloomington Lake would be reserved primarily for the Aqueduct and Rockville, as the Potomac River would be their only source of additional supply. Little Seneca Lake (113 mgd) in Montgomery County would furnish additional storage for WSSC, and a Potomac/Occoquan raw water interconnection (67 mgd) would provide needed water to FCWA. Each project would be operated independently to satisfy water needs in the individual service areas, and each project could be financed separately by the water utility it served.

Plan 3—Subregional Plan

Plan 3 was structurally similar to the Local Plan, but the operational characteristics were different and would require a greater degree of regional cooperation than the Local Plan. Water from Bloomington Lake would be shared by all four users as allocated by the Potomac Low Flow Allocation Agreement. Again, Conservation Scenario 3 would be applied to all water service areas. Separate projects were proposed for WSSC (Little Seneca Lake, 104 mgd) and FCWA (Potomac/Occoquan raw water interconnection, 76 mgd) in 1994, but sized to meet the particular service area's projected 2030 shortage plus one-half of the Aqueduct's and Rockville's combined 2030 deficit. Increased use of off-Potomac projects by WSSC and FCWA would decrease their reliance on the Potomac and would enable the Aqueduct and Rockville to withdraw more water from the Potomac River during drought periods. To operate effectively, Plan 3 would require a certain degree of regional cooperation, at least between WSSC and the Aqueduct/Rockville and also between FCWA and the Aqueduct/Rockville for cost-sharing and coordination of Potomac River withdrawals.

Plan 4—Regional Plan 1

Plan 4 took the final step toward total regional cooperation by assuming that all projects would be shared equitably, with regard to both benefits and costs. Conservation Scenario 3 would be applied to all four water service areas, and Little Seneca Lake (120 mgd) would be constructed on operational by 1994. Releases from Little Seneca Lake were added to the natural flow and the Bloomington augmented flow in the Potomac River, and the total flow was then divided among the four users according to the Potomac Low Flow Allocation Agreement. By 2017, a Potomac/Patuxent raw water interconnection (60 mgd) would be constructed to supply the region through the remaining portion of the planning period to 2030. Regional Plan 4 resulted in significant overall cost savings by bringing new projects on-line only as they were needed by the region. Plan 4, however, would require a high level of cooperation among the utilities for coordinating water withdrawals from the Potomac River and for negotiating acceptable cost-sharing arrangements.

Plan 5—Regional Plan 2

Because of the general opposition to new reservoirs in the Potomac River Basin, Plan 5 developed a re-

TABLE 5
PLANS FOR CHOICE, EARLY-ACTION PHASE *

PLAN COMPONENTS	DATE OPERATIONAL	QUANTITY SUPPLIED (MGD)	DEMAND REDUCED (MGD)	CONSTRUCTION COST** ($1,000/YEAR)	OPERATION & MAINTENANCE & REPLACEMENT COSTS ($1,000/YEAR)	AVERAGE ANNUAL COSTS*** ($1,000/YEAR)
PLAN 1 - WITHOUT CONDITION						
Potomac Low Flow Allocation Agreement	1980					
Existing Conservation Codes	1980					
Flowby - 100 mgd	1980					
WSSC						
400 mgd Potomac intake	1981					
55 mgd Patuxent	1980					
FCWA						
200 mgd Potomac intake	1982					
95 mgd Occoquan	1980					
Occoquan raised 2 feet	1981					
Bloomington Lake****	1981	135		50,740	96	2,160
Shortage						
Without Bloomington - 414 mgd						
With Bloomington - 279 mgd						
PLAN 2 - LOCAL PLAN						
All assumptions in Plan 1, plus:						
Reregulation	1980					
Conservation Scenario 3	1980		99	9,680		280
Little Seneca Lake	1994	113		22,960	44	580
Potomac to Occoquan RWI	1994	67		64,400	61	1,600
Subtotal		180	99	97,040	105	2,460
Bloomington Lake (primarily WAD)****	1981	135		50,740	96	2,160
Total		315	99	147,780	201	4,620
PLAN 3 - SUBREGIONAL PLAN						
All assumptions in Plan 1, plus:						
Reregulation	1980					
Conservation Scenario 3	1980		99	9,680		280
Little Seneca Lake	1994	104		22,960	44	580
Potomac to Occoquan RWI	1994	76		64,740	62	1,610
Subtotal		180	99	97,380	106	2,470
Bloomington Lake (all service areas)****	1981	135		50,740	96	2,160
Total		315	99	148,120	202	4,630
PLAN 4 - REGIONAL PLAN 1						
All assumptions in Plan 1, plus:						
Reregulation	1980					
Conservation Scenario 3	1980		99	9,680		280
Little Seneca Lake	1994	120		22,960	44	580
Potomac to Patuxent RWI	2017	60		46,370	45	290
Subtotal		180	99	79,010	89	1,150
Bloomington Lake (all service areas)****	1981	135		50,740	96	2,160
Total		315	99	129,750	185	3,310
PLAN 5 - REGIONAL PLAN 2						
All assumptions in Plan 1, plus:						
Reregulation	1980					
Conservation Scenario 3	1980		99	9,680		280
Potomac to Patuxent RWI	1994	180		103,830	117	2,590
Subtotal		180	99	113,510	117	2,870
Bloomington Lake (all service areas)****	1981	135		50,740	96	2,160
Total		315	99	164,250	213	5,030

* Cost comparison based on December 1978 price levels.
** Construction costs include interest during construction for all components.
*** Average annual costs for all components based on FY 1979 Federal discount rate of 6-7/8 percent with a base year of 1980 and a 50-year planning period with the exception of average annual costs for Bloomington Lake which were calculated using the project authorization rate of 3-1/4 percent
**** Only costs of future water supply storage included.

gional plan with only one large raw water interconnection (180 mgd) constructed by 1994 between the Potomac River and the Rocky Gorge Reservoir. Conservation Scenario 3 would also be applied to all service areas. The interconnection would be used during droughts to supplement low flows in the Potomac River. Because of the size of the interconnection and the timing of its construction, cost-savings similar to Plan 4 would not be possible. Like Plan 4, though, a high level of regional cooperation for both cost-sharing arrangements and water withdrawal schedules would be necessary.

Results of Early-Action Phase

The primary purpose in conducting the early-action phase was to identify immediate actions to be taken while studies continued on other long-range aspects of the water supply problem. The five "Plans for Choice" discussed in the previous section attempted to respond to the desire for immediately implementable water supply plans for the MWA. To distribute the information and findings developed during the early-action phase, the Corps published a series of Water Forum Notes and the ***Progress Report*** documenting the investigations. It was anticipated that the Water Forum Notes and the ***Progress Report*** would serve as the necessary vehicles to facilitate decisions for satisfying the immediate water supply needs. These publications were followed by a FISRAC meeting where it was agreed to form a regional task force to consider local implementation of some of the measures examined in the Corps' ***Progress Report***. These activities are further discussed in the following paragraphs and in the next chapter.

Water Forum Notes and Progress Report

Seven Water Forum Notes were distributed to everyone on the MWA mailing list (about 5000 listings) between November 1978 and September 1979. The Water Forum Notes were directed at the nontechnical reader who had a basic interest in MWA water supply matters. The first Water Forum Note described the MWA study process and the study schedule. Water Forum Notes 2, 3, and 4 discussed the early-action components while Notes 5 and 6 described the formulation of components into early-action plans. Water Forum Note 7, published in September 1979 just after the ***Progress Report*** was distributed for review, summarized the costs and impacts of the five early-action "Plans for Choice" contained in the ***Progress Report***. Many positive comments were received on the Water Forum Notes, especially in regard to the simple overview they provided of the MWA's complex water supply situation.

The August 1979 ***Progress Report*** consisted of a Main Report and nine supporting technical appendices. The Formulation, Assessment, and Evaluation of Detailed Plans Appendix of the ***Progress Report*** described the entire early-action phase at length. It is important to remember that the early-action phase, although originally intended to formulate plans to satisfy water needs to the year 2000, actually investigated plans capable of carrying the region through the year 2030 (at least for the four Potomac-dependent service areas).

Following the distribution of the ***Progress Report***, three public workshops and a public meeting were conducted in October 1979 to discuss the findings of the early-action phase. Generally favorable comments were received on the attempt to satisfy the water needs with programs and projects capable of being implemented within the MWA boundaries, the display of economic advantages for regional water supply management, the inclusion of water conservation in all the action plans, and the openness of the public involvement program. Unfavorable comments were received on the method of cost apportionment (especially costs apportioned to Virginia), the lack of consideration given to water quality, the assumed level of environmental flowby, the reality of achieving the interjurisdictional cooperation necessary to implement the regional plans (Plans 4 or 5), and the water demand projections which were based on Round I and not Round II growth forecasts by MWCOG.

The NAS-NAE committee met following the publication of the ***Progress Report***, and reviewed the assumptions, methodologies, and conclusions of the early-action phase. The committee submitted a formal report on their findings in October 1980. This report, titled ***Water for the Future of the Nation's Capital Area***, is contained in Annex C-IX and reflected many of the same compliments and concerns expressed through the general public involvement program. On the positive side, the NAS/NAE Committee felt that the early-action phase had improved the methodology for forecasting water use, had seriously considered non-structural options for augmenting supply, had demonstrated the desirability for regional cooperation, and had developed plans which were responsive to local desires. On the negative side, the NAS/NAE Committee was concerned

Little Falls Intake and Pumping Station, Washington Aqueduct

that the early-action phase did not consider the associated wastewater treatment investments which might accompany the alternative water supply schemes, did not attempt a benefit/cost analysis for the various alternatives, did not properly consider water quality differences of the various sources, and did not address how the needed regional cooperation was going to be achieved.

The Citizens Task Force (CTF) for the MWA Water Supply Study also reviewed the 1979 ***Progress Report*** and furnished comments to the Corps. These comments are contained in Annex C-VII. Briefly, the CTF took exception to five assumptions underlying the early-action planning effort. Those assumptions which were questioned were the following: (1) water sources available at the present time could be treated to potable levels throughout the planning period; (2) existing sources would still be available in year 2030; (3) 100 mgd flow to the Potomac Estuary would furnish adequate environmental flow-by; (4) existing reservoirs would furnish virtually the same storage in year 2030 as they presently provide; and (5) regional cooperation to implement the plan elements could be accomplished.

FISRAC Meeting

Recognizing that the impetus for any early-action plan would likely come from a consensus of the affected states and water supply utilities, the Corps convened a meeting of its FISRAC in December 1979. This committee had met on two previous occasions and provided valuable guidance and direction to the Corps during the formulation of the early-action plans. The expressed purposes of the December 1979 FISRAC meeting were to respond to concerns raised about the ***Progress Report*** and to decide on the future course of action for implementing a plan to avert MWA water shortages. In retrospect, this FISRAC meeting and actions stemming directly from it achieved far more than any of its participants envisioned at the time.

Consensus was reached on a number of extremely important items relating both to the study in particular and the water supply problem in general. First, the Committee acknowledged that a solution to the MWA's water supply problem, as displayed in the Corps' ***Progress Report***, could be implemented locally without Federal assistance. The observation was made that water supply is a 100-percent non-Federal cost responsibility; therefore, there was no reason to rely on the usually lengthy and costly Federal authorization and funding process to provide a project which would have to be totally repaid by the local jurisdictions. The prevailing attitude was that these local jurisdictions should decide on a water supply plan using the technical information prepared by the Corps, and then proceed to implement the plan with their own resources. No further action by the Federal government would be necessary except for the approval of certain permits and the execution of specific contractural arrangements. (This consensus ultimately led to the Corps' decision not to forward the ***Progress Report*** through higher authority to Congress for authorization of a "Federal" plan.)

The second important consensus was that the District of Columbia and Rockville could not independently solve their own water supply problems. Neither had existing reservoirs nor adequate land to develop them. Some form of regional coopration on the part of Maryland and Virginia was necessary to assist both Rockville and the District of Columbia.

Third, the members of FISRAC observed that a regional water supply plan, such as Plan 4 in the ***Progress Report***, resulted in significant cost-savings to the region. These savings could be achieved through sharing of water supply sources, by staging of new projects according to overall regional needs rather than strictly local (one water service area) needs, through areawide implementation of a water conservation plan similar to Conservation Scenario 3 in the Corps ***Progress Report***, and by conscious efforts on the part of WSSC and FCWA to take full advantage of the reregulation concept. The WSSC further mentioned that Little Seneca Lake, although originally designed as a local project, could actually be used to serve regional needs if appropriate cost-sharing arrangements could be negotiated. In essence, the FISRAC members identified Plan 4 as providing the basis for a cost-effective and acceptable framework for any regional plan.

Finally, these three conclusions led directly and naturally to a fourth consensus, perhaps the most important of all. The FISRAC participants agreed that the MWA's major jurisdictions using the Potomac River should cooperatively manage their collective existing water supplies and equitably share the benefits and costs of any new projects among all users. Participants viewed this cooperation as a logical extension of the coordination already initiated through the signing of the Potomac Low Flow Allocation Agreement in 1978 and the creation of the "Section" for Cooperative Water Supply Operations on the Potomac (CO-OP) by the Interstate Commission on the Potomac River Basin in November 1979.

Having reached these conclusions, the FISRAC participants asked Mr. Robert S. McGarry, General Manager of the WSSC, to form a task force of local elected officials. The purpose of this task force was to further develop and implement a regional water supply management strategy, using the Corps' ***Progress Report*** as a starting point and as a guide. The efforts of this task force and the results of its deliberations are described in the following chapter

Summary

In summary, then, the most significant accomplishments of the August 1979 ***Progress Report*** were that it demonstrated the measurable advantages of regional water supply cooperation and the feasibility of solutions implemented locally within the MWA boundaries. The findings of the ***Progress Report***, along with the CO-OP program initiated by ICPRB, provided both the background information and the necessary incentive for the local jurisdictions to undertake implementation of a regional water supply plan on their own. A fundamental objective of the Corps'early-action program was therefore achieved by means of the ***Progress Report***, i.e. to encourage decisions and implementation of high priority water supply plans in a timely fashion.

Chapter IV
Local Implementation of a Regional Water Supply Plan

With the completion of the Corps' *Progress Report* describing the early-action phase of study, local interests assumed the initiative for turning the conceptual schemes into actual water supply projects and programs. To a large degree, this responsibility was handled by the Metropolitan Washington Regional Water Supply Task Force which was formed by Mr. McGarry at the request of the FISRAC members. The Regional Task Force made excellent progress in its task, aided in large part by the growing spirit of cooperation among the various jurisdictions. Chapter IV describes the efforts of the Regional Task Force, the components of the regional water supply plan which were subsequently adopted, how the regional plan would operate to alleviate water supply shortages, and the effectiveness of the plan based on mathematical simulations of historical drought situations.

Efforts of the Regional Task Force

The Regional Task Force was created in early 1980. It was composed of elected officials from Prince Georges and Montgomery Counties in Maryland, Fairfax County in Virginia, and the District of Columbia. Its purposes were to formulate a water supply plan which would be acceptable to the entire region and to prepare the necessary contracts and agreements so that the designated plan could be implemented with a minimum of delay.

The Regional Task Force was aided in its work by both an appointed Technical Advisory Group and an appointed Citizens Advisory Group. These groups worked diligently throughout late 1980 and most of 1981 to formulate an acceptable regional water supply plan. The Regional Task Force and its advisory groups drew heavily from the data and findings contained in the Corps' *Progress Report*. At the same time, the ICPRB CO-OP program was developing joint operating procedures to maximize the water supply yield of the MWA's rivers and reservoirs. This information was also important to the Regional Task Force as the significant advantages of regional cooperation regarding use of the MWA's reservoirs were demonstrated.

By early 1982, the Regional Task Force had finalized a regional water supply plan amendable to timely local implementation without direct Federal involvement. This plan included such components as water conservation, reregulation, and Little Seneca Lake which had been examined in the *Progress Report*. Additionally, the plan incorporated the findings of the CO-OP modelling efforts to establish regional guidelines for coordinating reservoir releases and utilities' water withdrawals. The projects and programs composing the regional plan are more fully described in the next section.

Additionally, the Regional Task Force reached a consensus on the means by which the water supply plan could be implemented. This consensus actually took the form of several proposed agreements and contracts among the various water utilities and political jurisdictions. The salient features of the proposed agreements and contracts included the following:

(a) The WSSC, Aqueduct/DC, and FCWA should purchase from the Corps of Engineers all water supply storage in Bloomington Lake and relieve the Maryland Potomac Water Authority (the original purchaser of the project's "present" water supply storage) of any obligation for repayment. Yearly repayment to the Corps for capital and operation and maintenance (O&M) costs allocated to water supply should be shared among WSSC (50 percent), FCWA (20 percent), and Aqueduct/DC (30 percent).

(b) The WSSC, Aqueduct/DC, and FCWA should share the capital and operation and maintenance costs of the water supply portion of Little Seneca Lake, with WSSC assuming a 50 percent share, Aqueduct/DC assuming a 40 percent share, and FCWA assuming a 10 percent share. The costs of land for the buffer zone and for recreation should not be shared.

(c) The MWA utilities should share the O&M costs of Savage Reservoir, then being borne entirely by Allegany County, because Savage Reservoir releases will be necessary to neutralize acidic releases from Bloomington Lake. Annual shares should be repaid by WSSC (40 percent), FCWA (16 percent), Aqueduct/DC (24 percent), and Allegany County (20 percent).

(d) A regional agreement among WSSC, Aqueduct/DC, and FCWA should be formalized through ICPRB's CO-OP program to achieve the operational water supply objectives stated below:

(1) Maintain the risk of invoking the LFAA at less than 5 percent dur-

Control Tower, Bloomington Lake

Savage River Reservoir

ing the repeat of any historical drought.

(2) Maintain the risk of entering the Emergency Stage of the LFAA at less than 2 percent with full reservoirs on June 1.

(3) Maintain the risk of not refilling any reservoir used for water supply at less than 5 percent.

(4) Maintain the LFAA specified low flow over Little Falls dam at 100 mgd.

(5) Minimize conflict between normal utility operations and drought operations.

(6) Provide consistency with the requirements of the LFAA.

(e) The LFAA should be revised to: (1) eliminate the provisions that freezes the computation of each jurisdiction's low flow share after 1988, and (2) include Little Seneca Lake releases as flow subject to the allocation formula. These revisions should become effective only when Little Seneca Lake is operational and the regional operating agreement is in place.

(f) Cost for construction and O&M of any future MWA water supply project after Little Seneca Lake should be shared among the parties in accordance with the formulas listed in the box below. Further, water from such a project would be subject to allocation according to the LFAA. Symbols in the formulas are defined as follows:

A = The average number of gallons of processed water pumped daily by the Aqueduct to all its customers from all sources (expressed in million gallons per day) during the month of July in each of the five (5) years immediately preceding the award of a contract(s) for the construction of the additional water supply facilities.

B = The average number of gallons of processed water pumped daily by the Aqueduct to all its customers from all sources (expressed in million gallons per day) during the month of July in each of the years 1981 through 1985.

C = Same as A, except subsitute the number of gallons of processed water pumped daily by the FCWA.

D = Same as B, except substitute the number of gallons of processed water pumped daily by the FCWA.

E = Same as A, except substitute the number of gallons of processed water pumped daily by the WSSC.

F = Same as B, except substitute the number of gallons of processec water pumped daily by the WSSC.

District of Columbia's Share	$\% = \dfrac{(A\text{-}B)}{(A\text{-}B) + (C\text{-}D) + (E\text{-}F)} \times 100$
FCWA's Share	$\% = \dfrac{(C\text{-}D)}{(A\text{-}B) + (C\text{-}D) + (E\text{-}F)} \times 100$
WSSC's	$\% = \dfrac{(E\text{-}F)}{(A\text{-}B) + (C\text{-}D) + (E\text{-}F)} \times 100$

The Regional Water Supply Plan

Description of Plan Elements

The plan proposed by the Regional Task Force and subsequently adopted by the local jurisdictions is projected to satisfy the water supply needs of the Potomac water utilities (Washington Aqueduct, Washington Suburban Sanitary Commission, Fairfax County Water Authority, and Rockville) until at least the year 2030. The plan consists of numerous interlocking elements, as depicted on Figure 12. Taken together, the combination of structural projects, nonstructural programs, and the natural flow in the Potomac River form the regional plan which provides for an efficient balance of supplies and demands.

The key element on Figure 12, though, is the cooperative regional management of the water supply resources. When the system is managed as a regional unit, it is possible to obtain certain synergistic effects which improve the system's water supply capability. Without such management it is unlikely that the individual water supply system would be managed for the maximum benefit of all users, and shortages could result. The following paragraphs provide brief descriptions of the various elements that make up the MWA water supply plan and how they serve to satisfy the area's needs. For reference, Figure 13 shows the geographic location of the structural elements of the regional plan, along with some pertinent data relating to these projects.

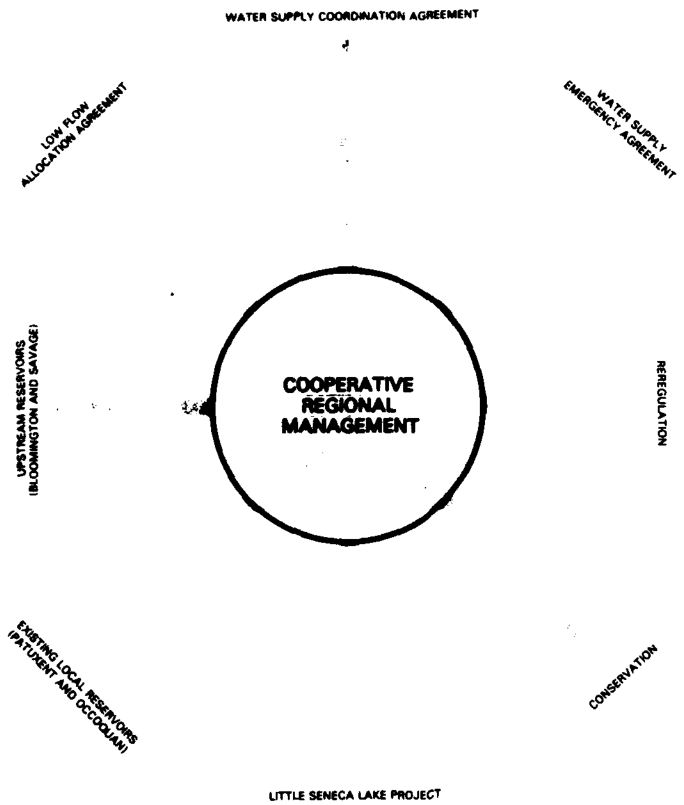
Low Flow Allocation Agreement

The Low Flow Allocation Agreement signed in 1978 and modified in 1982, provides for an equitable means of allocating Potomac River water among the MWA users during low flow periods so that no area suffers disproportionate shortages. The Agreement further provides for a review every five years to determine the fairness and reasonableness of the allocation formula. Should further action be needed in the future to balance supplies and demands, this Agreement furnishes the logical means by which needs can be identified and appropriate actions undertaken. The LFAA also stipulates that a certain amount of flow be allowed to enter the Potomac Estuary as environmental flowby. As discussed earlier, the LFAA signatories have adopted a 100 mgd value for flowby to the Estuary with a 300 mgd target for the stretch of river between Great Falls and Little Falls, based on the recommendations in Maryland's Flowby Study.

Water Supply Coordination Agreement

The Water Supply Coordination Agreement is an operational agreement among the Washington Surburban Sanitary Commission, the Fairfax County Water Authority, and the District of Columbia/Washington Aqueduct. This Agreement formalizes the region's commitment to coordinated operation of its water supply resources, and is the corner-

Fig. 12-Elements of the Regional Plan



stone of the cooperative regional management of the water supply system. The Interstate Commission of the Potomac River Basin, through their CO-OP Program, was identified as the appropriate existing agency to manage the technical programs necessary to sustain the regional cooperation. The Agreement also provides the cost-sharing arrangement for any future water supply projects for the MWA, if and when they are needed.

Emergency

Water Use Reduction

In recognition of possible water shortage situations in the MWA, the local governments had approved the Water Supply Emergency Agreement (WSEA) in 1979. This Agreement is incorporated into the regional plan along with the other elements developed by the Regional Task Force. Contained within the Agreement is a Water Supply Emergency Plan (WSEP) which details short-term emergency actions and curtailments that could be implemented in the event of water shortages. Such emergency actions include banning outdoor water use, eliminating street washings, and restricting the use of ornamental fountains to name only a few. By addressing means to conserve water use during shortage periods, this plan compliments the Potomac Low Flow Allocation Agreement, which is designed primarily to distribute available supply during times of water shortages.

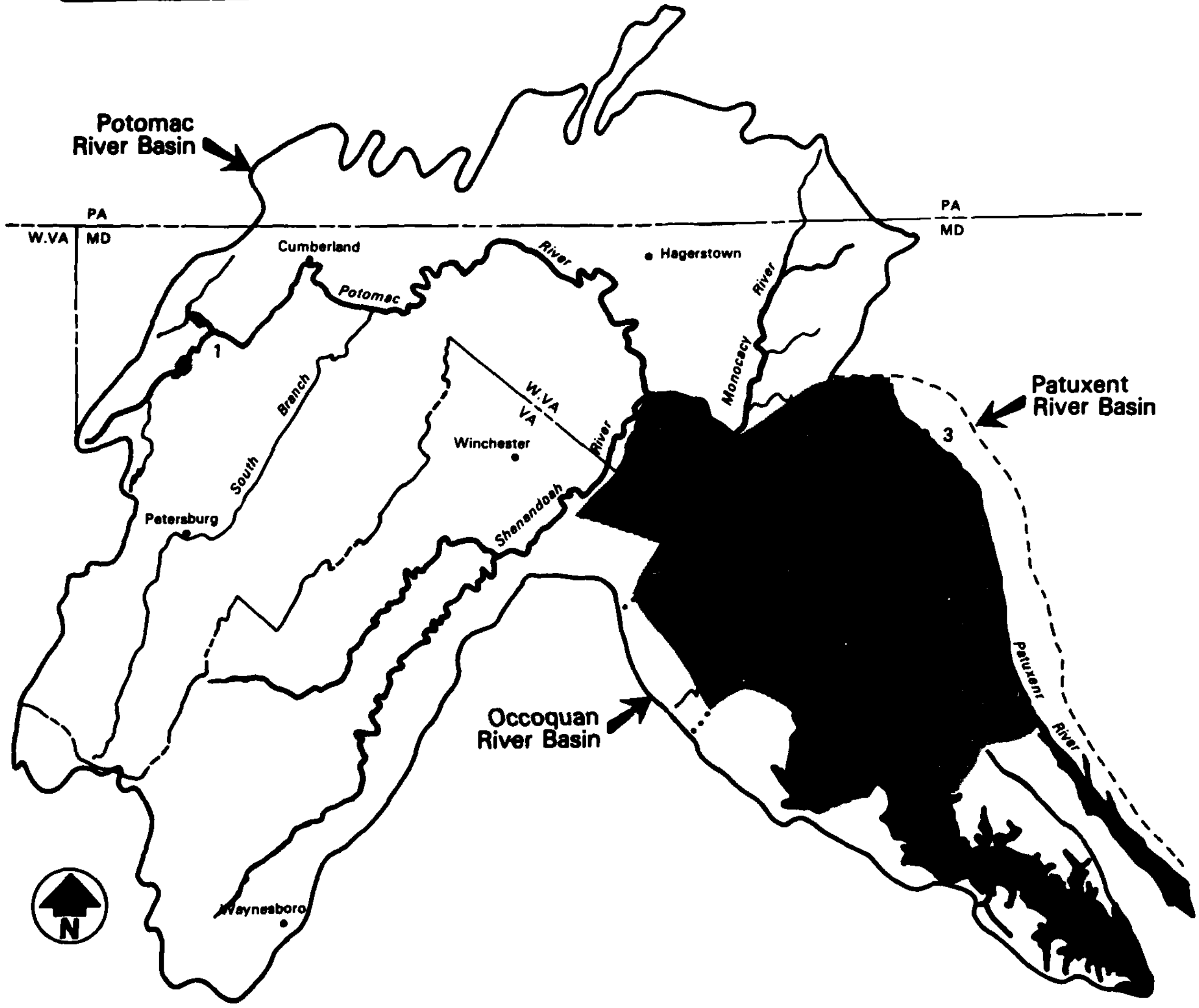
Long-Term Water Conservation

Water conservation and demand reduction measures are also part of the regional plan. These measures can be employed to use existing supplies more efficiently and to decrease the unnecessary use of water throughout the year. Some of the conservation measures include continuing consumer education on wise water use, metering of all connections, using pressure reducing valves, and implementing plumbing code regulations for water saving devices. A gradual implementation of such water conservation measures is expected to reduce MWA water demands about eleven percent by the year 2030.

Reregulation

Reregulation involves using both the Potomac River and an off-Potomac reservoir to serve a single water distribution system. This mode of operation requires a flexible distribution system that can be served by either of two sources. During normal conditions, the service area is served largely from the Potomac River, thereby conserving storage in the off-Potomac reservoir. During a low flow condition in the Potomac River, however, a greater area is served from the reservoir, thereby decreasing withdrawals from the river. Both WSSC and FCWA presently have the capability to employ reregulation. By maximizing the use of the Potomac River and minimizing use of the Patuxent and Occoquan Reservoirs during non-drought periods, water could be "conserved" in the reservoirs. This mode of operation insures maximum reservoir capacity at the onset of drought conditions in the Potomac River, when the reservoirs could be relied on more heavily. The WSSC and FCWA could then withdraw more water from the reservoirs during a drought, thus leaving more water in the Potomac River for the Aqueduct and Rockville which have no other source of water. The Potomac Low Flow Allocation Agreement employs the concept of reregulation as a fundamental requirement for allocating Potomac River water among the users.

Fig. 13-Location of Structural Elements of Regional Plan



Legend

Metropolitan Washington Area (includes the following: Washington, DC; Montgomery, Prince Georges and Charles counties in MD; and Arlington, Fairfax, Prince William and Loudoun counties in VA).

1 UPSTREAM RESERVOIRS

Approximate 7-Day Travel Time to MWA Intakes
Releases Blended to Improve Water Quality

SAVAGE RESERVOIR
Total Available Storage - 5900 Million Gallons
Maximum Release - 3130 MGD

BLOOMINGTON LAKE
Total Available Storage - 30,000 Million Gallons
Maximum Release - 10,710 MGD

2 LITTLE SENECA LAKE

Total Available Storage - 4020 Million Gallons
Maximum Release - 275 MGD
Approximate 1-Day Travel Time to MWA Intakes

3 PATUXENT RESERVOIRS

ROCKY GORGE & TRIADELPHIA
Total Available Storage - 10,100 Million Gallons
Max. Water Supply Withdrawal - 65 MGD

4 MWA INTAKES

	Maximum Withdrawal (MGD)	Treatment Capacity (MGD)
FCWA	200	50
WSSC	400	240
Rockville	8	8
Aqueduct	650	371

5 ENVIRONMENTAL FLOWBY

Environmental Flowby to the Estuary with a Minimum Value of 100 MGD

6 OCCOQUAN RESERVOIR

Total Available Storage - 10,300 Million Gallons
Max. Water Supply Withdrawal - 112 MGD

Little Seneca Lake

The Little Seneca Lake project, which is presently under construction, is located in the Seneca Creek Watershed, just northeast of Boyds in Montgomery County, Maryland. When completed, the project will provide an additional four billion gallons of water. Operation of the Little Seneca project as part of an overall system will allow this project to be operated as a supplemental source to respond to seasonal and/or daily variations in demand and supply. Simply stated, releases from the project will be used, if necessary, to supplement Potomac River flows during droughts. Unlike releases from Bloomington which may take several days to reach the MWA, releases from Little Seneca Lake will reach the MWA Potomac intakes in one day or less. This short travel time will allow the project to be used to make small adjustments in supply without "wasting" large amounts of upstream storage.

Local Reservoirs

The existing local reservoirs on the Patuxent River and Occoquan Creek provide a total of 20.4 billion gallons of storage and are also operated as part of the overall MWA water supply system. As noted earlier, the use of the Patuxent and Occoquan reservoirs can be minimized during non-drought periods so that storage is retained. During droughts, the reservoir storage would then be used more heavily by WSSC and FCWA. Thus, more water would remain in the Potomac River for use by the Washington Aqueduct and Rockville which have no other source of raw water.

Upstream Reservoirs

Lastly, the remaining elements of the system are the upstream reservoirs which include Bloomington

Lake with 30.0 billion gallons of storage and the Savage River Reservoir with 5.9 billion gallons of storage. Based on analyses conducted as part of the Corps' Bloomington Lake Reformulation Study, Bloomington and Savage will be operated in tandem to satisfy not only the upstream needs in the North Branch Potomac River, but also to provide supplemental water supply releases to benefit the MWA. Releases from the upstream reservoirs can be categorized as providing a generally constant increase to the Potomac River's base flow. The existing local reservoirs and Little Seneca Lake may then be regulated to account for daily fluctuations in either supply or demand. Thus, the conjunctive regulation of both the upstream and local reservoirs makes more effective use of the existing water supply resources and minimizes the environmental and social impacts of their use.

Assumptions

In formulating the regional plan, certain specific assumptions were made regarding flow rates, intake capacities, reservoir storage, and other parameters. These specific assumptions were in addition to those broad study assumptions cited in Chapter I. Table 6 lists the important assumptions for the adopted regional plan. Although too lengthly to discuss in this summary document, the reasons for selecting particular values are described at length in the various report appendices.

Description of Plan Operation During Droughts

To furnish an overview of ***how*** the MWA water supply system might operate during a drought, Figure 14 shows a schematic of a typical situation. The figure displays the drought's progression through an entire season as the demands gradually increase and the available natural Potomac flows decrease. Across the top of Figure 14 are listed the basic sequence of actions which could be taken to avoid potential shortages when demands begin to exceed supplies. These actions are geared to making the most efficient use of all sources from a regional perspective.

Moving left to right (spring to summer to fall) on Figure 14, the following sentences more fully describe the concepts which are embodied in the operational scheme displayed on the figure.

- During the early spring, reservoir releases (Bloomington, Savage, Occoquan & Patuxent) are minimized so as to retain as much water as possible in reservoir storage for later use. Water needs are served primarily with Potomac River water.
- During the late spring and early summer, reservoir releases are slowly increased as water needs grow and the natural Potomac River flows drop. Reregulation is employed to "even out" daily flucuations in the availability of Potomac River water. Withdrawals from the upstream and downstream reservoirs are proportioned so as not to stress one reservoir too heavily. Reservoir releases

and withdrawals are based on the principles of the Water Supply Coordination Agreement and the CO-OP forecasts for Potomac River flow.

- The alert, restriction, and emergency stages of the Low Flow Allocation Agreement are implemented when withdrawals from the Potomac River reach 50 percent, 80 percent, and 100 percent of the Potomac flow, respectively. When the emergency stage is reached, the Occoquan and Patuxent water treatment plants should be operating at their full capacity, and the mandatory water use restrictions of the Water Shortage Emergency Agreements should be in effect.
- If water shortages still appear likely, if releases from the upstream reservoirs will not arrive in time, and if the Occoquan and Patuxent water treatment plants are operating at full capacity, then water is released from Little Seneca Lake. Little Seneca Lake acts as a "safety valve" to supply needed water on short notice if shortages are imminent.
- Releases from Little Seneca Lake are adjusted as needed so that supply just matches demand, after providing the proper amount of flowby. Little Seneca Lake releases are discontinued when the shortage period is over.
- As water needs decrease and/or Potomac flows increase, reservoir releases are reduced. The cycle begins again as reservoir releases are minimized in order to retain more water in reservoir storage for a subsequent low flow period.

In summary, the underlying principle in this operational procedure is to reduce water wastage (i.e., unneeded reservoir releases) by making large reservoir releases only as necessary to meet water needs. The capability of existing suppliers can be substantially extended in this manner. Obviously, the regional agreement for cooperative system management is the critical element which allows the users to obtain the maximum benefits and reduce water wastage.

TABLE 6
ASSUMPTIONS FOR REGIONAL PLAN

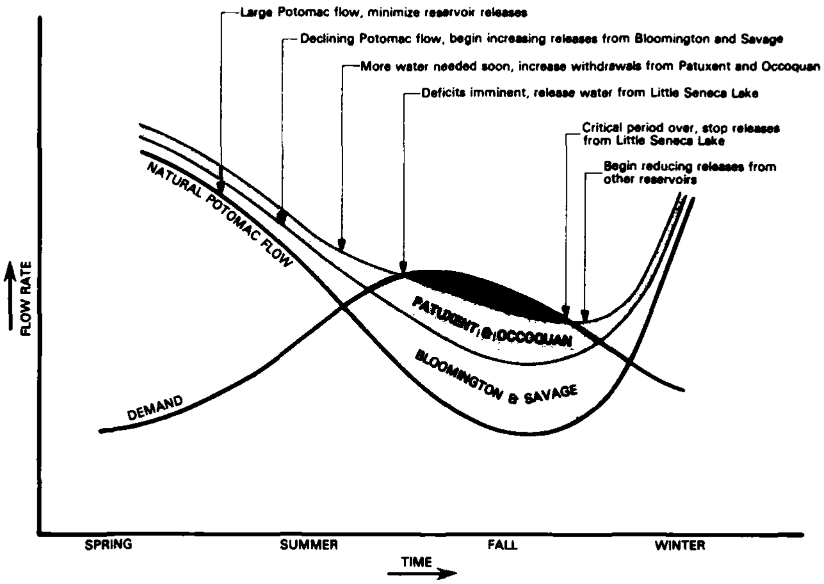
Parameters	Value
Bloomington Lake	
Total Conservation Storage	30,000 mg
Water Supply Storage	13,370 mg
Water Quality Storage	16,630 mg
Minimum Release	32 mgd
Maximum Release	10,710
Water Supply Release	variable
Seasonal Drawdown for Flood Control	yes
Savage River Reservoir	
Available Storage	5,900 mg
Minimum Release	13 mgd
Maximum Release	3,130 mgd
Seasonal Drawdown for Flood Control	yes
Upstream Releases	
Flow Target at Luke, Maryland	78 mgd
Bloomington/Savage Release Ratios	time-dependent, flow-dependent
Flow Loss Between Luke and MWA Intakes	0 mgd
Percent of Releases Arriving at MWA, 1st Week	47%
Percent of Releases Arriving at MWA, 2nd Week	53%
Occoquan Reservoir	
Water Supply Storage	10,300 mg
Environmental Flowby	0 mgd
Minimum Water Supply Withdrawal	30 mgd
Maximum Water Supply Withdrawal (7-day average)	95 mgd
Patuxent Reservoirs (Triadelphia & Rocky Gorge)	
Water Supply Storage	10,100 mgd
Environmental Flowby	10 mgd
Minimum Water Supply Withdrawal	20 mgd
Maximum Water Supply Withdrawal (7-day average)	55 mgd
Little Seneca Lake	
Water Supply Storage	4,020 mg
Environmental Flowby	1.12 mgd
Minimum Relase	0 mgd
Maximum Release	275 mgd
Potomac Intake Capacity	
Aqueduct	650 mgd
WSSC	400 mgd
FCWA	200 mgd
Rockville	8 mgd
Potomac Estuary Flowby	100 mgd
Demand Level	
Population Projections	MWCOG Round I
Conservation Level	Scanario 3
LFAA Provisions	1982 Modifications, No Freeze

Drought Simulation

A measure of the effectiveness of the regional plan would be to test the water supply system's actual performance during a severe drought. This would be a risky undertaking at best. Instead, a need was identified for a mathematical (computer) model to simulate historical droughts using recorded low flow conditions, assuming projects and programs such as those embodied by the Regional Task Force's plan.

Fortunately, a research team at Johns Hopkins University had been developing such a model in the late 1970's, even before the formation of the Regional Task Force. The Hopkins model, titled "Potomac River Interactive Simulation Model" (PRISM), was subsequently used by the Corps in the MWA Water Supply Study. The following sections briefly describe PRISM, application of PRISM to the MWA's regional water supply situation, the results of the computer modelling, and the sensitivity of the results to various flowby levels.

Fig. 14-Schematic of System Operation



Description of PRISM/COE

Background

At about the time the Corps was completing its ***Progress Report*** and the Regional Task Force was beginning its efforts, it was generally recognized that a different approach was required to fully describe the MWA's water supply problems. Whereas the Corps' early-action phase addressed the water supply problem almost exclusively in terms of a ***rate*** of required flow (in mgd) without regard to remaining reservoir storage, it was felt that further work should address the problem in terms of a ***volume*** of required water supply (in mg) to satisfy needs throughout a prolonged drought period. The advantages of the volume approach would be that: (1) it would enable a more thorough investigation of methods for cooperatively managing the MWA's several reservoirs, (2) it would realistically reflect information which the water utility managers would consider when making decisions on how to operate their systems during droughts, and (3) it would furnish an accurate picture of the sensitivity and hydrologic capabilities of the overall system with respect to changes in demand, supply, and flowby levels during historic droughts.

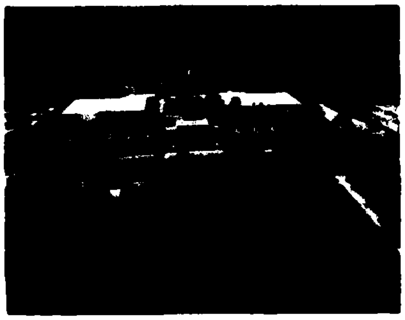
Low Flow, North Branch Potomac River

The need to reconsider the exact nature of the water supply problems became even more apparent following the initiation of the Bloomington Lake Reformulation Study. (This study, undertaken in 1980 in response to a request from five Congressional representatives from the MWA, was included as part of the overall MWA Water Supply Study; details of the investigation are contained in Appendix H.) This Bloomington study hac[illegible] major objectives: (1) to investigate regulation strategies to maximize the water supply capability of the existing Bloomington Lake project, and (2) to determine the feasibility of reallocating some Bloomington water quality or flood control storage to water supply storage to meet additional downstream needs. In the process of investigating the first objective, it was soon demonstrated that the Bloomington Lake project could provide substantially greater releases than originally envisioned if operated in conjunction with other reservoirs serving the MWA. (The early-action efforts had assumed a maximum release of only 135 mgd from Bloomington Lake). This finding was subsequently endorsed by the Regional Task Force and had far-reaching effects on redefining the water supply problem.

Capabilities of PRISM/COE

Given the desire to redefine the problems in terms of volume (mg) for droughts of record, the possibility of different regulation procedures for Bloomington Lake, and the availability of the Hopkins computer model, the Corps revised and modified PRISM to reflect the programs and projects being considered by the

Potomac Water
Treatment Plant, Washington
Surburban Sanitary Commission



South Branch Potomac River

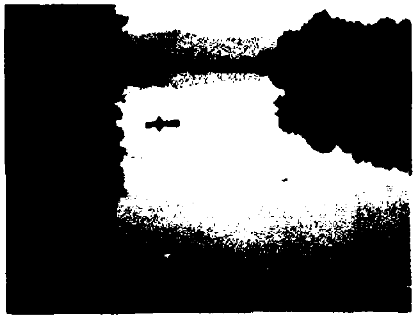
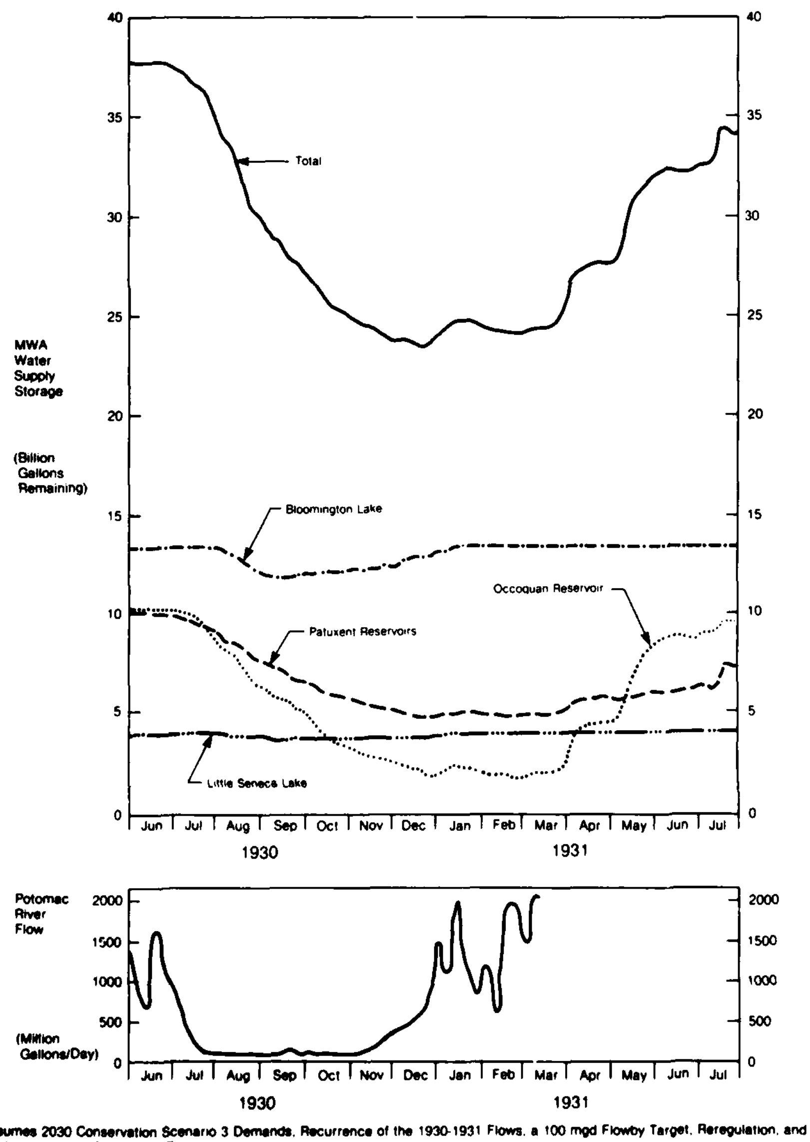


Fig. 15-Simulation Results for the Regional Plan

Figure 15
Simulation Results for the Regional Plan*



*Assumes 2030 Conservation Scenario 3 Demands, Recurrence of the 1930-1931 Flows, a 100 mgd Flowby Target, Reregulation, and Conjunctive Use of the MWA Reservoirs

Regional Task Force. The Corps' version of the computer model was titled PRISM/COE to differentiate it from the earlier Hopkins' version.

PRISM/COE is a basin-specific model which simulates the operation of the MWA water supply system on a weekly (7-day) basis. It includes important data such as major supply sources (Potomac River and Occoquan, Patuxent, Bloomington, and Savage Reservoirs), demands of the major users (Aqueduct, FCWA, and WSSC) by benchmark year, allocation ratios from the Potomac LFAA, water treatment plant capacities, streamflow targets, and 50 years of historic flow records from area streams. In simplified terms, PRISM/COE is an "accounting" mechanism for the regional water system. Given a set of operating conditions and assumptions, PRISM/COE reports the consequences of these scenarios on a week-by-week basis. PRISM/COE calculates the story remaining in each reservoir within the system, the flowby level at Little Falls, the demand of each user, the allocated share of Potomac River water, and the magnitude of any shortages.

Because PRISM/COE is a simulation model, it merely reports the consequences of a given set of conditions. It does not "optimize" system operation in the truest sense of the word. However, repeated application of the model with slightly different assumptions during each repetition allows the user to determine very good, if not optimal, regulation strategies. It was in this manner that PRISM/ COE provided its greatest utility. Many different assumptions and input values were tested, both quickly and inexpensively, to determine Bloomington Lake's response and the overall system's response to various management strategies.

Details concerning model development and application are contained in Annex H-III, ***PRISM Development and Application.*** It should be noted that PRISM/COE was strictly a water quantity model and did not explicitly consider water quality concerns. However, some of the assumptions used in PRISM/COE were based on the results of water quality analyses undertaken for the Bloomington Lake Reformulation Study. Annex H-II furnishes a discussion of these water quality examinations as they relate to Bloomington Lake and the North Branch Potomac River.

Results of Mathematical Simulations

Using the projects, programs, and assumptions of the regional plan as discussed in earlier sections of this chapter, hydrologic simulations were conducted using PRISM/COE. The hydrologic data used in the simulations included 50 years of flow records between 1929 and 1979 for the Potomac River, Occoquan Creek, and Patuxent River. As such, the data covered the two most severe droughts on record — the early 1930's and the mid 1960's.

The simulation results for the 1930–31 and 1966 droughts, assuming year 2030 demands, are presented in Table 7 and Figure 15. The results show that the MWA supply system, as it is currently envisioned with the regional plan, could satisfy 2030 demands (Conservation Scenario 3) with no difficulty. In fact, about 60 percent (over 40,000 mg) of the region's total water supply storage would still be available at the end of the 1930–31 drought, and nearly 75 percent (almost 47,000 mg) would remain at the end of the 1966 drought. For the longest historical drought (1930–31) as well as the most severe low flow occurrence (1966), then, the system would experience no shortages. The keys to the system's ability to avert shortages are the availability of Little Seneca Lake releases on short notice and the

TABLE 7
SUMMARY OF SIMULATION RESULTS FOR REGIONAL PLAN*

	1930–31	1966
Maximum Deficit (mgd)		
WSSC	0	0
FCWA	0	0
WAD	0	0
Region	0	0
Cumulative Deficit (mg)	0	0
WSSC	0	0
FCWA	0	0
WAD	0	0
Total	0	0
Available Storage Remaining (mg)		
Water Supply		
Bloomington11,822		
Occoquan	11,822	12,255
Patuxent	4,758	7,033
Little Seneca	3,797	3,082
Total	22,157	28,551
% of capacity (37,790 mg)	58.6%	75.6%
Non-Water Supply		
Bloomington	13,275	13,645
Savage	4,801	4,731
Total	18,076	18,376
% of Capacity (22,530 mg)	80.2%	81.6%
Total Storage Remaining	40,233	46,927
% of Capacity (60,320 mg)	66.7%	77.8%
Weeks at Minimum Flowby Level (100 mgd)	13	7

*Hydrologic simulation conducted using year 2030 Conservation Scenario 3 demands.

Fig. 16-Advantages of Regional Cooperation

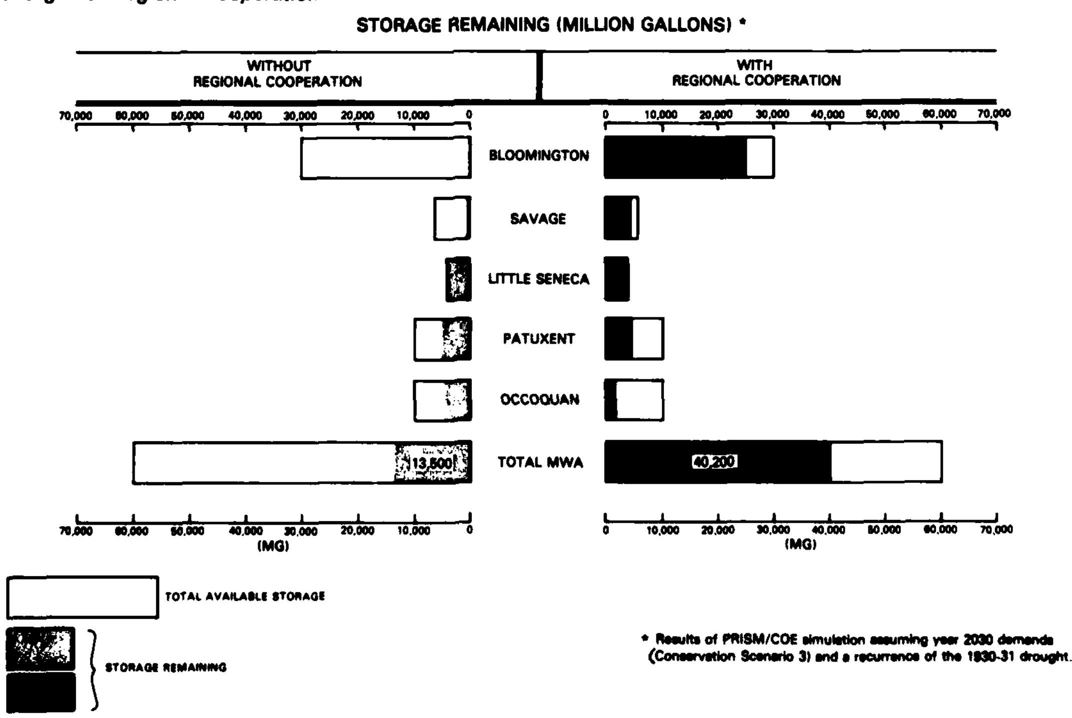


TABLE 8
SENSITIVITY OF REGIONAL PLAN TO DIFFERENT FLOWBY TARGETS*

	Flowby Level, mgd		
Maximum Deficit (mgd)	100	300	500
WSSC	0	38	173
FCWA	0	23	63
WAD	0	38	150
Region	0	99	362
Cumulative Deficit (mg)			
WSSC	0	835	14,503
FCWA	0	607	4,928
WAD	0	942	12,604
Total	0	2,384	32,035
Available Storage Remaining, mg			
Water Supply			
Bloomington	11,822	0	0
Occoquan	1,780	0	0
Patuxent	4,758	2,707	1,379
Little Seneca	3,797	0	0
Total	22,157	2,707	1,379
% of capacity (37,790 mg)	58.6%	7.2%	3.6%
Non-Water Supply			
Bloomington	13,275	6,852	6,778
Savage	4,801	543	0
Total	18,076	7,395	6,778
% of Capacity (22,530 mg)	80.2%	32.8%	30.1%
Total Storage Remaining	40,233	10,102	8,157
% of Capacity (60,320 mg)	66.7%	16.7%	13.5%
Weeks at Minimum Flowby Level	13	18	21

*Hydrologic simulation conducted using year 2030 Conservation Scenario 3 demands.

cooperative management of the river and reservoir system.

To demonstrate the advantage of cooperative management of the water supply system, an additional PRISM/COE simulation was conducted using the 1930–31 low flow records and year 2030 demands. All assumptions, projects, and programs were the same as those previously described for the regional plan, except that no cooperative management was included. Simply stated, Bloomington and Savage Reservoirs were operated to satisfy a constant flow target of 197 mgd at Luke, Maryland (as proposed in Bloomington's authorization document) with little regard to satisfying the fluctuating water needs in the MWA. Local reservoirs in the MWA were operated to furnish any additional water which was needed, up to the maximum withdrawal limits.

Figure 16 displays the remaining reservoir storage for two simulations, both with and without regional cooperation, for the 1930–31 drought. As the figure shows, about 13,500 mg of storage would remain at the end of the drought without regional cooperation whereas about 40,200 mg of storage would remain if regional cooperation was practiced. This "savings" of 26,700 mg (or reduced wastage as discussed earlier) is attributable to systems management, and demonstrates the desirability of such an approach. The "savings" in storage represents a valuable buffer should a drought more severe than 1930–31 occur, or should water needs grow more rapidly than presently projected.

Sensitivity Analysis

For the 1930–31 drought and year 2030 demands, the simulated system operated for 13 weeks at the minimum flowby level of 100 mgd, as depicted in the Potomac River hydrograph on Figure 15 and listed in Table 7. For the remaining years of flow record, the minimum flowby of 100 mgd was reached in a total of only 11 weeks of system operation: seven weeks during 1966, two weeks during 1964, and two weeks during 1982.

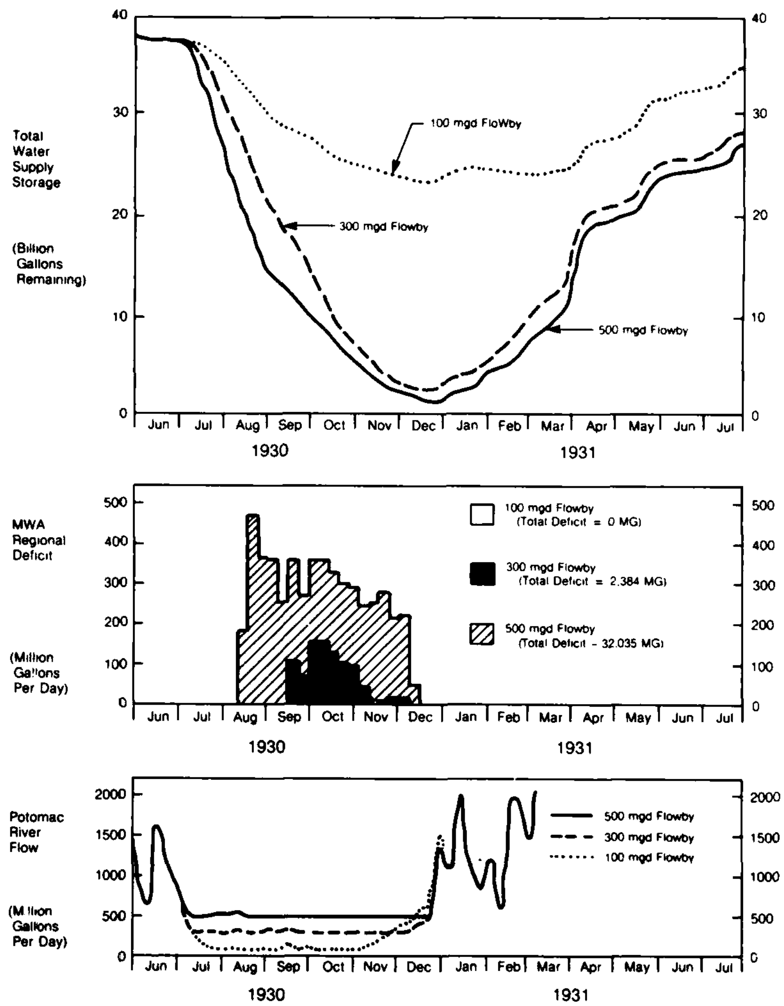
Noting that the PRISM/COE simulations indicated the system could easily handle historical droughts and year 2030 demands with the 100 mgd flowby target, a sensitivity analysis was conducted using higher levels of flowby to the Estuary. Flowby targets of 300 mgd and 500 mgd were selected for the sensitivity analysis. While the PRISM/COE simulations modelled the higher targets as an Estuary need, the higher flowbys could also be viewed as either additional system demands or as lower base flows than those recorded since 1929. The additional demands could be the result of (1) larger population growth than anticipated in the Round I forecast, (2) higher unit water use than that indicated by Conservation Scenario 3, or (3) reduction in the water supply capability of an off-stream source, such as the Occoquan or Patuxent Reservoirs.

For convenience in using PRISM/COE, though, higher flowby levels were used to evaluate the sensitivity of the MWA system to greater demands or lower supply conditions. The PRISM/COE simulations indicated that, with the 300 mgd Estuary flowby target and year 2030 demands, shortages would occur only for a 1930–31 flow recurrence. The 500 mgd flowby target would result in a severe MWA shortage with 1930–31 flows and year 2030 demands, and a moderate shortage with 1966 flows. The extent of the shortages, flow conditions, and remaining water supply shortages during the 1930–31 drought are compared in Table 8 and Figure 17 for the three flowby targets.

Subsequently, with an increase in demand or reduction in supply equivalent to 300 mgd flowby (200 mgd incremental change), the MWA system would severely tax its storage resources in a serious, long-term drought. The PRISM/COE simulations indicated that for the 1930–31 drought condition and year 2030 demands, the system's water supply storage would be reduced to only seven percent of its capacity. In addition, the system would experience a shortage of about 2,400 million gallons. For a 150-day drought (five months), this shortage would average about 16 mgd.

Larger increases in demand or reductions in supply would have even more significant effects. A flowby of 500 mgd (a change of 400 mgd) would result in a regional shortage of 32,000 million gallons over a five-month period during a recurrence of the 1930–31 drought with year 2030 demands, or an average of about 210 mgd. The system storage would be reduced to less than four percent of its capacity. To provide a measure of comparison for this shortage volume, the total conservation storage in Bloomington Lake (including both water supply and water quality storage) is 30,000 million gallons.

Fig. 17-Sensitivity of Regional Plan to Different Flowby Targets



*Assumes 2030 Conservation Scenario 3 Demands, Recurrence of the 1930-1931 Flows, Reregulation, and Conjunctive Use of the MWA Reservoirs.

Summary and Status of Plan Implementation

Using the Corps' *Progress Report* and the results of the ICPRB's CO-OP program to provide basic information, the Metropolitan Washington Regional Water Supply Task Force proceeded to develop a regional plan for local implementation. The Regional Task Force identified both structural and non-structural measures to avert potential water supply shortages through at least the year 2030, assuming a value of 100 mgd for flowby. Hydrologic simulation using PRISM/COE confirmed the findings of the Regional Task Force regarding plan effectiveness. In addition to identifying the measures necessary for a regional plan to operate successfully, the Regional Task Force also negotiated a series of interlocking agreements and contracts to implement its recommended plan.

At a historic signing ceremony held on 22 July 1982, the following actions were taken by the various local, state and Federal jurisdictions to implement the recommendations of the Regional Task Force. It is important to note that these actions are being undertaken at the local level, with no further action required by the Federal government to implement the plan.

(a) A contract was signed by WSSC, FCWA, Aqueduct/DC to purchase all water supply storage in Bloomington Lake from the Federal government (see Annex H-IX).

(b) The existing contract between the Corps of Engineers and the Maryland Potomac Water Authority for Bloomington Lake's initial water supply storage was terminated (see Annex H-X).

(c) An agreement among WSSC, FCWA, and Aqueduct/DC to share the cost of Little Seneca Lake was signed (see Annex B-II). Groundbreaking ceremonies for the project were conducted in September 1982 and construction initiated soon thereafter. Completion of the project is expected in late 1984.

(d) An agreement among WSSC, FCWA, Aqueduct/DC and Allegany County to share the O&M costs of Savage River Reservoir was signed (see Annex B-III).

(e) An operational agreement between WSSC, FCWA, and Aqueduct/DC to achieve the regional water supply objectives was signed (see Annex B-I).

(f) The LFAA was modified to include releases from Little Seneca Lake as part of the water subject to allocation and to remove the freeze provision; both provisions are to be effective when Little Seneca Lake is operational (see Annex D-IV).

(g) A cost-sharing arrangement for any future water supply projects for the MWA was negotiated and included in the Water Supply Coordination Agreement (seen Annex B-I).

In a related matter, proposed legislation has been submitted to Congress to permit the sale of water from the Federally-owned Washington Aqueduct to authorities in the State of Maryland in a manner similar to the sale of water to Virginia communities authorized under existing legislation. Such authorization would allow the construction of finished water interconnectons between the Aqueduct and the WSSC in order to provide more efficient management of existing water supplies and to provide for mutual assistance between the utilities in time of need. Such finished water interconnections were also a direct outgrowth of the Corps' *Progress Report* which examined these linkages between finished water distribution systems. All expenses are to be paid by the requesting entity, which shall also pay charges for the use of such water.

Chapter V
Long-Range Planning

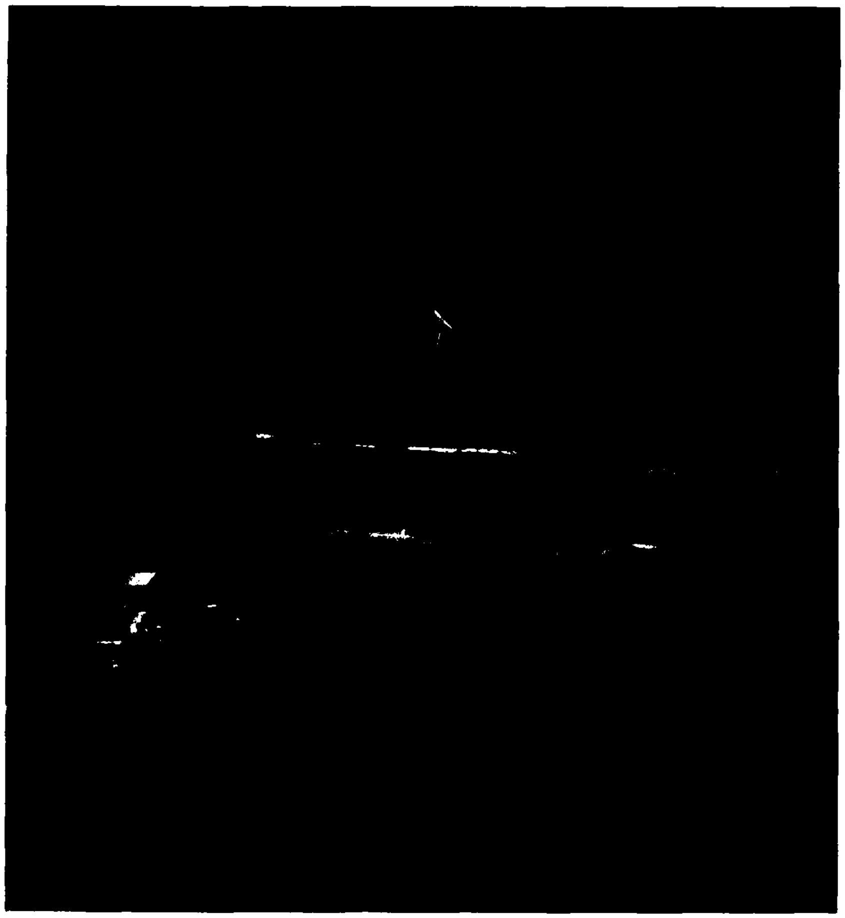
As originally envisioned, the long-range phase of the MWA Water Supply Study was to examine the water supply needs beyond the year 2000 and formulate plans by more fully considering the entire range of available water supply components. The findings of the early-action phase and the actions stemming from the ***Progress Report***, however, suggested a shift in focus be made for the long-range phase. It was no longer necessary to develop specific long-range "plans" to meet needs through the 50-year planning horizon because the contracts, agreements, and commitments to certain water supply projects discussed in the previous chapter would satisfy the region's needs through the year 2030. Consequently, the level of detail developed during the long-range phase was generally less than "feasibility scope." Only preliminary costs and impacts were generated to enable relative comparisons between the advantages and disadvantages of the various long-range components.

The emphasis in the long-range phase was placed on achieving three primary missions. The first was to respond fully to the study's authorizing legislation which required an examination of the complete spectrum of water supply options. Some of these examinations had been initiated shortly after the beginning of the study, and it was desirable to complete these analyses regarding the technical feasibility of less "traditional" supply and demand management options. The second mission was to use such technical information to evaluate, at least in a very preliminary fashion, the range of choices available to the region should the need for additional measures become apparent. Additional water supply needs could be a function of larger than anticipated demands, a higher minimum flowby level than is currently established, a decrease in available supplies, or any combination of factors. The third mission was to examine the needs of the outlying service areas and to examine general alternatives applicable to these areas.

Redefinition of the Base Condition

It is important to emphasize at the outset of this chapter that the "base condition" for the long-range phase was significantly changed from the base condition defined at the outset of the early-action phase. As discussed in Chapter IV, actions taken by the non-Federal sector in response to the 1979 ***Progress Report*** had significantly altered the earlier projections of water supply shortages. Projects to increase supply availability, programs to reduce water needs, and procedures to maximize operational efficiency all contributed to the prospect of eliminating any water supply shortages through the year 2030. Consequently, the base condition for the long-range phase of study was revised to include the elements of the regional plan described in the previous chapter. As such, the estimated water supply surpluses and/or shortages associated with the base condition for the long-range phase are the same as those computed by the PRISM/COE simulation model (see section titled "Drought Simulation" in Chapter IV).

Occoquan Dam and Reservoir, Fairfax County Water Authority



Description of Potential Long-Range Measures

Concurrent with the efforts of the Regional Task Force and the redefinition of the base condition, the Corps was undertaking studies for the long-range measures. These measures are listed in Table 9, and were identified through the study's authorizing legislation, through meetings with local officials, and through previous studies. These measures were judged to have potential applicability to the MWA in future years, given the right combination of financial, institutional, environmental, and social factors as well as a pressing need for additional demand reduction or supplemental supply measures.

Several of the measures listed in Table 9 were investigated in the early-action phase, including Conservation Scenarios 4 and 5, raw water interconnections, finished water interconnections, and some local reservoirs. They were reintroduced into the long-range phase because they still represented viable options for future water supply planning. Reregulation was not included in the list as it was already being practiced by WSSC and FCWA, and therefore was considered as part of the base condition. The remaining measures represented other approaches not explicitly considered in the early-action phase. The following sections provide a brief description of the measures.

TABLE 9
LONG-RANGE PLANNING MEASURES

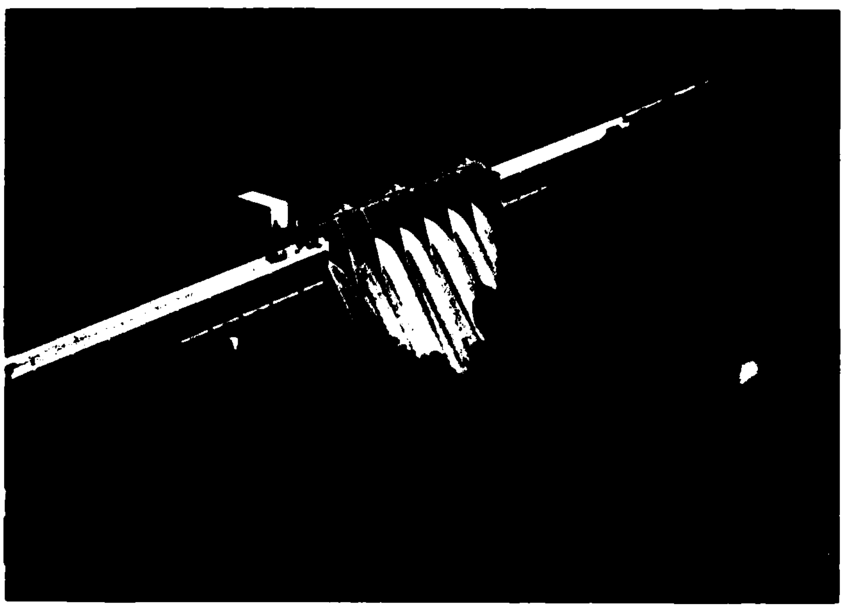
Water Conservation Scenarios 4 and 5
Raw Water Interconnections
Finished Water Interconnections
Pricing
Groundwater
Reservoirs
  Local
  Upper Potomac Basin
  Modification of Existing Reservoirs
Bloomington Lake Reformulation
  Changed Regulation Procedure
  Reallocation of Storage
Potomac Estuary Water Treatment Plant
Wastewater Reuse

Water Conservation

A previous section concerning the early-action phase has already summarized the development of five water conservation scenarios. Conservation Scenario 3 which projected an 11 percent demand reduction by 2030 was used for planning purposes in the early-action phase, and was subsequently included as part of the redefined base condition for the long-range phase. Water Conservation Scenarios 4 and 5 contain additional measures to reduce the total demand in 2030 by 13 percent and 27 percent, respectively. Appendix G-*Non-Structural Studies* contains detailed information on the development of the conservation scenarios.

Because Scenario 4 was similar to Scenario 3 in both effectiveness and cost, only Scenario 5 was considered further as a means to significantly alter demand. Scenario 5 represented the most stringent of the water conservation programs and was capable of the greatest level of potential reduction. Scenario 5 assumed the installation of the most efficient water-using devices in new residential construction, an intensive device installation program oriented towards existing residences, reductions in outdoor residential water use, a reduction in unaccounted for water, and reductions in indoor and outdoor non-residential water use. Implementation of Scenario 5 was projected to achieve approximately 16 percent more reduction in average annual demands than Scenario 3 demand levels by the year 2030 when compared to the baseline demands. Because of the intensiveness of Scenario 5, the capital cost projected for this measure would be high, approximately $183 million (October 1981 price levels) for the Aqueduct, FCWA, WSSC and Rockville service areas combined. Conservation Scenario 5 would produce little if any adverse environmental impacts.

T. Howard Duckett Dam and Rocky Gorge Reservoir, Washington Surburban Sanitary Commission



Raw Water Interconnections

Raw water interconnections serving the functions described in Chapter III and illustrated in Figure 8 were also considered further during long-range planning. Two projects were considered: one between the Potomac River at the WSSC intake and the Rocky Gorge Reservoir for Maryland users, and another between the Potomac River near the FCWA intake and the Occoquan Reservoir for Virginia users. The primary benefit of these projects would be to allow the utilities to serve more of their service areas from the reservoirs when Potomac River flows are low. Reversibility of flow adds to the flexibility of these components. Detailed descriptions of the projects are contained in Appendix E - ***Raw and Finished Water Interconnections and Reregulation.***

Various pipeline sizes were investigated for each route; however, it was assumed that a 60 mgd (54-inch pipe) Potomac-Rocky Gorge interconnection and a 65 mgd (60-inch pipe) Potomac-Occoquan interconnection would be the most reasonably sized projects given the water supply storages that would most likely be available under the existing regional reservoir operating agreements.

The capital costs would be approximately \$60 million and \$80 million (October 1981 price levels) for the Potomac-Rocky Gorge and the Potomac-Occoquan Reservoir projects, respectively. Raw water interconnections, therefore, would be fairly expensive projects. Environmental and social impacts would be the most severe during constructon while operational impacts after construction would be limited, with the possible exception of accelerated reservoir drawdowns during droughts.

Finished Water Interconnections

As discussed in Chapter III, finished water interconnections do not provide additional water to the region. By linking together independent finished water distribution systems, howeve added efficiency and emergency capability within the region would be created. This capability would be beneficial in the event of a failure or loss of water in any one system. Appendix E - ***Raw and Finished Water Interconnections and Reregulation*** contains the detailed cost and impacts of five interconnections which link the Aqueduct, FCWA and WSSC service areas. They range in cost from about \$70,000 to \$34 million (October 1981 pricing levels) depending upon size and length. These interconnections were further evaluated in the long-range phase because of their emergency capability.

Pricing

Water pricing as a tool for demand reduction represented another nonstructural approach considered in long-range planning. The primary purpose of the water pricing study was to determine if adjustments in the price charged to the consumer would be effective in reducing water demand in the MWA.

To answer this question, a marginal cost peak period pricing scheme was developed. This method represented the most efficient and equitable means of pricing from the viewpoint of economic theory. This scheme was tested with the known user costs associated with source development, treatment, transmission, O&M, and fixed costs for both water and sewer facilities.

The major finding of the pricing study was that the demand for water by the Potomac users could not be further reduced by implementation of marginal cost peak period pricing policies, at least in the immediate future. The relatively inexpensive cost of the supply management policies now being implemented in the MWA as part of the regional plan have the effect of making the planned new increments of supply so cost-effective that prices high enough to depress demand cannot be justified in terms of marginal peak costs.

Groundwater

Two areas having potentially high yields of groundwater were identified at the outset of the study. These areas were in the Hagerstown Valley of Western Maryland and the Atlantic Coastal Plain of Southern Maryland on the western shore of the Chesapeake Bay. Studies were undertaken by the United States Geological Survey (USGS) for both areas to estimate the probable yields; however, the Hagerstown Valley work was terminated due to strong local opposition and subsequent withdrawal of support by the State of Maryland. The Atlantic Coastal Plain study was continued to completion, and focused on four major water-bearing aquifers in Maryland within a 30-mile radius of Washington, D.C. These aquifers, listed in ascending order, include the Patuxent, Patapsco, Magothy, and Aquia aquifers. The Aquia aquifer, the uppermost

Fig. 18-Atlantic Coastal Plain, Potential Groundwater Development Sites

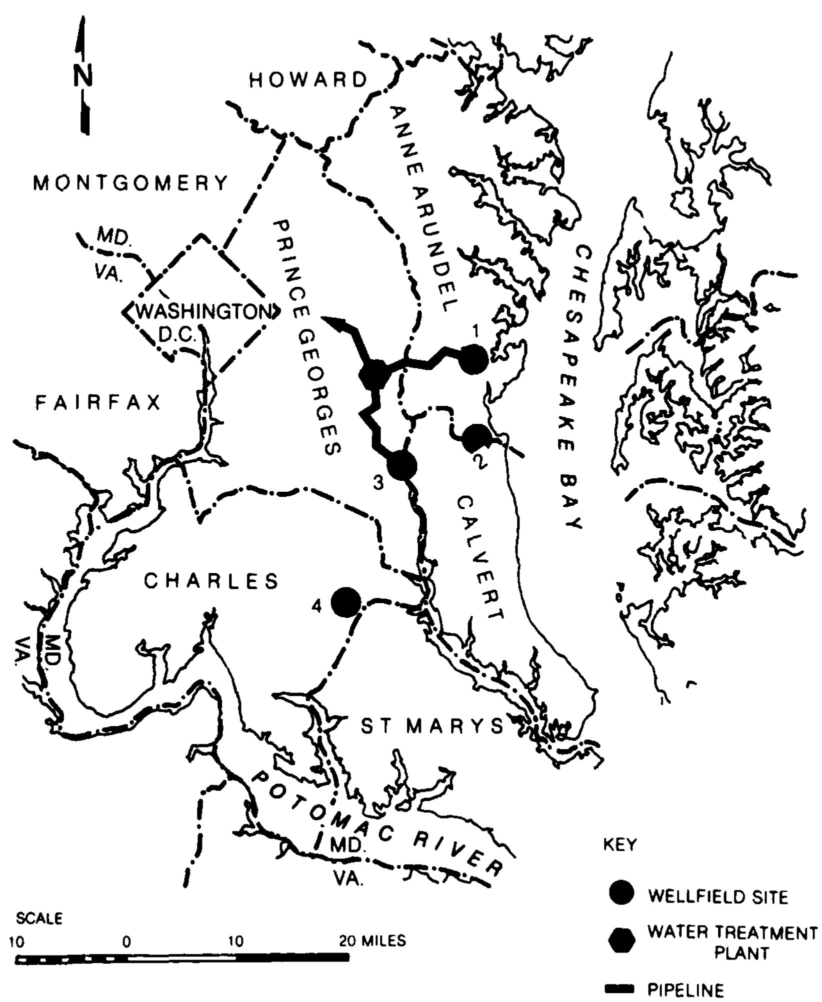
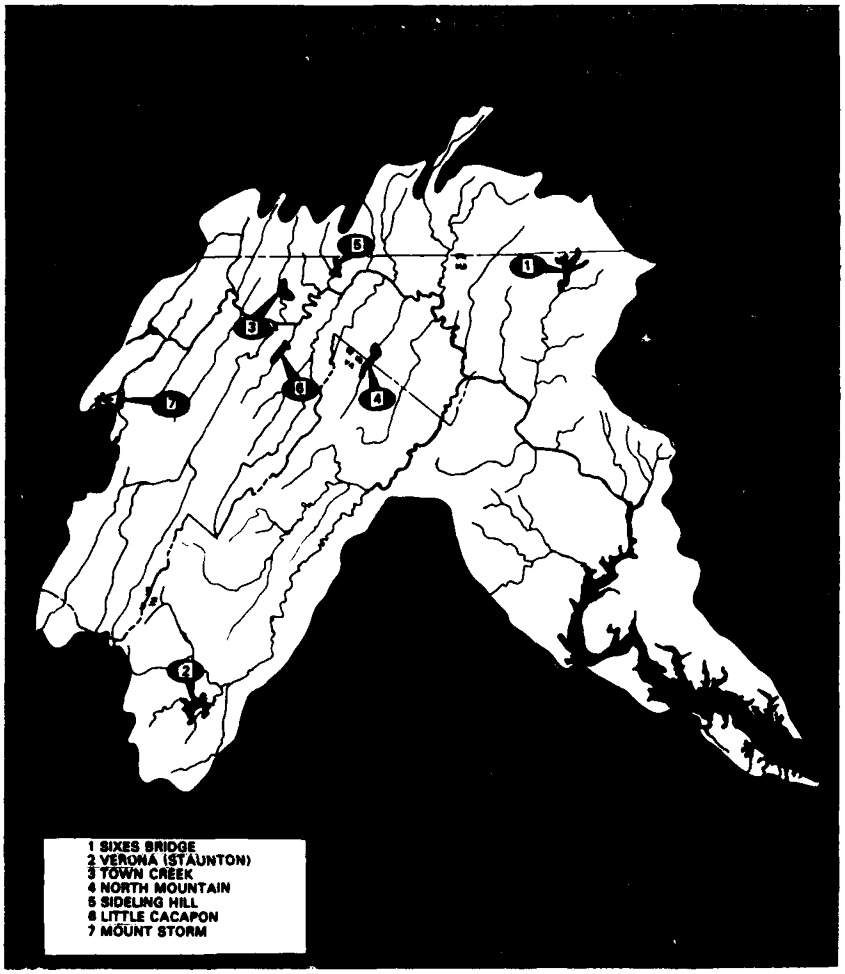


Fig. 19-Potential Upstream Reservoir Sites



aquifer, contains abundant water of high quality which presently furnishes most of the drinking water to communities in the area.

A computer model was developed by the USGS which was calibrated using existing groundwater information for the four aquifers. The model was used to determine yields and drawdown behaviors under various pumping scenarios. The four sites depicted on Figure 18 were selected for detailed computer modelling and preliminary design and cost estimates. These sites were chosen because of their collective potential to provide as much as 100 mgd during drought occurrences with minimal adverse impacts to local wells in the area and with minimal interference between aquifers.

Using the USGS information as a base, several pumping schemes were developed by the Corps of Engineers involving wellfield development at the four sites, water treatment, pumping, and conveyance to the MWA. It was determined that a scheme involving groundwater development at Sites 1 and 3, a centralized water treatment plant for both sites, and pumping of the treated water to the WSSC system near Largo, Maryland, represented the most cost-effective alternative (see Figure 18). The estimated capital cost for this scheme would be approximately $122 million (October 1981 price levels). Furthermore, at these sites only pumping in the Patuxent and Patapsco aquifers would be prudent since pumping in the Magothy aquifer would produce unacceptable drawdowns in the overlying Aquia aquifer which presently serves as a local supply source. It was also determined that presently operating wells in the Patapsco and Patuxent aquifers would not likely be affected by the scheme if developed; however, the effects on additional wells which may be drilled in these areas would need to be considered carefully.

It was also noted that a thorough test well program would be required to substantiate the USGS modelling study results prior to physical implementation of any of the schemes. Several other important findings related to the geo-hydrologic effects of pumping and the development of preliminary design and cost data are presented in Appendix F - ***Structural Alternatives.*** Environmental impacts would be temporary during the construction of the wellfields. No significant environmental impacts would likely result from project operation.

Reservoirs

Over the years, scores of reservoir projects have been evaluated by all levels of government for their potential to augment supplies for the MWA. Although few have been implemented, two key projects (Bloomington Lake and Little Seneca Lake) have either been constructed or are being constructed. Because of the great utility of reservoirs to achieve multiple purposes and because of changing economic, environmental, and social conditions and perceptions in the Potomac Basin, selected reservoir sites were reexamined in this study to better evaluate their viability in light of current conditions. Three broad categories of reservoirs were considered: new reservoirs in the upper Potomac Basin or "upstream reservoirs", new reservoirs within the MWA or "local reservoirs", and modification of existing reservoirs. Appendix F - ***Structural Alternatives*** contains detailed information about all three reservoir categories.

Upstream Reservoirs

Twenty-one upstream sites were reviewed including many originally recommended in the Corps' 1963 ***Potomac River Basin Report*** as well as others suggested by the U.S. Fish and Wildlife Service (USFWS). Of these, it was determined that the following seven reservoir sites deserved further consideration as a representative group considering today's environmental, social, economic and physical concerns: Sixes Bridge, Verona, Town Creek, North Mountain, Sideling Hill, Little Cacapon, and Mount Storm. These reservoirs are shown on Figure 19. The yields of these projects ranged from 32 mgd to 100 mgd and their capital costs ranged from $40,000,000 to $150,000,000 (October 1981 price levels).

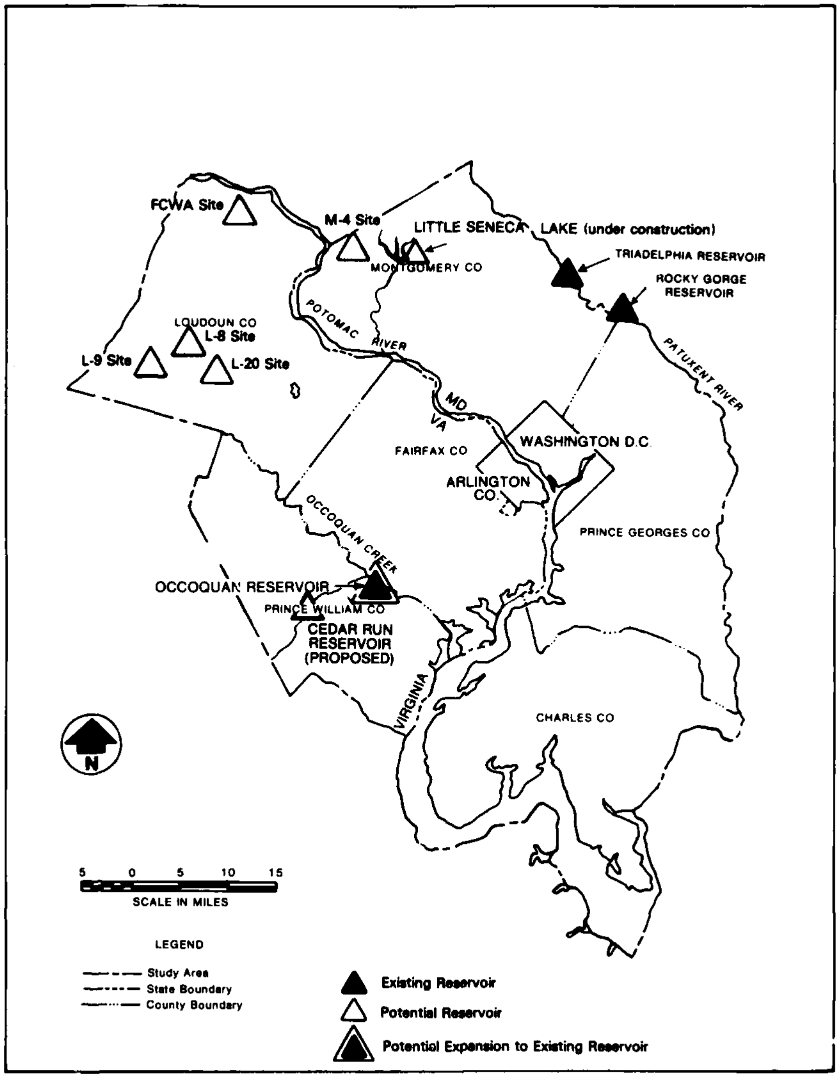
It should be noted that the upstream reservoir projects are presented only for comparative purposes to other water supply management options. The reservoir projects listed above are in either the inactive or deauthorized category at the present time, and it is unlikely that there would be local support for their construction in the immediate future.

Local Reservoirs

With respect to the local reservoirs, 21 sites (primarily pumped storage projects on small tributaries to the Potomac River) were also considered. These projects would generally be more expensive than the upstream sites because of the pumping which would be required to take advantage of their full storage capacity. In addition to these sites, expansion of the Occoquan Reservoir in Fairfax County was also considered and is discussed in the next section.

Of the 21 originally considered, it was concluded that six sites including five pumped storage projects and the Cedar Run Reservoir constituted a representative group of projects, each involving certain favorable characteristics considering yield, impacts, and costs. The locations of these local reservoirs are shown on Figure 20. The yields of these projects ranged from 12 to 125 mgd; and the costs ranged from $25 million to $190 million (October 1981 price levels).

Fig. 20-Potential Local Reservoir Sites



Modification of Existing Reservoirs

Two existing reservoirs which currently serve as regional supply sources for the major Potomac users were evaluated for their potential to provide additional supply to the region. These were the Occoquan Reservoir in Fairfax County, Virginia, and Bloomington Lake in Western Maryland and West Virginia. Only the Occoquan Reservoir is discussed here. The modification of the Bloomington Lake project was considered in the Bloomington Lake Reformulation Study and is discussed in more detail in the next section.

Modification of the Occoquan Reservoir by increasing the height of the Occoquan Dam by three more feet (in addition to the two foot extension added in 1980) could increase the storage capacity of this project by 2.2 billion gallons (bg) and increase the safe yield of the project by 12.5 mgd. The cost of the modifications would be approximately $2 million based on an update to October 1981 price levels of estimates originally made by a private consultant for the FCWA. Few, if any, adverse environmental impacts would result from this modification. However, additional lands may have to be acquired for flooding easements in certain parts of the reservoir, and these lands could be difficult to acquire. Significant social and institutional impacts could result.

Bloomington Lake Reformulation Study

The Bloomington Lake Reformulation Study was initiated in 198[illegible] at the request of five Congressional representatives from the MWA. As discussed earlier, its purposes were two-fold: (1) to investigate regulation strategies to maximize the water supply capability of the existing project, and (2) to determine the feasibility of reallocating some Bloomington water quality or flood control storage to water supply storage to meet addi-

tional downstream needs. The results of the reformulation study are included as part of the overall MWA Water Supply Study because Bloomington Lake is one of the key elements in satisfying the MWA's future water supply needs. Details concerning the Bloomington Lake Reformulation Study are contained in Appendix H which consists of a summary report and ten supporting technical annexes (see Table 1).

Regulation of Bloomington Lake

The authorization document for Bloomington Lake (1962) estimated that the combined safe yield of the Bloomington/Savage Reservoir system would be 197 mgd (305 cfs). This 1962 report envisioned that Bloomington and Savage would be regulated to maintain a relatively constant flow of at least 197 mgd past Luke, Maryland throughout the year. Very simply, the projects were viewed as means to supplement the Potomac River's base flow, but not capable of responding to short-term (less than one month) variations in demand. Little if any consideration was given to regulating these projects in concert with other downstream reservoirs to maximize water supply delivery to the MWA during certain critical periods. Even as late as the 1979 ***Progress Report***, Bloomington and Savage Reservoirs were assumed to provide a constant minimum flow of 197 mgd at Luke, Maryland.

With the development of the PRISM simulation model by the Johns Hopkins University and the early work of the CO-OP program in 1980, however, it became obvious that the Bloomington/Savage Reservoir system could be regulated in a more efficient manner. Technical studies documented in Appendix H revealed that both the North Branch Potomac River and MWA needs would be better served if the minimum flow target at Luke, Maryland, was set at 78 mgd (120 cfs) rather than at the maximum safe yield of 197 mgd. This minimum target of 78 mgd would promote improved water quality in the North Branch. At the same time, water supply storage in Bloomington Lake would be "saved" during most of the year so that much larger volumes (greater than 197 mgd) could be released for the MWA water utilities during the severest part of the drought.

These findings were the result of three major sub-studies conducted during the early part of the Bloomington Lake Reformulation Study. First, Annex H-II - ***Water Quality Investigations*** provides a discussion of the analyses to determine the proper mixing ratio of the normally acidic Bloomington releases to the alkaline Savage releases for North Branch Potomac River water quality control. The ratio was found to be dependent on the time of the year, the water quality character of reservoir inflows, and the desired volume of outflow. Second, Annex H-V contains the United States Geological Survey (USGS) report which determined that insignificant flow losses would occur between the North Branch reservoirs and the MWA Potomac intakes. The USGS report also concluded that the time of travel between the North Branch Potomac River reservoirs and the MWA was about 7 days, as opposed to earlier estimates of 30 days. This finding meant that Bloomington and Savage Reservoirs could be responsive to short-term variations in supply and demand within the MWA. The third, Annex H-III - ***PRISM/COE Development and Application*** provides a discussion of the determination of the proper balance between upstream reservoir (Bloomington and Savage) and downstream reservoir (Patuxent and Occoquan) usage. An optimum balance maximizes water supply availability throughout a drought and yet retains maximum flexibility within the system. Finding the optimum balance required consideration of hydrologic, environmental, water quality, and water supply concerns as well as a fine-turning of the system's regulation.

These important conclusions became the basis for initiating a change in the regulation procedures for Bloomington and Savage Reservoirs. Instead of providing a relatively large constant supplement to the Potomac River's base flow (197 mgd flow target at Luke), these upstream reservoirs are now considered as part of the MWA water supply system which can respond to flucuating supplies and demands. The conclusions regarding Bloomington and Savage Reservoir regulation were incorporated into the PRISM/COE model discussed in Chapter IV. These conclusions were also instrumental in assisting the Regional Task Force as it devised a regional plan centered on coordinated management of the MWA's reservoirs. As such, the revised regulation procedures for Bloomington and Savage Reservoir eventually became part of the base condition for the long-range phase.

Reallocation of Bloomington Lake Storage

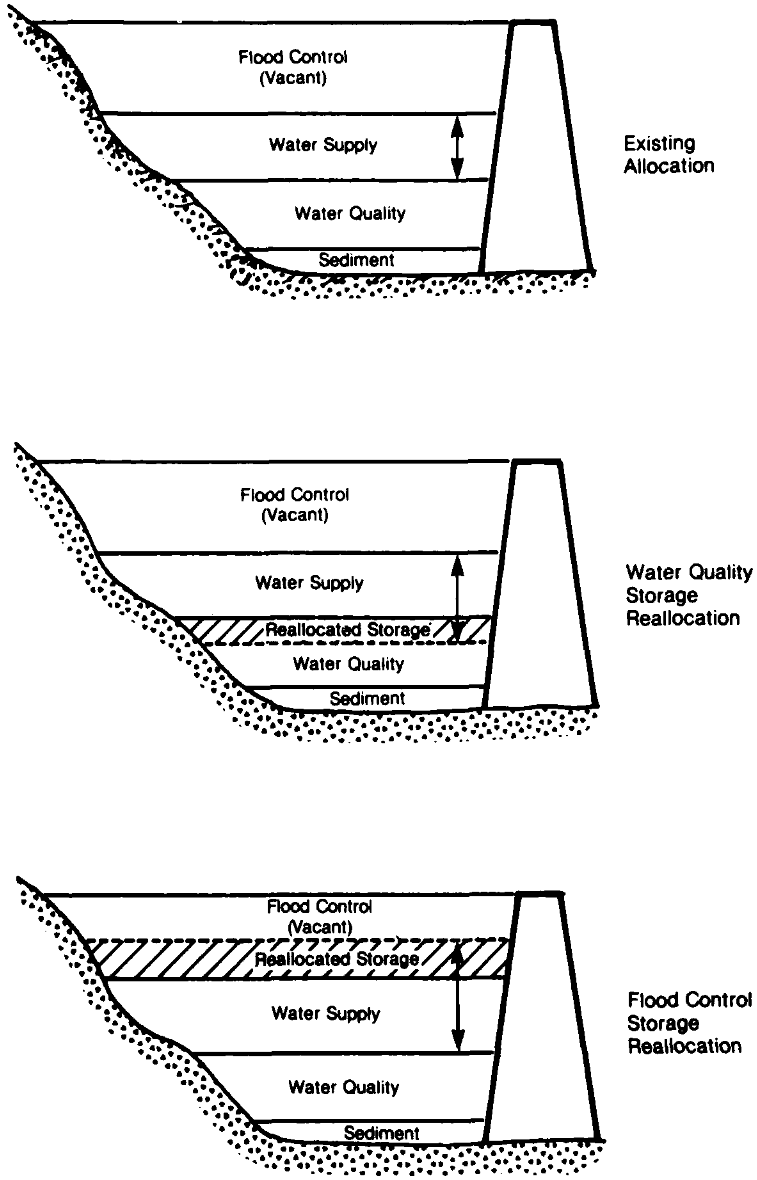
The second objective of the Bloomington Lake Reformulation Study addressed the feasiblity of reallocating some existing water quality and flood control storage to water supply storage. Figure 21 depicts the existing allocation and the two possibilities for storage reallocation.

The reallocation possibilities were evaluated using the PRISM/COE model discussed earlier. Water quality investigations of Bloomington releases indicated that up to 1.63 bg (5,000 acre-feet) of water quality storage would be available for reallocation without seriously compromising water quality conditions in the North Branch. This reallocation would not, however, eliminate regional water supply shortages in the MWA for the year 2030, given flowby levels ranging between 300 and 500 mgd. Because of this limitation and because this 1.63 bg would be better suited to increase the reliability for the existing system to meet the baseline needs during severe droughts, reallocation of water quality storage was not considered further in long-range planning.

Two levels of flood control storage reallocation were considered: reallocation of 25 percent (2.9 bg or 8,800 acre-feet) and 50 percent (5.9 bg or 18,200 acre-feet). A third level of reallocation (75 percent, 8.85 bg or 27,000 acre-feet) was dropped from consideration because of the unacceptable levels of flood benefit reduction that would result from this reallocation.

Table 10 summarizes the costs for these two alternatives and their effects on flood control benefits. Losses of flood control benefits were considered to be minor, with most losses occurring in rural areas and to transportation routes (see Annex H-IV - ***Flood Control Analyses***). Given a 500 mgd flowby target in the year 2030, water supply deficits in the MWA would not be eliminated entirely. It was determined, however, that the system could handle the 300 mgd flowby target with either flood control reallocation alternative.

Fig. 21-Schematic of Bloomington Lake Storage Reallocation



The total investment cost for these reallocation alternatives ($22,280,000 for the 1474 pool and $45,070,000 for the 1484 pool) would include the costs for structural modifications of the spillway, intake tower, and recreation areas to accommodate higher seasonal pool levels. These costs also include the reallocated cost of the portion of the original Bloomington Lake project which would now be associated with the newly created water supply storage. It was further determined that reallocation of flood control storage could reduce the capability of the reservoir to moderate the large pH fluctuations sometimes associated with small floods as well as reduce the ability of the Savage Reservoir to neutralize additional water supply releases from Bloomington Lake. For these reasons, no change to the existing storage allocation within Bloomington Lake is suggested at the present time. Storage reallocation, however, does remain as a viable option for long-range planning.

Potomac Estuary Water Treatment Plant

As noted in Chapter I, the authorizing legislation for the MWA Water Supply Study also directed the Corps to construct, evaluate, and operate an experimental project to test the feasibility of using the Potomac Estuary as a supplemental water supply source. In response to this directive, a 1.0 mgd capacity Potomac Estuary Experimental Water Treatment Plant (EEWTP) was constructed near the site of the Blue Plains wastewater treatment facility in Washington, D.C. The plant was tested between March 1981 and March 1983 to determine: (1) the treatability of Estuary water to a potable level under simulated drought conditions, and (2) the economic and technological feasibility of producing potable water from an ex-

TABLE 10
FLOOD CONTROL STORAGE REALLOCATION ALTERNATIVES -BLOOMINGTON LAKE REFORMULATION

Reservoir Pool Elevation (ft msl)	Storage Reallocated (bg)	Percent of Flood Control Storage	Reduction in Flood Control Benefits %	Remaining Deficit in MWA (mg) 300 flowby	Remaining Deficit in MWA (mg) 500 flowby	Cost of Structural Modifications* ($ mil)	Reallocated Water Supply Storage Costs ($ mil)	Total Investment Cost for Reallocation ($ mil)
1474	2.9	25	3	0	28,000	2.10	20.18	22.28
1485	5.9	5C	7	0	25,000	3.33	41.74	45.07

* October 1981 price levels.

Control Panel, Potomac Estuary Experimental Water Treatment Plant

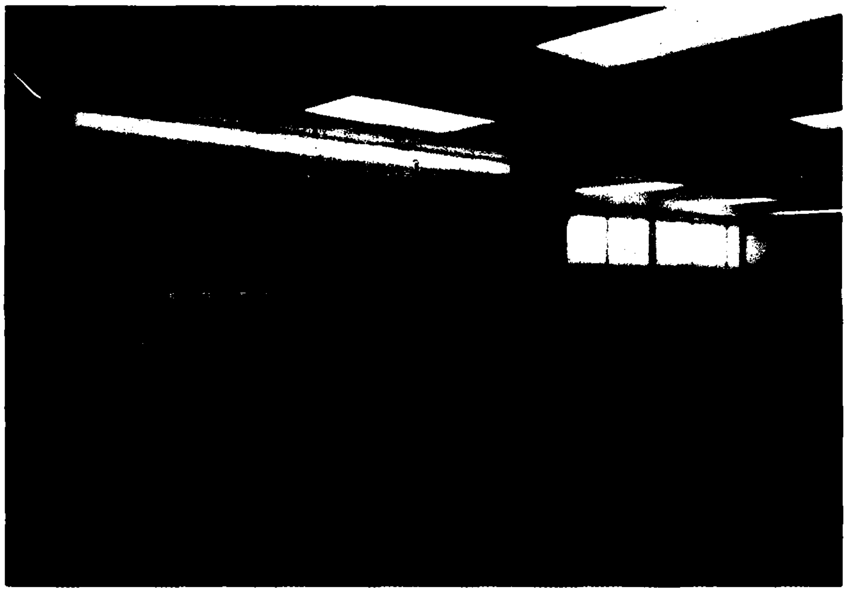


TABLE 11
PRELIMINARY COST ESTIMATES, 200 MGD POTOMAC ESTUARY PLANT

	Alum/ Chlorine Process	Lime/ Process Process	Conventional Process
Capital Cost ($ millions)	$122	$174	$63
Annual O&M Cost ($ millions)	$12.6	$15.9	$7.4
Cost in Cents/1000 Gal.	34*	48*	19*

* April 1983 Price Levels

panded version of the plant. A complete report concerning the EEWTP testing program and its results has been prepared as a separate document in direct response to the Section 85(b)(2) legislation. An overview of the testing program is provided in Appendix F -*Structural Alternatives* of the MWA Water Supply Study. A committtee also was established within NAS-NAE to review and provide written comment on the results of the EEWTP testing program; the NAS-NAE comments are expected within one year after the completion of the testing program.

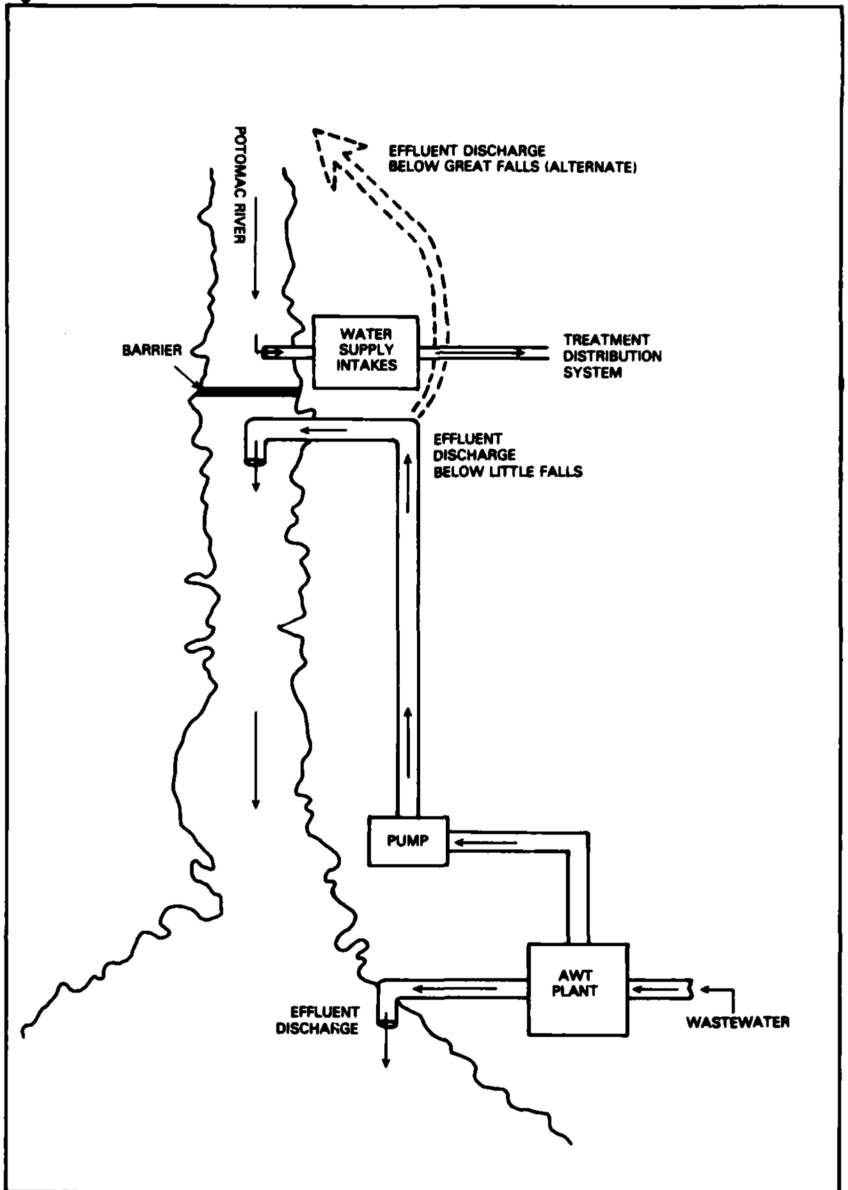
The EEWTP utilized a combination of physical and chemical processes capable of treating a mix of Estuary water and nitrified, unchlorinated effluent from the Blue Plains wastewater treatment facility. Based on numerical modelling of the Potomac Estuary, a 50/50 mix of these two "raw sources" was selected as a representative blend of the water quality that would likely exist in the upper Estuary given future drought conditions. Several water quality goals were set for the product water from the plant based on National and international drinking water quality standards. These were developed to ensure that an acceptable water quality could be achieved at minimal health risk.

Given the water quality goals and the nature of the influent to the EEWTP, several process configurations were employed to test the plant's ability to produce water satisfying the stated quality objectives. The two processes which most fully satisfied these objectives and which were evaluated most thoroughly were: (1) alum coagulation, intermediate oxidation with chlorine, granular activated carbon adsorption, and free chlorine disinfection; and (2) lime coagulation, granular activated carbon adsorption, final disinfection with ozone, and chlorination for a residual disinfectant.

Within the limits of analytical techniques used, the process combinations in the EEWTP were shown to be capable of producing a finished water of quality generally suitable for human consumption. For several water quality parameters, levels in the EEWTP effluent exceeded the highest levels observed in the finished waters of the three major MWA water treatment plants, but were still within permissable levels. For most parameters, the potential increase in health risks was judged to be negligible. The one exception was nitrate-nitrogen. Nitrate levels in the EEWTP effluent were significantly higher than values observed in the MWA water treatment plants, approaching an arithmetic average of approximately 7 mg/l as compared to the maximum level of 10 mg/l in the National Interim Primary Drinking Water Regulations (USEPA). While still below the maximum contaminant level of 10 mg/l, there would be very little factor of safety. Thus, the nitrate level could be a potential health issue should a full-scale estuary plant be constructed.

Cost estimates were developed for 200 mgd Estuary water treatment plant for both process configurations mentioned previously. For comparison, a cost estimate was also prepared for a similar sized plant of "conventional configuration" (i.e., a plant employing commonly used processes to treat raw water not subject to contamination). Table 11 displays the capital costs, the annual O&M costs, and the cost per 1000 gallons for the two process configurations which were tested. Also shown on Table 11 are similar estimates for a conventional plant. Due to the unknown exact location and operating philosophy of a full-scale Estuary plant, certain facilities were excluded from the cost estimates. Those facilities, which were excluded and which could substantially increase the cost of a complete water treatment plant, were the following: intake structure,

Fig. 22-Wastewater Reuse Scheme



Monitoring at Chesapeake Bay Hydraulic Model

intake pumping station, finished water pumping station, finished water reservoirs, finished water distribution piping, land purchase, and site preparation other than basic clearing and grading.

In connection with the EEWTP, the Corps of Engineers' Chesapeake Bay Hydraulic Model was used to obtain a better understanding of the Potomac Estuary's hydrodynamics under various flow conditions. Based on several model tests which simulated salinity concentrations in the Potomac Estuary under drought conditions, it was shown that rather high salinities could exist in the upper Estuary in the vicinity of an expanded Estuary treatment plant. These salinity concentrations could affect the operation of such a plant and would have to be evaluated further if such a plant were to be constructed.

Wastewater Reuse

Several forms of wastewater reuse were reviewed for their applicability and feasibility in the MWA. It was determined that a large-scale land application/water supply recovery scheme would have limited feasibility because of its land intensiveness, high costs, and limited public support. Other forms of non-potable reuse for agriculture and industry would also have limited feasibility for significantly increasing the water supply in the MWA because of the relatively small fraction of water attributed to these uses.

Two options for recharge of the Potomac River with Blue Plains wastewater treatment plant effluent were considered to hold the most promise. These options would involve pumping of 100 to 200 mgd of the highly treated effluent from Blue Plains to either of two discharge points: one immediately downstream of the Aqueduct's Little Falls intake and one just downstream of Great Falls (Figure 22). The former discharge location would supplement the flow to the Potomac Estuary, thereby permitting upstream water supply withdrawals to be increased to a commensurate level. The latter option constitutes direct flow augmentation of the free-flowing Potomac River. Preliminary cost estimates for these alternatives indicate that these schemes would, at the minimum, range between $50 million and $140 million (October 1981 price levels) depending upon the pipeline capacity and discharge location selected. A third recharge option, discharge in the vicinity of Dickerson upstream of all of the water supply intakes, was considered in the NEWS Study. It was not examined in the present effort because of the significant costs and impacts associated with the long pipeline.

Evaulation of Measures for Long-Range Planning

Given the technical findings developed for each of the measures, a further evaluation was undertaken using the set of evaluation parameters and criteria listed below:

- Degree of Additional Water Supply Provided or Demand Reduced
- Cost/MG of Supply Provided or Demand Reduced
- Minimize Cost
- Minimize Adverse Impacts
- Maximize Ease of Implementation
- Maximize Supply Dependability
- Minimize Use of Energy Intensive Projects
- Maximize Flexibility

TABLE 12
LONG-RANGE PLANNING MEASURES, TRADE-OFFS

Needs and Concerns	Individual Would Likely Favor	Limitations or Factors Individual Would Have to Accept
Would want to secure a cheap, dependable and implementable source of supply; would want to meet any demands required; emergency capability would be attractive.	a) Modifications of existing reservoirs to expand water supply capability of the Occoquan Reservoir and Bloomington Reservoir	—These alternatives have a limited storage potential and could not provide more than 100 mgd each during a prolonged drought. —Must be willing to accept reduced flood protection below Bloomington Rservoir and decreased control of pH on an infrequent basis. Higher cost/unit volume for Bloomington but a readily achievable and dependable source of supply.
	b) Upstream Reservoirs	—These alternatives would result in high public resistance from from those affected in the upper basin. —Must also accept removal of land areas and environmental habitat from present conditions. —Must be willing to accept travel time associated with releases from reservoirs (Reduced daily control).
	c) Finished Water Interconnections	—Does not augment supply base.
Would desire an additional source which would result in in minimal adverse environmental impacts at or near the site of development and would have a potential to enhance the enviroment.	a)Modification of existing reservoirs including expansion of the Occoquan and reallocation within Bloomington Reservoir	—These alternatives have a limited storage potential and could not provide more than 100 mgd each during a prolonged drought. —Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH on an infrequent basis.
	b) Conservation Scenario 5	—High relative cost. Higher degree of public cooperation required to reduce use.
	c) Pricing	—Reduced degree of certainty to achieve desired levels of reduction.

TABLE 12
LONG-RANGE PLANNING MEASURES, TRADE-OFFS

Needs and Concerns	Individual Would Likely Favor	Limitations of Factors Individual Would Have to Accept
	d) Raw Water Interconnections	—Would have to accept infrequent but rapid drawdowns of Occoquan and Patuxent Reservoirs. —Relatively high cost component.
	e) Groundwater	—Have to accept using considerable land area for maximum development. —Potential exists to preclude development of future supplies by locals. —Limited supply potential (100 mgd) at high cost of development.
Would want a safe (potable) and dependable source of water. Would also desire cheapest source given a choice.	a) Modifications of existing reservoirs including expansion of Occoquan Reservoir and Bloomington Reservoir.	—These alternatives have a limited storage potential and could not provide more than 100 mgd each during a prolonged drought. —Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH on an infrequent basis.
	b) Upstream Reservoirs	—These alternatives would result in high public resistance from those affected in the upper Potomac Basin. —Must also accept removal of land areas and environmental habitat from present conditions. —Must be willing to accept travel time associated with releases from reservoirs (Reduced daily control).
Preservation of land and water quality in the upper Potomac Basin. Regional economic growth.	a) All components with the exception of upstream reservoirs and reallocation of Bloomington Reservoir flood control storage.	—Could lose recreational opportunities and water quality improvements associated with upstream reservoir sites. —Lose opportunity to "buy into" water supply storage at these sites. —Would have to accept limiting factors listed for other components which were implemented.
Preservation of natural resources; protection of quality and quantity of groundwater.	a) All components with the exception of groundwater, the Potomac Estuary, and Potomac River recharge.	—Would have to accept limiting factors listed for all other components which were implemented.
Confident in new technologies and approaches for water supply; interested in developing new and untried sources.	a) Use of the Potomac Estuary potable source.	—Reluctance on the part of the public to accept estuary water as a —Potential environmental impacts of large withdrawals from the upper Potomac Estuary. —Potential for increased salinity levels in upper Estuary which might effect treatment capabilities of estuary plant.
	b) Potomac River Recharge	—Endanger the safety and potability of supply if discharge point is above MWA water supply intakes. —Significant social disruption during and possibly after pipeline construction.
	c) Conservation Scenario 5	—High relative cost. Higher degree of public cooperation required to reduce use.
	d) Pricing	—Reduced degree of certainty to achieve desired levels of reduction.
Effectiveness and efficiency in use of existing sources; non-development of new sources.	a) Conservation Scenario 5	—High relative cost. Higher degree of public cooperation required to reduce use.
	b) Pricing	—Reduced degree of certainty to achieve desired levels of reduction.
	c) Modifications of existing reservoirs to expand water supply capability of the Occoquan Reservoir and Bloomington Reservoir.	—These alternatives have a limited storage potential and could not provide more than 100 mgd each during a prolonged drought. —Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH on an infrequent basis.
	d) Potomac River Recharge	—Endanger the safety and potability of supply if discharge point is above MWA water supply intakes. —Possible conflict with Emergency Estuary Pumping Station operation if discharge point is below the MWA water supply intakes. —Significant social disruption during and possibly after pipeline construction.

These criteria were developed to facilitate a comparison of advantages and disadvantages of the measures considered. Figure 23 summarizes the relative effectiveness of each measure's ability to meet the planning criteria. A full discussion regarding the development of objectives and the evaluation conducted for each measure is presented in Appendix B - ***Plan Formulation, Assessment, and Evaluation***. Some of the salient observations resulting from this evaluation concerning the long-range measures are summarized in Chapter VIII - Summary and Conclusions.

As stated earlier, formulation of plans to carry the MWA through the 50-year planning period was no longer needed. Efficient use of the existing Bloomington Lake project and construction of Little Seneca Lake, coupled with the various regional water supply agreements, would eliminate water supply shortages through the year 2030 for the Potomac users. However, it was also recognized that consideration might be given in the future to further reducing demands or developing additional supplies over and above the present supplies. Table 12 contains a list of preferences or points of views that various sectors of the public might endorse in arriving at a decision as to which measure to support or study further. Given these preferences, the most likely projects to satisfy these desires are listed in Table 12 as well as the limiting factors or trade-offs which one would have to accept if these projects were to be implemented. Clearly, any individual or group may support one or more of the points of view which, in turn, may result in a group of projects or programs which sometimes conflict with each other. These differing perceptions and the resultant conflicts require compromise and trade-offs to arrive at the most acceptable course of action.

Fig. 23-Long-Range Planning Measures, Evaluation Matrix

PLANNING COMPONENTS	DEGREE OF ADDITIONAL WATER SUPPLY PROVIDED OR DEMAND REDUCED (MGD)				COST/MILLION GALLONS PROVIDED OR DEMAND REDUCED ($000)				MINIMIZE ADVERSE IMPACTS			MAXIMIZE EASE OF IMPLEMENTATION	MAXIMIZE DEPENDABILITY OF SUPPLY	MINIMIZE USE OF ENERGY INTENSIVE PROJECTS	MAXIMIZE FLEXIBILITY	MINIMIZE COST
	Not Effective	0-100	100-300	>300	<1	1-5	5-10	>10	ENV	SOC	CULT					
Conservation Scenario 5			x					x	●	◕	●	◑	◕	●	◕	◑
Raw Water Interconnections			x				x		◕	◑	◑	◑	●	◑	◑	◔
Finished Water Interconnections	x				NOT APPLICABLE				●	◑	●	●	N/A	●	◔	N/A
Pricing			x*		x				●	◑	●	◑	◔	●	◔	◕
Groundwater		x					x		◕	◕	◑	◔	◕	◑	◕	◔
Reservoirs Upstream				x		x			○	◑	◑	○	●	●	◑	◑
Local			x				x		○	◕	◑	○	●	◑	◑	◑
Modification To Existing Reservoirs Occoquan (+3 feet)		x			x				●	◑	◕	◑	●	●	○	◕
Bloomington Flood Control Reallocation		x					x		◕	◕	●	◕	●	●	○	◑
Potomac Estuary (PEWTP)			x			x			◑	◑	◑	◔	●	◑	◔	◑
Wastewater Reuse (Potomac River Recharge)			x			x			◑	◔	◑	○	◕	◑	◔	◑

N/A Not Applicable
○ Does Not Meet Criteria
◔ Low Ability of Meeting Criteria
◑ Partial Ability of Meeting Criteria
◕ Considerable Ability of Meeting Criteria
● Fully Meets Criteria

*Although the water pricing examination did not quantify an exact level of demand reduction, a "best estimate" of between 100 and 300 mgd was projected

Chapter VI
Outlying Service Areas

In addition to the major Potomac River users, the MWA Water Supply Study also addressed the water supply needs of four outlying service areas in the region. These areas are identified in Figure 24 as the Fairfax City Service Area, the Prince William County Service Area, the Loudoun County Service Area, and the Charles County Service Area. These areas presently provide about five percent of the total treated water in the MWA, and have only limited opportunities to take advantage of new supply sources which might be developed for the major Potomac users. These outlying areas are characteristically less developed than the areas closer to the urban core of Washington, D.C.; however, they are expected to grow significantly in population in the future. By the year 2030, these areas are expected to constitute about 13 percent of the average annual water demand in the MWA.

Because of the relatively small percentage of overall water use by these areas as well as the fact that the solutions for the Potomac users involve regionalized plans centered around use of the Potomac River, it was determined that a "less than feasibility scope" level of detail was appropriate for this part of the study. Therefore, planning for the outlying areas was undertaken independently from the planning efforts discussed in Chapters III, IV, and V.

The purposes of planning for the outlying areas (which is fully documented in Appendix I - *Outlying Service Area*), therefore, were to define in a general sense the water supply needs and opportunities of these areas and to present potential projects or actions that could be initiated to meet those needs. No specific recommendations are offered for the service areas studied; however, information on potential solutions is presented in a way to assist local planners in taking the necessary steps toward meeting their needs.

Demand Projections

The first step in determining the magnitude of the water supply need was to project future demand levels. Service area water demands were projected for the period 1980-2030 in ten year increments. These demands were developed using a computer-assisted demand projection methodology similar to the methodology used for the major Potomac service areas. (See Appendix G - ***Non-Structural Studies*** and Appendix D - ***Supplies, Demands, and Deficits***.) This methodology uses a number of variables which have a bearing on water demand including population, employment, water use, and household data.

Round II Cooperative Population Forecasts which were developed by the Metropolitan Washington Council of Governments in coordination with the local political jurisdictions served as the basic population data for the demand projections. These data, coupled with the 1980 Census data, provided the most accurate information available regarding future growth rates in the outlying communities. This information was supplemented with employment and household estimates for the areas, each of which was statistically extended to the year 2030. Local planning officials were consulted to determine the location and extent of future growth areas in the counties so that an estimate of the population to be served by public systems throughout the planning period could be made.

These data were combined with 1976 water use information to generate a set of average annual demands for each service area (Table 13). In all cases, demands projected for the 50-year planning period are expected to increase dramatically. In the cases of the Fairfax City, Prince William County, and Charles County Service Areas, the demands expected to be placed on public systems will quadruple by the year 2030, and in the case of the Loudoun County Service Area demands will increase by a factor of over sixteen. A comparison of the demand trends between the outlying areas and the major Potomac users is shown in Figure 25. Despite the fact that the aggregate demands for the outlying areas represented only a very small part of the overall MWA needs, the rate of increase in the smaller areas warranted concern because existing facilities and supplies would be severely taxed to meet these growing needs.

Supply Base

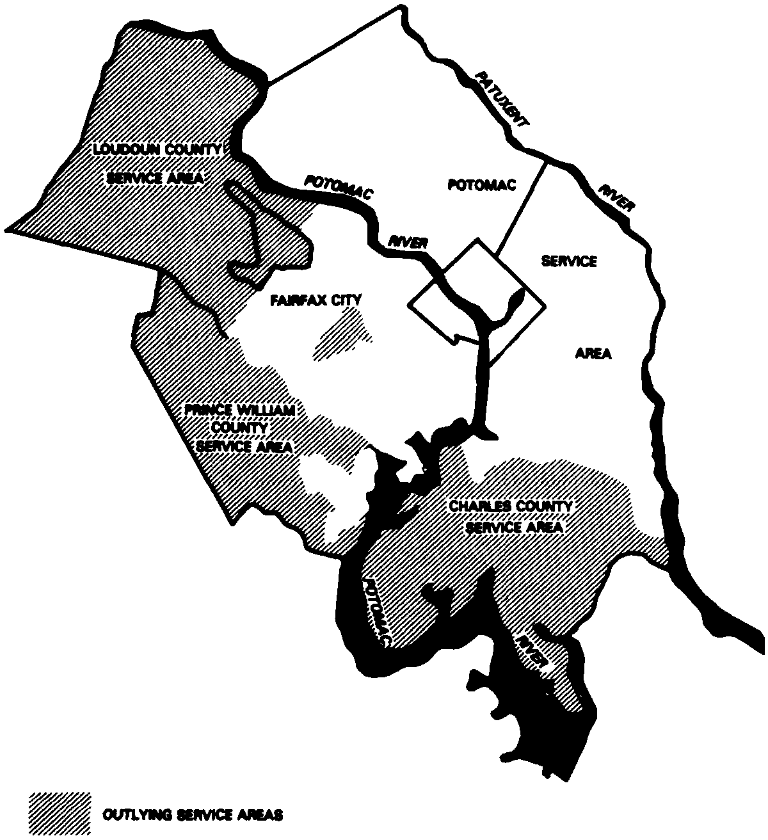
A survey of supply sources was undertaken to determine the nature

TABLE 13
OUTLYING SERVICE AREAS,
AVERAGE ANNUAL BASELINE DEMAND *

Service Area	1980	1990	2000	2010	2020	2030
Fairfax City, VA	10.8	15.4	19.0	23.8	30.1	37.2
Loudoun Co., VA	2.2	6.9	11.1	17.6	25.8	37.3
Prince William Co., VA	5.2	7.9	10.0	12.8	16.0	19.7
Charles Co., MD	3.0	5.2	7.0	9.0	11.6	13.1
Outlying Service Area Total	21.1	35.4	47.1	63.2	83.5	107.3

*In million gallons per day without conservation; based on MWCOG Round II population forecasts, 1980 census data, water use, and socio-economic data developed by the Baltimore District.

Fig. 24-Location of Outlying Service Areas



and quantity of supply in the outlying service areas. It was learned that the outlying service areas were comprised of numerous sub-areas which in many cases relied on separate and independent supply sources. Table 14 lists the sub-areas within each service area and the sources of supply upon which they depend. Reservoirs and, more commonly, groundwater comprise the bulk of the water supply base in these areas. Based on the projection of service area demands shown in Table 13 and the present level of supplies shown in Table 14, it was concluded that most of the outlying areas would be unable to meet their projected needs. Although exceptions to this may be possible in individual communities and regionalization of supplies might alleviate the problems in some areas, additional supplies will be needed, and the degree of their development will vary from area to area.

Alternatives Available

As a first step in identifying potential alternatives to meet the needs of the outlying areas, numerous planning reports and technical studies conducted by others were reviewed. Most commonly, the actions recommended for these communities included groundwater, additional reservoir storage, and interconnections with adjacent systems. Some projects have been implemented as a result of these studies while others are in various stages of planning or are no longer being considered. Furthermore, many of the studies were targeted for individual communities within the particular service area and for a relatively short planning horizon (to the year 2000, for example).

To provide a comprehensive approach in identifying potential solutions for the service areas in question, nine broad alternatives were developed as listed in Table 15. These alternatives were organized into two categories: those which were essentially non-structural in nature and would maximize the use of existing supplies, and those which would involve the development of additional supplies. The following sections discuss the findings regarding each alternative.

Water Conservation

Water conservation represents a means of decreasing the use of water, thus allowing more efficient use of available supplies. Five water conservation schemes similar to those developed for the Potomac River users were applied to the outlying service areas. It was concluded that long term demands could be realistically reduced by 10 percent, 11 percent, 6 percent, and 10 percent for the Fairfax City, Loudoun County, Prince William County, and Charles County service areas, respectively, by the year 2030 by implementing Conservation Scenario 3. The major benefit of conservation is that it could be applied uniformly to each of the service areas and could reduce demands to a level where the need for additional supplies could be delayed and/or the quantity, size, and cost of projects developed to provide new supplies could be significantly reduced. Furthermore, water conservation would involve little if any adverse environmental impact. Conservation, therefore, represents a wise "first step" in developing any water supply solutions in these areas.

Water Pricing

Findings from the water pricing study (Appendix G - *Non-Structural Studi s*) also had direct application to the outlying service areas. It was determined that marginal cost peak period pricing, which represents the most economically efficient and equitable means of water pricing, could not further reduce the near term demand forecasts in the outlying areas. This was due to the relatively high proportion of fixed costs to total costs for the utilities surveyed and the small escalation of the long-run marginal cost for water in these areas.

Interconnections

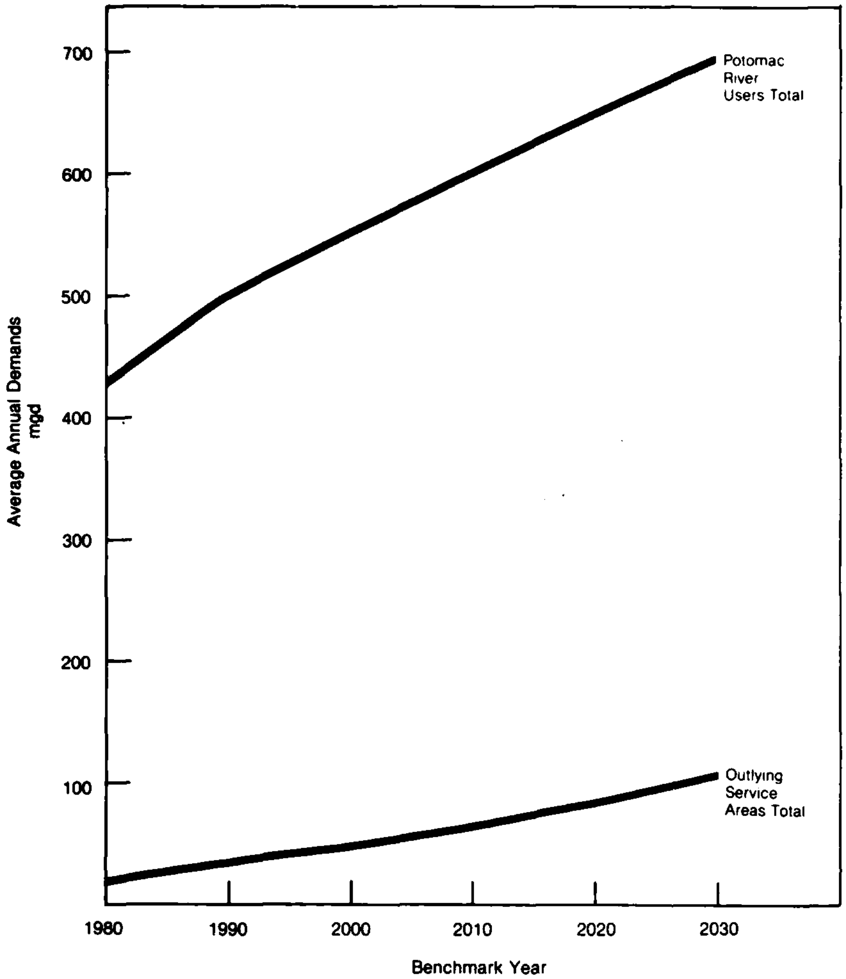
Interconnections involve the transfer of either finished or raw water from neighboring water supply systems which have excess capacity. The primary benefits of interconnections are the greater efficiency they can achieve by maximizing the use of available supplies and facilities and by more evenly balancing the geographic disparity of supply and demand in the region. An example of a useful finished water interconnection might be one which links the Towns of Hamilton, Purcellville, and Round Hill in western Loudoun County to the Leesburg system which has

TABLE 14
SUMMARY OF SUPPLY SOURCES - OUTLYING SERVICE AREAS

Service Area	Sub-Area	Supply Source(s)	Supply Yield	Remarks
Fairfax City	City of Fairfax Town of Herndon Loudoun County Sanitation Auth.	Goose Creek — Beaverdam Reservoir System	5.1 mgd[1]	
Loudoun County	Town of Leesburg	Potomac River Well system	10 mgd[2] 7 wells — 400 gpm (average yield per well)	Well System will be used as back-up after Potomac intake becomes operational.
	Town of Hamilton	Well system	9 wells — 30 gpm average test yield per well	
	Town of Purcellville	Springs	0.23 mgd average flow	Springs susceptible to depletion during extended droughts
	Town of Round Hill	Springs	Not available	Springs susceptible to depletion during extended dry periods. Water quality problems.
	Town of Hillsboro	Spring	Not available	
	Town of Lovettsville	Wells	2 wells — 86 gpm test yield average per well	
	Town of Middleburg	Wells	2 wells — 150 gpm for one well only	
	Other small systems	Wells	Not available	
Prince William County	City of Manassas	Broad Run Reservoir Well system	15.3 mgd 0.7 mgd[3]	Recent evidence of lowering of groundwater table.
	City of Manassas Park	Well system	0.7 mgd	Also interconnected w/FCWA, City of Manassas and Yorkshire Sanitary District.
	Greater Manassas Sanitary District	Well system	2.07 mgd	Also interconnected w/FCWA, City of Manassas, Yorkshire Sanitary District.
	Yorkshire Sanitary District	Well system	1.12 mgd	Also interconnected w/City of Manassas Park and Greater Manassas Sanitary District.
	Other small communities	Well systems	0.77 mgd[4]	
Charles County	Charles County Dept. of Public Works	Well systems	4.0 mgd (6.1 mgd)[5]	Elevation of Magothy Aquifer water level declining.
	Town of Indian Head Dept. of Public Works	Well system	4 wells — 0.28 mgd avg yield per well	
	Town of LaPlata Dept. of Public Works	Well system	5 wells — 0.24 mgd avg yield per well	
		Tilghman Lake	16 mg capacity	Used to augment groundwater supplies as needed.
	Other small communities	Well systems	3.7 mgd	

[1] safe yield
[2] maximum intake capacity
[3] 1980 pumpage
[4] based on available pumping records
[5] projected by 1990

Fig. 25-Comparison of Average Annual Demands, Outlying Service Areas vs. Potomac Users



recently been granted permission to use the Potomac River. A major potential benefit for interconnections would be to allow reserves such as groundwater to naturally recharge and be saved for emergency use. Interconnections would provide a means by which these areas could rely on water "rich" areas during non-drought periods. An example of this arrangement might be a WSSC interconnection with communities in northern Charles County.

Reservoirs

A generalized reservoir cost curve was developed to show the range of costs associated with construction of a typical small reservoir of varying capacity. The curve shows that a reservoir of about 8 billion gallons would cost approximately $22 million at October 1981 price levels. (This closely approximates the Prince William County estimated cost for the proposed Cedar Run Reservoir.) This reservoir size represents an upper limit of storage volume that would be required to meet the needs of any one service area during a prolonged (5 month) drought. Any point along the curve represents a reservoir size and corresponding cost that could match the needs of various sized communities within the outlying areas. Many of the reservoir sites identified by the local studies mentioned earlier could serve as potential locations for these reservoirs. The major drawbacks of reservoir construction in the outlying areas are the environmental and social impacts

Lake Manassas (Broad Run Reservoir) and Water Treatment Plant, City of Manassas

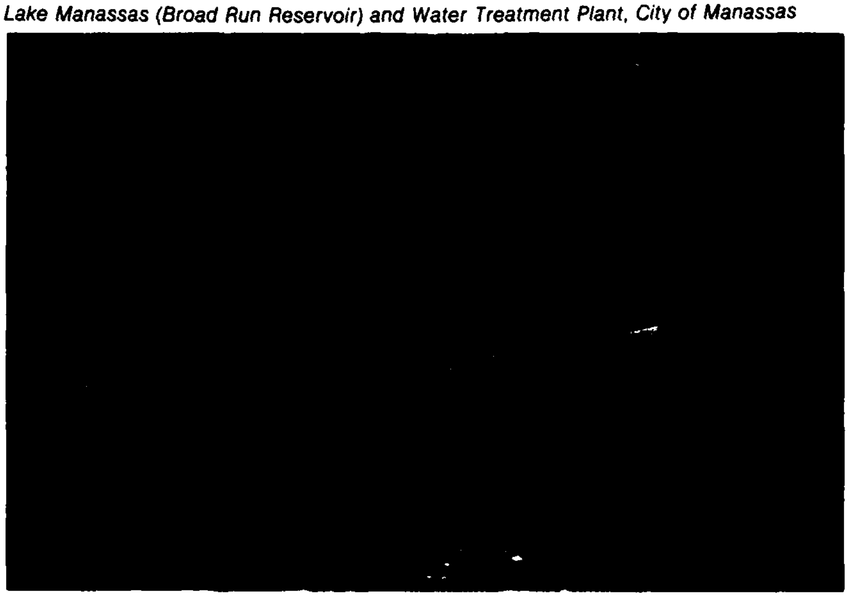


TABLE 15
LIST OF ALTERNATIVES OF OUTLYING SERVICE AREAS

I. MAXIMIZE USE OF EXISTING RESOURCES
- Water Conservation
- Water Pricing
- Interconnections and/or Purchase from Existing Systems

II. WATER SUPPLY DEVELOPMENT — AUGMENTATION
- Reservoirs
- Groundwater
- Water Treatment Plant Expansions
- Use of Potomac Estuary
- Wastewater Reclamation
- Potomac River Pumpover

and public opposition. Reservoirs would be a possibility in all areas with the exception of Charles County which has significant topographic limitations.

Groundwater

A set of cost curves similar to those developed for the reservoir sites was also generated for a typical wellfield located in each of the following three distinct geologic regions: the Blue Ridge, Triassic Lowland, and Coastal Plain. These curves revealed that the Coastal Plain aquifers hold the greatest potential for groundwater development followed by the Triassic Lowland and Blue Ridge aquifers, respectively. Furthermore, the capital cost per mgd of development would be the most expensive in the Blue Ridge and least expensive in the Coastal Plain. Large-scale development of wellfields was found to be more costly, less reliable, and more likely to impact existing wells in the outlying areas than the development of small wellfields for a restricted number of users. Much additional field testing would be required to accurately determine the yield potential at any given location. Environmental and social impacts for wellfield development would generally be much less severe than those expected for reservoir development.

Water Treatment Plant Expansions

It was concluded that either new or expanded water treatment facilities would be required to treat the additional water needed in the outlying areas. Water treatment facility cost curves for various capacity plants were generated for full-scale filtration facilities which would be needed for surface water development and for simple chlorination facilities required for groundwater development. As expected, full scale filtration costs exceeded the costs for simple chlorination by several orders of magnitude. For example, capital costs for a 50 mgd full-scale filtration plant would approach $37 million (October 1981 price levels) whereas similar capacity for a chlorination plant would be approximately $235,000. These cost relationships could be applied to any of the outlying service areas depending upon the nature of the supply sources to be developed.

Use of Potomac Estuary

It was determined that the potential for use of the Potomac Estuary as a source of supply for the outlying areas may be limited. The greatest potential for use of the Potomac Estuary is within the Prince William and Charles County service areas which are adjacent to the Potomac Estuary about 10 to 15 miles south of the present Potomac Estuary Experimental Water Treatment Plant. The likely lack of economies-of-scale and public acceptance constitute two major problems for this alternative in these areas. Interconnection with a larger regional Estuary water treatment plant may be feasible at some time in the future, should such a plant for the Potomac users ever be constructed.

Wastewater Reclamation

Recovery after land application as well as other reuse strategies have limited potential as potable water supply alternatives in the outlying areas. Since commercial/industrial uses average only between 10 and 12% in these areas (these uses may or may not require a potable source), non-potable reuse is also limited. Recharge of aquifers via land application or wastewater well injection does not appear feasible due to stringent health regulations regarding the use of groundwater sources subject to wastewater recharge.

Potomac River Pumpover

It was concluded that the freshwater portion of the Potomac River represented the most likely raw water source for a pumpover and as such would be most applicable to communities in northern Loudoun County or the Fairfax City Service Area. For northern Loudoun County, raw water pumpovers could be coupled with high-flow skimming reservoirs. However, to benefit from economies-of-scale, the alternative would be more cost-effective if it were designed for an aggregation of small communities rather than an individual community. The present organization of water supply facilities in this area is not structured to benefit from a regional scheme and would have to reorganize to gain its full advantage.

A drought simulation was performed for the Fairfax City Goose Creek/Beaverdam Reservoir system which indicated that an approximate 30 to 40 mgd raw water interconnection with the Potomac River could be used to avert reservoir depletion and deficits. The greatest limitation of a pumpover to the Fairfax City system, however, is that in time of greatest needs, available flows in the Potomac River are most limited. Any additional sizeable withdrawal from the Potomac River during critical low flow periods will affect the ability of the major Potomac River users to meet the balance of water supply and flowby which will be required in the future.

Planning Steps

As a general conclusion to the outlying service area are investigations, several planning steps were developed which the outlying areas could follow to satisfy their individual water supply needs. These are discussed more fully in Appendix I. The basic planning steps offer a rational procedure for a "typical" community to follow using some of the information developed in this study as well as from others. The planning steps are as follows:

- STEP 1—Demonstrate Need for Action
- STEP 2—Establish Broad Alternatives to Existing Supplies
- STEP 3—Develop Preliminary Design for Project Alternatives
- STEP 4—Evaluate Alternatives
- STEP 5—Recommend Course of Action

These are the same planning steps which were followed in the early-action planning process for the Potomac River users which led to the successful implementation of a regional water supply plan.

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Chapter VII
Public Involvement

Citizen interest in water resource planning and the desire to take part in the planning process has resulted in public involvement becoming an integral part of the planning process. This increased citizen interest requires a commitment from both the citizen and the planner to be willing to communicate with each other. Once effective communication is established, common goals can be defined, conflicts resolved, and agreement reached on proposed solutions to the problems.

The public involvement program discussed in detail in Appendix C was designed to establish effective communication between the planners and the many "publics" during the conduct of the study. The term "public" was defined as "any affected or interested non-Corps of Engineers entity." This included other Federal, State and local government agencies as well as public and private organizations and individuals.

Purposes of the Program

The purposes of this public involvement program were:

1. To solicit opinions and perceptions of problems, issues, concerns, and needs from the public.
2. To promote public understanding of the manner and means by which water resource problems and needs are investigated and solutions are proposed.
3. To keep the public fully informed regarding the status and progress of the study.
4. To provide a forum for public discussion and consensus concerning the Corps' findings and recommendations.

Description of Program

To accomplish the above purposes, a structured public involvement program was devised to encourage participation and interest by many different segments of the public. Additionally, several special committees were established to assist and advise the Corps concerning particular aspects of its study. The following paragraphs describe the measures which were used to elicit participation, the relationship between the major study phases (early-action and long-range) and the public involvement program, and the nature of the special committees.

Public Involvement Measures

Three basic measures were used to initiate and sustain public involvement throughout the study. These three measures provided for: (1) general information, (2) interaction-dialogue, and (3) review-reaction. Each measure was designed to reach different levels of the public in the study area. Likewise, each measure was geared to evoking a different degree of involvement or response from each level of the public.

General Information

This measure was used to distribute information about the MWA Water Supply Study's progress and results to as many people as possible. Usually, this measure provided for only one-way communication with the public. Mechanisms such as the series of nine Water Forum Notes, newspaper articles, special publications, public displays, press releases, and spot announcements through the media were used to reach most levels of the public.

Interaction-Dialogue

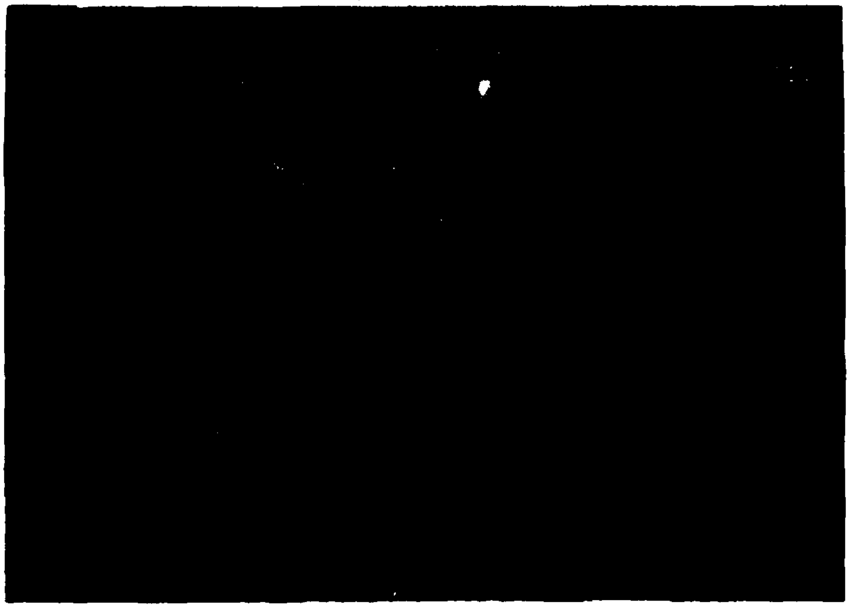
Interaction-dialogue provided for two-way communication between the planners and the public. It required a certain amount of involvement by the interested public to obtain a better knowledge of the planning process, as well as a certain amount of involvement by the planners to find out public needs and desires. Interaction-dialogue mechanisms such as workshops, planned educational programs, speeches to organized groups, opinion surveys, and interviews were techniques that were employed to reach those who were either interested, involved, or were decision-makers.

Review-Reaction

Review-reaction was used to obtain feedback from those who were most directly involved with the MWA Water Supply Study. Special Committees or advisory groups were formed to accomplish this purpose. The most important of these committees were the Federal-Interstate-State-Regional Advisory Committee (FISRAC), the Citizens Task Force (CTF), and the National Academy of Sciences-National Academy of Engineering (NAS-NAE). Committee meetings, formal public meetings, progress reports, interim reports, and draft and final reports were used to garner the important opinions and values of the involved public and the decision-makers.

Relationship to the Planning Process

The public involvement program was an integral part of the study process from beginning to end. In fact, it was through the initial public involvement program that the actual structure of the study was determined. Early coordination revealed a great sense of urgency among all participants to do "something" to forestall the prospect of imminent water supply shortages. Although nearly everyone recognized the desirability of formulating long-range plans, most people urged the Corps to concentrate its efforts on programs for the immediate future. As a result of a series of public meetings, workshops, questionnaires, and correspondence, the Corps devised the two-phased approach (early-action and long-range) which has been discussed in previous chapters. The initial public involvement activities were also used



South Branch Potomac River near Royal Glen

to identify alternatives which were to be examined in detail in the early-action phase (see Chapter III).

During the early-action phase, the public involvement program assumed an established routine. This routine typically involved the following steps: (1) technical analyses and documentation prepared by the Corps, (2) distribution of technical documents (such as progress reports) to review committees with general summaries (such as Water Forum Notes) to the public-at-large, (3) workshops and meetings with the general public, (4) individual group meetings and discussions with the various review committees (CTF, FISRAC, NAS-NAE, ICPRB, etc.), and (5) provision of guidance regarding work efforts to be conducted in the next iteration of planning. This routine was repeated several times during the early-action phase, and led to the publication of the ***Progress Report*** in 1979, which was in turn followed by a series of workshops, committee meetings, and a public meeting.

The most significant outcome of the early-action public involvement program was the decision by some of the participants to create the Metropolitan Washington Regional Water Supply Task Force (RTF). This RTF, composed entirely of non-Federal members was able to use the ***Progress Report*** to reach a consensus concerning a regional plan. More importantly, the RTF was able to devise, concurrent with the study's long range phase, the necessary series of interlocking agreements and contracts to successfully implement the regional plan (see Chapter IV).

During the long-range phase, the degree of public involvement was less intense than during the early-action phase, but followed somewhat the same procedure and format. Several Water Forum Notes were published, and interim reports were distributed for committee reviews. Most of the public attention, however, was focused on the on-going efforts of the RTF which was preparing its implementation package for the agreed-upon regional plan.

After the signing of the regional agreements in July 1982, the Corps again assumed a more visible role as it concluded the long-range phase of the study activity and began to assemble its ***Final Report***. A draft of the ***Final Report*** which documented the entire seven year study was circulated for review and comment in March 1983. Because the draft report was primarily an informational document with no recommendations for action by the Corps of Engineers, no public meeting was conducted. Instead, a comprehensive Water Forum Note was widely distributed to summarize the study findings, conclusions, and recommendations.

Special Committees

Of the many committees, agencies, and organizations participating in the MWA Water Supply Study, three deserve particular mention for their continued efforts throughout the study. The Citizens Task Force (CTF) was created specifically to review the study's progress from a "citizen's" viewpoint, and to provide a direct channel for participation by interested people. Members included some representatives from MWCOG's Citizens Advisory Committee as well as representatives from areas upstream and downstream of the MWA. During the study, the CTF accomplished many tasks, such as: (1) identification of local concerns; (2) garnering of opinions from groups in the MWA, and areas upstream and downstream; (3) proffering of suggestions for study direction; (4) assistance in assessing alternatives; (5) review of present institutional resources to implement various alternatives; (6) sharing in the sponsorship and direction for a broader public involvement and education program; and (7) report review. Not only did the CTF review information prepared by the Corps, but members also examined related water supply investigations prepared by other organizations (such as the Potomac River Flowby Study prepared by the State of Maryland and the environmental impact analysis for Little Seneca Lake prepared by WSSC and the Corps). The CTF met eight to ten times a year throughout most of the study, and furnished numerous resolutions and comments. Pertinent correspondence received from the CTF is contained in Annex C-VII. A summary of the CTF concerns is provided later in this chapter under the section titled "Public Views and Comments."

A second group which directly affected the conduct of the study was the review committee established by the National Academy of Sciences -National Academy of Engineering (NAS-NAE). This group was composed of eminent scientists and engineers who had broad experience in water resources planning. The study authorization specifically directed the Chief of Engineers to "...request NAS-NAE to review and by written report comment upon the scientific basis for the conclusions reached by the investigation and study of the future water resource needs of the Washington Metropolitan Area and the pilot project for the treatment of water from the Potomac Estuary." To accomplish the necessary review and comment, the NAS-NAE committee chose to meet periodically throughout the study. Then, at the study's completion, the committee would prepare its formal written report on the basis of its involvement throughout the study. (This report by NAS-NAE is to be submitted to the U.S. Congress within one year of completion of the Corps' study.) Normally, the NAS-NAE committee met twice a year, with additional subcommittee meetings as necessary. The primary tasks of the committee throughout this period were to provide an impartial scientific appraisal of the Corps' technical methods and to furnish suggestions based on broad water resource experiences. Written comments received from the NAS-NAE committee are contained in Annex C-IX. Many more comments, suggestions, and critiques were made verbally at the various meetings. A summary of the major NAS-NAE comments and concerns are also provided later in the section titled "Public Views and Comments."

Finally, the third committee which provided a significant contribution to the study was the Federal-Interstate-State-Regional Advisory Committee (FISRAC). The group was composed of representatives from the water supply utilities, the state natural resources agencies, areawide planning organizations, and the Federal resource agencies. The purposes of FISRAC were to provide overall study guidance, to review the Corps' technical documents for consistency with other MWA planning efforts, and to comment on the acceptability and feasibility of the alternatives proposed for consideration. FISRAC was particularly active during the early-action phase, conducting several meetings at key decision points. As discussed earlier in this chapter, it was at FISRAC's suggestion that the RTF was created to examine ways of implementing some of the alternatives described in the 1979 ***Progress Report***. Minutes of the FISRAC meetings are contained in Annex C-VIII, along with pertinent correspondence from other sources. Comments from the FISRAC members concerning the draft of the ***Final Report*** are discussed in the next section.

Public Views and Comments

An active exchange of ideas, criticisms, and suggestions occurred throughout the study. This exchange occurred not only with the three committees discussed previously, but also with many other organizations and individuals. Annex C-VIII - ***Background Correspondence*** contains a chronological assembly of important study correspondence from 1976 through 1983, and provides some sense of the views and concerns of participants as the study progressed.

To conclude the study, a draft of the ***Final Report*** was distributed for review in March 1983. This draft report documented the entire study process, including the status of the RTF's regional plan as well as the conduct of the early-action and long-range phases. Comments were requested on the draft report, and all those received are contained in Annex C-X - ***Comments and Responses Concerning Draft Report***. Where appropriate, the ***Final Report*** has been revised to accommodate a particular comment, or a response has been prepared and included in Annex C-X.

Several very complimentary comments were received concerning the draft report and the study's conduct over seven years. Most comments supported the Corps' recommendations, and endorsed the RTF's regional plan. Many reviewers merely responded with "No Comment," suggesting that the report and recommendations were acceptable to them. Several comments, notably from Loudoun and Charles Counties, expressed concern about future development of large regional water supply projects in their particular areas. Both counties felt that such projects could foreclose opportunities for construction of smaller projects by the individual governments to satisfy their local needs. Both counties stated the need for extensive studies and active public participation programs before implementing any of the regional projects considered in the long-range phase. Montgomery County also expressed a concern that any increase in the adopted minimum flowby level be undertaken only after extensive analyses which considered the adverse biological and recreational impacts of reservoir drawdowns which may offset any beneficial impacts in the Potomac Estuary.

Perhaps the most extensive series of comments came from the CTF and NAS-NAE committees. While not in disagreement with the report's recommendations, these two committees felt that some improvements could possibly be made in the ***Final Report***. The concerns of these two committees, which shared somewhat similar concerns throughout the study, are discussed in the following paragraphs.

The CTF, in particular, requested that the list of tentative recommendations in the draft report be extended to include a recommendation for additional water quality studies. This request reflected the CTF's criticism throughout the study that the Corps should devote more effort to the examination of both raw and finished water quality. The major concern relating to water quality was that existing water supply sources may not continue to serve as potable supplies in the future. A second CTF comment questioned the continued effectiveness of the new regional agreements and contracts in future years. The CTF suggested that wherever the phrase appeared saying that regional shortages are not expected before the year 2030, a qualifying phrase be added to state the assumption of continued regional cooperation throughout the period. A related third comment suggested that alternative long-range plans should be developed, just in case the regional plan recently undertaken by the RTF did not work as expected. In essence, the CTF wanted contingency plans to be developed for several different future scenarios. A fourth comment requested that the public involvement chapter in the ***Final Report*** be revised and expanded to furnish more information about public participation and the public's views on the study. Finally, the CTF expressed reservations regarding the adoption of the 100 mgd value for environmental flowby to the Potomac Estuary. Although this concern was not raised explicitly during the CTF's review of the draft report, CTF members had raised questions previously about the scientific validity of the State of Maryland's flowby examination.

The NAS-NAE committee provided a series of informal comments concerning the Corps' draft report. (The formal NAS-NAE report to the U.S Congress will be completed after the publication of the Corps ***Final Report***.) Many of the comments were of a positive nature regarding: (1) the thorough analysis of supply availability using PRISM/COE, (2) the application of sectoral and seasonal variances in projecting water needs, (3) the realistic consideration of different water conservation measures as means to reduce demands, (4) the honest attempt to seek active public participation, and (5) the innovative character of the regional plan involving cooperative management of supplies. Criticisms of the study were as follows: (1) long-range plans beyond 2030 should have been developed, (2) a recommendation should be made suggesting the preservation of the most desirable reservoir sites, given that surface water storage appears to be the "best" alternative for large quantities of high quality water, (3) technical findings in the ***Final Report*** should not be overshadowed by political and/or social considerations, and (4) the conclusions regarding the EEWTP should reflect the second year of testing. Furthermore, the NAS-NAE committee noted the same deficiency as the CTF concerning water quality studies of both raw and finished water supplies. The water quality examination (which was conducted near the end of the study at the urging of the NAS-NAE and CTF committees) appeared to be too limited in scope, time and funding to permit any conclusive evaluations. Underscoring the NAS-NAE committee's long-standing concern, members requested that every effort be made in future water supply studies to consider water quality on equal terms with water quantity.

Evaluation of Public Involvement Efforts

If the progress toward implementation of a plan is a measure of success, then the MWA Study efforts should be considered successful. Local agencies and water suppliers have moved very purposefully toward implementing a number of the measures examined in the early-action phase. While there was certainly not universal agreement on all the measures proposed, it was most gratifying to see local agencies working together to solve a water supply problem that had a high degree of both technical and institutional complexity. It is believed that the coordination and information developed as part of the study process made a significant contribution to the positive actions taken by the local interests.

A second factor to be considered in evaluating the public involvement program was the effectiveness of the program in disseminating information to the general public. In this case, the information to be conveyed could be generally classified as identification of the problem, the alternatives, and the solutions. The Water Forum Notes, public presentations, news releases and other broad-based public information documents succeded in educating an interested public. To say that all of the several million people affected by the problem were fully attuned to the MWA study and findings would be a gross overstatement; however, there was a strong indication that the general public did have an above average understanding of the problems and solutions. The level of understanding was attributable to recent drought experiences and the attendant media coverage, the studies and public information activities of others, and the Corps' MWA study efforts.

Lastly, what appeared to be the most beneficial aspect of the program was the interaction-dialogue element which was designed around workshop exercises and committee interaction. The documentation referenced earlier is evidence that the various study committees met frequently throughout the course of the study to provide their viewpoints. The advice and/or input obtained from these committees was most valuable in gaining an insight into the desires of local interests.

Chapter VIII Summary and Conclusions

Summary

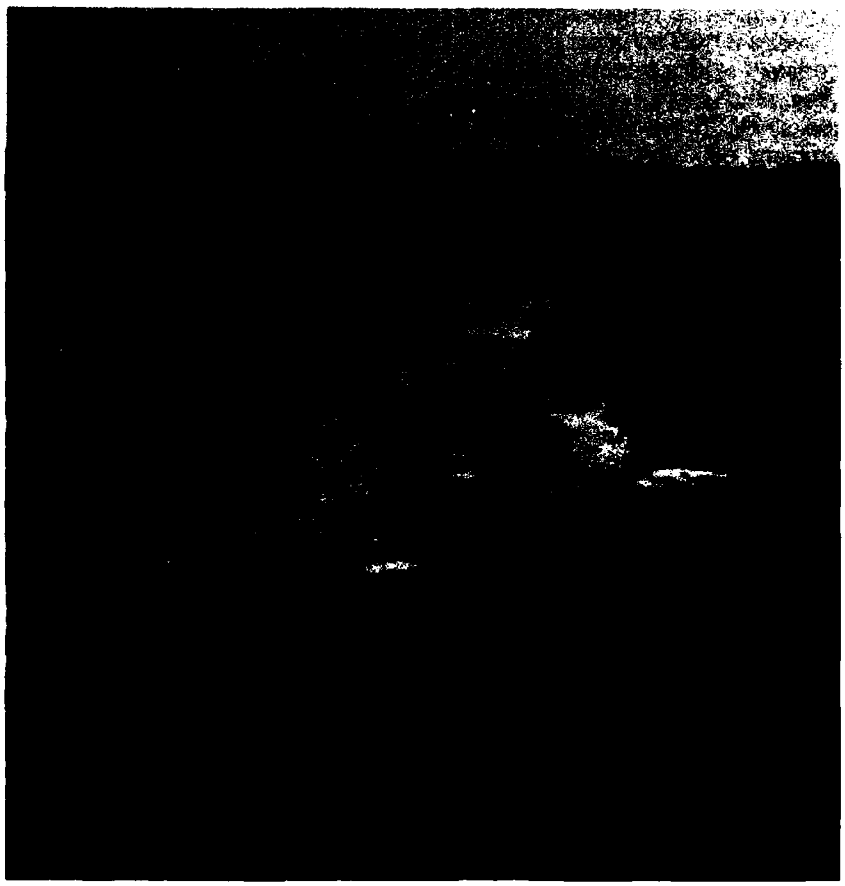
The Metropolitan Washington Area Water Supply Study was a comprehensive examination of the water supply problems facing Washington, D.C., and seven surrounding counties in Maryland and Virginia. Severe water supply shortages had been forecast for the Metropolitan Washington Area, and the study was undertaken to identify and evaluate alternative methods of alleviating future deficits.

Following an intensive public involvement program to identify the most acceptable alternatives for detailed examination, the study was conducted in two distinct phases. The first or early-action phase examined the most immediate problems and formulated several alternatives for local consideration. A *Progress Report* describing the results of the early-action phase was released in August 1979 so that decisions concerning high priority water supply plans could be made without waiting for overall study completion. The early-action phase concluded that future water supply shortages were not nearly as severe as first projected, and that alternatives were available which could provide adequate water for the region well into the 21st century.

The second or long-range phase analyzed the full spectrum of water supply alternatives available to the Metropolitan Washington Area. These alternatives might be used to furnish flowby levels greater than 100 mgd to the Potomac Estuary, to satisfy demands greater than presently anticipated, to provide reliable water supply sources during droughts worse than those previously recorded, to satisfy needs beyond the year 2030, or any combination of these factors. As part of the long-range phase, a reformulation study of the Bloomington Lake project was also conducted to determine if revised regulation procedures for the project would increase water supply availability and to determine if reallocation of some additional storage for water supply would be feasible. Additionally, some technologically advanced alternatives were investigated that might have applicability in future years; however, these alternatives were not developed in as much detail as the early-action components. Both the early-action and long-range phases are discussed in this ***Final Report*** for the Metropolitan Washington Area Water Supply Study.

The water supply situation was far from static during the seven-year study as the major water supply utilities continually sought to improve their capabilities so as to avoid severe water shortages. Aided to a large degree by the efforts and interim reports produced by the Corps of Engineers through its study, the non-Federal interests accomplished several significant milestones as the study progressed. Some of the more important accomplishments, listed in chronological order, included the following: adoption of the Potomac Low Flow Allocation Agreement in 1978; construction of a FCWA Potomac River intake and enlargement of the WSSC Potomac River intake, both in 1980; completion of the flowby study in 1981 by the State of Maryland; construction of a FCWA Potomac River treatment plant in 1982; signing of a contract by the MWA water utilities in 1982 to purchase all of the water supply storage in Bloomington Lake; an agreement in 1982 to coop-

Potomac River at Great Falls, Low Flow in 1969



eratively manage all water supply sources on a regional basis for the benefit of all users; and initiation of the construction of the Little Seneca Lake project in 1982. While all of these achievements were not directly attributable to the Metropolitan Washington Area Water Supply Study, they benefited nevertheless from the information and decisions generated by the study.

Such accomplishements, in turn, significantly altered the magnitude of the MWA's water supply problem while the Corps' study was being conducted. Whereas large potential water shortages were forecast at the beginning of the study, the cumulative effect of the actions taken by the non-Federal interests was to substantially eliminate projected shortages for the major utilities until at least the year 2030. The ***Final Report*** for the Metropolitan Washington Area Water Supply Study is therefore an information document for non-Federal decision-makers rather than an authorization document recommending specific actions by the Corps of Engineers.

Significant Findings

The following statement of findings provides a brief synopsis of the most pertinent results from the many analyses which were undertaken during the study. These findings relate to problem definition, management of the existing water supply system, important planning issues. and alternatives for future water supply planning. The final section of this chapter then provides general conclusions related to the overall study.

Supplies

The Potomac River is the MWA's major source of supply, furnishing about 70 percent of the area's water supply needs. With the completion of Bloomington Lake in 1981 and the expected completion of Little Seneca Lake in the mid-1980's, supplemental releases will be available during naturally low flow periods in the Potomac River. Other major sources of supply are the Occoquan Reservoir in Virginia and the Patuxent Reservoirs in Maryland furnishing about 12 percent and 14 percent, respectively, of the MWA needs. Together these three sources furnish 96 percent of the water used in the MWA. Because of the extreme variability of natural flow in the Potomac River and because it is the MWA's primary source of water supply, prudent use must be made of existing reservoir storage capacity available to the MWA.

Demands

Average annual water demands within the MWA, after accounting for a realistic conservation factor of approximately 11 percent, are expected to increase from around 440 mgd in 1980 to about 680 mgd in 2030. Seasonal summer peak use will be well in excess of the average annual value and is projected to range as high as 970 mgd by 2030. Categorical breakdowns of water use show that single and multi-family residential units are estimated to account for about 62 percent of total water use. Percentages in other use categories are: unaccounted - 13 percent; commercial/institutional - 11 percent; Federal government - 9 percent; and non-Federal government/institutional - 5 percent.

Within the MWA, there are 25 independent water service areas. Four of the more highly developed areas are served by the WSSC, FCWA, Aqueduct, and Rockville which satisfy about 96 percent of the MWA's total demand. These four service areas are either partially or wholly dependent upon the Potomac River, and were the primary focus of this report. The remaining service areas were defined as the outlying communities and were analyzed to a lesser degree of detail.

Shortages

Large water supply deficits for the MWA had been forecast when the study was initiated. As the nature of the supplies, demands, and capabilities of the existing resource base were better defined, the magnitude of the problem was found to be less severe than originally estimated. Certain actions by non-Federal entities during the course of the study further reduced the deficits which were first projected.

With the series of regional agreements signed in July 1982, the availability of Bloomington Lake and Little Seneca Lake, and the implementation of certain conservation measures, no shortages are now projected for the four major Potomac users within the planning horizon (year 2030). This statement is predicated upon the assumption of a minimum 100 mgd flowby target during severe droughts, coordinated regional management by the major utilities to make the most efficient possible use of the river and reservoir sources, and the occurrence of a drought no worse than the most severe on record (1930-31).

Flowby

As part of its responsibilities under the LFAA, the State of Maryland in cooperation with others conducted an investigaion of environmental flowby into the Potomac Estuary. The State recommended that a minimum target of 100 mgd be established for flow into the Estuary, with a 300 mgd flow target for the reach of the Potomac River between Great Falls and Little Falls. The LFAA signatories later adopted these recommendations, and they were subsequently used for planning purposes throughout the MWA Water Supply Study. Analyses were performed, however, to determine the sensitivity of the projected surpluses and shortages in the year 2030 to other flowby levels. Two levels of flow into the Estuary, 300 and 500 mgd, were selected for examination. Results of the examination simulating a recurrence of the 1930-31 drought indicated that a 300 mgd flowby target would cause only small shortages throughout the water supply system in year 2030; however, nearly all of the system's storage would be exhausted (Bloomington, Savage, Occoquan , Patuxent, and Little Seneca). For a 500 mgd flowby target and simulation of the 1930-31 drought, large shortages would occur throughout the system in year 2030 and all reservoirs would be emptied. The shortages associated with 300 and 500 mgd flowby targets in the year 2030 would approach 2.0 bg and 32.0 bg, respectively.

Water Quality

The water quality of existing and proposed water supply sources was of particular concern to the NAS-NAE Review Committee and the Citizens Task Force throughout the study process. Investigations were undertaken by USEPA to determine the potability of existing sources. Based on limited available data, the USEPA study concluded that the existing water treatment plants are capable of producing water from their respective sources which satisfies current drinking water standards. Additionally, the existing water treatment plants are capable of responding to moderate changes in raw water source quality, should such changes occur, without large scale modifications to the treatment processes.

Nevertheless, strong watershed protection programs should be enacted for those areas upstream of the MWA's water supply reservoirs in order to maintain or improve the water quality of reservoir inflows. These watershed protection programs should be accompanied by an intensive and continuing water quality monitoring network to detect changes in the raw water sources that are used for potable purposes.

Outlying Service Areas

Although the outlying communities make up only a small percentage of the MWA's overall water supply needs, they face potential shortages well before the major utilities. The nature of these shortages and the alternatives available to overcome them are specific to each outlying community. This report contains some general planning guidelines which could be adopted to any area. Some of the same alternatives formulated for the major utilities would also apply to the outlying communities, but developed to a smaller scale. The most likely future sources for the outlying communities appear to be groundwater development and small reservoirs.

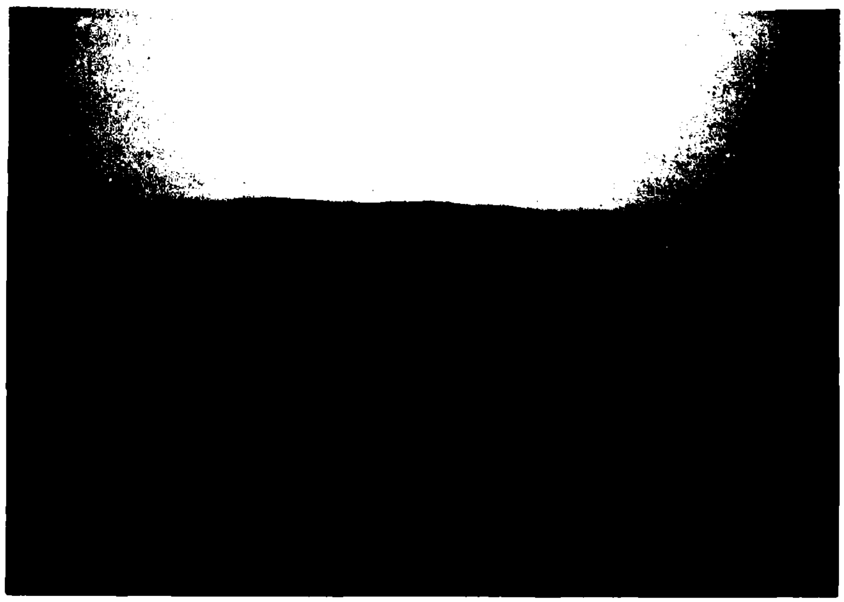
System Operation

The basic cornerstone to satisfying future water supply needs for the major Potomac users is cooperative regional management of the entire water supply system. With operation of the system as a regional unit, it is possible to obtain certain synergistic effects which improve the system's water supply capability. A system model (PRISM/COE) was used to evaluate the regional management strategies which offered the most promise. Selection of an appropriate release balance between upstream reservoirs (Bloomington and Savage) and downstream reservoirs (Patuxent and Occoquan), for instance, can reduce the storage "wasted" early in the water supply season and conserve water for later use during a more critical period. With conjunctive operation of all reservoirs, drawdowns could also be kept to a minimum throughout the reservoir system. Regulation of the system in such a manner would furnish an adequate base supply for most situations; however, Little Seneca Lake would be available as an emergency supplemental source should Potomac flows be lower than projected or demands greater than anticipated. Regulation of the entire water supply system as a regional unit also offers added flexibility in responding to seasonal and daily variations in supply and demand, and would have generally positive effects on the associated environmental resources.

Bloomington Lake Reformulation Study

Bloomington Lake represents a major new source of water for the MWA, and its use directly affects water supply management decisions in the MWA. The Bloomington Lake Reformulation Study was undertaken to answer two questions: (1) Could the existing project be regulated in a more efficient manner than the method suggested in the project's 1962 authorization document, and (2) Could more water supply storage be made available within the project by reallocating either flood control or water quality storage?

Bloomington Lake



Reregulation of Existing Project

The Bloomington Lake Reformulation Study revealed that regulating the project to maintain a continuous flow target of 197 mgd (305 cfs) at Luke, as suggested in the 1962 authorization document, would be very inefficient from a water supply viewpoint, and detrimental to the water quality in the North Branch as well. Present studies indicate that the minimum flow target at Luke should be approximately 78 mgd (120 cfs) to be met by releases from nearby Savage River Reservoir and Bloomington Lake's water quality storage. Given the flow target at Luke, supplemental releases for the MWA can then be made from Bloomington Lake's water supply storage, buffered as necessary by joint releases from Savage River Reservoir. Concurrent analysis resulted in the development of a series of seasonally-dependent and flow-dependent ratios to be used in balancing the potentially acidic releases from Bloomington with the normally alkaline releases from Savage. Projections by the USGS estimated the transit loss between Bloomington Lake and the MWA to be insignificant even at low flows. Furthermore, the USGS estimated that 47 percent of any release would arrive at the MWA within the first seven days, with the remaining 53 percent arriving during the subsequent seven days. In another related investigation, it was determined that the Bloomington Lake project should continue to be regulated to provide a winter drawdown for flood control and water quality purposes.

Storage Reallocation

Two storage reallocation possibilities were considered for Bloomington Lake - water quality storage to water supply and flood control storage to water supply. Studies indicated that all of Bloomington Lake's existing water quality storage (16.6 bg) should be reserved for satisfying flowby targets at both Luke, Maryland, and downstream in the MWA during low flow periods. On the other hand, up to 50 percent (5.9 bg) of the projects' existing flood control storage could conceivably be reallocated to water supply storage with only a seven percent reduction in the project's average annual benefits. The perceived loss of flood damage protection, however, may be objectionable to communities immediately downstream of the project without some form of mitigation. To accommodate the increase in water supply storage, certain physical modifications would have to be made to the intake tower, spillway, and boat launching areas. The costs for these items, as well an an allocated share of the project's original cost, would have to be repaid by a non-Federal sponsor. Environmental impacts of creating a larger lake would be minor, representing a loss of about 117 acres of terrestrial habitat which is of marginal value due to its steep nature. Water quality in the lake would be only slightly improved with a larger and deeper lake; however, downstream water quality, pH, and temperature may often show a sudden drop because flood releases through the gated spillway would occur more often.

Raw Water Interconnections

Two raw water interconnections were identified as having potential to serve MWA water supply needs - a Potomac to Rocky Gorge interconnection for WSSC and a Potomac to Occoquan interconnection for FCWA. Sizes could vary, but studies indicated that the most appropriate capacity for each interconnection would be between 60 and 70 mgd. Reversible capability in both interconnections would add significant flexibility to the water supply systems by taking full advantage of the water treatment plant capacities at either end of the interconnections. Raw water interconnections would be expensive projects, and would cause some social and environmental disruption during construction. The most significant impact during the operation phase would be the possibility of accelerated reservoir drawdowns. Water quality in both the Rocky Gorge or Occoquan Reservoirs would be slightly degraded and treatment costs at the reservoir treatment plants would be slightly increased if Potomac River water was discharged directly into the reservoirs. The water quality effects of pumping reservoir water to the Potomac River would be minimal.

Finished Water Interconnections

While finished water interconnections would not provide any "new" water to the MWA, they would improve the capability of the overall system to respond to localized emergencies in any one area. Furthermore, appropriate finished water interconnections could make use of potentially available treatment capacity at the Washington Aqueduct, thus deferring the need for construction of additional treatment facilities by other utilities. Five finished water interconnections were considered with capacities ranging from 4 to 60 mgd.

Cost-savings would be possible if the pipeline construction costs and the associated plant modifications were less costly than treatment plant expansion. Environmental impacts related to construction activities would be negligible; however, some social disruption could occur as most of the finished water interconnections would be constructed in highly urbanized areas. Operational impacts would be minimal except that environmental quality of the Potomac River upstream of the Aqueduct intakes could be slightly improved because of reduced FCWA and WSSC withdrawals. The blending of water from different sources within a single distribution system would not be expected to produce any significant adverse effects on water potability in the MWA as the raw water sources and treatment plant processes are relatively similar in character.

Reregulation

With the completion of the FCWA Potomac treatment plant, both WSSC and FCWA can now take advantage of reregulation and are proceeding to do so. Reregulation allows for the efficient and flexible use of reservoir storage capacity in both systems. Withdrawals from the reservoirs can be reduced during periods of adequate flow in the Potomac River, thereby saving stored water in the reservoirs for later use during critical low flow periods. By nature, reregulation saves small amounts of water over an extended period, and must be consciously implemented well in advance of the probable low flow season to be fully effective. Reregulation is a very low cost alternative as maximum use is made of existing facilities and no structural modifications are required. Environmental impacts of reregulation would be negligible, with the possible exception of accelerated reservoir drawdowns during low flow periods in the Potomac River. Water potability would not be adversely affected due to reregulation in either the WSSC or FCWA system. The USEPA's drinking water standards would not be violated.

Water Conservation

Permanent water conservation and demand reduction measures have the potential to substantially decrease projected MWA baseline demands throughout the planning period. A distinction was made between permanent conservation measures which were addressed in this study and temporary emergency measures which had already been addressed as part of MWCOG's Water Supply Emergency Agreement. Five water conservation scenarios were developed which proposed permanent measures capable of reducing the year 2030 demands between 7 and 27 percent. For planning purposes, the MWA water utilities adopted Conservation Scenario 3 which assumed an approximate 11 percent water use reduction. Any of these conservation scenarios would be extremely flexible in that they could be independently applied in any service area and could be implemented in combination with other water supply measures. Although non-structural in nature, successful water conservation programs would probably require some direct expenditures by consumers. Water conservation could also result in some significant cost savings to the water and wastewater utilities by delaying or negating the need to enlarge treatment plants and pipelines.

Upstream Reservoirs

Seven upstream reservoir sites were examined, ranging in storage capacity from 8.8 bg to 33.9 bg and in yield potential from 32 mgd to 110 mgd. The upstream reservoirs could be developed as multiple-purpose sites to include recreation and flood control as well as water supply. As a component group, the upstream reservoirs would provide the greatest supply of high quality water for the MWA at the lowest unit cost. However, they could create adverse environmental and social impacts, depending on the characteristics of a specific project area. In the past, residents in the upper Potomac River Basin have objected strongly to major storage projects that primarily serve downstream municipalities.

Local Reservoirs

In addition to Little Seneca Lake, six new local reservoirs were examined which would have capabilities for providing water supply to the MWA. These local sites could also offer multi-purpose potential, such as recreation or flood control. The sites ranged in storage capacity from 3.3 bg to 39.1 bg, and in yield potential from 12 mgd to 125 mgd. Such local reservoirs would generally represent relatively costly approaches to satisfying needs, primarily because they would have to be constructed as high-flow skimming projects with accompanying pipelines to the Potomac River. The environmental impacts of the various local reservoirs would obviously vary according to the specific dam site, reservoir size, and pipeline length, but the stream valleys in question are generally very sensitive environmental areas. Water quality at most of the sites is good. In the past, development of such local reservoir sites has generally faced strong public opposition.

One other local reservoir possibility within the MWA would be to raise the Occoquan Reservoir level by three feet to provide 2.2 bg of additional storage and an increase in yield of about 12 mgd. This project modification would increase the flexibility of the regional system, but could create significant social and institutional impacts as additional land would have to be acquired.

Groundwater

Initially, two sites were identified as having potential for groundwater development - one in Maryland's Hagerstown Valley and a second in Maryland's Atlantic Coastal Plain. The Hagerstown Valley examination was terminated soon after study initiation due to strong local and state opposition; thus, no statement can be made regarding the yield, feasibility, costs, or impacts of developing this source.

The analysis of groundwater development in the Atlantic Coastal Plain was carried to completion, and it was determined that the maximum yield from the deep aquifers would be about 100 mgd. Groundwater development in the Coastal Plain represents one of the most costly alternatives available to the MWA. Wells, pumping stations, pipelines, and water treatment plants would be required, with accompanying environmental and social impacts during construction. Water quality in the deep aquifers, based on a limited comparison with deep wells in the area, is projected to be acceptable for potable use after chlorination. Before actual development of large-scale groundwater projects in the Atlantic Coastal Plain, pumping tests should be conducted in the deep aquifers to confirm estimated drawdown rates, yields, and zones of influence. A significant institutional constraint at this time is the State of Maryland's policy prohibiting the export of groundwater from the Atlantic Coastal Plain because its shallow aquifers presently provide nearly all of the area's domestic water supply.

Potomac Estuary

From an examination of the findings from the EEWTP testing program, it appears technologically feasible to treat Potomac Estuary water to provide a potable water supply source. There may be some undetermined health risks, however, in using a source such as the Potomac Estuary which is subject to discharges from large wastewater treatment plants and from untreated nonpoint sources. Results from the Chesapeake Bay Hydraulic Model testing program also indicate that the salinity concentration at an estuary treatment plant intake may rise to unacceptable levels during prolonged use in a severe drought. The aquatic resources of the upper Potomac Estuary may also be adversely affected by the increase in salinity levels associated with use of the Estuary. Due to the many uncertainties with regard to Estuary use, public acceptability remains as a major unresolved issue. Preliminary cost data suggest that a full scale Estuary water treatment plant, when considering the transmission, land, and pumping requirements along with the actual treatment costs, may be a very expensive alternative. As a general note, the data and experiences gained from the EEWTP testing program for the Potomac Estuary may have applicability in other cities or countries which are contemplating the use of degraded brackish water as a possible source of water supply. Documentation of the entire testing program is contained in a special report being submitted directly to the U.S. Congress.

Pricing

Adjustment in the price of water charged to consumers was investigated as a possibility for reducing the overall demand for water. Marginal cost peak period pricing was determined to be the most applicable method within the MWA as it would assure efficiency in resource use and equity in cost distribution among resource users. However, investigation of this pricing policy revealed that prices high enough to depress demand could not be justified on the basis of marginal costs at this time. This finding reflected the recent progress by the non-Federal entities in implementing new increments of capacity at relatively inexpensive costs. It also reflected the high proportion of fixed costs to total costs in the major Potomac utilities which had the effect of keeping marginal cost peak period rates below present rates. Moreover, the recent cost-sharing formula for future projects, incorporated into the Water Supply Coordination Agreement, provides strong incentives for participating utilities to reduce peak demands. In the future, marginal cost peak period pricing may be considerably more effective when the benefits from existing supply management have been maximized and the need and cost for new supplies has increased.

Wastewater Reuse

Several forms of watewater reuse for water supply were considered, including land application with subsequent reclamation, agricultural and industrial use of partially treated wastewater, groundwater recharge, and surface water recharge. Most of these options were found to have limited application in the MWA because of the large acreage requirements for land application, minimal use of water by industry and agriculture, and insignificant reliance by the major utilities on groundwater sources. The remaining option was surface water recharge which was investigated through a scheme to pump Blue Plains treated wastewater effluent to a discharge point immediately downstream of the Washington Aqueduct's Little Falls intake. This scheme, in effect, would furnish flowby while allowing the water utilities to withdraw most of the Potomac River's natural flow. The transfer pipeline would involve costly urban construction (with associated high levels of social and cultural impacts) adjacent to streets, parks, buildings, and historic sites of national significance.

Conclusions

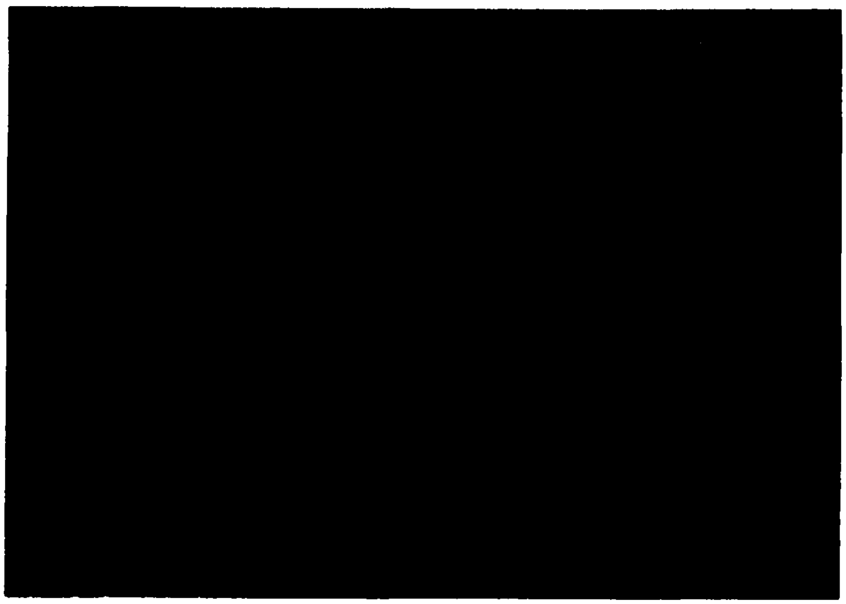
Several noteworthy conclusions and observations were made at the completion of the study which deserve explicit statement. They pertain to the overall study and are provided below.

(1) The proposed programs embodied by the series of agreements signed on 22 July 1982 are projected to satisfy water supply needs of the Potomac water utilities until at least the year 2030 under the revised assumptions of supply and demand used as the base condition during the long-range phase of study. These programs resulted, in part, from the information and decisions generated as part of the Corps' early-action study phase.

(2) There is no need for additional water supply projects or programs by the Corps of Engineers, such as those studied in the long-range phase, at this time. Institutional arrangements, either existing or newly created by the July 1982 agreements, are capable of implementing the proposed programs and are proceeding smoothly.

(3) Given that there is no need for additional water supply projects, further work on the Verona Lake project (authorized for Phase I Advanced Engineering and Design by Section 85(a) of P.L. 93-251) near Staunton, Virginia is not required. The Commonwealth of Virginia concurs in this decision (see Annex C-VIII - Background Correspondence) as there are no local needs in the Staunton area for a Federal water supply project. Thus, the Metropolitan Washington Area Water Supply Study and *Final Report* are considered to be responsive to Section 85(a) of the

Jefferson Memorial, Washington, DC



Water Resources Development Act of 1974. The Sixes Bridge project, also authorized for Phase I Advanced Engineering and Design by Section 85(a), was deauthorized in December 1981.

(4) The Interstate Commission on the Potomac River Basin's CO-OP (Cooperative Water Supply Operations on the Potomac) Program is the appropriate mechanism to promote and sustain the necessary level of regional cooperation endorsed in the recent series of agreements and contracts. The Water Supply Coordination Agreement formalizes the region's commitment to cooperative management from an overall perspective. Without such regional management, it is likely that the separate water supply systems would not be managed for the maximum benefit of all users throughout the MWA and shortages could result.

(5) PRISM/COE is an effective planning tool for investigating how the water supply systems of the major utilities will respond to different drought scenarios and for examining alternative system regulation schemes on a weekly basis. Improvements, refinements, and additions to PRISM/COE, such as those undertaken by CO-OP, have also made the model applicable for day-to-day operational decisions. PRISM/COE and its derivatives are extremely valuable assets to any water supply manager in the MWA and should be updated periodically to reflect changes to the water supply system.

(6) Modification Number 1 to the Potomac Low Flow Allocation Agreement provides for a review every five years to determine the fairness and reasonableness of the allocation formula. This periodic review also requires a forecast of the MWA supplies and demands for coming years. Should further action be needed in the future to balance supplies and demands, the provisions of the LFAA furnish the logical means by which such needs can be identified sufficiently in advance of a shortage situation to undertake appropriate management actions. This periodic review of the water supply situation will also allow the LFAA signatories to assess the effectiveness of the various agreements and contracts in satisfying water supply needs.

(7) Conjunctive regulation of Bloomington Lake and Savage River Reservoir to (a) satisfy a minimum flow target at Luke of 78 mgd (120 cfs), (b) maximize the amount of water available for downstream users, and (c) improve water quality in the North Branch Potomac River, is within the authority of the District Engineer. There is no need, at the present time, to reallocate either flood control or water quality storage to provide more water supply storage in Bloomington Lake.

(8) The alternatives investigated during the long-range phase appear to have limited application in the immediate future because: (a) they are not cost-effective, (b) they create potentially significant adverse environmental impacts, (c) they represent options which have been generally opposed by the public in recent years, (d) they are not engineeringly feasible given the current technology, or (e) they contain a combination of the drawbacks listed in (a) through (d). Furthermore, there is no pressing desire for implementation of any of these alternatives at the present time as the needs are projected to be satisfied with the implementation of some of the early-action programs. Should additional water supply programs be needed in the future, the work accomplished as part of the long-range phase would be an appropriate starting point for more detailed investigations.

(9) Although water potability studies were performed which indicated that the current drinking water standards could be met now and in the foreseeable future, these studies were admittedly of a limited nature. Any future study of water supply needs in the MWA should consider a more thorough examination of the quality and/or potability of different water sources. Additionally, strong watershed protection programs and water quality monitoring systems should be undertaken now to prevent the degradation of existing raw water supplies and to collect data regarding water quality trends throughout the MWA, respectively.

Chapter IX
Recommendations

Although large potential water supply shortages were forecast prior to and during the early stages of the Metropolitan Washington Area Water Supply Study, non-Federal agencies and organizations have made significant progress recently in implementing regional solutions to the water supply problems in the Metropolitan Washington Area. This progress was aided in large part by the technical work conducted by the Corps of Engineers as part of its study and made available to the non-Federal interests on a continuing basis. Thus, a fundamental goal of the Metropolitan Washington Area Water Supply Study was achieved. That goal was to provide the necessary technical support and direction to enable responsible decisions by local officials concerning implementation of high priority water supply programs.

I have reviewed all documents and analyses concerning the Metropolitan Washington Area Water Supply Study as well as the stated views of other interested agencies, the concerned public, and the National Academy of Sciences - National Academy of Engineering to determine the overall public interest. Public meetings and workshops have been conducted throughout the study and progress reports have been coordinated with the appropriate agencies, groups, and interests at various times. Additionally, I have examined the status of the recent regional commitments to supplemental water supply programs.

In light of the findings and conclusions discussed in the foregoing chapters, in view of the fact that the non-Federal interests have already used the Corps' study to undertake their own water supply programs, and based on the expectation that the non-Federal agencies will continue to adhere to the regional agreements and contracts signed in 1982, I recommend that:

(1) The Corps of Engineers take no further action at this time to satisfy Metropolitan Washington Area water supply needs:

(2) The *Final Report* for the Metropolitan Washington Area Water Supply Study be transmitted to Congress as an information document, in accordance with the directives of the study's authorizing legislation - Section 85 of the Water Resources Development Act of 1974 (Public Law 93-251).

Due to of the concerns regarding the future quality of raw water sources in the Metropolitan Washington Area, I further recommend that appropriate Federal, state, and local agencies undertake the necessary programs to protect and enhance the quality of both present and potential raw water sources. These programs, as a minimum, should include watershed protection programs and water quality monitoring programs.

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II. Committees

A. Federal-Interstate-State - Regional Advisory Committee

B. Citizens Task Force for the MWA Water Supply Study

C. National Academy of Sciences - National Academy of Engineering

D. Water Resources Planning Board for MWCOG

E. Water Supply Advisory Committee for MWCOG

F. Washington Metropolitan Regional Water Supply Task Force

G. Cooperative Water Supply Operations on the Potomac, Interstate Commission on the Potomac River Basin

III. Contractors and Consultants

A. Enviroplan, Inc. - Water quality evaluation for raw water interconnections

B. GKY and Associates - Raw water interconnections, engineering data and modelling

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List of Abbreviations

Ac-Ft	Acre-Feet
Aqueduct (WAD)	Washington Aqueduct Division, Corps of Engineers
AWT	Advanced Waste Treatment
BERH	Board of Engineers for Rivers and Harbors
bg	billion gallons
cfs	cubic feet per second
CO-OP	Cooperative Water Supply Operations on the Potomac
CTF	Citizens Task Force
D.C.	District of Columbia
DES	D.C. Department of Environmental Services
EEWPS	Potomac Estuary Emergency Water Pumping Station
EEWTP	Potomac Estuary Experimental Water Treatment Plant
EQ	Envionmental Quality
FCWA	Fairfax County Water Authority
MPWA	Maryland Potomac Water Authority
msl	mean sea level
MWA	Metropolitan Washington Area
MWCOG	Metropolitan Washington Council of Governments
FISRAC	Federal-Interstate-State-Regional Advisory Committee
FWI	Finished Water Interconnections
gpd	gallons per day
ICPRB	Interstate Commission on the Potomac River Basin
JHU	Johns Hopkins University
LCSA	Loudon County Sanitation Authority
LFAA	Low Flow Allocation Agreement
mg	million gallons
mgd	million gallons per day
M-NCPPC	Maryland - National Capital Park and Planning Commission
NAS-NAE	National Academy of Sciences-National Academy of Engineering
NED	National Economic Development
NEWS Study	Northeastern United States Water Supply Study
O&M	Operation & Maintenance
P.L.	Public Law
PRISM/COE	Potomac River Interactive Simulation Model/Corps of Engineers

PRV	-	Pressure Reducing Valve
RWI	-	Raw Water Interconnection
SCS	-	U.S. Soil Conservation Service
UPRC	-	Upper Potomac River Commission
USEPA	-	U.S. Environmental Protection Agency
USFWS	-	U.S. Fish and Wildlife Service
USGS	-	U.S. Geological Survey
WAD	-	Washington Aqueduct Division, Corps of Engineers
WRC	-	Water Resources Council
WSEA	-	Water Supply Emergency Agreement
WSEP	-	Water Supply Emergency Plan
WSSC	-	Washington Suburban Sanitary Commission
WTP	-	Water Treatment Plant

ment program was devised to en-
courage participation and interest by

public needs and desires. Interaction-
dialogue mechanisms such as work-

vious chapters. The initial public in-
volvement activities were also used