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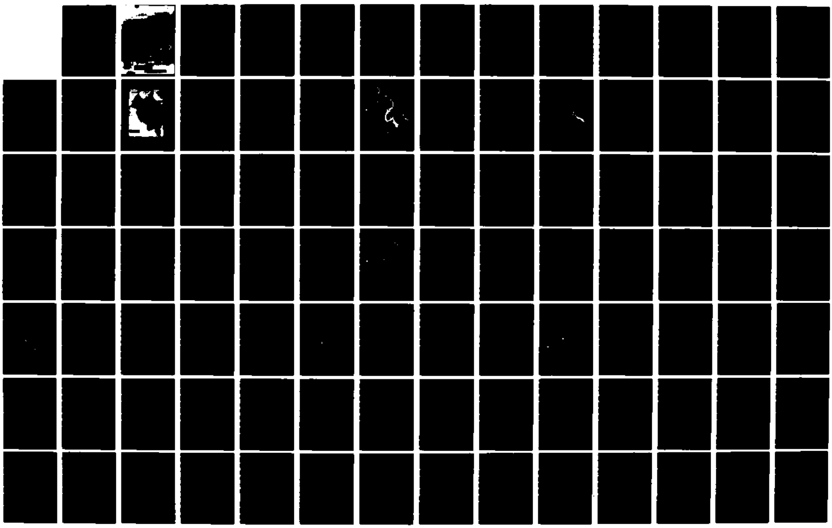

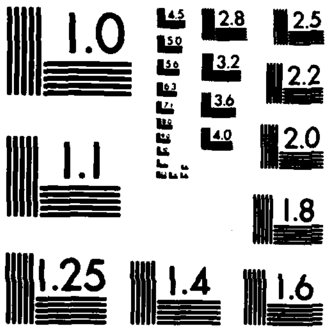


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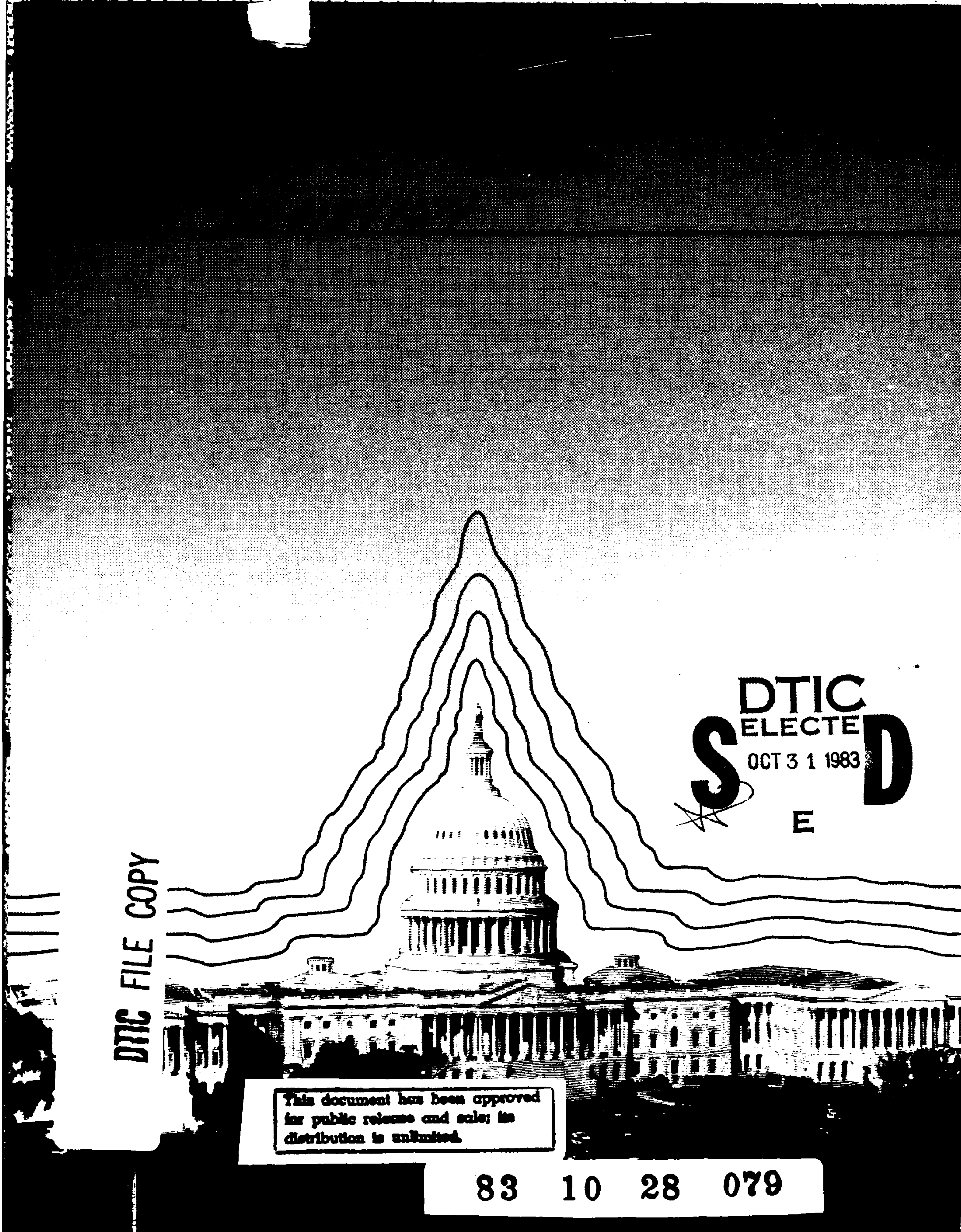

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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.

# METROPOLITAN WASHINGTON AREA
# WATER SUPPLY STUDY

## APPENDIX B
## PLAN FORMULATION, ASSESSMENT, AND EVALUATION




Department of the Army
Baltimore District, Corps of Engineers
Baltimore, Maryland


September 1983

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 |
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| | | C-X | Comments and Responses Concerning Draft Report |
| D | Supplies, Demands, and Deficits | D-I | Water Demand Growth Indicators by Service Areas |
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| | | H-IV | Flood Control Analysis |
| | | H-V | US Geological Survey Flow Loss and Travel Time Studies |
| | | H-VI | Environmental, Social, Cultural, and Recreational Resources |
| | | 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.

METROPOLITAN WASHINGTON AREA WATER SUPPLY STUDY

APPENDIX B

PLAN FORMULATION, ASSESSMENT, AND EVALUATION

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# APPENDIX B

## PLAN FORMULATION, ASSESSMENT AND EVALUATION

The nation's capital and surrounding counties in both Maryland and Virginia face potential water shortages in the future. Such water shortages appear likely during drought years unless specific actions are taken to reduce water demands, provide new supply sources, and/or better manage existing water supply systems. Despite many investigations of the water supply situation, positive actions to provide new sources of water of sufficient quantity and quality for the Metropolitan Washington Area (MWA) are just now being initiated. This Metropolitan Washington Area Water Supply Study draft report furnishes a comprehensive evaluation of the problems, needs, and opportunities associated with various water supply plans for the MWA.

The MWA was defined as the Washington Standard Metropolitan Statistical Area which as shown on Figure B-1, includes: Montgomery, Prince Georges, and Charles Counties in Maryland; Arlington, Fairfax, Prince William, and Loudoun Counties in Virginia; and the District of Columbia. These areas include 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 about 25 water supply systems, with the 3 largest systems (Washington Suburban Sanitary Commission, Fairfax County Water Authority, and Washington Aqueduct Division) providing almost 95 percent of the MWA's treated water supply.

The Metropolitan Washington Area Water Supply Study was authorized by Section 85 of the Water Resources Development Act of 1974 (Public Law 93-251, 7 March 1974). The study's purposes 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. Section 85, P.L. 93-251, also authorized the construction and testing of a Pilot Estuary Water Treatment Plant (one million gallon per day, nominal capacity) to test the feasibility of using the Potomac River estuary as a permanent supplemental water supply source.

### PURPOSE OF APPENDIX

The purpose of this appendix is to present the formulation, assessment, and evaluation procedures which were used to develop plans for satisfying the Metropolitan Washington Area's water supply problems to the year 2030. This appendix identifies the many diverse elements of the complex 7-year study, and demonstrates the interrelationships among these many elements. The appendix also summarizes the objectives, methodologies, technologies, criteria, plan components, and design considerations as well as the formulation procedures leading to important decisions. The plan formulation, assessment, and evaluation sequence described in this document is further supported by detailed data and analytical methods more fully described in other appendices and annexes to the Main Report. ~~These~~ other volumes are referenced throughout the text as appropriate; Figure B-2 is a schematic diagram of the organization for the MWA Water Supply Study draft report.

FIGURE B-1

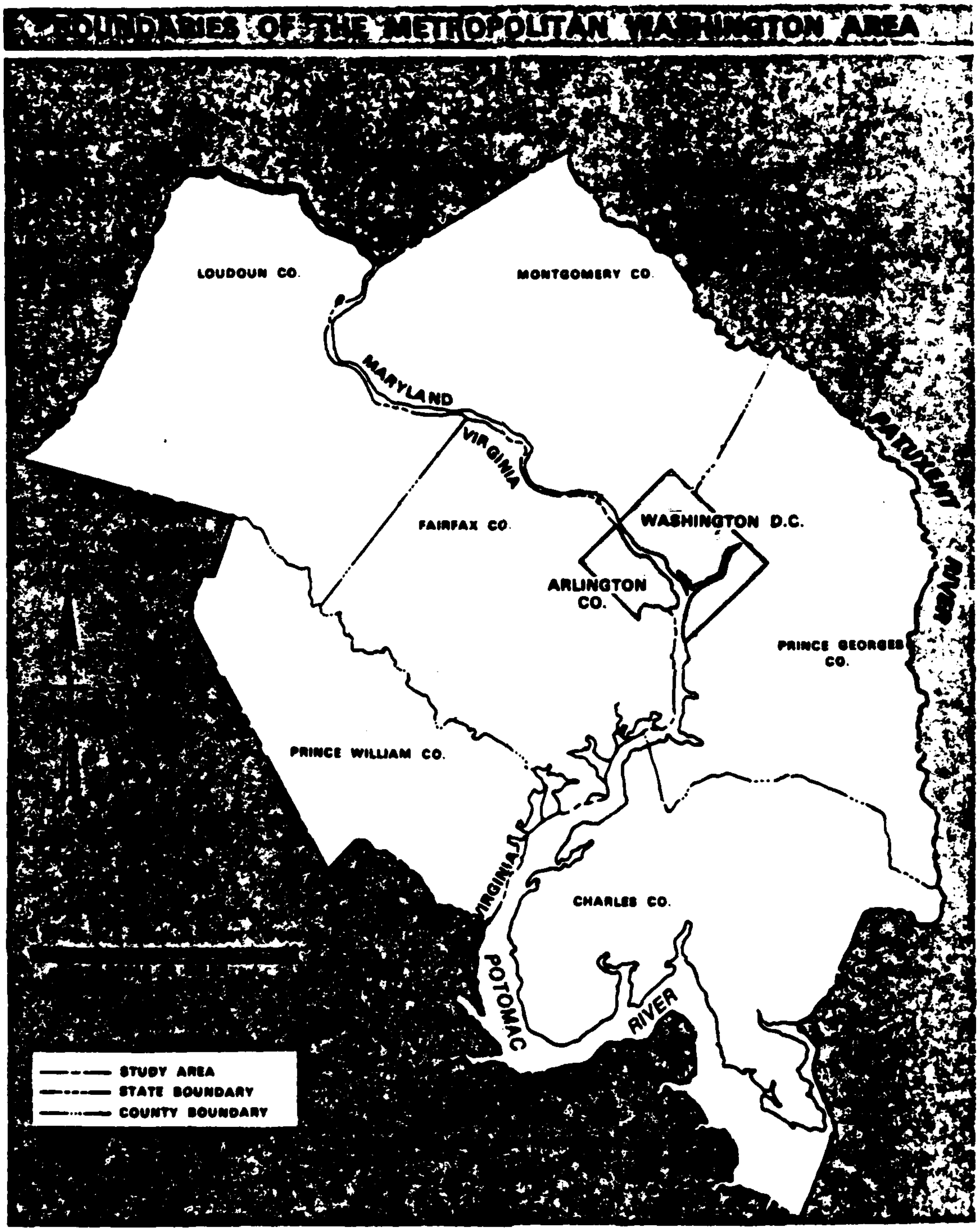
BOUNDARIES OF THE METROPOLITAN WASHINGTON AREA
LOUDOUN CO.
MONTGOMERY CO.
MARYLAND
VIRGINIA
FAIRFAX CO.
WASHINGTON D.C.
ARLINGTON CO.
PRINCE GEORGES CO.
PATUXENT RIVER
PRINCE WILLIAM CO.
VIRGINIA
CHARLES CO.
POTOMAC RIVER
STUDY AREA
STATE BOUNDARY
COUNTY BOUNDARY

FIGURE 2

REPORT ORGANIZATION*

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## OVERVIEW OF STUDY PROCESS

### PHASES

Work on the Plan of Study for the Metropolitan Washington Area Water Supply Study began in 1976 immediately following appropriation of study funds by Congress. Because of the expressed desire for immediate solutions to the MWA's most pressing water supply needs, and because of the projected lengthy nature of some of the related investigations (notably the Potomac Estuary Experimental Water Treatment Plant (EEWTP) design, construction, and testing program), the Corps of Engineers proposed a two phase study program in the Plan of Study. The first phase, called the early-action phase, was to be completed in three years and was to address the immediate short-range water supply problems (prior to year 2000) of the MWA with special emphasis on readily implementable solutions. The expressed purpose of the early-action phase was to report the study's progress at the approximate mid-point so that immediate actions could proceed on high priority water supply plans without waiting for completion of the full study report. The second phase, called the long-range phase, was to be completed concurrently with the EEWTP testing program and was to examine the feasibility of the full spectrum of water supply alternatives over the remainder of the planning period (up to year 2030).

The early-action phase culminated in August 1979 with the publication of a document called Progress Report - Metropolitan Washington Area Water Supply Study for the Potomac River Users. This report evaluated several plans for satisfying the immediate needs of the MWA, particularly plans making more efficient use of existing supplies. Furthermore, the report concluded that these so-called "early-action plans" could satisfy water supply needs well beyond the year 2000, provided the appropriate regional management techniques were employed. Using the August 1979 Progress Report as the foundation, non-Federal participants have proceeded to implement some of the proposed measures and have made significant committments to cooperatively manage the various water supply sources. Later sections in this appendix discuss more fully the analysis and results of the early-action phase.

The long-range phase concentrated on analyzing alternatives not examined in the previous phase to determine their feasibility for further reducing water needs or providing new water supply sources. Additionally, a reformulation study of the Corps' existing Bloomington Lake project on the North Branch Potomac River was conducted during the second phase to determine the maximum water supply capability of the existing project. Reallocation of storage in such an existing project may be economically and environmentally preferable to constructing new projects if additional water supply is needed. The potential long-range alternatives are also described more fully in later sections of this appendix. The long-range phase of study is culminating with the publication of the final report for the entire MWA Water Supply Study.

### ITERATIONS

Within both of these two study phases, several iterations of plan formulation were accomplished in general accordance with the U.S. Water Resources Council's Principles and Standards. An iteration was usually structured to successively narrow the range of alternatives while developing more detailed information about the remaining alternatives. Each iteration usually consisted of six steps, as follows:

(1) specification of the problems and opportunities,
(2) inventory, forecast, and analysis of the conditions in the planning area,
(3) formulation of alternative plans,
(4) evaluation of the effects of the alternative plans,
(5) comparison of alternative plans, and
(6) selection of a plan(s) for further study or for recommendation

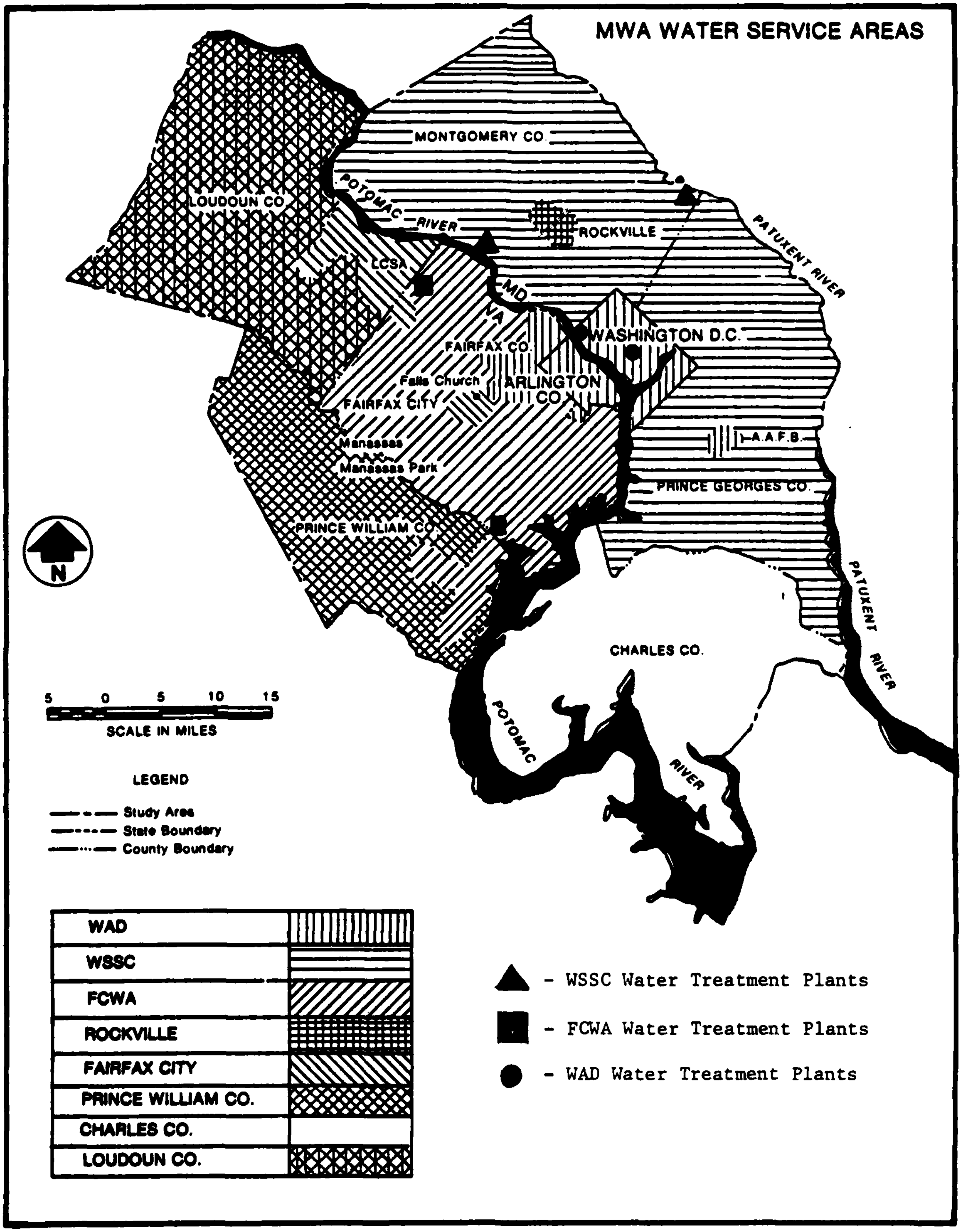
The first two steps, problem specification and conditions inventory, refer to the process of defining the nature of the resource management problems and the physical area that the study will address. The third task, the formulation of alternatives, develops a range of resource management plans that addresses the planning objectives. The effect evaluation task identifies the changes associated with the alternative plans and ascertains the full range of economic, social, and environmental effects of those changes. This step provides the information required for the tasks of plan comparison and selection. The comparison step sets forth, in an organized manner, the beneficial and adverse contributions of each alternative plan. The sixth step either identifies those plans to be carried into the next iteration, or selects a final plan for recommendation, all based on the information developed in the preceeding five steps. The Plan Formulation, Assessment, and Evaluation Appendix describes the sequential process of decision-making through the various phases, iterations, and steps.

## STUDY AREA

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. The existing physical, demographic, ecological, and economic characteristics of both the demand and supply areas are described in Appendix A - Background Information and Problem Identification. A short summary of pertinent information follows.

### DEMAND AREA

As shown on Figure B-1, the MWA was identified as the following: the counties of Loudoun, Prince William, Fairfax, and Arlington and the independent cities of Alexandria, Fairfax, Falls Church, 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 about 25 independent water supply systems ranging in capacity from less than 1 mgd to several hundred mgd. The three largest water supply systems - the Washington Suburban Sanitary Commission (WSSC), the Fairfax County Water Authority (FCWA), and the Washington Aqueduct Division (Aqueduct) - furnish over 95 percent of the MWA's treated water supply. These three service areas are shown on Figure B-3 and were the primary focus of the MWA Water Supply Study. The smaller service areas in Loudoun, Prince William and Charles Counties surrounding this urban core were not examined in as great a detail as the three major service areas; some reconnaissance level investigations were made, however, and these efforts are documented in Appendix I - Outlying Service Areas.


MWA WATER SERVICE AREAS
MONTGOMERY CO.
LOUDOUN CO.
POTOMAC RIVER
ROCKVILLE
PATUXENT RIVER
LCSA
MD
VA
WASHINGTON D.C.
FAIRFAX CO.
Falls Church
ARLINGTON CO.
FAIRFAX CITY
A.A.F.B.
Manassas
Manassas Park
PRINCE GEORGES CO.
PRINCE WILLIAM CO.
N
CHARLES CO.
5 0 5 10 15
SCALE IN MILES
POTOMAC RIVER
LEGEND
Study Area
State Boundary
County Boundary
WAD
WSSC
FCWA
ROCKVILLE
FAIRFAX CITY
PRINCE WILLIAM CO.
CHARLES CO.
LOUDOUN CO.
- WSSC Water Treatment Plants
- FCWA Water Treatment Plants
- WAD Water Treatment Plants

As shown on Figure B-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 just downstream of 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 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 small water supply system, the City of Rockville, also uses the Potomac River as its sole water supply source. Figure B-3 shows the locations of the intakes, treatment plants, reservoirs, and service area delineations for the major water supply systems in the MWA. Figure B-4 displays a schematic of the MWA's water supply system, showing (a) sources of raw water (solid box); (b) supply agencies (shaded box) which produce finished water; (c) a delineation of service areas (broken box); and (d) a definition of major jurisdictions served (ellipse) where service area geographical coverage is not obvious. The supply agencies shown on Figure B-4 have treated and distributed over 500 mgd on many summer days during recent years.

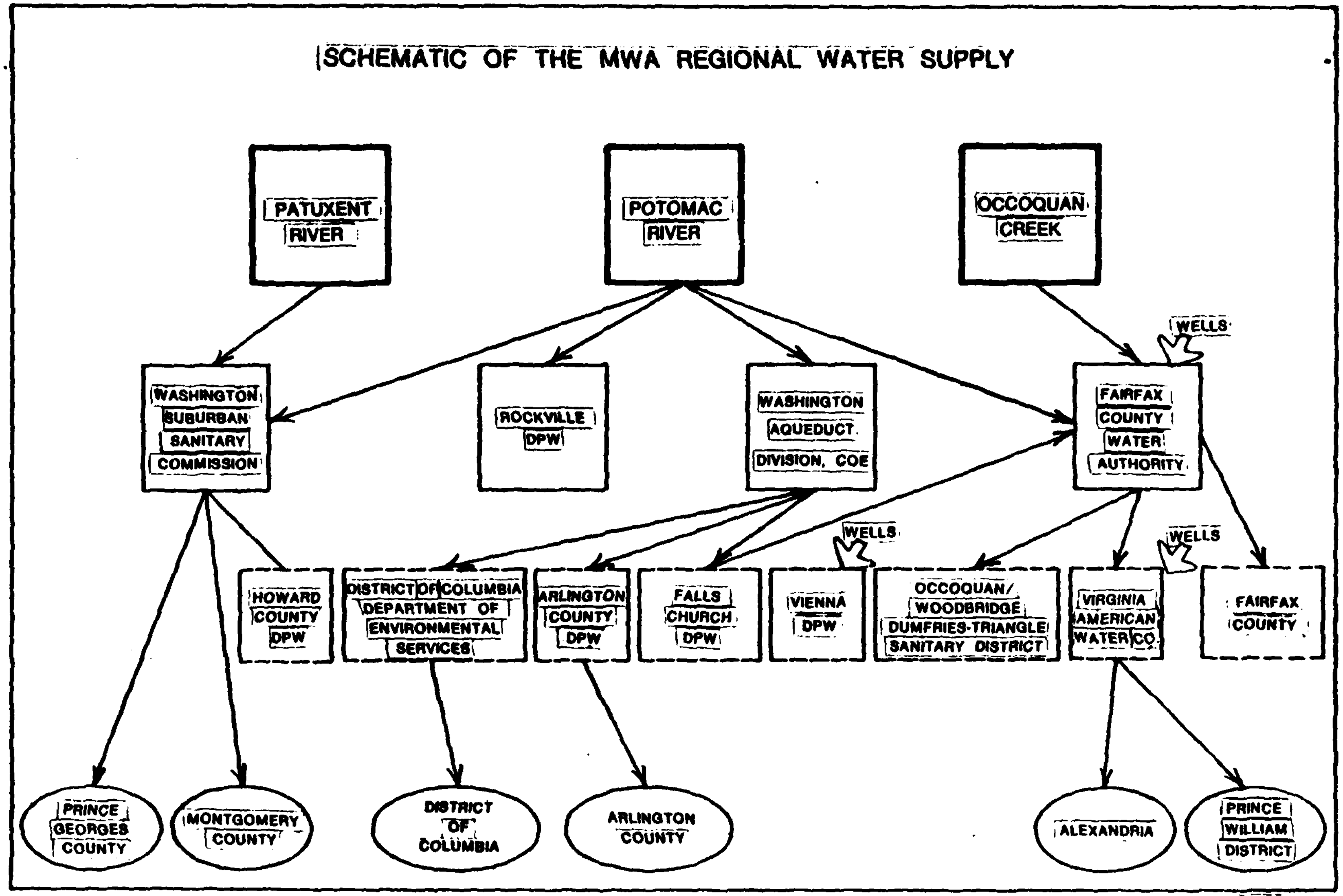
SUPPLY AREA

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 within and outside the immediate demand area. The most obvious supply area is the Potomac River Basin above Little Falls which currently provides about 70 percent of the MWA's water supply. As shown on Figure B-5 the Potomac River drainage area above Little Falls covers about 11,560 square miles and furnishes an average annual flow of 7,206 mgd. Summertime flows, however, have been observed as low as 388 mgd.

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 constructed with a specific purpose for downstream water supply. 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 storage 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 to areas immediately downstream of the project.

A second supply area is the Patuxent River Basin upstream of Laurel, Maryland (see Figure B-5). This portion of the drainage basin contains about 132 square miles. Runoff 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.

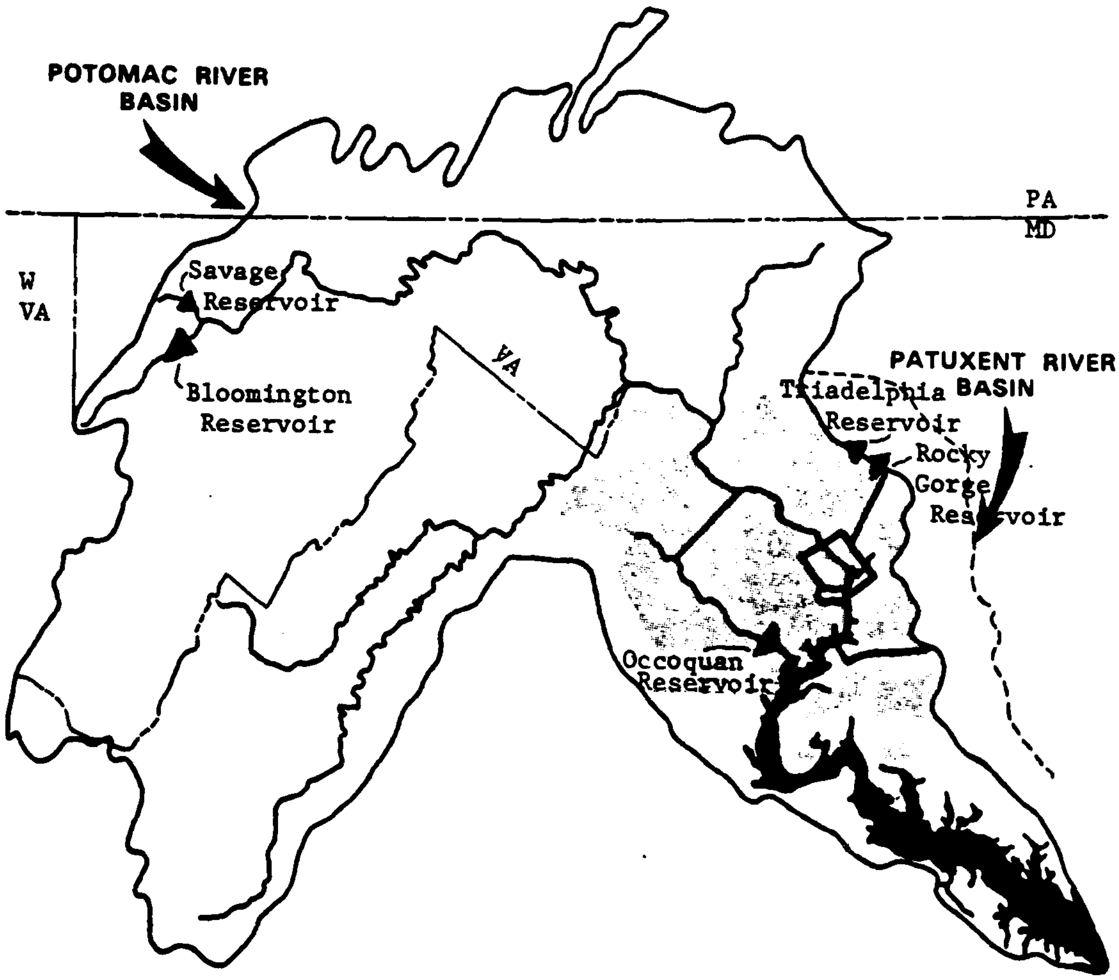
FIGURE B-4



SCHEMATIC OF THE MWA REGIONAL WATER SUPPLY
PATUXENT RIVER
POTOMAC RIVER
OCCOQUAN CREEK
WELLS
WASHINGTON SUBURBAN SANITARY COMMISSION
ROCKVILLE DPW
WASHINGTON AQUEDUCT DIVISION, COE
FAIRFAX COUNTY WATER AUTHORITY
WELLS
WELLS
HOWARD COUNTY DPW
DISTRICT OF COLUMBIA DEPARTMENT OF ENVIRONMENTAL SERVICES
ARLINGTON COUNTY DPW
FALLS CHURCH DPW
VIENNA DPW
OCCOQUAN/ WOODBRIDGE DUMFRIES-TRIANGLE SANITARY DISTRICT
VIRGINIA AMERICAN WATER CO.
FAIRFAX COUNTY
PRINCE GEORGES COUNTY
MONTGOMERY COUNTY
DISTRICT OF COLUMBIA
ARLINGTON COUNTY
ALEXANDRIA
PRINCE WILLIAM DISTRICT

FIGURE B-5

DRAINAGE BASINS SERVING THE METROPOLITAN WASHINGTON AREA



A third supply area is the Occoquan River Basin along the southwestern edge of the MWA in Virginia as shown in Figure B-5. A number of water supply impoundments are located in the Occoquan River 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 10.2 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 95 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, 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).

## STATEMENT OF PLANNING OBJECTIVES

The establishment of planning objectives guided the formulation and evaluation of plans for solving the problems. These objectives were employed throughout the study as a framework for comparison and evaluation of alternative components and plans. Simply stated, the objectives provided the yardstick against which the alternative plans were measured. Two levels of objectives were considered important for the MWA Study: National planning objectives and study planning objectives.

### NATIONAL PLANNING OBJECTIVES

Guidelines for the formulation and evaluation of plans of improvement for all Federal water and related land resource activities are 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 require that Federal and Federally-assisted water and land activities be planned toward achievement of National Economic Development (NED) and Environmental Quality (EQ) as co-equal national objectives. The components of the NED objective include:

- 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 include:

- 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 committments of resources to future needs.

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

## STUDY PLANNING OBJECTIVES

Within the framework of National objectives, a second level of planning objectives was developed which related to the problems, needs, concerns, and opportunities of the specific study area. Study planning objectives are expressions of public and professional concerns about the future use of water and related land resources. They were derived through an analysis of the existing resource base and the expected future conditions within the study area. The purpose in defining study planning objectives was to establish "targets" to guide the formulation of alternative plans and to enable evaluations of the plan effectiveness. Planning objectives sometimes conflicted with each other, reflecting different perceptions of how the water resources should be managed in the future.

The objectives of the Metropolitan Washington Area Water Supply Study were developed through meetings, discussions, workshops, and correspondence with local individuals, governmental officials, water resource managers, local planning agencies, and citizens groups, and others in the study area. Earlier reports 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 existing water supply sources and facilities (such as Bloomington) to the maximum extent practicable.

- Provide solutions to the water shortage problem within the MWA 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 among 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.

## DEVELOPMENT OF A PLAN OF STUDY

When the study was beginning in 1976, the MWA had witnessed nearly two decades of rapid population growth with accompanying increases in needs for dependable public water supply sources. A severe drought in 1966, in fact, had dangerously tested the maximum water supply capabilities of the MWA system. No significant projects had been added, however, even 10 years later when the study was beginning. Thus, there was strong sentiment by many organizations and individuals at the study outset to address the most immediate water supply needs as quickly as possible. To determine exactly what approach the study should take, the Corps of Engineers initiated an intensive public involvement program in 1977 to obtain public input on suggested study efforts.

### COMMITTEE STRUCTURE

A formal committee structure was established to encourage active and continued participation by governmental, non-governmental, and individual interests at all levels. This formal structure included the following committees:

a. a Federal-Interstate-State-Regional Advisory Committee (FISRAC).

b. the Water Resources Planning Board (WRPB) with members from the Metropolitan Washington Council of Governments (MWCOG) plus other jurisdictional leaders in areas outside of the MWCOG's auspices.

c. a Citizens Task Force (CTF).

d. a Technical Task Force (TTF).

e. the MWCOG's Water Supply Advisory Committee (WSAC).

f. an Interagency Review Panel (IRP) of other governmental agencies.

g. the National Academy of Sciences - National Academy of Engineering (NAS-NAE).

FEDERAL-INTERSTATE-STATE-REGIONAL ADVISORY COMMITTEE (FISRAC)

The FISRAC was formed specifically for the MWA Study to include the MWA's primary decision-makers for water supply matters. The purpose of the FISRAC was to continually review the results of the MWA Study and provide the District Engineer with recommendations for overall guidance and direction of the Study. It was anticipated that the combined expertise of the FISRAC in matters of policy and interpretation of guidelines for water resources planning within the various agencies would keep the MWA Study responsive to most interests.

WATER RESOURCES PLANNING BOARD (WRPB)

The existing committee structure of the WRPB within MWCOG was used to provide the District Engineer with a continuing local assessment of proposed water supply projects, particularly from the viewpoint of existing political, legal, financial, and institutional constraints. These viewpoints would be considered along with those from the FISRAC in evaluating projects for potential implementation.

CITIZENS TASK FORCE (CTF)

The CTF provided a basic link between the Corps of Engineers and the citizens who were concerned about the problems of future water supply in the MWA. This committee integrated the viewpoints of citizens representing diverse idealogical and geographical backgrounds, including some members of the MWCOG's Citizen Advisory Committee as well as those from within, and upstream and downstream of the MWA.

TECHNICAL TASK FORCE (TTF)

The purpose of the TTF was to review and react to water supply management alternatives in terms of technical adequacy, and to make recommendations regarding the engineering aspects of the Study. This committee was comprised of some existing members of the MWCOG's Technical Advisory Committee with broad based interest and technical background in regional water resources matters as well as the Water Supply Advisory Committee discussed below.

WATER SUPPLY ADVISORY COMMITTEE (WSAC)

To encourage the implementation of an eleven-point program of methods on improving the water supply for the MWA, the Board of Directors of MWCOG requested that a steering committee, the WSAC, be set up to oversee the action program. Because the WSAC's sole interest was water supply for the MWA, this committee was one of the primary coordination mechanisms among the MWCOG and the Corps of Engineers during the early part of the study.

## INTERAGENCY REVIEW PANEL (IRP)

The original intent in proposing an IRP was to provide a focal point for study review and comment in view of the many governmental agencies having a responsibility and interest in water resources management in the MWA. As the study progressed, however, such coordination took the form of the normal review procedures which the Corps follows for any traditional study, and the IRP was never formally established. These normal review procedures provided an additional management tool for the District Engineer in directing the course of the MWA Study.

## NATIONAL ACADEMY OF SCIENCES-NATIONAL ACADEMY OF ENGINEERING (NAS-NAE)

This committee was formed as a result of the enabling legislation for the MWA Study. Section 85-b(3) of Public Law 93-251 directed the Secretary of the Army, acting through the Chief of Engineers, to request the NAS-NAE "to review and by written report comment upon the scientific basis of conclusions" reached by the MWA Study within one year after the completion of the Study. Building upon this directive, the District Engineer requested that the NAS-NAE perform periodic reviews of the outputs of the MWA Study and provide comments on the status of various investigations as the Study progressed. These periodic reviews would furnish an impartial and scientific appraisal of the Study progress.

## NEWS STUDY

At the same time the detailed MWA Water Supply Study was getting underway, a much broader water supply study for the entire northeastern United States was just being completed by the Corps of Engineers. This study, titled the Northeastern United States Water Supply (NEWS) Study, identified the MWA as one of three regions along the northeastern Atlantic seaboard facing potentially severe water shortage problems (the other regions were the New York Metropolitan Area and the Eastern Massachusetts-Rhode Island Metropolitan Area). For the MWA, the NEWS Study initially considered a wide range of water supply alternatives as listed in Table B-1.

Many of these alternatives relied on advanced but not thoroughly tested or proven technologies. From this list, the NEWS Study analyzed seven alternatives which were felt to have direct application in the MWA: upstream reservoirs, local impoundments, raw water interconnections, groundwater withdrawal, indirect use of advanced waste treatment effluent, use of the Potomac estuary, and land application of secondary treatment effluent. These seven alternatives were combined in a series of programs aimed at satisfying the MWA regional water needs.

A draft report for the NEWS Study was released in November 1975, and a final report in July 1977. In particular regard to the MWA, the following major conclusions were set forth in the NEWS Study:

a. Water supply deficits of one month duration or longer were unacceptable in the Metropolitan Washington Area.

TABLE B-1

INITIAL PROJECTS CONSIDERED BY NEWS STUDY

Two-Pipe Systems

Self-Contained Recycling

Upstream Reservoirs

Weather Forecasting and/or Modification

Small Storage Tanks or Reservoirs

Local Impoundments

Underground Reservoirs

Desalting

Raw Water Interconnections

Finished Water Interconnections

Collection of Urban Runoff

Montgomery County and Occoquan Quarry Pits

Groundwater Withdrawal

Interbasin Transfers from the Susquehanna and
Rappahannock Basins

Indirect Reuse of AWT Effluents

Seneca Dam

Estuarine Water Supply

Air-Conditioning Recirculation

Industrial Reuse of Water

Land Application of Secondary Treatment Effluent

Pricing

b. Further studies were needed to:

(1) Determine the reliability and acceptability of available groundwater.

(2) Determine the feasibility of supplying fresh water from the Potomac Estuary.

(3) Determine precise impacts of water use restrictions in the MWA.

(4) Refine the methodology of predicting monthly, 7-day, and daily flows and demands with consideration into increasing the number of stream-flow monitoring locations.

c. The efficient use of water is of prime importance in the MWA based on concerns expressed about the control of growth, conservation of resources, and demand restrictions.

d. The MWA's water deficit problem is regional in the sense that many users rely on the Potomac River as a source. It would be almost impossible for local municipalities to implement feasible water supply solutions for the entire MWA as action taken by any user affects other users.

## SCREENING OF NEWS ALTERNATIVES

Recognizing that a significant amount of technical work had already been accomplished through previous efforts studies such as the NEWS Study, the Corps of Engineers structured its early public involvement program to elicit comments on this previous work. The purpose of this public involvement program was to identify potential solutions to the water supply problem that were: (1) technically feasible; (2) socially and politically acceptable to area residents; (3) environmentally sound; (4) economically affordable; and (5) most importantly, implementable either with or without direct Federal involvement. The underlying motivation during this public review process was to screen out alternatives which were totally unacceptable so that study efforts could be concentrated on a few alternatives having widespread support.

A three-pronged approach was used to identify water supply alternatives (NEWS projects as well as others) having good possibilities for implementation which were to be investigated further in the MWA Water Supply Study. These included: public workshops throughout the MWA; review of previous reports, primarily the NEWS Study, by FISRAC; and review of the NEWS Study by NAS-NAE.

## PUBLIC WORKSHOPS

During the late spring of 1977, the Corps of Engineers worked with Interstate Commission on the Potomac River Basin (ICPRB) and the MWCOG to structure a broad-based public participation program for soliciting comments and reactions about projects proposed by NEWS as well as inform the citizens about the upcoming MWA Water Supply Study. A series of public workshops in conjunction with a newsletter and opinion survey were used to accomplish this. (See Appendix C - Public Involvement, for additional details).

Generally, both the public workshops and opinion survey highlighted one major point - that the MWA should attempt to solve its water supply program within its own borders before looking to outside areas for solutions. Water conservation, small local impoundments, and interconnection of existing water supply systems received the most mention as methods for solving the immediate water supply problems. Longer range needs were considered to require other methods of solution, such as indirect use of advanced treatment effluent, upstream reservoirs, land application of secondary effluent, and groundwater.

FISRAC REVIEW OF NEWS

Concurrent with the public involvement program just described, the FISRAC committee members met to review and identify the NEWS components which were most acceptable and deserved detailed attention in the MWA Study.

The results were as follows:

1. The concept of interconnecting the Potomac River with existing off-river reservoirs such as the Patuxent or Occoquan impoundments received favorable support from nearly all members. As proposed, such an alternative had the potential to meet the MWA's water supply needs through the year 2000 by skimming high flows from the Potomac for storage in existing reservoirs with subsequent use during water shortages. Some FISRAC participants also favored studies of additional local impoundments with the potential for high flow skimming.

2. The FISRAC also expressed general support for water conservation as a means to reduce water demand in the near future. An active program of water conservation and demand reduction was recommended to be formulated along with structural projects. The existing conservation programs of WSSC and FCWA were mentioned as examples. Additionally, some participants also recommended that the Corps investigate various drought management techniques for implementation in crisis situations.

3. The State of Maryland, through the Water Resources Administration (WRA) of the Department of Natural Resources, suggested further investigation of upstream reservoirs proposed in the 1969 Chief of Engineers report along with Soil Conservation Service projects. The Maryland WRA also recommended that a study of groundwater use in the Coastal Plan be made, addressing the impacts to existing users of exporting groundwater to the Maryland suburbs of Washington, D.C. It also recommended that the study to determine the availability of groundwater in the Hagerstown Valley be discontinued.

4. The Commonwealth of Virginia, through the State Water Control Board (SWCB), withheld comment on the acceptability of study for any project until completion of the legislative directed Northern Virginia Water Supply Study which was identifying potential alternatives.

5. The District of Columbia, through the Department of Environmental Services, recommended that the Corps continue to study the use of Potomac Estuary water based on the findings of the Potomac Estuary Experimental Water Treatment Plant.

Most FISRAC participants also expressed an interest in detailed institutional studies to propose methods for project implementation. A major shortcoming in past studies had been the failure to recognize the complex legal and institutional environment of the MWA. The FISRAC participants, however, were generally opposed to a single water and wastewater management agency to handle project implementation.

NAS-NAE REVIEW OF NEWS

The Baltimore District Engineer also requested the National Academy of Sciences-National Academy of Engineering (NAS-NAE) to review the NEWS Report. Whereas the objectives of the public involvement program and FISRAC meeting were to identify NEWS alternatives for further investigation, the purpose of the NAS-NAE review was to comment on the adequacy of the NEWS Study investigations which had already been performed. These comments were solicited to help outline the study work plan described in the next section.

The NAS-NAE comments about the NEWS Study revolved around three primary topics: (1) the inadequacy of population and demand forecasting and the evaluation of deficits; (2) the public health significance of continuing to withdraw water from the Potomac River; and (3) the institutional arrangements necessary to permit optimizing the use of water resources in the region.

## PLAN OF STUDY

Given the findings of the NEWS Study, the comments by the various review committees, the reactions at public workshops and public meetings, and opinion expressed in much correspondence, the Corps of Engineers developed a Plan of Study which was formally released in March 1978. The general purposes of the Plan of Study were to identify study objectives, to describe work tasks to be accomplished during the remainder of the study, and to establish a sequence diagram for performing these tasks.

The Plan of Study attempted to devise a work program that was responsive to both the general public's desire for immediate solutions to impending water supply problems as well as the Congress' desire (expressed through the study's authorizing legislation - Section 85(b)(1) of P.L. 93-251) for a comprehensive investigation of long-range improvements. To satisfy these desires, the Corps proposed a two phase study program to first develop early-action plans to satisfy immediate water needs, and then to concentrate on long-range plans to meet future water supply needs. The two phases are further defined and described in the following sections.

An important observation should be made at this point. At the time the Plan of Study was being prepared, it was impossible to foresee all of the events and decisions regarding water supply planning in the next seven years. Hence, the Plan of Study was necessarily general in its approach to work tasks. Nevertheless, certain adjustments and modifications of the study effort were required to respond to these changed conditions during the course of the study. These changes in study direction are discussed at the appropriate time throughout the remainder of this appendix. Plate C-1 in Appendix C provides a chronological diagram of study activities as they were actually accomplished.

EARLY-ACTION PHASE

As originally envisioned, the early-action phase was to develop plans to satisfy water supply needs up to the year 2000 by making maximum use of existing or readily implementable water supply projects or programs. The results of the public involvement activities undertaken in developing the Plan of Study helped to define the direction of the early-action phase. 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.

Because of the length of the overall study (seven years), the Plan of Study further proposed that an interim or progress report be published at the completion of the early-action phase. Immediate actions could then proceed, if necessary, on high priority water supply plans while studies on long-range solutions were continuing.

LONG-RANGE PHASE

The study's long-range phase was to consider the MWA's water supply needs and capabilities between the years 2000 and 2030. The full spectrum of water supply possibilities was to be investigated, including the feasibility of using the Potomac estuary as a permanent supplemental source. (This separate companion study was authorized by Section 85(b)(2) of P.L. 93-251, and involved the design, construction and testing of a Potomac Estuary Experimental Water Treatment Plant (EEWTP) with a one mgd capacity.) A general goal of the long-range phase was to advance the level of technical knowledge of such water supply alternatives as estuary use, wastewater use, and groundwater use from deep Coastal Plain aquifers that might conceivably be applied within the MWA sometime in the future.

Due to the length of time required to examine some of the long-range alternatives, certain efforts were initiated simultaneously with the early-action phase and continued to overall study completion. Completion of the long-range phase was geared to the completion of the associated EEWTP testing program, scheduled for early 1983. Upon completion of the long-range phase, a comprehensive report documenting the entire study effort was to be prepared and appropriate recommendations made.

## EARLY-ACTION PHASE

### OVERVIEW

Water supply shortages had been forecast for the MWA in many different water supply planning documents through the years. In the early 1970's, the Northeastern Water Supply (NEWS) Study concluded that the MWA, as well as other large metropolitan centers in the northeast, was approaching a critical period for water supply. At the local level, a growing awareness of the potential for future shortages was also evident. Realizing the limitations of their systems, many of MWA's water purveyors were either completing or were involved with water resource studies aimed at identifying alternatives for meeting future water needs. However, there was no comprehensive study which addressed the water supply needs from a regional perspective. Hence, the Corps attempted to use as much of this existing information as possible to formulate a regional approach to the water supply problem.

The original intent of the early-action phase, as stated earlier, was to develop plans to satisfy water supply needs to the year 2000. As the study progressed through the early-action phase, though, several significant findings dictated that the direction of the early-action phase be somewhat modified.

Most importantly, the investigations revealed that population estimates reflecting slower growth rates, combined with revised water use estimates for different user categories, produced lower overall water needs. Furthermore, the alternatives identified for examination in the early-action phase had the potential to satisfy water needs well beyond the year 2000 if properly managed from a regional viewpoint. Lastly, it was determined that the MWA demand area could be subdivided into two distinct zones for planning purposes. One zone included the service areas either served or partially served by the Potomac River; i.e., the WSSC, FCWA, Aqueduct, and Rockville service areas. Together, these four areas accounted for over 95 percent of the entire MWA's water supply needs in 1976 and were expected to demonstrate similar characteristics in the future. The second zone was the area within the MWA, but outside the "urban" core, consisting of Charles County, Fairfax City, and large portions of Prince William County and Loudoun County. These outlying areas were not anticipated to generate large water demands in comparison to the urban core. Further, they were not expected to place any significant demands on the Potomac River and were not bound by the terms of the Potomac Low Flow Allocation Agreement.

In view of these findings, the early-action phase was redirected to formulate plans for only the Potomac River water service areas - the areas exhibiting the largest potentially unsatisfied water demands. Additionally, the components identified through the initial public involvement program for thorough examination in the early-action phase were structured to carry the Potomac River service areas throughout the planning period to the year 2030, if possible. The remainder of this section on the early-action phase therefore addresses the Potomac River service areas through the year 2030. Later sections in this appendix discuss the long-range planning activities involving other possible water supply measures for the MWA. The outlying communities are addressed separately in Appendix I.

## PROBLEM DEFINITION

### WATER DEMANDS

The Corps of Engineers devoted a significant amount of effort to forecasting water needs in future years for each service area by considering population, employment, and housing trends. 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 and aggregated for each benchmark year, and modified to reflect monthly patterns of water use. Within each month, the demands were further modified to estimate the maximum 7-day average and 1-day peak demand. Details of the procedure used to forecast future water needs within each service area are contained in Appendix D - Supplies, Demands, and Deficits. Table B-2 contains a list of the 30, 7, and 1-day demand data for the Aqueduct, Rockville, WSSC, and FCWA for each 10-year period through 2030. For reasons explained shortly, the demand data presented in Table B-2 are for the month of August.

SUPPLIES

Projected water supply availability in the MWA's Potomac service areas is affected to a large degree by the variable flows in the Potomac River. To determine water supply availability as it related to Potomac River flow, a range of low flow frequencies (or recurrence intervals) and durations was examined to help define potential deficits. A recurrence interval was defined as the average interval in years between the occurrence of a flow, in this case a low flow, of a specified magnitude and an equal or more severe low flow. For the early-action phase, U.S. Geological Survey frequency curves were used to account for low flow frequency. Flow duration referred to the average length of time a given low flow would persist. Each flow duration was also associated with a particular recurrence interval. Table B-3 contains a list of the 30, 7, and 1-day low flow data for the Potomac River during the month of August, for four recurrence intervals (once in 100 years, once in 50 years, once in 20 years, and once in 10 years).

SHORTAGES

Based on work performed by the NEWS Study and confirmed during 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 the four recurrence intervals and three durations. Maximum capacities for 1, 7, and 30-day durations were computed for both the Occoquan and Patuxent Reservoir water treatment plants by using 100, 85, and 75 percent, respectively, of the plants' design capacities. For the Occoquan water treatment plant, the corresponding treatment rates were 112, 95, and 84 mgd; for the Patuxent water treatment plant, the appropriate treatment rates were 65, 55, and 49 mgd, respectively, for the 1, 7, and 30-day durations. Other important planning assumptions included a continuous release of 135 mgd from Bloomington Lake throughout August, an environmental flowby to the Potomac estuary of 100 mgd, and enforcement of the then current plumbing codes aimed at water use reduction. Given these data and assumptions regarding water demand and supply, Table B-4 provides a summary of the expected regional surpluses and shortages for the Potomac River users according to 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 one hundred year recurrence shortage could be expected to surface as early as 1982 for a 1-day duration and as late as 2005 for a 30-day duration (see Figure B-6). Similarly, shortages could begin as early as 1986 and reach 279 mgd by the year 2030 for the 7-day, once in one hundred year probability, whereas for the once in ten frequncy 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 B-7).

TABLE B-2

REGIONAL AND WATER SERVICE AREA BASELINE DEMANDS
(AUGUST)

| BENCHMARK YEAR | WATER SERVICE AREA | AUGUST BASELINE DEMANDS (MGD) | | |
| --- | --- | --- | --- | --- |
| | | 1-Day | 7-Day | 30-Day |
| 1980 | WAD | 253 | 237 | 226 |
| | WSSC | 191 | 178 | 162 |
| | FCWA | 96 | 90 | 80 |
| | Rockville | 6 | 5 | 5 |
| | Regional Total | 546 | 510 | 473 |
| 1990 | WAD | 284 | 265 | 253 |
| | WSSC | 248 | 231 | 210 |
| | FCWA | 122 | 113 | 101 |
| | Rockville | 7 | 7 | 6 |
| | Regional Total | 661 | 616 | 570 |
| 2000 | WAD | 300 | 280 | 267 |
| | WSSC | 286 | 267 | 243 |
| | FCWA | 142 | 132 | 118 |
| | Rockville | 7 | 7 | 6 |
| | Regional Total | 735 | 686 | 634 |
| 2010 | WAD | 307 | 287 | 274 |
| | WSSC | 324 | 301 | 274 |
| | FCWA | 161 | 150 | 134 |
| | Rockville | 7 | 7 | 6 |
| | Regional Total | 799 | 745 | 688 |
| 2020 | WAD | 316 | 295 | 282 |
| | WSSC | 358 | 333 | 303 |
| | FCWA | 186 | 174 | 155 |
| | Rockville | 8 | 7 | 6 |
| | Regional Total | 868 | 809 | 746 |
| 2030 | WAD | 324 | 303 | 289 |
| | WSSC | 386 | 360 | 327 |
| | FCWA | 209 | 195 | 174 |
| | Rockville | 8 | 7 | 6 |
| | Regional Total | 927 | 865 | 796 |

TABLE B-3

POTOMAC RIVER FLOWS (MGD)
DURATION AND FREQUENCY DATA FOR AUGUST*

| Frequency of Event | Duration | | |
| --- | --- | --- | --- |
| | 30-Day | 7-Day | 1-Day |
| Once in 100 years | 493 | 401 | 369 |
| Once in 50 years | 552 | 454 | 419 |
| Once in 20 years | 654 | 546 | 505 |
| Once in 10 years | 762 | 642 | 593 |

*Source: United States Geological Survey, Low Flow Frequency Curves for Potomac River Flow Frequency Curves for Potomac River (adjusted) near Washington, D.C., Annual Series for the period 1931-1978.

The regional surpluses and shortages cited in Table B-4 for the Potomac users were further disaggregated to the four service areas. This disaggregation was accomplished by applying the terms of the Potomac Low Flow Allocation Agreement (PLFAA) which was signed in January 1978. The PLFAA contains a formula which allocates a share of Potomac River flow to each user based on previously established water needs. Although the PLFAA does not furnish additional water, it does assure that the existing water resource is equitably distributed during low flow periods.

Table B-5 provides a service area tabulation of the projected surpluses and shortages through the year 2030 for WSSC, WAD, FCWA, and Rockville, allocated according to the terms of the PLFAA. Appendix D - Supplies, Demands, and Deficits contains detailed information on the application of the PLFAA to the projected supply and demand data. For reasons discussed later in the section, the "without condition" for the purpose of sizing new facilities was defined to be the shortage which would occur when flow in the Potomac River dropped to the predicted minimum 7 day average level having a once in 100-year change of occurrences (Q-7-100). The surpluses and shortages listed in Table B-5 assume this "without condition."

## DROUGHT SIMULATION

As an additional source of information on the nature of the MWA's water supply problem, a drought simulation exercise was conducted. The purpose of the simulation was to trace the effects of a prolonged drought on the MWA's existing water supply system, using a recorded low flow event coupled with projected demands.

Table B-6 lists the assumptions which were used in the drought simulation, and Figure B-8 displays the resulting effects of the drought on Potomac River flows, remaining Occoquan storage, and remaining Patuxent storage. As shown, the flow in the Potomac River would remain at or near 100 mgd throughout the summer of 1930. At the same time, however, storage would be available in the Patuxent and Occoquan Reservoirs. Nevertheless, because of the geographical disparity of supply, demand, and treatment

TABLE B-4

SURPLUSES AND SHORTAGES FOR THE POTOMAC DEPENDENT USERS*

YEAR AND DURATION WITH SURPLUSES AND SHORTAGES (MGD)

| FREQUENCY OF EVENT | | 1980 | | | 1990 | | | 2000 | | | 2010 | | | 2020 | | | 2030 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 7 | 1 | 30 | 7 | 1 | 30 | 7 | 1 | 30 | 7 | 1 | 30 | 7 | 1 | 30 | 7 | 1 |
| 1/100 | 188 | 76 | 35 | 91 | -30 | -80 | 27 | -100 | -154 | -27 | -159 | -218 | -85 | -223 | -287 | -135 | -279 | -346 |
| 1/50 | 247 | 129 | 85 | 150 | 23 | -30 | 86 | -47 | -104 | 32 | -106 | -168 | -26 | -170 | -237 | -76 | -226 | -296 |
| 1/20 | 349 | 221 | 171 | 252 | 115 | 56 | 188 | 45 | -18 | 134 | -14 | -82 | 76 | -78 | -151 | 26 | -134 | -210 |
| 1/10 | 457 | 317 | 259 | 360 | 211 | 144 | 296 | 141 | 70 | 242 | 82 | 6 | 184 | 18 | -63 | 134 | -38 | -122 |

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

SHORTAGES FOR ONCE IN ONE HUNDRED YEAR RECURRENCE EVENT

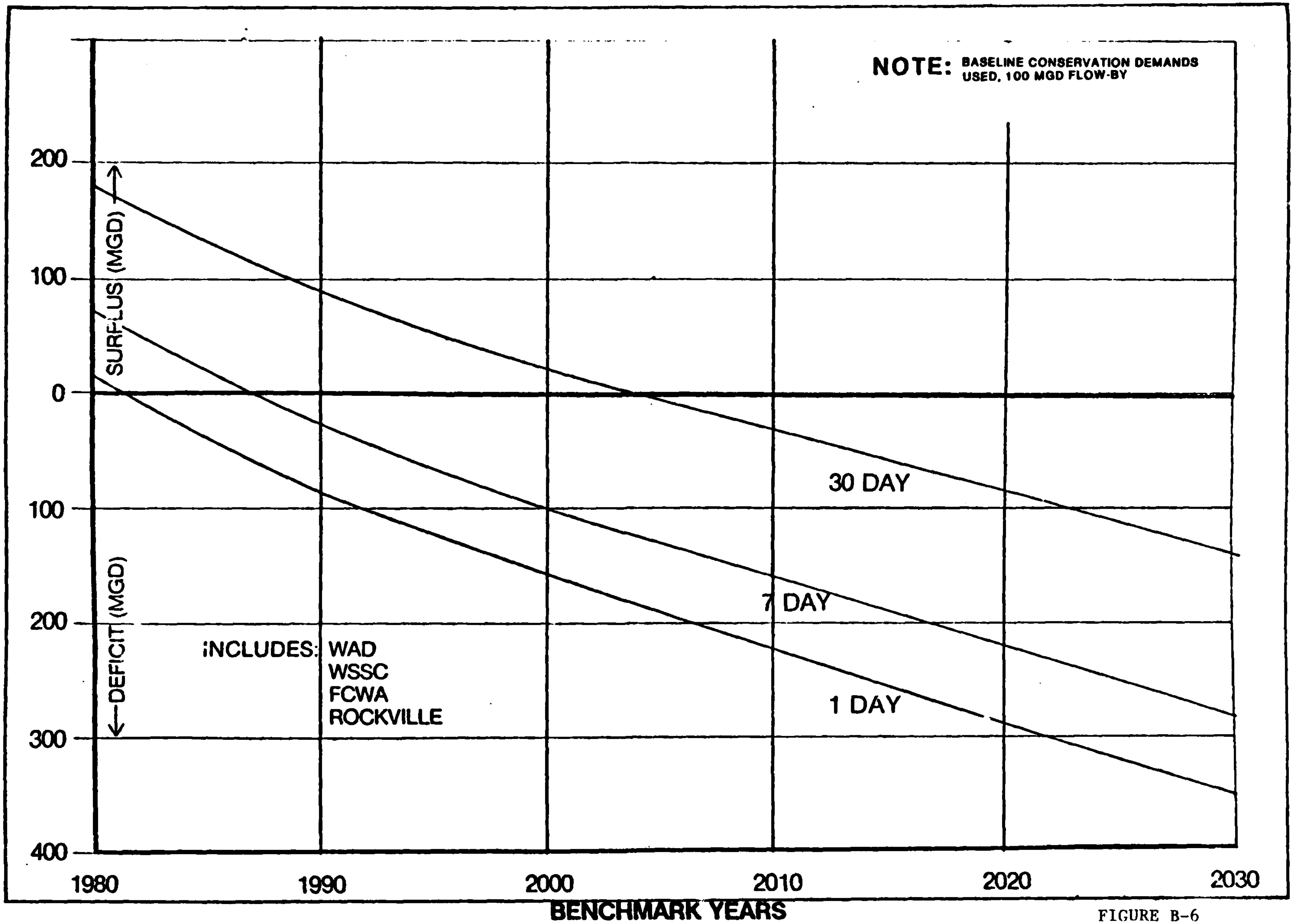



FIGURE B-6

FIGURE B-7

## FREQUENCY SENSITIVITY: POTOMAC RIVER DEPENDENT SERVICE AREA SHORTAGES FOR 7-DAY DURATION *

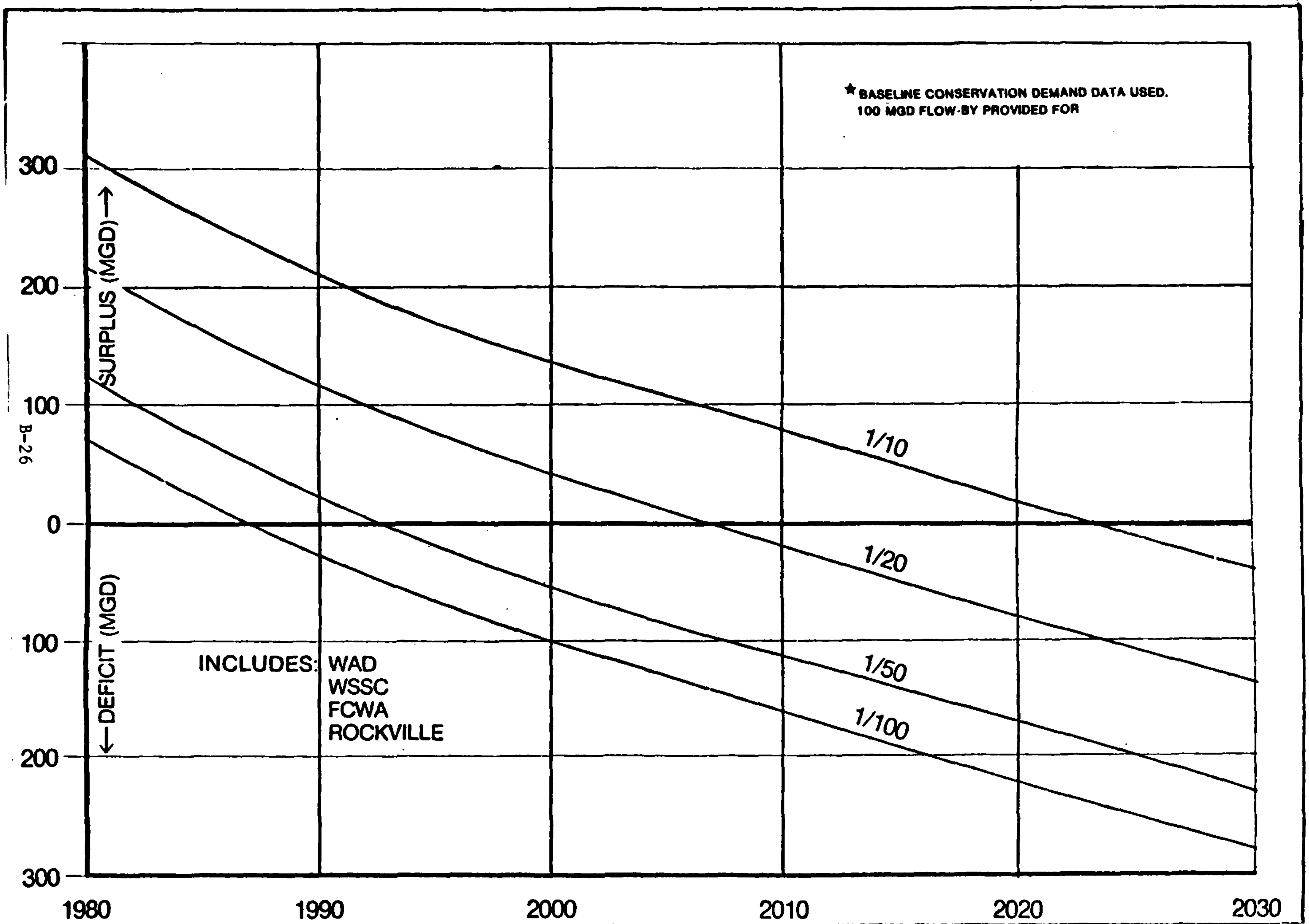


TABLE B-5

EARLY-ACTION PHASE WITHOUT CONDITION
SERVICE AREA SURPLUSES & SHORTAGES* (MGD)

| SERVICE AREA | 1980 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| WSSC | +26 | -17 | -44 | -69 | -95 | -119 |
| FCWA | +5 | -10 | -24 | -38 | -55 | -70 |
| WAD | +44 | -3 | -31 | -51 | -71 | -88 |
| ROCKVILLE | +1 | 0 | -1 | -1 | -2 | -2 |
| REGIONAL TOTAL | +76 | -30 | -100 | -159 | -223 | -279 |

*Surplus and shortages for individual service areas are based on application of the Potomac Low Flow Allocation Agreement, without the freeze provision. Calculations assumed August Baseline demands, 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.

plants, shortages would be experienced by the Potomac users in August of 1930. Later in the simulation period (February and December, 1931), when the Occoquan and Patuxent storage is depleted, respectively, off-Potomac service areas would experience shortages despite available Potomac River water.

The non-concurrent shortages in different zones of the service areas emphasized the complex nature of the MWA's water supply problem. Specifically, any plan to satisfy projected shortages must consider the dual problem of low Potomac River flows and low reservoir levels which probably would not occur simultaneously.

## COMPONENT DEVELOPMENT

Using the results of the NEWS Study, the opinions expressed at the public workshops, and the general consensus of the various study committees, five components were identified for detailed investigation 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. Local storage could potentially provide additional supplies in the future. Water use reduction through conservation could promote more efficient use of available water and decrease its unnecessary use.

## TABLE B-6

## ASSUMPTIONS FOR DROUGHT SIMULATION OF THE WITHOUT CONDITION EARLY-ACTION PHASE

Supply: 1930-1932 monthly average flows for Potomac, Patuxent, and Occoquan streams.

Demand: Year 2030 baseline monthly average demands for WAD, FCWA, WSSC, and Rockville with no conservation programs enacted other than existing legislation.

Potomac River:

a. USGS (adjusted) Washington, D.C. gaging station data (1930-1932).
b. 100 mgd flow (as per the NEWS Study) to the estuary is maintained.
c. Bloomington Releases based on a 30-day analysis: 60 mgd in July; 135 mgd in August, September, and October; 75 mgd in November (as per NEWS Study).

Local Reservoirs:

a. Both Patuxent and Occoquan reservoirs are full at beginning of drought in April 1930.
  1. Occoquan at 10.2 billion gallons (BG)
  2. Patuxent at 10.1 billion gallons

b. Evaporation losses and downstream releases from reservoirs vary with time of year, inflow, and surface area of lake.
c. Reservoirs operated condinuously at their rated safe yield.
  1. Occoquan at 69 mgd.
  2. Patuxent at 32 mgd.

Operation:

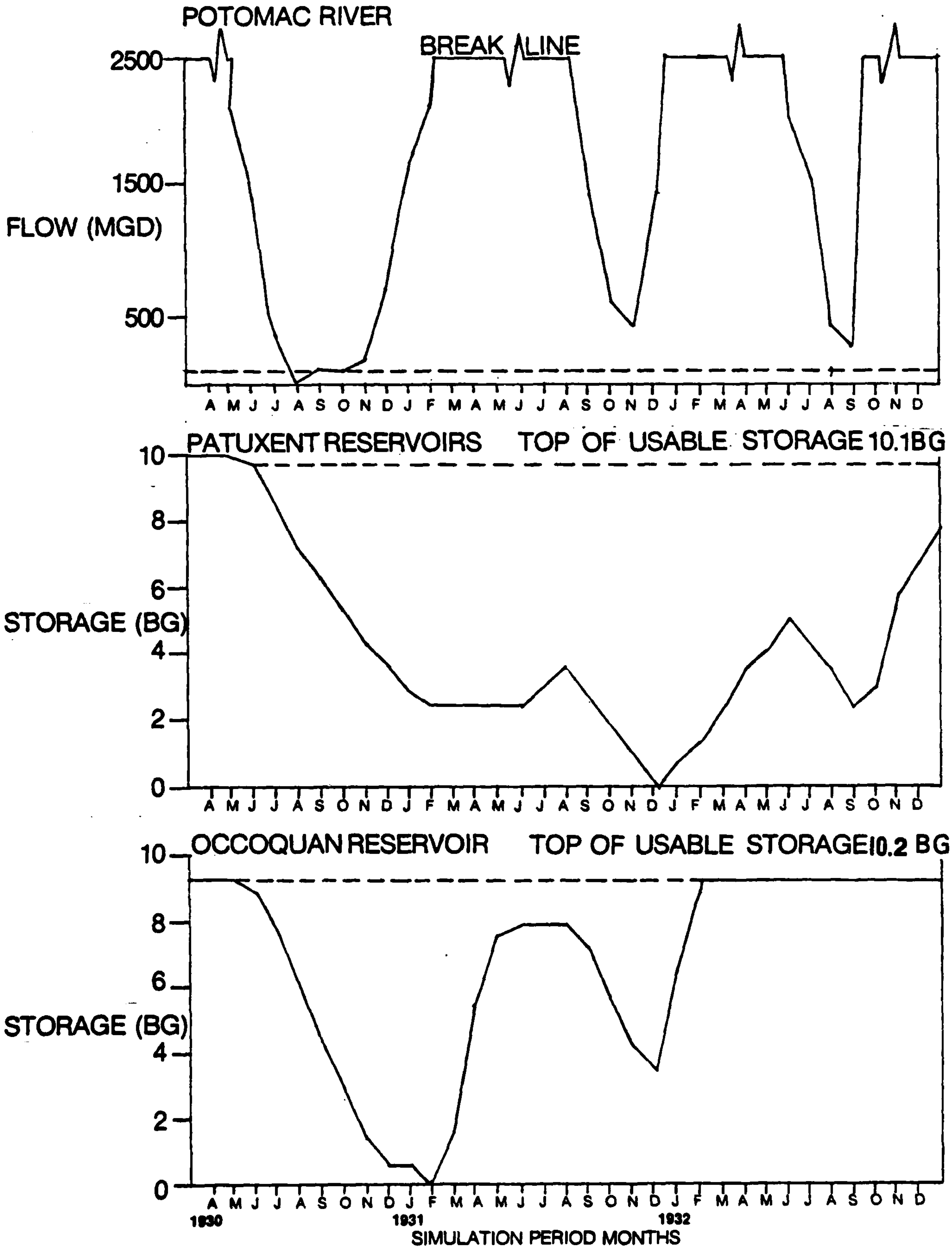
a. Potomac Demand
  1. WSSC's Potomac demand is total WSSC minus 32 mgd.
  2. FCWA's Potomac demand is total FCWA minus 69 mgd.
  3. WAD and Rockville place their total demand on Potomac.
  4. Total Potomac demand is sum of 1, 2, and 3.

b. Flow remaining in the Potomac is Potomac supply minus Potomac demand.
c. Withdrawal rates from reservoirs are converted to storage and subtracted from previous month to yield new end-of-month storage.

FIGURE B-8

# SIMULATION OF THE WITHOUT CONDITION

(EARLY-ACTION PHASE)



The detailed information required to analyze these components was developed through both outside contracts and in-house efforts. The initial efforts were characterized by base data generation, development of preliminary costs, and preliminary impact assessment for each of the components. Detailed data about the components are contained in the other report appendices). Subsequent iterations formulated various combinations of components to satisfy the project water shortages; this formulation exercise is the subject of a later section.

## RAW WATER INTERCONNECTIONS

### General Description

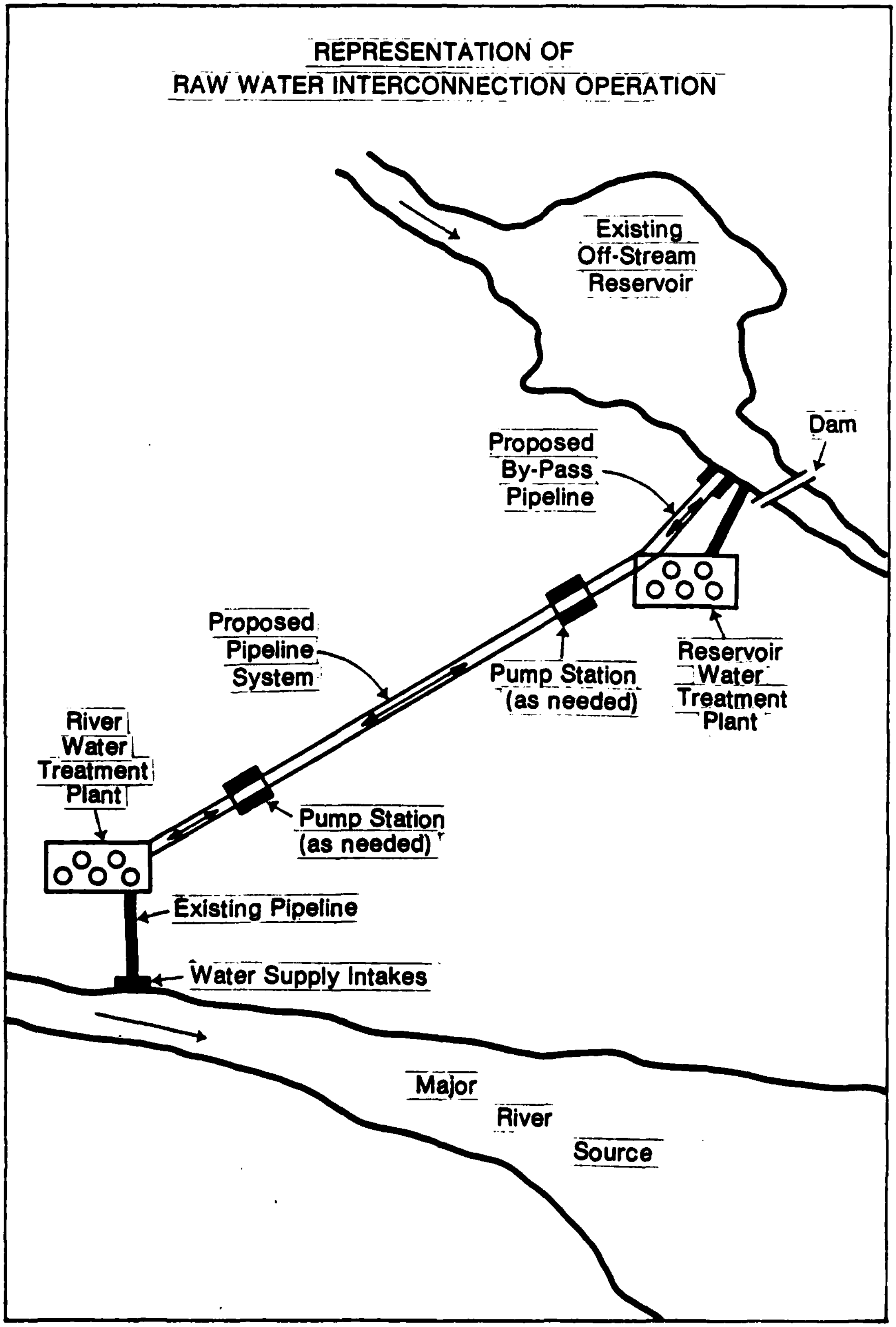
A raw water (untreated water) interconnection system is shown in schematic form in Figure B-9. There are three basic features necessary for a raw water interconnection system: a river or stream source of water supply; an off-stream reservoir; and a pipeline and pump connecting the two. The primary purpose of a raw water interconnection is to transfer water to storage or treatment facilities during periods of high stream flow so that stored water could be used more effectively during low flow periods. This type of operation provides a potential mechanism with which to better utilize the existing water resource. 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 could be used to supplement the river source when natural flows are low, or piped directly to a water treatment plant for treatment and distribution. This augmentation would be achieved by pumping water from the reservoir through the pipeline to the river or to the treatment plant.

### Route Identification

The concept of raw water interconnections was not new to the MWA. Several previous reports had investigated raw water interconnections for different service areas. Using these previous reports plus additional new information, the Corps of Engineers identified feasible connection points for raw water transfers. Streams of major concern included the Potomac River and the Shenandoah River. Existing reservoirs of major concern included the Triadelphia and Rocky Gorge Reservoirs on the Patuxent River, the Occoquan Reservoir on the Occoquan Creek, and the Beaverdam Reservoir on Beaverdam Creek, a tributary of Goose Creek.

Having identified the connection points for the raw water transfers, the next effort was to lay out alternative pipeline routes between the connection points. In some instances, alternative routes which had already been identified in other reports were used. In other instances, alternative pipeline routes were identified using environmental and engineering judgement. Topographic maps and aerial photography of the MWA were used as well as field reconnaissance investigations were used as tools to aid in this effort. Attempts were made in laying out a number of pipeline routes to look at a range of possible alternative alignments. For some routes, there was an effort to minimize pipeline length and elevation change as a means of achieving low cost. For other routes, there was an attempt to avoid as many communities as possible and to avoid social disruption during construction. Other routes were designed to following existing transportation and utility rights-of-way as a means of minimizing social and ecological impacts.

FIGURE B-9



REPRESENTATION OF
RAW WATER INTERCONNECTION OPERATION
Existing
Off-Stream
Reservoir
Dam
Proposed
By-Pass
Pipeline
Proposed
Pipeline
System
Pump Station
(as needed)
Reservoir
Water
Treatment
Plant
River
Water
Treatment
Plant
Pump Station
(as needed)
Existing Pipeline
Water Supply Intakes
Major
River
Source

The initial interconnection routes are tabulated in Table B-7 showing source stream, direction of flow in pipe, reservoir and route designation. Figure B-10 schematically shows the interconnection route alignments and reservoirs. A detailed description of the alignment of these routes can be found in Appendix E - Raw and Finished Water Interconnections and Reregulation. Interconnection of reservoirs to other reservoirs (such as Patuxent Reservoirs to Occoquan Reservoir, Occoquan Reservoir to Goose Creek Reservoir, Patuxent Reservoirs to Little Seneca Lake, etc.) were not investigated because transfer of stored water from one impoundment to another would not increase the total stored water available to the region. On the other hand, large surplus flows on the Potomac during certain times of the year made it a prime element for investigation for raw water transfers.

## Data Development

After the connection points and alternative pipeline routes were identified, the next step was to analyze which raw water interconnections would provide, in the absence of other components being studied, the "best" solutions to the water shortage problems. The qualifying criteria used to identify preferred interconnections were that they prove feasible from technical, economic, and environmental standpoints.

### Optimization Analysis

A linear program was developed under contract by GKY and Associates, Inc. The purpose of the linear program was to determine the optimum combination of raw water interconnections which, when tested against the critical supply period (July through December 1930) could meet the average monthly demands at minimum capital cost. A similar analysis was conducted for 7-day duration drought. Output from this analysis indicated which interconnections were needed and what size of pipe would be required to transfer water to meet the projected needs if no other water supply augmentation other than Bloomington Lake were implemented in the near future.

Salient findings of GKY's optimization analysis were the following: (1) raw water interconnections were feasible and could provide a mechanism to move water to service areas which experience shortages. With raw water interconnections in place and properly sized, sufficient water could be transferred and/or stored to meet projected demands until well beyond the year 2000, on both a 30-day and a 7-day basis; (2) pipelines to either the Patuxent system or the Occoquan system were feasible; (3) either a Potomac to Occoquan, Potomac to Cub Run, or Shenandoah to Broad Run pipeline would be feasible for interconnecting the Occoquan Reservoir; and (4) increasing the volume of flowby (volume of flow allowed to pass the last intake and enter the Potomac estuary) directly affects the size and timing of required raw water interconnections.

### Impact Assessment

An in-house assessment of impacts associated with the raw water interconnection routes was acccomplished concurrently with the optimization analysis. Using the available pipeline routes, this work effort was geared to achieve two broad aims. The first was to provide a comprehensive basis for identifying the significant impacts of the proposed projects. The second was to reduce, in conjunction with the results of the optimization analysis, the number of routes for consideration in the formulation of early-action plans.

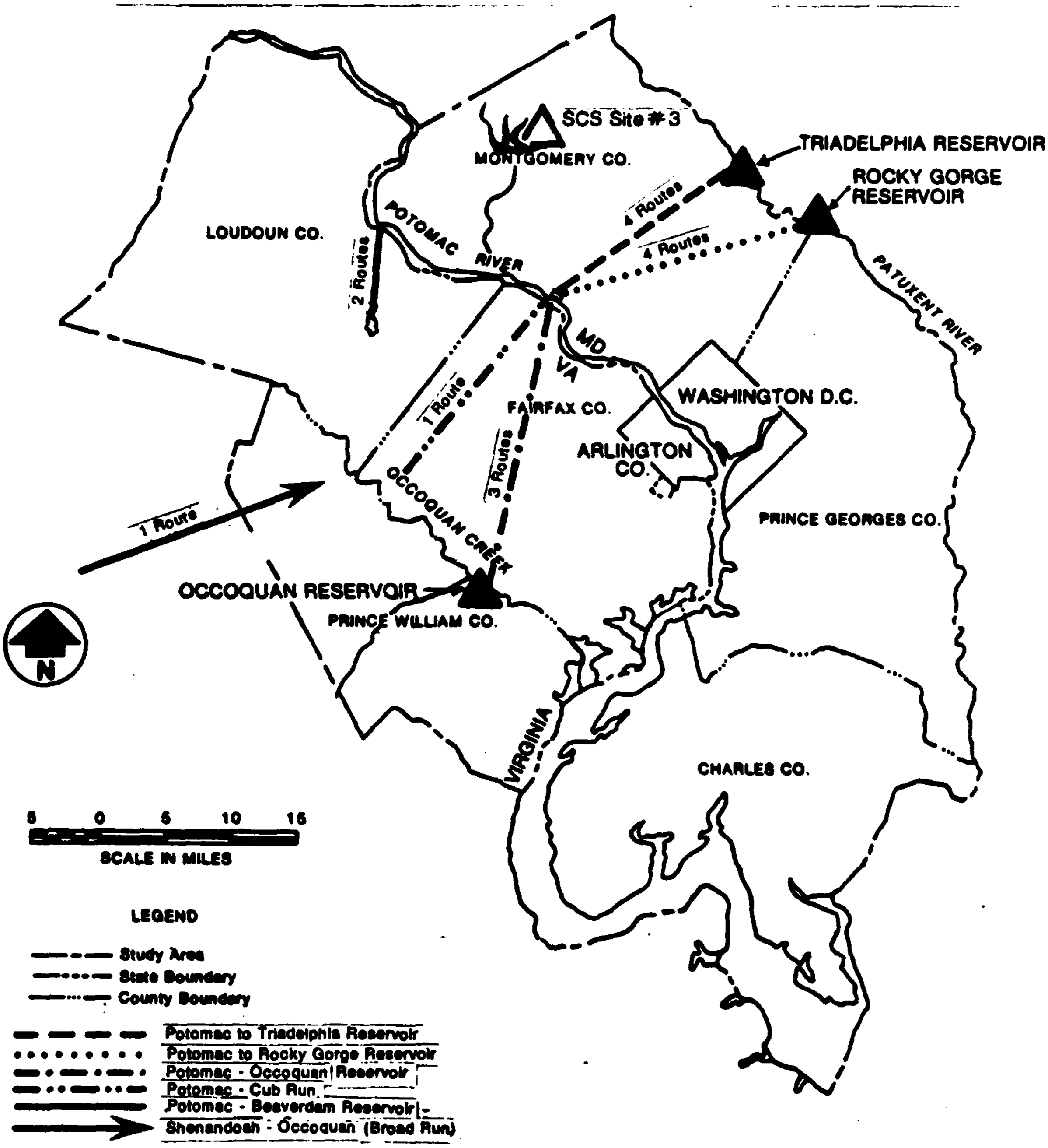
TABLE B-7

INITIAL RAW WATER INTERCONNECTION ROUTES*

| Source Stream | Direction of Flow | Route Reservoir | Number |
|---|---|---|---|
| Potomac | ←----→ | Triadelphia | P-T #1 |
| " | " | " | P-T #2 |
| " | " | " | P-T #3 |
| " | " | " | P-T #4 |
| Potomac | ←----→ | Rocky Gorge | P-R #1 |
| " | " | " | P-R #2 |
| " | " | " | P-R #3 |
| " | " | " | P-R #4 |
| Potomac | ←----→ | Occoquan | P-O #1 |
| " | " | " | P-O #2 |
| " | " | " | P-O #3 |
| Potomac | ------→ | Beaverdam | P-B #1 |
| " | " | " | P-B #2 |
| Potomac | ------→ | Cub Run | P-C #1 |
| Shenandoah | ------→ | Occoquan | S-O #1 |

*--------- Reversible Route
---------- One-Way Route
See Figure B-10 for general schematic

# SCHEMATIC REPRESENTATION OF PROPOSED RAW WATER INTERCONNECTION ROUTES IN THE MWA



An interdisciplinary team, representing diverse areas of specialization, relied on four major sources of information for the impact analysis: existing reports and publications; photo-revised USGS 1:24,000 topographic quads; 1977 aerial photographic coverage of the study area; and field reconnaissance. "Impacts corridors" were identified for each pipeline and preliminary economic, social, and environmental impacts were quantified where possible and tabulated into impact assessment matrices.

Screening of Routes

Preliminary Screening

Two sets of pipelines between the Potomac River and the Patuxent System were identified at the onset; one set from the Potomac River to the Triadelphia Reservoir and one set from the Potomac River to the Rocky Gorge Reservoir. Both sets were compared to determine if one provided significant advantages over the other in the transfer of raw water between the Potomac and Patuxent Basins and vice versa. The comparison of the two configurations indicated that the Rocky Gorge interconnection had decided advantages over the Triadelphia interconnection for the following reasons:

1. With proper operation, a Rocky Gorge interconnection system could make use of the available storage in both the Rocky Gorge and Triadelphia Reservoirs which reduced the risk of shortage in the event of a drought. An interconnection to the Triadelphia Reservoir could only utilize the storage from the one reservoir.

2. The proximity of treatment facilities to either end of the Rocky Gorge pipeline proivded for a more effective and rapid response time for raw water delivery from its source to treatment. Thus, water could be more readily made available for distribution to the users. Potomac water could also be transferred directly to the Patuxent treatment plant without the need for putting the transferred water into the reservoir. When operating in this mode, withdrawals from the reservoir could be decreased.

3. The Bi-County Water Supply Task Force, comprised of representatives from the Washington Suburban Sanitary Commission (WSSC) and Prince Georges and Montgomery Counties, Maryland had recently contracted for an alignment study of the proposed cross county pipeline between the Potomac River and Rocky Gorge Reservoir and the Potomac and Patuxent Treatment facilities. This action was based on results of a 2-year study which found the reversible pipeline to be a favorable project.

On the basis of these points, the Potomac-Rocky Gorge interconnection was retained for futher investigation and the Potomac-Triadelphia interconnection was not studied further.

Using a process of data tabulation, ranking, and evaluation, each of the remaining configuration groupings was analyzed according to the degree of preferability within impact categories. Table B-8 expresses the preferability of routes among the major impact categories. Since only one route alignment was considered for the Shenandoah-Occoquan and Potomac-Cub Run interconnections, they were not included in this table.

The results of this impact ranking process were evaluated in conjunction with the technical results from the optimization analysis. Eight out of the original configurations were retained for further consideration. They were as follows:

TABLE B-8

TRADE-OFF ANALYSIS FOR RAW WATER INTERCONNECTIONS
(WITHIN GROUPINGS)

| | Criteria/ Ranking | ROUTES PREFERRED Most Preferred | Next Preferred | Next Preferred | Least Preferred |
|---|---|---|---|---|---|
| Potomac to Rocky Gorge Reservoir | Capital Costs | PR-1 | PR-2 | PR-3 | PR-4 |
| | Real Estate Costs | PR-2 | PR-4 | PR-3 | PR-1 |
| | Effects on: | | | | |
| | Environmental Quality | PR-3 | PR-1,2 | PR-4 | |
| | Land Use | PR-2 | PR-3 | PR-4 | PR-1 |
| | Transportation | PR-4 | PR-2 | PR-3 | PR-1 |
| | Cultural Resources | PR-1 | PR-2 | PR-4 | PR-3 |
| | Ease of Implementation | PR-1 | PR-2 | PR-3,4 | |
| Potomac to Occoquan Reservoir | Capital Costs | PO-1 | PO-2 | | PO-3 |
| | Real Estate Costs | PO-3 | PO-1 | | PO-2 |
| | Effects on: | | | | |
| | Environmental Quality | PO-2 | PO-1 | | PO-3 |
| | Land Use | PO-1 | PO-3 | | PO-2 |
| | Transportation | PO-3 | PO-1 | | PO-2 |
| | Cultural Resources | PO-2,3 | PO-1 | | |
| | Ease of Implementation | PO-2 | PO-1 | | PO-3 |
| Potomac to Beaverdam Reservoir | Capital Costs | PB-1 | | | PB-2 |
| | Real Estate Costs | PB-1 | | | PB-2 |
| | Effects on: | | | | |
| | Environmental Quality | PB-2 | | | PB-1 |
| | Land Use | PB-2 | | | PB-1 |
| | Transportation | PB-2 | | | PB-1 |
| | Cultural Resources | PB-2 | | | PB-1 |
| | Ease of Implementation | PB-2 | | | PB-1 |

| | |
|---|---|
| Patuxent Basin Interconnections | |
| Potomac-Rocky Gorge Reservoir | P-T #1, 2 |
| Occoquan Basin Interconnections | |
| Potomac-Occoquan Reservoir | P-O #1, 2 |
| Potomac-Cub Run | P-C #1 |
| Shenandoah-Broad Run (Occoquan) | S-O #1 |
| Potomac Beaverdam Reservoir | P-B #2 |

Through numerous field visits, more detailed data regarding the potential impacts associated with these remaining routes were developed. On the basis of the information gathered, some minor realignment of the configurations was undertaken. This was done to mitigate, where feasible, the significant impacts that might be experienced during pipeline construction and reduce the potential for irretrievable impacts.

Two routes between the Potomac River and Beaverdam Reservoir in northwestern Fairfax County were also considered. Of the two, PB-1 was considered to be unacceptable because it followed Goose Creek which had been classified as a Scenic River by the Commonwealth of Virginia. This route would also violate the intent of Executive Order 11988 which limits adverse development on 100-year floodplains. PB-2 was considered further as it largely followed the rights-of-way of the Virginia Electric Power Company (VEPCO) transmission facilities, thus minimizing environmental and social disruption.

Final Screening

The results of the preliminary screening process were then taken one step further to select, where possible at this stage of the analysis, revised pipeline configurations for consideration in plan formulation. The results of this additional screening are described in the following paragraphs. The impact assessment information in Table B-9 provided, in part, a means by which to evaluate the route further.

On the Virginia side of the Potomac, three sets of interconnections were available for satisfying FCWA shortages: Potomac-Occoquan #1 and #3; Shenandoah-Occoquan #1, and Potomac-Cub Run #2. Because the Potomac-Occoquan #3 would avoid the densely populated areas of Fairfax County and could use or parallel utility rights-of-way for large portions of the route (and thus minimize environmental and social impacts) it would be preferred over the Potomac-Occoquan #1. Further evaluations were needed to assess the trade-offs between the Potomac-Occoquan, Shenandoah-Broad Run, and Potomac-Cub Run interconnections. More work was accomplished during plan formulation to determine the relative advantages and disadvantages of each route to the Occoquan Basin.

Having eliminated the Potomac-Triadelphia routes from further consideration, a decision was needed as to the choice for a Potomac-Rocky Gorge interconnection route. Data generated as a result of the impact assessment indicated that there was no large difference in the overall impacts for any of these pipelines. Although institutional problems might arise in the future should the Potomac-Rocky Gorge Route #1 be used jointly with the proposed Intercounty Connector roadway, there had been no firm commitment as to the final selection of an Intercounty Connector alignment. Because much of the land available for the potential roadway was owned by Montgomery County

## TABLE B-9

## IMPACT ASSESSMENT FOR FINAL RAW WATER INTERCONNECTION ROUTES

| | | | FCWA | | WSSC | | Fairfax City |
|---|---|---|---|---|---|---|---|
| | Potomac River to Occoquan Reservoir #1 | Potomac River to Occoquan Reservoir #3 | Potomac River to Cub Run | Shenandoah River to Broad Run | Potomac River to Rocky Gorge Reser. #1 | Potomac River to Rocky Gorge Reser. #2 | Potomac River to Beaverdam Reservoir #2 |
| **ECONOMIC*** | | | | | | | |
| Total Miles of Pipeline | 28.9 | 29.4 | 18.2 | 28.0 | 22.7 | 24.7 | 8.0 |
| Preliminary Capital Costs | — | 43.9 | 12.6 | 34.8 | 29.8 | — | 7.5 |
| **ENVIRONMENTAL** | | | | | | | |
| # of 100-Year Floodplain Crossings | 6 | 9 | 4 | 5 | 10 | 8 | 5 |
| Total Miles Along Major Stream Valleys | 3.2 | 4.0 | 2.4 | 2.5 | 2.0 | 4.5 | 0 |
| Potential Critical Wildlife Habitat Affected | NONE | | | | | | |
| Potential Threatened or Endangered Species Affected | NONE | | | | | | |
| Miles Through or Adjacent to Farmland Habitat | 9.0 | 10.0 | 3.4 | 20.0 | 14.0 | 8.0 | 4.0 |
| Miles Through or Adjacent to Woodland Habitat | 13.7 | 17.0 | 8.0 | 6.3 | 14.0 | 10.0 | 4.0 |
| **TRANSPORTATION & UTILITIES** | | | | | | | |
| *Total Miles Along Transportation Routes* | 21.0 | 10.5 | 5.4 | 26.8* | 5.4 | 14.8 | 3.1 |
| Dual | - | - | - | - | - | - | - |
| Primary | - | - | - | - | 3 | - | - |
| Secondary | 18.3 | 8.1 | 1.0 | - | - | 4.5 | - |
| Others | 2.7 | 2.4 | 4.4 | - | 1.4 | 10.3 | 3.1 |
| # of Intersections With Transportation Routes | 22 | 21 | 16 | 12 | 24 | 20 | 1 |
| Dual | 5 | 5 | 4 | 1 | 7 | 4 | 1 |
| Primary | - | - | 2 | 4 | 5 | 6 | - |
| Secondary | 16 | 15 | 9 | 7 | 11 | 10 | - |
| Railroads | 1 | 1 | 1 | - | 1 | - | - |

*Parallel to Route I-66

TABLE B-9 (Continued)

IMPACT ASSESSMENT FOR FINAL RAW WATER INTERCONNECTION ROUTES

| | Potomac River to Occoquan Reservoir #1 | Potomac River to Occoquan Reservoir #3 | FCWA Potomac River to Cub Run | Shenandoah River to Broad Run | WSSC Potomac River to Rocky Gorge Reser. #1 | WSSC Potomac River to Rocky Gorge Reser. #2 | Fairfax City Potomac River to Beaverdam Reservoir #2 |
|---|---|---|---|---|---|---|---|
| Total Miles Along Existing | | | | | | | |
| Utilities | 7.3 | 21.6 | 12.5 | - | 6.0 | 11.0 | 5.5 |
| Gas | 5.0 | 1.3 | 12.5 | - | 2.0 | 9.0 | - |
| Electric | 2.3 | 10.3 | - | - | 4.0 | 2.0 | 5.5 |
| Intersections with Major | | | | | | | |
| Utilities | 10 | 11 | 4 | - | 5 | 9 | 3 |
| Gas | 6 | 6 | 3 | - | 2 | 6 | 2 |
| Electric | 4 | 5 | 1 | - | 3 | 3 | 1 |
| CULTURAL RESOURCES | | | | | | | |
| # of Know Resource Areas | 6 | 2 | - | - | 2 | 8 | - |
| # of Potential Resource Areas | | | | HIGH POTENTIAL | | | |
| LAND USE | | | | | | | |
| Agriculture | 9.0 | 10.0 | 3.5 | 20.0 | 14.0 | 8.0 | 4.0 |
| Woodlands | 13.7 | 17.0 | 8.0 | 6.5 | 14.0 | 10.0 | 4.0 |
| Commercial/Industrial | - | - | - | - | 2.0 | 3.0 | - |
| Public | 1.0 | 0.5 | 0.5 | - | 0.5 | 0.5 | - |
| Recreation | 4.0 | 2.5 | 1.0 | - | 4.0 | 3.5 | - |
| REAL ESTATE* | | | | | | | |
| Total Real Estate Costs ($ Mil) ** | 11.0 | 10.0 | 6.0 | 7.0 | 10.0 | 12.0 | 3.0 |
| Land | 8.0 | 8.0 | 4.0 | 4.0 | 7.5 | 8.5 | 2.0 |
| Improvement | 1.5 | 1.0 | 1.0 | 1.5 | 1.5 | 2.0 | 0.5 |
| Severance | 1.5 | 1.0 | 1.0 | 1.5 | 1.0 | 1.5 | 0.5 |
| Relocation | 1.5 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 0.25 |
| # of Owners Affected | 350 | 250 | 150 | Not Available at this time | 250 | 450 | 50 |

*Costs given at December 1978 price levels
**Does not include relocation costs

and was undeveloped, it provided a low socially disruptive pipeline corridor. Coupled with its relative low cost in comparison with Potomac-Rocky Gorge Route #2, Rocky Gorge #1 was selected as the Patuxent interconnection route for further planning. More detailed data regarding environmental and social impacts and real estate parameters for both of these routes is presented in the Appendix E.

On the basis of the previous discussions regarding the optimization analysis, impact assessment, and implementation considerations, the following raw water interconnections were carried forward for further planning consideration in the formulation and evaluation of early-action plans:

- Patuxent Interconnection
  - Potomac River to Rocky Gorge Reservoir Route #1
- Occoquan Interconnection
  - Potomac River to Occoquan Reservoir Route #3
  - Shenandoah River to Broad Run Route #1
  - Potomac River to Cub Run Route #1
- Goose Creek Interconnection
  - Potomac River to Beaverdam Reservoir Route #2

## FINISHED WATER INTERCONNECTIONS

### General Description

A finished water (treated water) interconnection between two adjacent distribution systems is shown in schematic form in Figure B-11. 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 the presently independent water supply with pipelines. If a drought or emergency (source contamination, power outage, pump failure, etc.) should occur in one distribution system, water could be made available to it from an adjacent distribution system via an interconnecting finished water pipeline. It should be noted that a finished water interconnection pipeline could have an extra benefit of reversibility. Reversibility of systems would permit the supply of water to and/or from either of the interconnected systems, thus allowing for maximum transferability during periods of need in either area.

### Route Identification

There presently exist a number of small finished water interconnections which provide local suppliers with the capability to exchange treated water between systems. In this study, however, the interconnections investigated were designed to transfer larger quantities of water between major lines of water distribution.

Similar to the situation for raw water interconnections, a number of previous reports had investigated the feasibility of finished water interconnections between the MWA's major water distribution systems. Working with the Interstate Commission on the Potomac River Basin (ICPRB), the Corps of Engineers identified five finished water interconnections for further analysis. These interconnections are listed in Table B-10 and their approximate locations are shown on Figure B-12.

FIGURE B-11

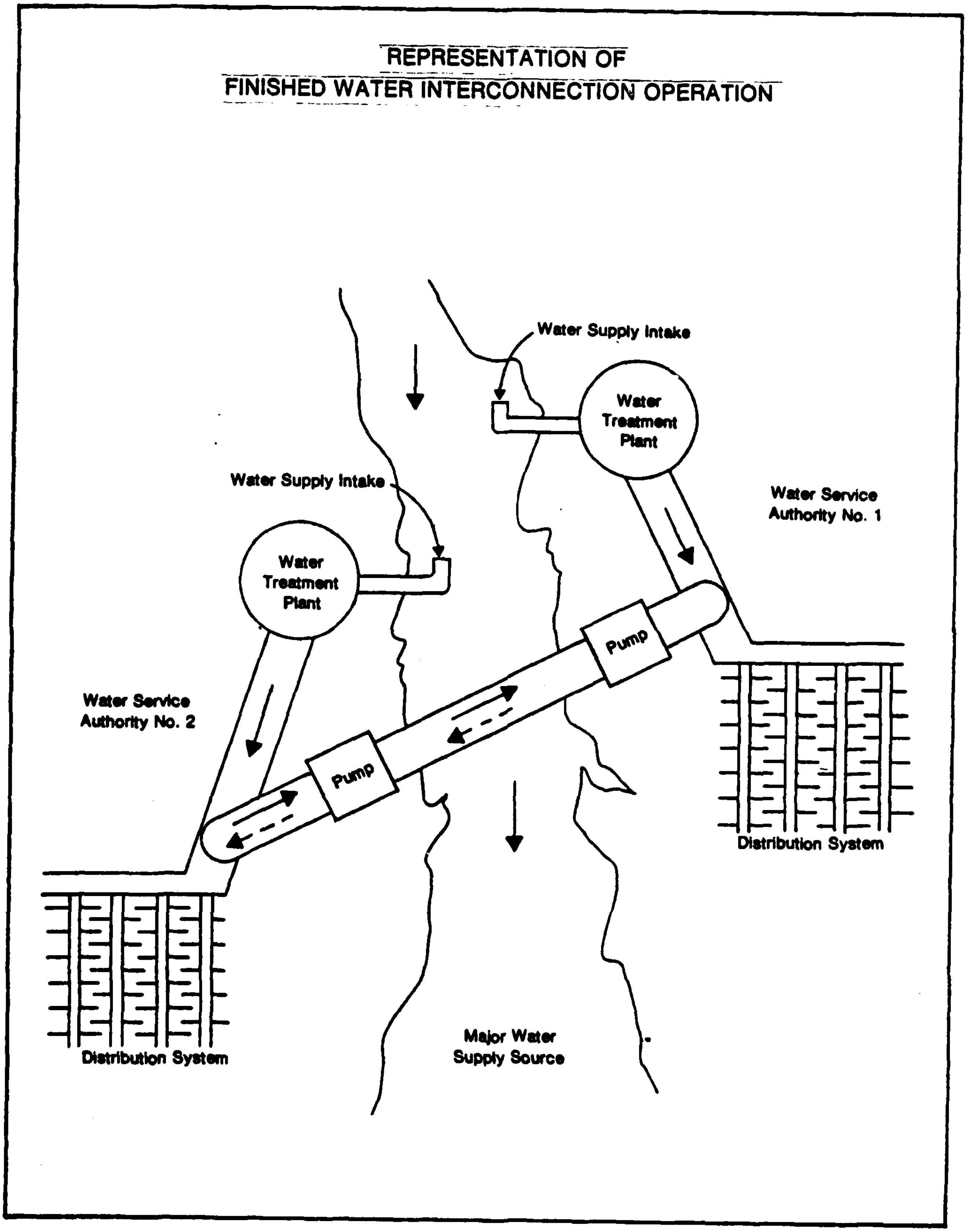
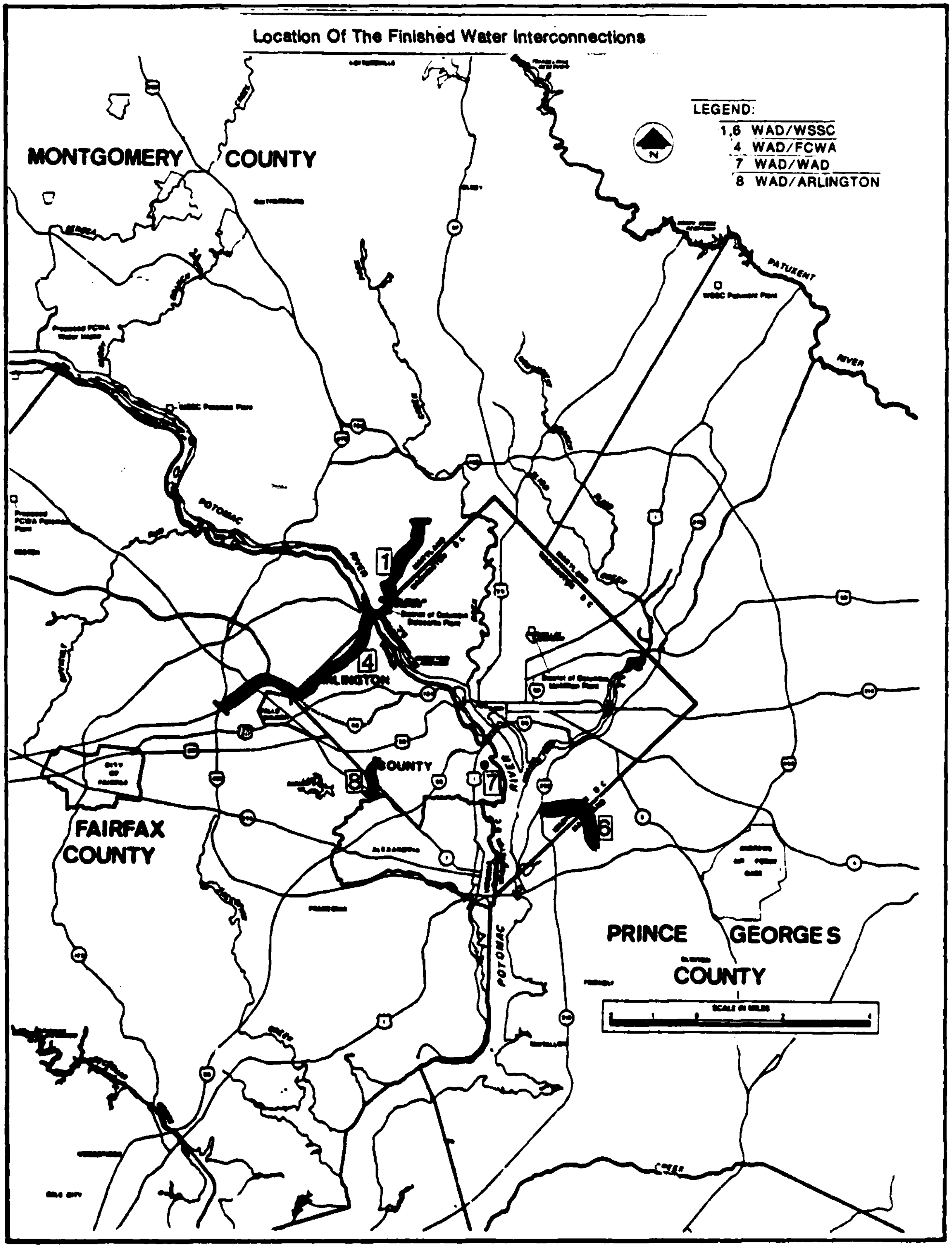

REPRESENTATION OF
FINISHED WATER INTERCONNECTION OPERATION
Water Supply Intake
Water Treatment Plant
Water Service Authority No. 1
Water Supply Intake
Water Treatment Plant
Pump
Pump
Water Service Authority No. 2
Distribution System
Distribution System
Major Water Supply Source

FIGURE B-12



Location Of The Finished Water Interconnections
LEGEND:
1,6 WAD/WSSC
4 WAD/FCWA
7 WAD/WAD
8 WAD/ARLINGTON
MONTGOMERY COUNTY
FAIRFAX COUNTY
PRINCE GEORGES COUNTY
POTOMAC
RIVER
PATUXENT
RIVER
ARLINGTON
COUNTY
1
4
6
7
8

## Data Development

### Hydraulic Modeling

Under contract to the Corps, the ICPRB undertook a hydraulic investigation to explore certain aspects of finished water interconnections such as: (1) the potential for increase in dependable yield; (2) hydraulic capacities of the systems; (3) cost; and (4) implementation feasibility. To perform the hydraulic investigation, ICPRB utilized an exsting linear computer model entitled "Analysis of Pressure and Flow in Pipe Systems" written by Dr. Donald Wood of the University of Kentucky. Equations were developed and solved to balance the flow, flow rate, and energy in the network. Model input data collection and implementation comprised a major portion of the work effort. Much of the model's input data was hydraulic criteria collected directly from the local utilities. Other data were obtained from distribution system maps at a scale of 1/200 or larger (a complete listing of the input data collected for each system is given in Appendix E - Raw and Finished Water Interconnections and Reregulation).

TABLE B-10

FINISHED WATER INTERCONNECTIONS*

| Systems Connected | Location | Reversibility | Primary Beneficiary | Pipeline Capacity (mgd) | Pipeline Diameter (inches) |
|---|---|---|---|---|---|
| WAD-WSSC #1 | Montgomery Co. | Yes | WSSC | 60 | 60 |
| WAD-WSSC #6 | Prince Georges Co. | No | WSSC | 10 | 24 |
| WAD-FCWA #4 | Fairfax Co. | No | FCWA | 40 | 48 |
| WAD-FCWA #8 | Fairfax Co. | Yes | FCWA | 8 | 36 |
| WAD/WAD #7 | Arlington Co. | Yes | WAD | 7 | 24 |

*See Figure B-12 for general location

After all the model input data were collected, individual runs were performed on the model for each major subsystem of the water service areas. The model was structured to test the feasibility of the proposed finished water interconnections operating within the existing distribution system. All were found to be feasible; sizes and capacities are given in Table B-10.

### Impact Assessment

An in-house impact assessment was performed on the finished water interconnections similar to that undertaken on the raw water routes. Details of this analysis can be found in Appendix E. The work effort was geared to providing a comprehensive basis for identifying the significant impacts of the proposed finished water pipeline routes. Table B-11 presents impact assessment information gathered for the finished water interconnection routes.

TABLE B-11

IMPACT ASSESSMENT - FINISHED WATER INTERCONNECTION ROUTES

| | WAD-WAD #7 Arlington Pentagon | WAD-WSSC #1 Dalecarlia Water Treatment Plant to Chevy-Chase Terrace | WAD-FCWA #4 Dalecarlia Water Treatment Plant to I-66 & I-495 Interchange | WAD-WSSC #6 Naval Research Lab to Forest Heights | WAD-FCWA #8 Baileys Crossroads |
|---|---|---|---|---|---|
| **ECONOMIC** | | | | | |
| Miles of Pipeline | .04 | 3.2 | 8.4 | 1.9 | 1.6 |
| Preliminary Construction Cost* ($ millions) | .05 | 15.6 | 25.6 | 8.0 | 8.0 |
| **ECOLOGICAL** | | | | | |
| Miles Along Stream Valleys | 0 | 2 | 0 | 0 | 0 |
| Number of 100-Year Flood Plain Crossings | 0 | 1 | 1 | 2 | 0 |
| Critical Wildlife Habitat Areas Affected | NONE | NONE | NONE | NONE | NONE |
| Threatened or Endangered Species Affected | NONE | NONE | NONE | NONE | NONE |
| Miles Through or Adjacent to Farmland Habitat | NONE | NONE | NONE | NONE | NONE |
| Miles Through or Adjacent to Woodland Habitat | NONE | NONE | NONE | NONE | NONE |
| **SOCIAL** | | | | | |
| Total Miles Along Transportation Route | 0 | 2.5 | 4.5 | 1.0 | 1.6 |
| Dual Road | 0 | .75 | 0 | 0 | 0 |
| Primary Road | 0 | 0 | 0 | 1.0 | 0 |
| Secondary Road | 0 | 0 | 4.5 | 0 | 1.1 |
| Number of Intersections with Transportation Routes | 4 | 13 | 4 | 4 | 3 |
| Miles Along Major Utility Rights-of-Way | NONE | NONE | NONE | NONE | NONE |
| Number of Intersections with Major Utilities | NONE | NONE | NONE | NONE | NONE |

TABLE B-11 (Continued)

IMPACT ASSESSMENT - FINISHED WATER INTERCONNECTION ROUTES

| | WAD-WAD #7 Arlington Pentagon | WAD-WSSC #1 Dalecarlia Water Treatment Plant to Chevy-Chase Terrace | WAD-FCWA #4 Dalecarlia Water Treatment Plant to I-66 & I-495 Interchange | WAD-WSSC #6 Naval Research Lab to Forest Heights | WAD-FCWA #8 Baileys Crossroads |
|---|---|---|---|---|---|
| Number of Crossings Along Known Cultural Resources Sensitivity Areas | 0 | 2 | 0 | 0 | 0 |
| Number of Crossings over Potential Cultural Resources Sensitivity Areas | HP | HP | HP | HP | HP |
| Miles Adjacent to Land Use Type | | | | | |
| Agricultural | 0 | 0 | 0 | 0 | 0 |
| Wooded Land | 0 | 2 | 2 | 1.5 | 0 |
| Commercial/Industrial | 0 | 0 | .5 | 1.5 | .5 |
| Recreational | 0 | 2 | 1.5 | 1.5 | 0 |
| Percent of Affected Area in High Density Urban Development | 0 | 33 | 100 | 60 | 75 |
| Ease of Implementation | ----- | -----NONE----- | ----- | ----- | |
| **REAL ESTATE*** | | | | | |
| Cost of Land | 0 | 4.0 | 5 | 2 | 2 |
| Improvements Costs ($ millions) | 0 | 1.0 | 1 | 1 | 1 |
| Severance Costs ($ millions) | 0 | 1.0 | 1 | 1 | 1 |
| Relocation Costs ($ millions) | 0 | .5 | 1.5 | 1 | .5 |
| Total Real Estate Costs ($ millions) | 0 | 6.5 | 8.5 | 6.0 | 4.5 |
| Approximate Number of Properties Affected | 5 | 100 | 300 | 100 | 100 |

*Costs given at December 1978 price level

Unlike the raw water interconnection, the finished water interconnections would be short in length and would pass almost entirely through the most urbanized portions of the MWA. Because of that, finished water interconnections in most cases (with the exception of WSSC-WAD #1, which passes through a park) would cause little, if any environmental harm in the area. Social impacts would likely to be felt during the construction phase with disruption to normal residential activities. These impacts would be temporary in nature and non-existent in the post-construction period.

Screening

As a result of the analysis performed on the finished water interconnections, two important points were noted with regard to water supply. The first was that finished water interconnections could not provide additional supplies to the region nor could they directly solve water supply shortages because no "new" water was provided. Their major merit, however, stemmed from their capability to provide redundant or back-up treatment capability to the three major service areas (WAD, WSSC, and FCWA) in the event of failures in any one part of the system. Even though finished water interconnections would not directly satisfy projected water shortages, it was decided to develop design and cost data for all five routes to be provided as information to the local water suppliers.

REREGULATION

General Description

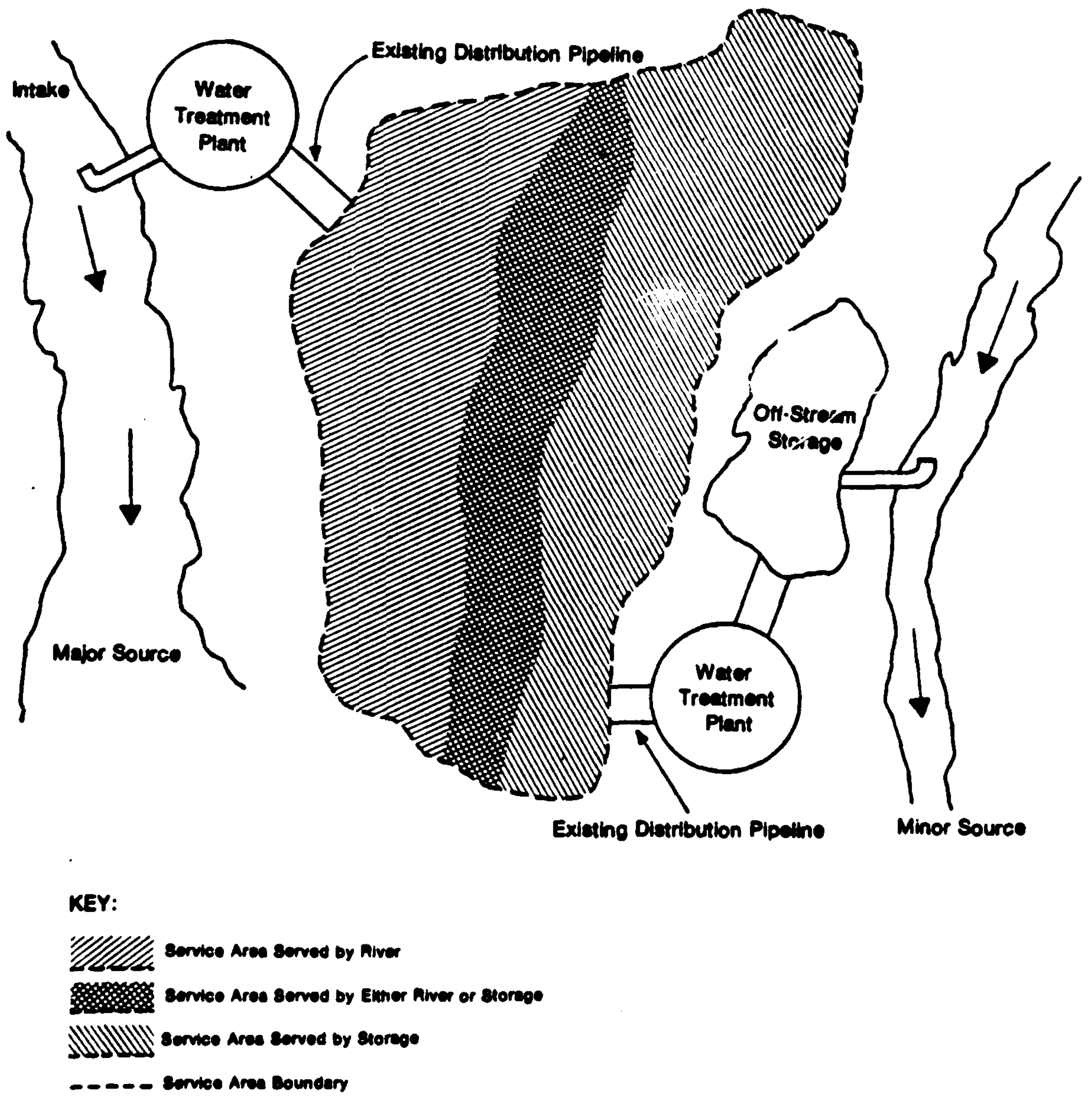
Intrasystem transfer of water by reregulation involves distribution of the water within a given service area which is served by both a river and a reservoir source and two independent water treatment plants. During normal conditions, the service area is served largely from the river source, thereby conserving storage in the reservoir. During a low flow condition in the river, however, a greater area is served from the reservoir which decreases withdrawal from the river. This mode of operation requires a flexible distribution system (pipe, pumps, and water treatment plants) which can be served by either of two sources. This type of operation and arrangement is depicted in Figure B-13.

Hydrologic Simulation

Because the dependable output of a water supply system is highly dependent on the way it is operated, the relative timing of water withdrawal from various sources during different times of the year is of great importance. The objective of this segment of work was to determine if the existing rates of withdrawal, treatment and pumping could be managed more efficiently from a water balance standpoint. The underlying concept would be to increase the dependable supply of water in the MWA during a drought situation by maximizing use of the Potomac River when available and minimizing use of existing Occoquan and Patuxent 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. Water service areas with reservoir supplies could then withdraw water from storage, leaving more water in the Potomac for the WAD and Rockville which have little raw water storage capability.

FIGURE B-13

## REPRESENTATION OF REREGULATION (INTRASYSTEM TRANSFER OF WATER)



A series of operating rules was devised to trigger increases and decreases in withdrawals from the Potomac or off-stream reservoir sources. These operating rules were then tested through hydrologic simulation against the 1930-1932 drought to determine how well they responded to an actual drought event. Data required to perform this analysis consisted of reservoir capacities, maximum and minimum water treatment plant capacities, Potomac River flows, reservoir inflows, flowby requirements, and water demands.

### Results

After several refinements and adjustments, an operating rule based on monthly averages supplies and demands was devised as shown in Table B-12. The information presented in Table B-12 is by no means meant to imply that this is an optimum operating rule for system management, only that it is one of many possible rules which might be used to help alleviate severe shortages during a drought situation. Reregulation by adopting this or a similar operating rule would be most effective if followed on a continuous year-round basis instead of on an as-needed temporary basis. By its very nature, reregulation would "save" small volumes of water in the off-stream reservoirs over an extended period so that a large volume of water could be made available during a severe drought period. One additional finding was that reregulation was already practiced to a limited degree by WSSC, but further benefit could be derived by conscious application of the reregulation principle. More details about the reregulation concept are provided in Appendix E - Raw and Finished Water Interconnections and Reregulation.

## LOCAL STORAGE

### General Description

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.

### Site Location and Impact Assessment

At the time of the early-action phase, three reservoirs were actively being studied by local water utilities to provide future supply to meet local needs. These storage facilities were of importance in a regional sense because they would provide new sources of supply and increase regional storage capabilities. The three reservoirs evaluated as part of the early-action phase included: Little Seneca Lake (SCS #3) on Seneca Creek in Montgomery County for the WSSC; Cedar Run Reservoir on Cedar Run for Prince William County; and a 5-foot raising of the existing Occoquan Reservoir in Fairfax County for the FCWA (later work by FCWA also examined a 2-foot raising). The location of these proposed local storage projects are shown on Figure B-14. Table B-13 summarizes the physical characteristics of the sites investigated while Table B-14 summarizes the environmental and socal impacts of the proposed local storage projects. Much of the data in these two tables were taken from existing engineering reports which had been prepared previously. Additional details are contained in Appendix F - Structural Alternatives.

TABLE B-12

RERERULATION OPERATING RULES
(MONTHLY FLOWS)

| | | |
|---|---|---|
| CASE I | IF: | Both reservoirs are full with adequate flow in the Potomac, and inflow to each reservoir is greater than withdrawals (sum of demands plus evaporation losses plus downstream releases), |
| | THEN: | Patuxent WTP "$Q_p$" is operated at 49 mgd (.75 x 65 mgd) and remainder of WSSC demand is made up from Potomac. Occoquan WTP "$Q_o$" is operated at 69 mgd and remainder of FCWA is made up from Potomac. |
| | | $Q_p = 49$ and $Q_o = 69$ |
| CASE II | IF: | Both reservoirs are full with adequate flow in the Potomac, but inflow to either reservoir is less than the desired withdrawal rate as specified in Case I, |
| | THEN: | Patuxent WTP is operated at a rate so reservoir just stays full ($Q_p$ = Inflow - Evaporation - Downstream Releases), but never less than 20 mgd. Remainder of WSSC demand is made up from Potomac. Occoquan WTP is also operated at a rate so reservoir just stays full ($Q_o$ = Inflow + STP (Sewage Treatment Plant anticipated from the Upper Occoquan Sewage Authority Treatment Plant located upstream of the Reservoir) - Evaporation), but never less than 30 mgd. Remainder of FCWA demand is made up from Potomac. |
| | | $20 \leq Q_p \leq 49$<br>$30 \leq Q_o \leq 69$ |
| Case III | IF: | Patuxent is full, Occoquan is not full, adequate water in Potomac, but inflow to either reservoir is less than desired withdrawal rate as specified in Case I, |
| | THEN: | Operate Patuxent WTP as in Case II. Operate Occoquan WTP at 30 mgd. |
| | | $Q_p$ = 20 mgd<br>$Q_o$ = 30 mgd |
| Case IV | IF: | Occoquan is full, Patuxent is not full, adequate water in Potomac, but inflow to either reservoir is less than desired withdrawal rate as specified in Case I, |
| | THEN: | Operate Patuxent WTP at 20 mgd. Operate Occoquan WTP as in Case II. |
| | | $Q_p = 20$<br>$30 \leq Q_o \leq 69$ |

TABLE B-12 (Continued)

Case V IF: Neither reservoir is full, but there is adequate flow in the Potomac,

THEN: Patuxent WTP is operated at a minimum of 20 mgd and Occoquan WTP is operated at a minimum of 30 mgd. All remaining demands are met from the Potomac.

$Q_p$ = 20 mgd
$Q_o$ = 30 mgd

Case VI IF: Neither reservoir is full and there is not sufficient water in the Potomac to meet projected Potomac withdrawals, but there is sufficient capacity at the reservoir WTP's to meet the unmet demands,

THEN: 100 mgd is retained in the Potomac for flow-by, WAD and Rockville demands are met from the Potomac. The remainder of the Potomac flows are divided between FCWA and WSSC such that the withdrawal from the Occoquan is approximately 1.5 times the withdrawal from the Patuxent.

$Q_o = 1.5\ Q_p$

$Q_o$ max = 84 = (.75 x 112 mgd)

$Q_p$ max = 49 = (.75 x 65 mgd)

Case VII IF: Neither reservoir is full and there is some Potomac flow and the maximum output of reservoir WTP will nt meet demands,

THEN: 100 mgd is retained in the Potomac for flowby, and the LFAA formula is used to allocate flows to the different users. The Occoquan and Patuxent WTP's are operated at their maximum capacities of 84 and 49 mgd, respectively.

$Q_o$ = 84
$Q_p$ = 49

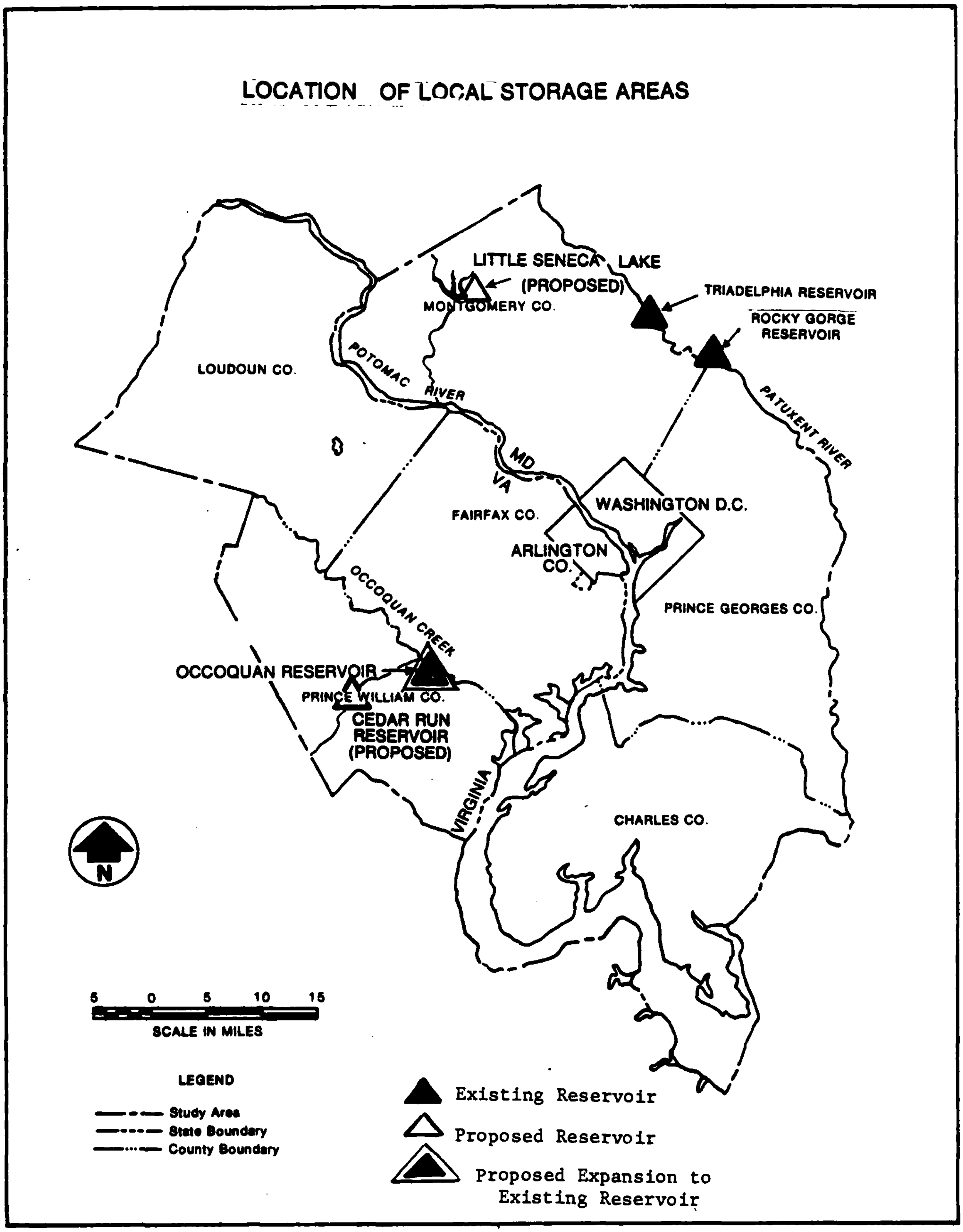

LOCATION OF LOCAL STORAGE AREAS
LITTLE SENECA LAKE (PROPOSED)
TRIADELPHIA RESERVOIR
ROCKY GORGE RESERVOIR
MONTGOMERY CO.
LOUDOUN CO.
POTOMAC RIVER
PATUXENT RIVER
MD
VA
WASHINGTON D.C.
FAIRFAX CO.
ARLINGTON CO.
PRINCE GEORGES CO.
OCCOQUAN CREEK
OCCOQUAN RESERVOIR
PRINCE WILLIAM CO.
CEDAR RUN RESERVOIR (PROPOSED)
VIRGINIA
CHARLES CO.
N
5 0 5 10 15
SCALE IN MILES
LEGEND
Study Area
State Boundary
County Boundary
Existing Reservoir
Proposed Reservoir
Proposed Expansion to Existing Reservoir

TABLE B-13

PHYSICAL CHARACTERISTICS OF PROPOSED LOCAL STORAGE PROJECTS*

| Sites | Location | Pool Elevation** (ft. above msl) | Surface Areas (Acres) | Length of Shoreline (Miles) | Water Supply Storage (billions of gallons) | Safe Yield (mgd) |
|---|---|---|---|---|---|---|
| Seneca Lake | Little Seneca Creek, Montgomery County, Md. | 380 (392.2) | 2200 (3300) | 14 | 3.6 | 9.1 |
| Cedar Run Reservoir | Cedar Run, Prince William Co., Virginia | 180 (187) | 2650 (4050) | 53 | 2.5 | 25.0 |
| Occoquan Reservoir +5 feet | Occoquan Creek, Fairfax Co., Virginia | 125 | 1800 to 2200 (2600 to 3000) | 69+ | +4.1 (8.4 to 12.5) | +9.1 (44.6 to 53.7) |

*Based on local reports
**Information in parentheses refers to flood pool; Non-parentheses, operating pool.

TABLE B-14

LOCAL STORAGE ASSESSMENT

| | Little Seneca Lake | Cedar Run | Occoquan 5 ft. Ext. |
|---|---|---|---|
| **ENVIRONMENTAL** | | | |
| Additional Miles of Stream Valley Inundated | 8 | 27 | INCREASE |
| Acres of Forest Area Inundated | 235 | 2170 | INCREASE |
| Effect of Critical Habitat | Significant | Significant | Not Significant |
| Effects on Threatened or Endangered Species | None | None | None |
| **SOCIAL** | | | |
| Permanent Pool | | | |
| New or Additional Surface Area Created (acres) Permanent Pool | 525 | 2550 | 480 |
| Flood Pool | 600 | 3240 | ** |
| Length of New or Additional Shoreline (miles) | 14 | 53 | Increase |
| Recreational Potential | High | High | High |
| Acres of Agricultural Land Inundated | 212 | 1880 | * |
| Buffer Zone Created (feet) | 500 | 200 | 300 |
| Existing Significiant Mineral Sites Inundated | None | None | None |
| Known Cultural Resource Areas Affected | 0 | 28 | 22 |
| Potential Cultural Resource Areas Affected | Low | High | High |
| Number of Property Relocations | 20 | 117 | None |
| Number of Transportation Relocations | 1 | 7 | 0 |
| Number of Utility Relocations | 5 | 1 | 0 |

TABLE 14 (Continued)

LOCAL STORAGE ASSESSMENT

Cost Data:

1. SCS #3 - Henningson, Durham, and Richardson, 1978 updated to Dec 78 COE
2. Cedar Run - Wiley & Wilson, 1977 updated to Dec 78 COE
3. Occoquan - Five foot extension - Telephone conversation with FCWA, Jan 79, Fred Griffith

Other:

*Information not available

**FCWA has no specific provisions for allocation of flood control storage in the Occoquan Reservoir.

***Operation and Maintenance Costs for Cedar Run and SCS #3 are .0075% of Capital Cost. O & M Costs for Occoquan is 3% of Capital Costs.

****FCWA owns easement rights for an additional 650 acres. Therefore, no additional land acquisition is needed.

## WATER CONSERVATION AND DEMAND REDUCTION

### General Description

Conservation and demand reduction measures are employed to more efficiently use the available supply of water and to decrease unnecessary use of water. These measures may be implemented intermittently or actually incorporated into daily routines depending upon the scope and intensity of the particular program. The aim of conservation and demand reduction measures is to lessen the effects a severe drought by decreasing the use of water. The measures used to induce conservation reduce water use may be either structural or non-structural in nature but any successful program would probably contain elements of both.

The consulting firm of Water Resources Engineers, Inc. (WRE), a division of Camp, Dresser, and McKee was contracted to examine the various means of reducing water use in the MWA and to analyze the effects of these measures for long term needs. A complete discussion and presentation of the methods used in accomplishing these tasks and the results can be found in Appendix G - Non-Structural Studies. The following sections discuss the types of various conservation programs used and their development.

### Methodology

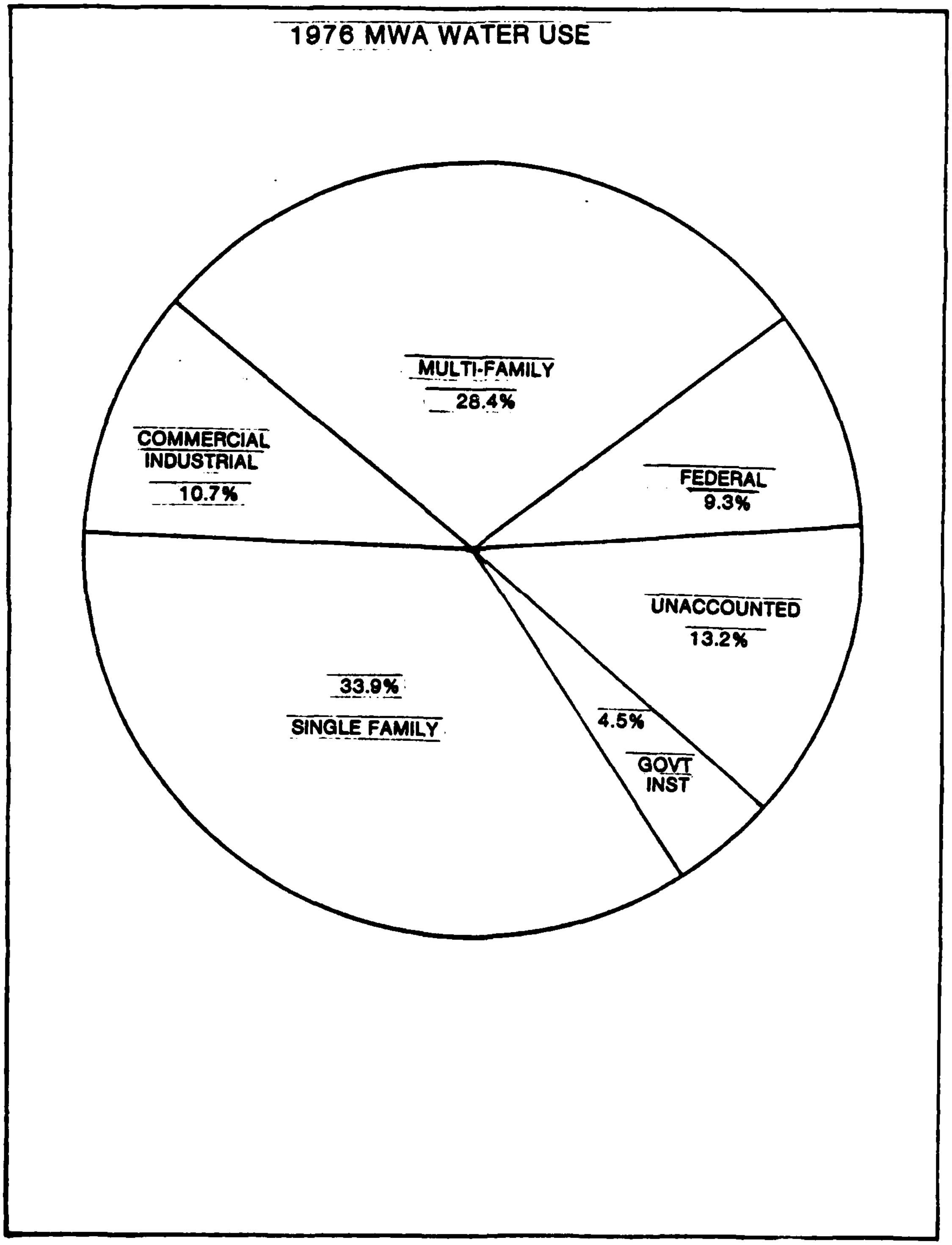
The initial step in this analysis was to understand the nature of water use in the MWA so that subsequent conservation programs could be properly designed. For the early action phase, 1976 was the most recent year for which water use data could be obtained and it was found that these data were representative of average data from previous years. Because of the diverse water use types in the MWA, water use was disaggregated to several water use categories. Within each of the water service areas, as many as seven water use categories were identified. These included:

1. Single family residential water use.
2. Multi-family residential water use.
3. Commercial and industrial water use.
4. Government and institutional water use, including state and local government.
5. Federal government water use.
6. Unaccounted water use.
7. Bulk sales of water.

In all of the water service areas, the first five categories represented the marjority of water use used. Figure B-15 illustrates the relative percentage of water used among these user categories.

Following the analysis of water use, a presentation of available types of water saving devices was made along with estimates of the amount of water that could be saved. Practicable devices such as toilet dams, vacuum-flush toilets, shower control inserts,

FIGURE B-15



1976 MWA WATER USE
MULTI-FAMILY
28.4%
COMMERCIAL
INDUSTRIAL
10.7%
FEDERAL
9.3%
UNACCOUNTED
13.2%
33.9%
SINGLE FAMILY
4.5%
GOVT
INST

aerators, shut-off valves, and pressure-reducing valves were presented as means of reducing indoor water use. Devices useful in reducing outdoor water use were examined as well as non-structural measures such as education and metering. While a number of water conserving devices were surveyed, those which were ultimately included in conservation programs were considered able to satisfy the following criteria:

- the devices would save a significant amount of water
- the devices were technologically and economically feasible
- there are practical means to insure their widespread use.

Development of Water Conservation Scenarios

Based on the projections of water demand by user category to the year 2030 and the proven effectiveness of the various water saving devices explored, six basic conservations programs or "scenarios" were developed to facilitate an assessment of the contribution by various categories of users toward water use reduction. Some demand areas demonstrated that considerable reductions in demand could be achieved within certain user categories. This was particularly true for the residental sector (single-family and multi-family categories) comprising nearly 62 percent of the total regional water use. Because of this, all of the action scenarios incorporated mechanisms for reduction in the sector.

Table B-15 outlines the elements of which each of the long-term conservation scenarios are comprised. Water saving devices, water conservation educational campaigns, system improvements, and plumbing regulations are the basic elements of these scenarios which are targeted for different user categories. Short-term emergency demand reduction measures were not investigated because the water utilities felt that they were in the best position to handle emergency situations and because the local jurisdictions (including the water utilities) were already devising a Water Supply Emergency Agreement to address such problems.

The Baseline Scenario incorporated current plumbing regulations in the MWA which were being implemented at the time of the early-action phase. This condition was considered the most probable condition given no further action. Each of the five remaining scenarios were designed to build upon the Baseline Scenario and represented increasing levels of user participation.

Screening of Conservation Scenarios

The relative effect of each of these scenarios on projected average daily demands for the plannng period is presented in Figure B-16. The maximum reduction in future water use achieved from these scenarios ranged from a low of 7 percent to a high of 28 percent.

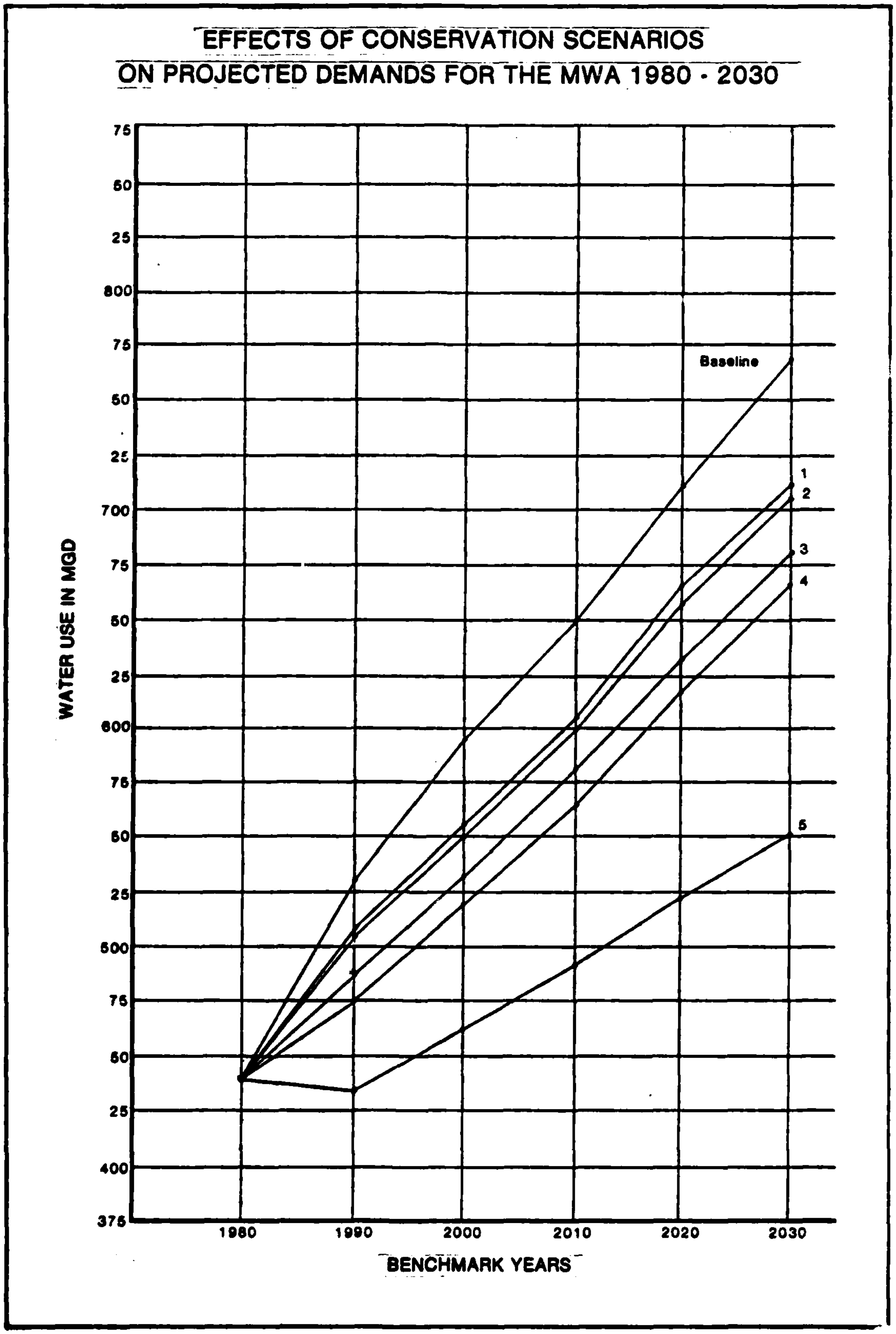
At this point, it was decided to select particular scenarios which were feasible and could achieve a meaningful reduction in overall water use. On the basis of the percent reduction in water use, feasibility of implementation, and cost, the available scenarios were further screened.

TABLE B-15

SUMMARY OF ALTERNATIVE WATER CONSERVATION SCENARIOS

| | |
|---|---|
| BASELINE - | Incorporates new and antiticipated plumbing regulations. |
| SCENARIO 1 - | Baseline plus: Additional low water use fixtures to new residential construction; retrofitting water-saving devices to existing residential. |
| SCENARIO 2 - | Scenario 1 plus: A reduction in outdoor residential water use achieved through a water conservation educational campaign directed at changing individual water use habits. |
| SCENARIO 3 - | Scenario 2 plus: A reduction in indoor and outdoor nonresidential water use acheived through a water conservation educational campaign directed at employees personal use and managements water use habits. |
| SCENARIO 4 - | Scenario 3 plus A reduction in the unaccounted for water use by minimizing the amount of water lost from leaks through system improvements. |
| SCENARIO 5 - | The most efficient use of available low-water use fixtures to indoor new residential and non-residential; retrofitting water-saving devices to existing residential; a behavior modification to indoor and outdoor, new and existing residential and non-residential water use; and a reduction in unaccounted for water use by minimizing the amount of water lost from leaks through system improvements. |

FIGURE B-16



EFFECTS OF CONSERVATION SCENARIOS
ON PROJECTED DEMANDS FOR THE MWA 1980 - 2030
75
50
25
800
75
50
25
700
75
50
25
600
75
50
25
500
75
50
25
400
375
WATER USE IN MGD
Baseline
1
2
3
4
5
1980
1990
2000
2010
2020
2030
BENCHMARK YEARS

The Baseline Scenario represented an important level of conservation to consider should the MWA not implement additional mechanisms of demand reduction other than those already planned locally. In addition to this, the Baseline reductions acheived through this "no further action" scenario represented a comparison from which stricter conservation levels could be contrasted. Scenarios 2 and 4 were not selected for use because the approximate reduction achieved by each were not significantly different (although slightly higher in cost) from those achieved by Scenarios 1 and 3 respectively.

Conservation Scenario 5 was also eliminated from futher consideration at this stage. The potential for this scenario to achieve the greatest reduction in water use of all the scenarios considered was based in part by the assumption that the devices employed could attain their highest tested rate of reduction. In addition, in some instances, new and innovative water saving devices not employed in the other scenarios, such as siphon jet toilets, were assumed in Scenario 5 to be implemented by 100 percent of the new users. Furthermore, the amount of reduction to be achieved in unaccounted category by leak detection and repair is suspect because of the uncertainties and controversy existing as to how much of the unaccounted water is actually subject to system loss. Indeed, if a program to reduce leaks was initiated, it might not prove to be cost-effective when considering the incremental reduction achieved. Therefore, as the maximum reduction in water use achieved by Conservation Scenario 5 might not be realistically attainable, it was dropped from further consideration. Only the Baseline Scenario and Scenarios 1 and 3 were retained for further planning in the early-action phase. These represented the most realistic levels of water use reduction.

Impact Assessment

The implementation of the long-term conservation scenarios over the course of the planning period generally related to the availability of water and the effects of program implementation. Only minor construction impacts would be associated with any of these programs and these would be limited to the actual installation of devices by users. Table B-16 lists the average annual costs that would be incurred by each service area to implement these scenarios and the projected water savings. The following list cites some of the social and environmental impacts which may also occur:

1. Water users may perceive slight changes in water delivery from these devices; therefore, there may be an initial period of adjustment on the users' part to the effects of the new devices.

2. Possible changes in water use habits may be observed because of an increased awareness of the limits of water availability.

3. A reduction in the amount of water used, thereby allowing for a greater reserve (based on treatment capacity) or water for more people: a true water savings.

4. Less water treated and used means more water remains in the rivers or reservoirs. Slight improvement in water quality conditions than otherwise anticipated without conservation.

TABLE B-16

AVERAGE ANNUAL COSTS AND WATER USE REDUCTION FOR CONSERVATION SCENARIOS 1 AND 3 BY WATER SERVICE AREA*

| | Scenario 1 | | | Scenario 3 | | |
|---|---|---|---|---|---|---|
| Demand Area | Present Worth ($) | Annual Cost $/Year | Approximate % Reduction by 2030 | Present Worth ($) | Annual Cost $/Year | Approximate % Reduction by 2030 |
| WAD | 1,208,300 | 86,200 | 6.8 | 1,350,700 | 96,300 | 11.4 |
| WSSC | 1,231,600 | 87,800 | 7.2 | 1,351,800 | 96,400 | 11.0 |
| FCWA | 724,700 | 51,700 | 6.3 | 817,800 | 58,300 | 11.3 |
| Rockville | 104,300 | 7,400 | 5.8 | 137,700 | 9,800 | 11.3 |

* Dollar values given for December 1978 price levels, with a base year of 1980 and a Federal discount rate of 6 7/8 percent.

5. While water use may decrease, this does not necessarily mean the cost of water to the user will decrease, since water rates are based upon the total costs which are then distributed to the users.

6. Decreased water use means less water is treated and distributed. Because of this, a savings in energy and energy cost is observed. Besides a decrease in energy use to treat and distribute water, the use of chemicals (some energy intensive) is also decreased. Therefore, by conserving water, an overall cost savings for production and distribution per unit of water is decreased.

7. Implementation of Scenarios 1 and 3 would require future changes to local plumbing regulations.

## PUBLIC INVOLVEMENT DURING COMPONENT DEVELOPMENT

As the early-action phase progressed and the committees met to review the study products, a review procedure was established to provide opportunities for public input. This aspect of the study concentrated on an evaluation of the five components. Recommendations for study direction were received as a result of this effort. A complete listing and discussion of the public involvement program can be found in Appendix C - Public Involvement.

On 14 September 1978, a meeting was held at the Washington Aqueduct among representatives of the Corps of Engineers, the three major water supply agencies, and the technical consultants for the MWA Water Supply Study. This meeting was held to familiarize the local suppliers with the technical work completed so that appropriate inputs could be gained. Although no major decisions were reached as far as the direction of the study was concerned, comments on the data thus far developed and the assumptions used for the various technical approaches were received.

Additionally, the Water Supply Advisory Committee, the Water Resources Planning Board, and the Citizens Task Force met to review and comment on the technical work concerning the five components. This effort began in May 1978 and was completed in November 1978. The WSAC was kept appraised of the progress of MWA study as well as other supply studies in the region on a continual basis through a series of status reports provided by the MWCOG. Each group was able to meet approximately four times during this stage of analysis and was able to provide recommendations to the Corps for further investigation and consideration. The following is a synopsis of some of the comments and clarifications that were requested by the committees:

1. Different types of water rate structures (including seasonal) should be investigated in the water conservation analysis.

2. Water metering should be investigated as a method to promote water conservation.

3. Reduction in sewage flows should be a parameter in evaluating demand reduction measures.

4. Population forecasting should be coordinated with local government for the purposes of assessing water demand.

5. Basic data and methodologies for generating water demand forecasts should be available for inspection by local governments.

6. Water use by local government agencies should be investigated.

7. The Corps should continue to coordinate the MWA Study with other water supply studies in the area.

8. Seven and one-day demands should be used in the study as well as the 30-day demands initially used. This would enable planning for peak water use.

9. Water pumps that are idle between droughts must be maintained and their maintenance costs should be included in the project costs.

In November and December 1978, four Water Forum Notes were mailed to the public addressing the concepts of each of the planning components and a summary of the work accomplished thus far through the early-action. These Forum Notes helped prepare the public for a series of public workshops and public meeting on the early-action phase in early 1979.

## COMPONENT SUMMARY AND FINDINGS

Due to the large number of potential components available for plan formulation, the analyses of the various water supply components were conducted independent of each other. The final outcome of component development stage was a selection of components that could be further analyzed and formulated into regional early-action water supply plans. A list of these components appears below:

Raw Water Interconnections
- Potomac River to Rocky Gorge Reservoir #1
- Potomac River to Occoquan Reservoir #3

- Shenandoah River to Broad Run #1
- Potomac River to Cub Run #1
- Potomac River to Beaverdam Reservoir #2

Finished Water Interconnections
- WAD to WSSC #1
- WAD to FCWA #4
- WAD to FCWA #8
- WAD to WAD #7
- WAD (Low) to WSSC #6

Conservation
- Baseline Scenario
- Scenario #1
- Scenario #3

Local Storage Reservoirs
- Little Seneca Lake
- Cedar Run
- Raise Occoquan level by five feet

Reregulation
WSSC
FCWA

On the basis of the technical analyses summarized in the previous sections, the assessment of impacts, and recognition of how and which service areas derive direct and indirect benefits from the implementation of each component, several overall findings were made. These are discussed below for each component and formed the basis for development of early-action plans as discussed in a later section.

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 system would be an integral part in the operation of raw water interconnections as they would allow for storage of excess Potomac River Flows.

3. Raw water interconnections to the Patuxent and Occoquan systems would be flexible in that they 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, which would cause disruption to the environment during construction. These impacts, however, would not be long lasting.

6. There are several interconnections that could meet the needs of the FCWA. These area: a Shenandoah River to Broad Run interconnection, a Potomac River to Cub Run interconnection, or a Potomac to Occoquan interconnection. More work needed to be done to determine the relative advantages of each one.

7. A Potomac to Beaverdam Reservoir interconnection could solve problems specific to Fairfax City; however, it would provide no direct benefits for other service areas in the region.

Finished Water Interconnections:

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

2. Finished water interconnections would, however, improve the "fail-safe" capability (short term emergency capacity) of the three major service areas (WSSC, WAD and FCWA) in the event of failures in one part of the system.

3. Finished water interconnections could make use of total potential treatment capacity at the WAD, thus deferring the need for construction of additional treatment facilities by FCWA and WSSC.

4. Finished water interconnections may improve environmental quality of the Potomac River upstream of the WAD intake by reducing the impacts associated with increased upstream withdrawals.

5. Potential cost savings could be achieved by constructing pipelines for finished water transfers when compared to the cost of constructing additional treatment facilities.

6. Finished water interconnections would require interagency agreement for purchase of water and construction of pipelines and would also require congressional authorization for interconnections between the Washington Aqueduct and WSSC.

Reregulation

1. Reregulation would require at least two sources of supply, one of which has to be a reservoir, serving one area, and a river source.

2. 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.

3. WSSC and FCWA would gain flexibility in operation from reregulation.

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

5. Reregulation would not be suited to meet needs during periods of peak demands (1 or 7-day duration).

6. Environmental impacts would not be expected as a result of reregulation during its operation during non-critical periods.

7. Reregulation would benefit the downstream users (Rockville and WAD) who rely solely on the Potomac River for nearly all their available supply, because it would provide a net reduction of Potomac withdrawals upstream by the FCWA and the WSSC.

Local Storage

1. Local storage projects could provide new additional water 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 the 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 or the Occoquan Reservoir raising would require an evaluation of their mutual interaction and possible agreements between FCWA and Prince William County as to their implementation.

Conservation

1. The scenarios presented would be flexible and they 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 meet the total demand. Conservation alone could not satisfy the water supply shortages identified in the region.

3. The Baseline Scenario projected a certain level of demand reduction achieved in the MWA by total implementation of the conservation measures then required by regulations.

4. Conservation Scenario #5 would be the most optimistic of the scenarios. Water savings from this scenario would be questionable, as they were based upon the highest effectiveness of each measure.

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

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

7. The additional costs required to include PRVs and insulation with any scenario would be considerable. Only a relatively small decrease in water use would be associated with these expeditures.

EARLY-ACTION PLAN FORMULATION - ITERATION I

Having completed the analysis and preliminary screening of the individual components, the next step was to formulate a series of early-action plans using combinations of these components. This formulation process enabled a comparison of complete plans. All of these plans were structured to accomplish the same objective of satisfying the water supply needs through 2030, but by a variety of approaches. Impacts of the plans were also assessed and evaluated to further facilitate comparisons among plans.

The early-action plan formulation process progressed through three seperate iterations with each iteration producing a set of plans for review by other agencies and organizations. Based on review comments, the number of plans for further consideration were reduced while the level of technical detail for those that remained was expanded. The following sections discuss the technical data that were developed during these iterations and the rationale for decisions as the study progressed.

## REGIONAL WATER MANAGEMENT CONCERNS

Several water resource management concerns, issues, and agreements existed in the region which had direct bearing on the progress and hence, the results of the early-action phase. The study team maintained a constant awareness of these concerns which, in some cases, were of major significance in the assumptions used in the formulation of plans. Of noted significance were the issues surrounding the Low Flow Allocation Agreement (LFAA), environmental flowby and Bloomington Lake.

The LFAA was signed in January 1978 by the U.S. Government, the State of Maryland, the Commonwealth of Virginia, the District of Columbia, the Washington Suburban Sanitary Commission, and the Fairfax County Water Authority. Its purpose was to provide a fair and equitable means of allocating the regions water supply during periods of low flow so that no one area would suffer disproportionate shortages. Although the Agreement insures that the water resource is fairly distributed, it does not eliminate shortages.

A principal feature of the Agreement was a formula which limits the amount of water that may be withdrawn by each of the Potomac users during periods when flows in the Potomac are insufficient to meet the total demands. A clause also existed which allowed any of the signatories to "freeze" the allocation ratios after 1988 pending the negotiation of a revised formula.

Because this Agreement would have a direct, although variable, effect on future shortage conditions within the MWA, it was of prime importance and a basic element applied in plan formulation activities. Further details regarding the Agreement and the allocation formula can be found in Appendix D - Supplies, Demands, and Deficits.

Environmental flowby was defined as the amount of water allowed to flow past the last water intake on the Potomac River (WAD), over Little Falls, and into the Potomac Estuary for environmental purposes. The issue of flowby was a direct outgrowth of the negotiations leading to the signing of the Low Flow Allocation Agreement. The Agreement stipulated that in calculating the water available for allocation that the WAD would, based upon the data submitted by the State of Maryland regarding a flowby value, determine any amount needed for flow in the Potomac River for the purpose of maintaining environmental flowby and would balance such needs against essential human, industrial, and domestic requirements for water.

As part of their responsibility under the LFAA, the State of Maryland in coordination with the U.S. Fish and Wildlife Service initiated a study to determine an appropriate flowby value. Various values had been proposed for an appropriate level of environmental flowby, ranging from 0 to 600 mgd with some values even higher. Because flowby would have a direct bearing on the timing and magnitude of shortages, the selection of an appropriate level was of major importance for plan formulation activities.

The State of Maryland flowby study, however, was not completed until late 1981 and thus the results were not available for the early-action phase of study. For the purposes of this early-action phase then, the Corps of Engineers did not develop flowby values. Rather, a 100 mgd flow value (per the NEWS Study) was used as the base environmental flow for all plans. In addition, the study investigated a range of flowby levels in calculating water supply deficits. This sensitivity analysis permitted an assessment of the effects of various flowby values on both the timing and magnitude of drought shortages.

Also during the conduct of the early-action phase, Bloomington Lake was being constructed on the North Branch Potomac River for the purposes of water supply, water quality, flood control, and recreation. This project was expected to provide supplemental flow to the MWA during the summer months, but a detailed regulation schedule for water supply had not yet been prepared. Development of the Bloomington regulation manual was complicated by the need to examine changes in the regulation of nearby Savage River Reservoir to minimize potential water quality problems in the North Branch Potomac River, as well as the need to examine the nature and timing of water supply demands. In a parallel study effort, Johns Hopkins University personnel were developing a computer model to simulate the interactions of MWA reservoirs (Bloomington, Savage, Patuxent, Occoquan) and Potomac River during a drought. Yet another source of uncertainty regarding Bloomington Lake was the question of future water supply storage. Although a small portion of the water supply storage in Bloomington Lake had been purchased by the Maryland Potomac Water Authority, the majority of the water supply storage was not committed to any user at the time of the early-action phase. The cost associated with the uncommitted storage was estimated at $43,300,000. In light of these many uncertainties, several assumptions about Bloomington Lake were necessary for the early-action phase. These assumptions were that the future water supply storage would be purchased by a user or users in the MWA, the cost of Bloomington's future water supply storage should be part of the cost of any early-action plan, and Bloomington Lake could supplement the flow in the Potomac River at Washington, D.C. by as much as 135 mgd throughout a severe drought period.

## DESCRIPTION OF PLANS

Having defined the water supply problem earlier as both short term peaking shortages on the Potomac River as well as long-term storage manipulation problems on the local reservoirs, plans were formulated using various combinations of available components to provide a wide range of potential solutions. The goals of the first iteration were to formulate a set of initial plans and screen them based on their ability to meet average 30-day demands, their relative environmental and social impacts, and their potential implementation.

Eighteen individual plans constituting five basic groups were developed. Each of the 18 plans, with the exception of the Without Condition, included either raw water interconnections, local storage, or reregulation as means to satisfy both Potomac and reservoir shortages. Table B-17 outlines these plans.

Each of the five plan groupings addressed the 30-day duration problem of water supply shortages in different ways. Although each plan was designed to solve the same problem, some were dissimilar in operation or geographic application. The groupings permitted a wide range of choice as well as helping to isolate decision variables such as conservation levels, Occoquan raw water linkages, and reregulation versus raw water interconnections. The following sections explain these plans by grouping in greater detail.

TABLE B-17

LIST OF EARLY-ACTION PLANS: ITERATION I

WITHOUT CONDITION PLAN

NON-STRUCTURAL PLANS (REREGULATION AND CONSERVATION)

1. FCWA and WSSC reregulation with Baseline Conservation.

2. FCWA and WSSC reregulation with Conservation Scenario #1.

3. FCWA and WSSC reregulation with Conservation Scenario #3.

STRUCTURAL PLANS (RAW WATER INTERCONNECTION AND CONSERVATION)

4. Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Baseline Conservation.

5. Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Conservation Scenario #1.

6. Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Conservation Scenario #3.

7. Potomac to Patuxent and Shenandoah to Occoquan raw water interconnections with Baseline Conservation.

8. Potomac to Patuxent and Potomac to Cub Run (Occoquan) raw water interconnections.

PROPOSED UTILITIES PLANS

9. Occoquan plus 5 feet and Little Seneca Lake plus FCWA and WSSC reregulation with Baseline Conservation.

10. Occoquan plus 5 feet and Little Seneca Lake plus FCWA and WSSC reregulation with Conservation Scenario #1.

11. Occoquan plus 5 feet and Little Seneca Lake plus FCWA and WSSC reregulation with Conservation Scenario #3.

OTHER COMBINATIONS

12. Potomac to Patuxent raw water interconnection plus FCWA reregulation with Baseline Conservation.

13. Potomac to Patuxent raw water interconnection plus FCWA reregulation with Conservation Scenario #1.

TABLE B-17 (Continued)

LIST OF EARLY-ACTION PLANS: ITERATION I

14. Potomac to Patuxent raw water interconnection plus FCWA reregulation with Conservation Scenario #3.

15. An Occoquan raw water interconnection plus Little Seneca Lake, and WSSC reregulation with Baseline Conservation.

16. An Occoquan raw water interconnection plus Little Seneca Lake, and WSSC reregulation with Conservation Scenario #1.

17. An Occoquan raw water interconnection plus Little Seneca Lake, and WSSC reregulation with Conservation Scenario #3.

Without Condition

Plan 1, the Without or Baseline Condition Plan, was developed to establish a basis for comparison of the other "action" plans. This basis portrayed the conditions which would exist through the planning period (to the year 2030) in the absence of any water supply projects or measures other than those already on line or planned for implementation. In addition to the existing facilities, the following projects were assumed to be part of the Without Condition:

1. Construction of 400 mgd water supply intake on the Potomac River by the WSSC.

2. Construction of 200 mgd FCWA Potomac River water supply intake concurrent with 50 mgd Potomac treatment plant staged to full treatment capacity of 200 mgd by 2011.

3. Completion of Bloomington Dam by 1981 to provide an additional of 135 mgd for water supply to the MWA.

4. State plumbing regulations effective in both Maryland and Virginia to reduce water use; Department of Environmental Services plumbing codes amended for the District of Columbia.

Non-Structural Plans (Reregulation and Conservation)

Plan 2 - FCWA and WSSC Reregulation, Baseline Conservation
Plan 3 - FCWA and WSSC Reregulation, Conservation Scenario 1
Plan 4 - FCWA and WSSC Reregulation, Conservation Scenario 3

Each of the non-structural plans (2, 3, and 4) consisted of the reregulation component combined with increasing levels of water use reduction through more intensive water conservation programs. These plans were essentially non-structural in character. Only minor system modifications were required to the FCWA finished water distribution system once the Potomac River intake and water treatment plant became operational. The WSSC system does reregulate the distribution of water between its Potomac and Patuxent filtration plants effectively in times of need.

The Baseline Conservation Scenario component in Plan 2 incorporated current and anticipated MWA plumbing regulations which was considered the most probable demand situation given no further action. Scenario 1 of Plan 3 and Scenario 3 of Plan 4 built upon the Baseline Scenario and reflected increasing degrees of user participation. Both Conservation Scenarios 1 and 3 required minor structural modifications for new residences and minor remodeling for existing residences.

Implementation of any of the three plans required regional cooperation and agreements regarding the amount and timing of withdrawls from the Potomac River. Conservation Scenarios 1 and 3 were uniformly applied to each service area within the MWA so that six and 10 percent reduction in water use could be achieved by each scenario, respectively.

Due to the minor amount of construction required to implement any of these plans, little adverse environmental impacts would result. The only impacts likely to occur would be the stress of fish populations in the existing reservoirs during period of rapid reservoir drawdown.

As a group, the non-structural plans posed the least adverse environmental impact of all of those under consideration in Iteration I. In addition, because of the relatively small amount of capital required for construction, operation, and maintenance, they represented the lowest cost plans available in the first interation to satisfy 30-day shortages.

Structural Plans (Raw Water Interconnections and Conservation)

Plan 5 - Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Baseline Conservation

Plan 6 - Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Conservation Scenario #1

Plan 7 - Potomac to Patuxent and Potomac to Occoquan raw water interconnections with Conservation Scenario #3

Plan 8 - Potomac to Patuxent and Shenandoah to Occoquan raw water interconnections with Baseline Conservation

Plan 9 - Potomac to Patuxent and Potomac to Cub Run (Occoquan) raw water interconnections with Baseline Conservation.

Plans 5 through 9 represented raw water interconnection plans in conjunction with conservation. The raw water interconnections provided a mechanism of water transfer between flowing streams and local reservoir storage, whereas conservation promoted a reduction in water use.

Each of these plans contained a reversible raw water interconnection between the Potomac River and the Rocky Gorge Reservoir to provide a water supply solution to the WSSC service area in Montgomery and Prince Georges Counties, Maryland. This type of arrangement permitted the transfer of Potomac River water between either Potomac and Patuxent Filtration Plants or to the Rocky Gorge Reservoir. On the Virginia side, alternative raw water interconnections were investigated.

Plans 5, 8, and 9 were developed to facilitate a comparison between the three potential ways to transfer raw water to the Occoquan Reservoir. Plan 5 (and its variations in conservation represented by Plans 6 and 7) represented a direct reversible transfer of Potomac River water to the Occoquan Reservoir via its water treatment plants. Plans 8 and 9 involved alternative one-way pipelines emanating from the Shenandoah and Potomac Rivers, respectively, and discharging into upstream tributaries of the Occoquan. Although these latter two alternatives would help maintain high levels of storage in the Occoquan Reservoirs, additional treatment facilities would be required to obtain their full benefit. A further analysis of these alternatives is presented later in this chapter.

As with the non-structural plans, regional coordination agreements would be required, particularly in the case of Potomac River interconnections, as to the timing and magnitude of withdrawals. As stated previously, plans with reversible capability provided more flexibility by taking advantage of available treatment facilities. The maximum impacts generated from any of these plans would be those during construction and those would generally be short-term and affect more significantly the social environment. Social disruption could be reduced by use of existing rights-of-way for interconnection facilities. Minimal recreational benefits would be generated from any of these projects. Taken in aggregate, these plans constituted relatively expensive solutions which varied with each different level of conservation employed.

On the other hand, all of these plans with the exception of Plan 8 could be implemented within the boundaries of the MWA. Raw water interconnections had received planning attention by the FCWA and the WSSC.

Proposed Utilities Plans (Reservoirs, Reregulation, Conservation)

Plan 10 - Raise Occoquan Reservoir five feet, Little Seneca Lake, FCWA and WSSC Reregulation, Baseline Conservation

Plan 11 - Raise Occoquan Reservoir five feet, Little Seneca Lake, FCWA and WSSC Reregulation, Conservation Scenario #1

Plan 12 - Raise Occoquan Reservoir five feet, Little Seneca Lake, FCWA and WSSC Reregulation, Conservation Scenario #3

The proposed utilities plans were basically reservoir and reregulation plans with varying levels of conservation. They employed local reservoir projects which had received active planning consideration by local water suppliers, including raising the level of the Occoquan Reservoir by five feet and the construction of Little Seneca Lake.

These plans provided the benefits of increasing local storage on both sides of the river, thus enabling the water suppliers to be better prepared to meet both long-range and peak demand shortages. The reregulation components added the benefits of more efficient use of existing supplies by balancing withdrawals from both the Potomac River and the reservoir sources. The distinguishing variable among these utilities plans was a different level of conservation representing variations in water use reduction that could be achieved.

Construction of Little Seneca Lake would provide a facility that could be used for flood control, sediment control, and aquatic and non-aquatic recreation as well as water supply. The structure would also protect the downstream channel from erosion. At the same time, however, permanent flooding of over 450 acres would destroy valuable agriculture, forest, and floodplain habitats. Impacts associated with raising the Occoquan level by five feet would be significantly less as it would inundate land presently within the flooding limits of the existing reservoir.

Similar environmental impacts would be generated from the reregulation and conservation components of the Utilities Plans as discussed previously for the Non-Structural Plans. As a group, the utilities plans would be less expensive than the structural plans, but more expensive than the non-structural plans.

Other Plan Combinations

Plan 13 - Potomac to Patuxent Raw Water Interconnections, FCWA Reregulation, Baseline Conservation

Plan 14 - Potomac to Patuxent Raw Water Interconnections, FCWA Reregulation, Conservation Scenario #1

Plan 15 - Potomac to Patuxent Raw Water Interconnections, FCWA Reregulation, Conservation Scenario #3

Plan 16 - An Occoquan Raw Water Interconnection, Little Seneca Lake, WSSC Reregulation, Baseline Conservation

Plan 17 - An Occoquan Raw Water Interconnection, Little Seneca Lake, WSSC Reregulation, Conservation Scenario #1

Plan 18 - An Occoquan Raw Water Interconnection, Little Seneca Lake, WSSC Reregulation, Conservation Scenario #3

Plans 13 through 18 combined the different components of the Sturctural, Non-Structural, and Utilities Plans to meet shortages on both sides of the River. A conservation scenario was applied to each of the six plans to enable a comparison at various demand levels. These plans also provided for the evaluation of either raw water interconnections, local storage, and reregulation as they were employed separately in either the FCWA or WSSC service area. Because these plans were aggregated from the components represented in other plans, they share some of the benefits and problems associated with each. Furthermore, where reregulation or raw water interconnections were used, some type of regional agreement would be needed to ensure an ample supply of water in the Potomac River for all users.

Of the six plan combinations, Plans 16 through 18 would create different enviornmental impacts by virtue of the construction of Little Seneca Lake and the Occoquan interconnection. The impacts associated with these projects were described in previous sections. The non-structural elements of these plans would have minimal impacts, both enviornmentally and socially.

## PUBLIC INVOLVEMENT

The purpose of the public involvement program in this iteration was to provide for opportunities for public input in the inital formulation of plans. These inputs proved invaluable to the study effort. It was through these exchanges of information and perspectives between Corps staff and the public, particularly the local water suppliers, that issues for the formulation process were raised and discussed, and critical key decisions were made.

In December of 1978, a fifth Water Forum Note was mailed to the public to present the series of 18 plans addressing the water supply problem. This Water Forum Note built upon the previous four Water Forum Notes dealing with each of the individual study components.

In January 1979, three public workshops and a public meeting were held to appraise the public on the progress of the study and gain their inputs. Discussion on the individual components and the first set of plans took place. During the public meeting, presentations were made by the Metropolitan Washington Board of Trade; and by the League of Women Voters. Both groups supported the Corps efforts but did not endorse any plan at that time.

During the period January through March 1979, the Corps also made presentations to the area's major water suppliers and to other agencies for their evaluation of the water supply plan. In particular, the session with representatives of the FCWA, WAD and WSSC in January 1979 provided important technical inputs and recommendations regarding these plans. These inputs provided the Corps with a better appreciation of the nature of the water supply problem and local preferences regarding approaches towards solutions. As a result, the Corps was able to focus further efforts based largely on the following recommendations.

1. That the water suppliers could use reregulation to manage storage in their reservoirs so that storage would be conserved on a long-term (more than 30 days) basis, and the reservoirs would be kept as full as possible.

2. That the facilities should be designed to meet peak shortages in the Potomac service areas of 7 or 1-day durations, assuming there is sufficient water in the local reservoirs.

3. That cost savings attributable to size reductions in pipelines as a result of the conservation programs should be displayed.

4. That the Fairfax County Water Authority would prefer to see a cost comparison for the three Occoquan interconnection alternatives where the cost of additional treatment and distribution are considered as well.

The direction furnished by these recommendations for the formulation of plans is discussed in the following sections.

## REFINEMENTS, MODIFICATIONS AND DECISIONS

On the basis of the review of the 18 plans through the workshops, public meeting, and water suppliers meetings, certain refinements and modifications were made to both the data and the approach to the water shortage problems before proceeding into the second iteration. The following sections briefly discuss these adjustments which assisted the Corps in narrowing the range of choice to a more manageable number of plans.

### Use of Reregulation for all Further Action Plans

During meetings with the local water suppliers, the Corps presented a reregulation schedule with a set of several operating rules which, when implemented in the FCWA and WSSC, could effectively meet the 30-day needs of the Potomac-based region. The operating rules were designed to shift the demand away from the off-Potomac reservoirs if they were experiencing a rapid drawdown under a 30-day drought situation. The schedule was tested successfully using a 1930-1932 30-day drought simulation.

It was pointed out by members of the WSSC that they did reregulate their system occassionally to better utilize their water resources and could operate in the manner prescribed by the Corps of Engineers. The FCWA could also operate in a similar fashion upon completion of the construction of its Potomac River intake and water treatment plants. Thus, there was generally agreement that the Corps reregulation schedule was feasible and should be a key element in any action plan further developed.

Investigation of Peak Shortages

The most immediate concern to the water suppliers was the ability to satisfy peak shortages of a 7-day or 1-day nature in the Potomac service areas given the fact that the local reservoirs could be operated to have adequate storage available to help satisfy such shortages. These concerns were translated into design criteria which dictated that structural facilities be sized to meet either 7-day or 1-day shortages, depending on the cost and impacts of the project. Along with these design criteria for 7-day and 1-day shortages was the implicit assumption that the reservoir water treatment plants would be operated at the maximum possible rate during low flow conditions, in accordance with the provisions of the Potomac Low Flow Allocation Agreement. The directions for the second iteration then, was to investigate methods of satisfying 7-day and 1-day maximum demands coupled with minimum flows in the Potomac. Because the reservoir water treatment plants were assumed to be producing the maximum amount of water possible, any remaining shortage would have to be satisfied through some type of supply augmentation or demand reduction at the Potomac water treatment plants. As investigated in the next iteration, two structural components (raw water interconnections and Little Seneca Lake) and two non-structural components (Conservation Scenarios 1 and 3) would be available to satisfy the projected shortages along with reregulation in both the FCWA and the WSSC. One additional observation was made for the raw water interconnections: to meet peak demands in the Potomac service areas, water would have to be transferred from the reservoirs to the Potomac water treatment plants to make up the difference in demand not met by the Potomac. This observation again underscored the water suppliers' desire to include reregulation as an initial action in any plan to "save" water in the reservoirs.

FCWA Plans for the Occoquan Reservoir

The FCWA indicated that it had adopted a plan to raise the Occoquan Dam by two feet. As a result, this additional storage capacity would be included as part of the Without Condition for subsequent planning. Since, however, the possibility still existed that the FCWA could raise the dam three more feet for a total of five feet at some future date, this component was investigated further.

Occoquan Interconnection Comparison

In reviewing the 18 plans, the FCWA noted that Plans 5, 8, and 9 were formulated to provide comparison on different means of interconnecting the Occoquan Reservoir. These different means included interconnections from Shenandoah to Broad Run, Potomac River to Cub Run, and Potomac River to the Occoquan Reservoir. In these plans, only one-way pipelines from the river source to the reservoir watershed were investigated for the Shenandoah River to Broad run and Potomac River to Cub Run raw water interconnections. A reversible pipeline was considered for the Potomac-Occoquan raw water interconnection.

The FCWA, however, pointed out that merely providing additional water to the Occoquan Reservoir would not help to meet peak demands, because the system would be constrained by the water treatment plant capacity at the Occoquan WTP. To provide this extra treatment capacity, it would be necessary either to provide additional facilites at the Occoquan WTP or pump water from the Occoquan Reservoir to the Potomac WTP (which would have excess capacity when Potomac flows are low).

Consequently, the Corps undertook a short analysis to determine the most cost-effective system of raw water interconnections and water treatment plants within the FCWA service area. Five different alternatives were investigated as described in Annex E-1, using different combinations of FCWA raw water interconnections and treatment plant additions or expansions. For a number of reasons, the conclusion of this analysis was that a reversible pipeline between the Potomac and the Occoquan Reservoir would add the most flexibility to the FCWA system in meeting peak shortages on the Potomac River. Thus, only the reversible Potomac-Occoquan pipeline was retained for further investigation in the next iteration.

## EARLY ACTION PLAN FORMULATION - ITERATION II

At the end of Iteration I, the MWA water suppliers made recommendations regarding the 18 water supply plans which had thus far been developed. On the basis of their guidance plus further in-house evaluation efforts, the 18 plans were screened and reformulated for further consideration in this second iteration.

The following planning tasks guided the work efforts during this iteration:

1. Plans that could meet the 7-day peak demand needs would be formulated.

2. The plans would be formulated and designed to meet the needs of those service areas with a major dependency on the Potomac River. These included the FCWA, City of Rockville, WAD, and the WSSC.

3. A sensitivity analysis of duration, frequency, and conservation would be conducted to determine the effects of these variables on the staging, sizing, and cost for implementation.

## ASSUMPTIONS

As the early-action plan formulation phase progressed into the second iteration, several assumptions were made for continued planning purposes. These assumptions were as follows:

- Use of 1/100 drought frequency.

- Baseline Conservation assumed for all plans.

- 100 mgd flowby to the Potomac Estuary.

- 135 mgd supplied by Bloomington Lake for August (as per NEWS Study)

- Little Seneca Lake could provide up to 120 mgd on a 7-day basis.

- Each raw water pipeline was assumed to provide up to 180 mgd (96 inch pipe).

- Sufficient regional cooperation would exist to permit the successful implementation and operation of these plans.

- Reregulation in both the FCWA and WSSC service areas would be integrated as a first action in any water supply plan.

## PLAN DESCRIPTION

Recognizing that the problems of implementation and local cooperation might pose a constraint for effectively carrying out the potential water supply plans, two groups of plans were developed in this planning iteration; sub-regional plans and regional plans. Subregional plans were those which could be implemented within individual service areas (with provisions for the WAD) to meet individual needs. Regional plans were developed, both in design and in operation, to meet the needs of all of the service areas with a major dependency on the flows in the Potomac River. These plans would require far greater cooperation among the area's users than the subregional plans. Using these two general approaches, the Corps was able to compare the implications in terms of desirability from an economics, environmental, and implementations standpoint.

Nine plans were formulated in Iteration II, the Without Condition Plan and eight action Plans as listed in Table B-18. Each of the Action Plans contained components to supplement flows in the Potomac River to prevent peak shortages. The structural components available to achieve this included the following:

1. A reversible Potomac to Patuxent (Rocky Gorge Reservoir) interconnection.
2. A reversible Potomac to Occoquan Reservoir raw water interconnection.
3. Little Seneca Lake.

Both the subregional and regional plans were developed in such a way so that the needs of the WAD, which has no storage of its own and relies entirely on the natural flows of the Potomac River, would be met through the actions of the other Potomac based service areas. The subregional plans, therefore, contained components which provided water to meet the needs of individual service areas plus an equal share of the supply required to meet the needs of the WAD. The regional plans were all designed to allow enough flow in the Potomac River for the projected needs of the Aqueduct.

The timing or staging of projects also provided a means of comparison of the subregional and regional plans. In general, the subregional plans which were developed required the construction of projects on both the Virginia and Maryland side of the river early in the planning period, whereas components of the regional plan were staged so that only one construction project would be impacting the region at a given time.

### Without Condition

As discussed earlier, the Without Condition Plan represented the water supply condition that would exist in the absence of any future water supply plans other than those already scheduled for implementation. The Without Condition was redefined for further consideration based on the water suppliers request that the water supply plans be investigated to meet peak 7-day duration shortages.

As a first step to calculating peak shortages, the supplies which could be reasonably expectec from the reservoirs were determined. For both the Occoquan and the Patuxent Reservoirs, the peak possible supplies were a function of water treatment plant capacities well in excess of the rated safe yield of the reservoirs (this created an additional incentive for the suppliers to use reregulation to maintain a fuller reservoir).

## TABLE B-18

## LIST OF EARLY-ACTION PLANS: ITERATION II

I. Without Condition

Subregional

II. 1. Reregulation
2. Potomac-Patuxent RWI** (WSSC & WAD)
3. Potomac-Occoquan RWI (FCWA & WAD)

III. 1. Reregulation
2. SCS Site 3 (WSSC & WAD)
3. Potomac-Patuxent RWI (WSSC & WAD)
4. Potomac-Occoquan RWI

Regional

IV. 1. Reregulation
2. Little Seneca Lake
3. Potomac-Patuxent RWI

V. 1. Reregulation
2. Little Seneca Lake
3. Potomac-Occoquan RWI

VI. 1. Reregulation
2. Potomac-Occoquan RWI
3. Little Seneca Lake

VII. 1. Reregulation
2. Potomac-Occoquan RWI
3. Little Seneca Lake

VIII. 1. Reregulation
2. Potomac-Patuxent RWI
3. Potomac-Occoquan RWI

IX. 1. Reregulation
2. Potomac-Occoquan RWI
3. Potomac-Patuxent RWI

* Parenthesis indicates only those service areas which benifit from a particular component.

** Raw Water Interconnection

Knowing the magnitude of demands to be satisfied from the reservoirs, the remainder of the demands were placed on the Potomac River. Shortages occurred when minimum 7-day flows (or 1-day flow) in the Potomac were unable to satisfy peak 7-day (or 1-day) August demands in the benchmark years. The provisions of the LFAA were also worked into these figures. Shortages were thus calculated for the four service areas individually, and for the four areas combined.

Figure B-17 represents the projected shortages that could be experienced regionally and within the major service areas. These Potomac shortages provided the target or baseline from which to stage and size components for the "action" plans.

Subregional Plans

The subregional plans were designed whereby the FCWA would act to solve its own shortages (and a share of the WAD's shortage) and the WSSC would act to solve its shortage (and a share of WAD's shortage). This approach required that additional facilities be constructed on both sides of the river early in the planning period. The FCWA and WSSC systems would be largely independent of each other, but the WAD would be dependent on the actions of both.

Plan II represented a subregional approach to the water supply problem using raw water interconnections on both sides of the Potomac as well as reregulation implemented in both the FCWA and the WSSC. To meet the projected shortages on the Maryland side, a 170 mgd pipeline (about 90 inches in diameter) between the Potomac River and the Rocky Gorge Reservoir, via the Potomac and Patuxent Water Filtration Plants, would be required. This pipeline would have reversible capability so that during high Potomac flows water could be pumped directly to the Patuxent Filtration Plant from the Potomac River and thus relieve demands on the Patuxent storage reservoirs. The determining factor in sizing the pipeline, however, was the return flow from the Patuxent Reservoir to the Potomac WTP required to meet the maximum 7-day shortage caused by low flows in the Potomac.

On the Virginia side of the Potomac River, a slightly smaller shortage was anticipated in 2030 which would require a 120 mgd pipeline. This pipeline would have reversible capabilities, and could connect both the Occoquan Reservoir and Potomac River via the FCWA Potomac Water Treatment Plant near Herndon, Virginia, and the FCWA Occoquan WTP near the reservoir. The pipeline would operate in a similar fashion to the WSSC interconnection. During high Potomac River flows, water could be pumped directly to the Occoquan WTP, thus reducing withdrawals maintaining higher levels in the Occoquan Reservoir.

Plan III offered a second subregional approach using Little Seneca Lake as the initial component to provide 120 mgd to meet the projected needs of the WSSC and part of WAD. This project would be followed by construction of a 50 mgd reversible interconnection between the Potomac and the Patuxent in the year 2016 to carry the areas to the year 2030. As with this Plan II, a 120 mgd Potomac-Occoquan reversible interconnection was used to meet the FCWA water supply requirements. Reregulation would be implemented in both the FCWA and the WSSC.

## SURPLUS/DEFICIT CURVE FOR THE REGION AND THE MAJOR POTOMAC SERVICE AREAS — THE WITHOUT CONDITION

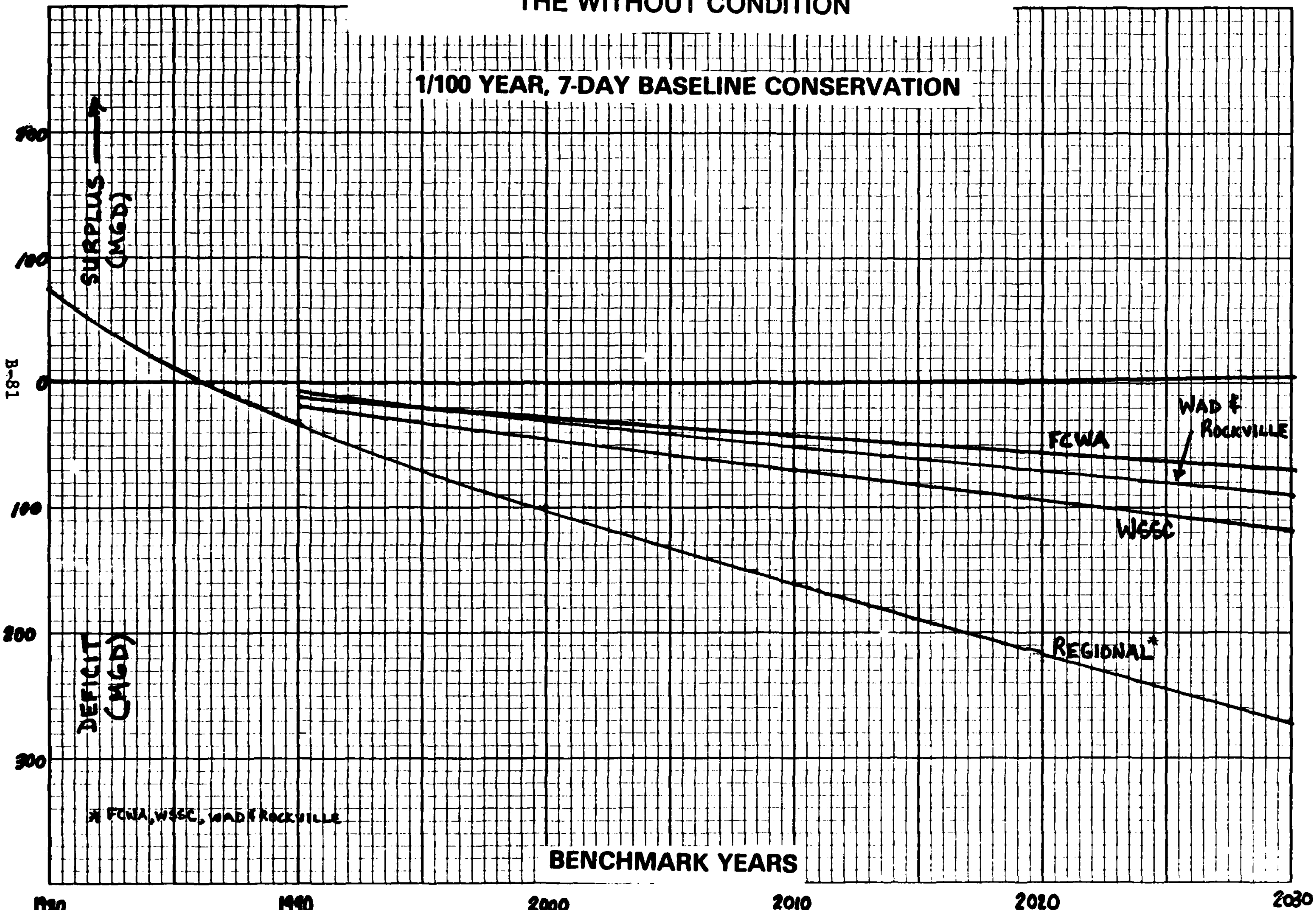



FIGURE B-17

Regional Plans

The regional water supply solutions listed as Plans IV through IX represented approaches whereby individual projects would be used to satisfy the entire Potomac service area shortages as long as possible. The regional approach would result in a staging of projects throughout the planning period rather than intensive capital improvements at the beginning of the planning period as in the subregional plans. For example, if the Little Seneca Lake were the first project to be constructed for the region, its storage could be shared among all Potomac users, requiring the construction of only one project at the beginning of the planning period. Reregulation was a basic component of all of the regional plans. Each of the six regional action plans represented a different combination and order of implementation of the three major water supply components - Little Seneca Lake, Potomac-Occoquan raw water interconnection, and Potomac-Patuxent raw water interconnection. A variety of combinations and sequences of components within a plan was sought to facilitate a comparison of staging and costs which will be shown in detail in a later section of this chapter.

Plan IV proposed the construction of two projects on the Maryland side of the Potomac River to satisfy the entire Potomac-based shortages for the region. In this plan, a Virginia water supply component was not needed. The Little Seneca Lake would satisfy the regional needs until the year 2003 at which time a reversible Potomac-Patuxent raw water interconnection would provide the mechanism for supplying the remaining need of 160 mgd through the year 2030. This regional plan, as well as each of the subsequent action plans, included reregulation as the initial component for the WSSC and FCWA. Total Potomac service area reliance on the Maryland based projects benefited users other than the WSSC in two ways. The first was that Potomac River flows could be directly augmented during peak demand condition through controlled releases from the Little Seneca Lake. This mechanism would provide more river flow for the WAD, WSSC, and FCWA. A second was the decreased reliance of the WSSC on the Potomac River through operation of the Potomac-Patuxent raw water interconnection. Operation of this project would make more Potomac water available for withdrawal by the other users of the river.

Plan V differed from Plan IV in that it substituted the Potomac-Occoquan raw water interconnection for the Potomac-Patuxent raw water interconnection as the second stage component. This plan would provide an alternative to Plan IV and would include projects on both sides of the Potomac River. The Little Seneca Lake and the Potomac-Occoquan raw water interconnection would be implemented in 1986 and 2003, respectively.

The plan differed from Plan IV in that it would decrease the reliance of the FCWA service area on the Potomac River during peak demand periods by using the water made available to its Potomac Water Treatment Plant via the Occoquan Reservoir raw water interconnection. On the Maryland side, the WSSC would withdraw additional supplies from the Potomac River made available through decreased FCWA Potomac withdrawls, in conjunction with augmented flows from the Little Seneca Lake. In either instance, sufficent water would be retained in the Potomac River for the WAD and the City of Rockville.

The components of Plan VI were identical to Plan IV with the exception of the ordering of implementation. In this plan, the raw water interconnection between the Potomac River and the Patuxent would be the first project initiated. As such, it would provide supplies slightly further into the planning period (2010) at which time the Little Seneca Lake would be required.

Plan VII was the fourth of the reservoir/raw water interconnection regional plans. Its components would be the same as those in Plan V; however, the Potomac-Occoquan raw water interconnection would be substituted as the initial project for implementation. In the year 2010, the Little Seneca Lake would be constructed to provide the needed supplies for the remainder of the planning period.

Plan VIII represented a feasible 7-day alternative plan by using only raw water interconnections on both sides of the Potomac River. This plan, as well as Plan IX, represented a departure from the regional reservoir/raw water interconnection plans previously described. In Plan VIII, withdrawals from the Potomac River, Occoquan Reservoir, and Patuxent Reservoir would be balanced in such a way to meet the Potomac-based needs through the entire planning period. Operational dates required for each of the interconnections would be 1986 and 2010, respectively.

Plan IX reversed the order of implementation of the components in Plan VIII. This variation permitted a comparison of variable costs associated with the order of implementation. It would provide an alternative to Plan VIII if an interconnection should be easier to implement on one side of the river as opposed to the other.

## COST COMPARISON

Table B-19 provides a summary comparison of the sizing, staging, and preliminary costs of the subregional and regional plans under consideration. This information provided a useful basis for comparison of the costs of plans that could be achieved from staging.

The first year of operation for each component was determined. Reregulation was assumed operational and implementable by 1980. Both first costs and present worth costs were presented in millions of dollars at December 1978 price levels, using the Federal discount rate of 6-7/8 percent and a base planning year of 1980. The cost for each component as well as the cost for the entire plans are given. Operation and maintenance costs were not shown included. All plans in Table B-19 were sized to meet 7-day duration shortages, 1/100 year recurrence intervals, with Baseline Conservation.

Valuable conclusions were drawn from this preliminary cost evaluation. These were summarized as follows:

1. In general, the regional plans were more cost effective than the subregional plans. The sizing and phasing of components of plans to meet the regional 1/100, 7-day shortages was cheaper than implementing separate projects to meet the needs of independent service areas.

2. Regional Plan IV was the lowest cost plan among all of the action plans on a present worth basis and a first-cost basis.

3. A regional plan with Little Seneca Lake as a first project were less expensive than regional plans with a pipeline as a first project.

4. The second project required for implementation for all regional plans would not be needed until after the year 2000. In both subregional plans, projects would be required on both sides of the river as early as 1986.

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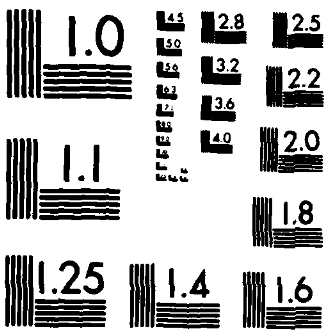



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE B-19

COST COMPARISON OF PLANS*
ITERATION II

| PLAN | COMPONENT | SIZE (mgd) | OPERATION DATE | FIRST COST** ($ mil) | PRESENT WORTH** ($ mil) |
|---|---|---|---|---|---|
| I | Without | | | | |
| II | Patuxent-Potomac RWI | 170 | 1986 | 94.3 | 63.2 |
| | Occoquan-Potomac RWI | 120 | 1986 | 96.5 | 64.8 |
| | | | | 190.8 | 128.0 |
| III | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Occoquan-Potomac RWI | 120 | 1986 | 96.5 | 64.8 |
| | Patuxent-Potomac RWI | 50 | 2016 | 47.0 | 4.3 |
| | | | | 163.7 | 82.7 |
| IV | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Patuxent-Potomac RWI | 160 | 2003 | 92.7 | 20.1 |
| | | | | 112.9 | 33.7 |
| V | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Occoquan-Potomac RWI | 160 | 2003 | 114.5 | 24.8 |
| | | | | 134.7 | 38.4 |
| VI | Patuxent-Potomac RWI | 160 | 1986 | 92.7 | 62.2 |
| | Little Seneca Lake | 120 | 2010 | 20.2 | 2.7 |
| | | | | 112.9 | 64.9 |
| VII | Occoquan-Potomac RWI | 160 | 1986 | 114.5 | 76.8 |
| | Little Seneca Lake | 120 | 2010 | 20.2 | 2.7 |
| | | | | 134.7 | 79.5 |
| VIII | Patuxent-Potomac RWI | 160 | 1986 | 92.7 | 62.2 |
| | Occoquan-Potomac RWI | 120 | 2010 | 96.6 | 13.1 |
| | | | | 189.3 | 75.3 |
| IX | Occoquan-Potomac RWI | 160 | 1986 | 114.5 | 76.8 |
| | Patuxent-Potomac RWI | 120 | 2010 | 78.2 | 10.6 |
| | | | | 192.7 | 87.4 |

* Only projects that required construction are shown. Reregulation was the first component for each plan; no costs were assumed. Also assumed 7-day duration, Baseline Conservation, 1/100 year frequency for August.

** December 1978 price levels, 6-7/8 percent Federal discount rate, 1980 base year for planning.

## IMPACT ASSESSMENT

The "action" plans were comprised of a combination of three structural components including either the Potomac-Patuxent raw water interconnection, the Potomac-Occoquan raw water interconnection, or the Little Seneca Lake, and the non-structural components of conservation and reregulation. The major benefit associated with these plans as compared to the Without Condition was the elimination of projected 7-day shortages on the Potomac River through the year 2030. Decreased reliance on the natural flow of the Potomac River as a major source of withdrawal during this period would be achieved in basically two ways. Firstly, uniform reduction in water use could be attained by implementation of different conservation scenarios. In addition, operation of raw water interconnections on either or both sides of the river would result in increased reliance during critical periods on the water stored in offstream reservoirs as opposed to the Potomac River. Thus, a more efficient utilization of the existing water resource would be possible through implementation of any of the action plans, and therefore avert the potential adverse impacts on economic and social activities that would otherwise be present.

In addition to the elimination of peak shortages, other impacts would be incurred during the construction of the structural projects. These impacts included those associated with pipeline projects (Potomac to Occoquan and Potomac to Patuxent) and those associated with Little Seneca Lake. A tabulation of these impacts is represented in Table B-20.

Because of the linear nature of the raw water interconnections and because they would be buried underground for the most part, their major impacts would be temporary and restricted to the period of their construction. Potential detrimental environmental impacts could occur should withdrawals occur which rapidly deplete reservoir storage.

Generally, major portions of both of the interconnections under consideration would be located in areas of relative low density development and higher wildlife values relative to the urban core of the MWA. None of the areas impacted, however, possessed unique value, and in most cases there would be enough of a given type of habitat in any one area that relocation, at least by mobile organisms, could be expected.

The most significant impact associated with the construction of pipeline projects would be anticipated in habitats associated with streams and adjacent floodplains. Where alteration of riparian and bottom land vegetation through trenching occurs, habitat losses would be greatest. Impacts associated with streams and floodplains, however, could be kept temporary in nature if the proper precautions, such as strict erosion and sedimentation controls, were employed.

Impacts on agricultural and woodland habitats were considered minor, particularly in the former case where impacts would be temporary and where over time habitats could recover to the pre-pipeline condition. In wooded areas, this condition would be pre-empted by the overriding need for right-of-way access. Woodland areas would, therefore, require more permanent relocation of terrestrial species.

Neither critical wildlife habitats nor threatened or endangered species would be affected by either pipeline configuration.

TABLE B-20

IMPACT ASSESSMENT OF PLANS, ITERATION II

| | NO ACTION | SUBREGIONAL | | REGIONAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX |
| | | Pot-Pat RWI<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Occ RWI<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Occ RWI | Pot-Pat RWI<br>Little Seneca Res | Pot-Occ RWI<br>Pot-Occ RWI<br>Little Seneca Res | Pot-Pat RWI<br>Pot-Occ RWI | Pot-Pat RWI<br>Pot-Occ RWI |
| **ECOLOGICAL** | | | | | | | | | |
| Total Miles of Pipeline | | 52.1 | 52.1 | 22.7 | 29.4 | 22.7 | 29.4 | 52.1 | 52.1 |
| No. of 100-year Flood Plain Crossing | | 19 | 19 | 10 | 9 | 10 | 9 | 19 | 19 |
| No. of Stream Crossing | | 58 | 58 | 18 | 40 | 18 | 40 | 58 | 58 |
| Total Miles Along Stream Valleys | | 6 | 6 | 2 | 4 | 2 | 4 | 6 | 6 |
| Miles of Stream Valley Inundated* | | N/A | 8 | 8 | 8 | 8 | 8 | N/A | N/A |
| Potential for Critical Wildlife Habitat Affected | | | | | | | | | |
| Interconnections | | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE |
| Storage | | N/A | SIGNIFICANT | SIGNIFICANT | SIGNIFICANT | SIGNIFICANT | SIGNIFICANT | N/A | N/A |
| Effect on Threatened or Endangered Species | | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE |
| Miles Through or Adjacent to Farmland | | 24 | 24 | 14 | 10 | 14 | 10 | 24 | 24 |
| Acres of Farmland Inundated* | | N/A | 280 | 280 | 280 | 280 | 280 | N/A | N/A |
| Miles Through or Adjacent to Forested Areas | | 31 | 31 | 14 | 17 | 14 | 17 | 31 | 31 |

TABLE B-20 (Cont'd)

IMPACT ASSESSMENT OF PLANS, ITERATION II

| | NO ACTION | SUBREGIONAL | | REGIONAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX |
| | | Pot-Pat RWI Pot-Pat RWI | Little Seneca Res Pot-Occ RWI Pot-Pat RWI | Little Seneca Res Pot-Pat RWI | Little Seneca Res Pot-Occ RWI | Pot-Pat RWI Little Seneca Res | Pot-Occ RWI Little Seneca Res | Pot-Pat RWI Pot-Occ RWI | Pot-Pat RWI Pot-Occ RWI |
| Acres of Forested Areas Inundated | | N/A | 235 | 235 | 235 | 235 | 235 | N/A | N/A |
| SOCIAL | | | | | | | | | |
| Existing Significant Mineral States Affected | | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE |
| Miles Along Existing Transportation Routes | | | | | | | | | |
| Dual | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Primary | | 3 | 3 | 3 | 0 | 3 | 0 | 3 | 3 |
| Secondary | | 8.1 | 8.1 | 0 | 8.1 | 0 | 8.1 | 8.1 | 8.1 |
| Other | | 3.8 | 3.8 | 1.4 | 2.4 | 1.4 | 2.4 | 3.8 | 3.8 |
| Number of Major Roadway Intersections | | | | | | | | | |
| Dual | | 12 | 12 | 7 | 5 | 7 | 5 | 12 | 12 |
| Primary | | 5 | 5 | 5 | 0 | 5 | 0 | 5 | 5 |
| Secondary | | 26 | 26 | 11 | 15 | 11 | 15 | 26 | 26 |
| Intersections with Railroad Right-of-Way | | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| Number of Road Relocations* | | N/A | 1 | 1 | 1 | 1 | 1 | N/A | N/A |
| Number of Railroad Relocations* | | N/A | 0 | 0 | 0 | 0 | 0 | N/A | N/A |

TABLE B-20 (Cont'd)

IMPACT ASSESSMENT OF PLANS, ITERATION II

| | NO ACTION | SUBREGIONAL | | REGIONAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX |
| | | Pot-Pat RWI<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Occ RWI<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Pat RWI | Little Seneca Res<br>Pot-Occ RWI | Pot-Pat RWI<br>Little Seneca Res | Pot-Occ RWI<br>Little Seneca Res | Pot-Pat RWI<br>Pot-Occ RWI | Pot-Pat RWI<br>Pot-Occ RWI |
| Miles Along Existing Utilities | | | | | | | | | |
| Gas | | 13.3 | 13.3 | 2 | 11.3 | 2 | 11.3 | 13.3 | 13.3 |
| Electric | | 14.3 | 14.3 | 4 | 10.3 | 4 | 10.3 | 14.3 | 14.3 |
| Number of Utility Intersections | | | | | | | | | |
| Gas | | 8 | 8 | 2 | 6 | 2 | 6 | 8 | 8 |
| Electric | | 8 | 8 | 3 | 5 | 3 | 5 | 8 | 8 |
| Number of Utility Relocations* | | N/A | 5 | 5 | 5 | 5 | 5 | N/A | N/A |
| Number of Known Cultural Resource Areas Affected | | 4 | 4 | 2 | 9 | 2 | 9 | 4 | 4 |
| Potential for Cultural Resource Areas Affected | | HIGH | HIGH | HIGH | HIGH | HIGH | HIGH | HIGH | HIGH |
| Miles Through or Adjacent to | | | | | | | | | |
| Agricultural Land | | 24 | 24 | 14 | 10 | 14 | 10 | 24 | 24 |
| Forest Land | | 31 | 31 | 14 | 17 | 14 | 17 | 31 | 31 |
| Commercial/Industrial | | 2 | 2 | 2 | 0 | 2 | 0 | 2 | 2 |
| Public | | 1 | 1 | .5 | .5 | .5 | .5 | 1 | 1 |
| Acres of Agricultural Land Inundated* | | N/A | 280 | 280 | 280 | 280 | 280 | N/A | N/A |

TABLE B-20 (Cont'd)

IMPACT ASSESSMENT OF PLANS, ITERATION II

| | NO ACTION | SUBREGIONAL | | REGIONAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX |
| | | Pot-Pat RWI Pot-Pat RWI | Little Seneca Res Pot-Occ RWI Pot-Pat RWI | Little Seneca Res Pot-Pat RWI | Little Seneca Res Pot-Occ RWI | Pot-Pat RWI Little Seneca Res | Pot-Occ RWI Little Seneca Res | Pot-Pat RWI Pot-Occ RWI | Pot-Pat RWI Pot-Occ RWI |
| Acres of Forested Land Inundated* | | N/A | 235 | 235 | 235 | 235 | 235 | N/A | N/A |
| Number of Recreational Areas Affected | | 12 | 12 | 7 | 5 | 7 | 5 | 12 | 12 |
| Number of Residences within 500 ft. of right-of-way | | 3760 | 3760 | 3000 | 760 | 3000 | 760 | 3760 | 3760 |
| Number of Property relocations (homes)* | | N/A | 20 | 20 | 20 | 20 | 20 | N/A | N/A |
| Water Surface Acres Created for Recreation* | | N/A | 450 | 450 | 450 | 450 | 450 | N/A | N/A |

*Criteria which are applicable to plans with storage component

The major social impacts would be generated during the construction phase of these projects, although these too would be temporary. The paralleling and intersecting of transportation routes would create short term traffic disruption to the residents and commuters in the areas involved. Where interconnections would be placed wholly or partially within the right-of-way of existing utilities, impacts would be greatly reduced.

Residences may experience, to varying degrees of intensity, the annoyances and disruptions that would accompany pipeline construction. These would include noise, dust, temporary increased vehicular traffic from construction vehicles, and overall temporary aesthetic degradation.

Little long term impacts should be experienced in areas of differing land use. Although almost half (24 miles) of the pipeline projects would be adjacent to or traverse agricultural lands and pasture, much of these lands are devoted to grazing which may continue, subsequent to pipeline construction, in an almost undisturbed state. Existing and potential historical and prehistorical resources may be disturbed or completely destroyed during the trenching phase of pipeline construction.

The development of the Little Seneca Lake project would create greater and longer-lasting impacts in comparison to the interconnection components. In general, the Little Seneca Lake component of Plans III through VII would make these plans less environmentally acceptable than pipeline plans. The principal environmental effect of this reservoir site would be the permanent and intermittent flooding of existing floodplain and terrestrial habitats. Approximately eight miles of riverine and wetland habitats would be permanently lost from the development of this site. Even though no threatened or endangered species or critical habitat areas would be affected, several hundred acres of prime riparian habitat would be destroyed. Attendant adverse effects of sedimentation and erosion would be felt during construction activities; however, these would be minimized with proper erosion control practices.

The major benefits afforded by the Little Seneca Lake which would not exist for the interconnection components is the recreational opportunities created through its 14 miles of new shoreline and 510 acres of water surface area generated by the permanent pool. Those plans which contain Little Seneca Lake as a component would provide additional recreational activities to the region including boating, hiking, picnicking, and water sport activities.

Water conservation and demand reduction was also investigated in Iteration II, primarily through the sensitivity analyses discussed in the next section. Use of higher levels of conservation would reduce the costs for individual projects as it provided for smaller design capacities of structural components. Therefore, considerable cost saving for the public was a primary impact of conservation. In addition, slight improvements to the regional wastewater situation may result by reducing the volume of the projected wastewater flows to the treatment facilities. A detailed comperison of the potability of one source versus another source was not conducted in the early-action phase.

SENSITIVITY ANALYSIS

As a further step, Regional Plan IV was selected as a basis to compare other variables including conservation, duration, and recurrence interval. A separate analysis was also conducted to determine the sensitivity of shortages to various levels of flowby into the Potomac Estuary. These comparisons were useful in determining the preferred sizing of projects to meet different needs and the cost differential associated with them. In addition, it served as a useful tool for reviewing and screening these plans with members of the various review committees.

## Conservation

Three levels of long-term conservation (Baseline, Conservation Scenario 1, and Conservation Scenario 3) were investigated, each of which furnished different percentage reductions in demand. These reductions in demand in turn translated into smaller shortages in the year 2030: 280 mgd shortage with Baseline Conservation, 230 mgd shortage with Conservation Scenario 1, and 180 mgd shortage with Conservation Scenario 3 (see Figure B-18 for comparison of shortages with Plan IV and the three conservation levels).

Table B-21 shows that the cost of each successive conservation program more than offsets the cost of the structural components such as raw water interconnections, by reduction in sizing. As expected, the enactment of conservation reduces overall plan costs as well as enabling structural projects to provide longer service.

TABLE B-21

COST COMPARISON FOR CONSERVATION*
ITERATION II

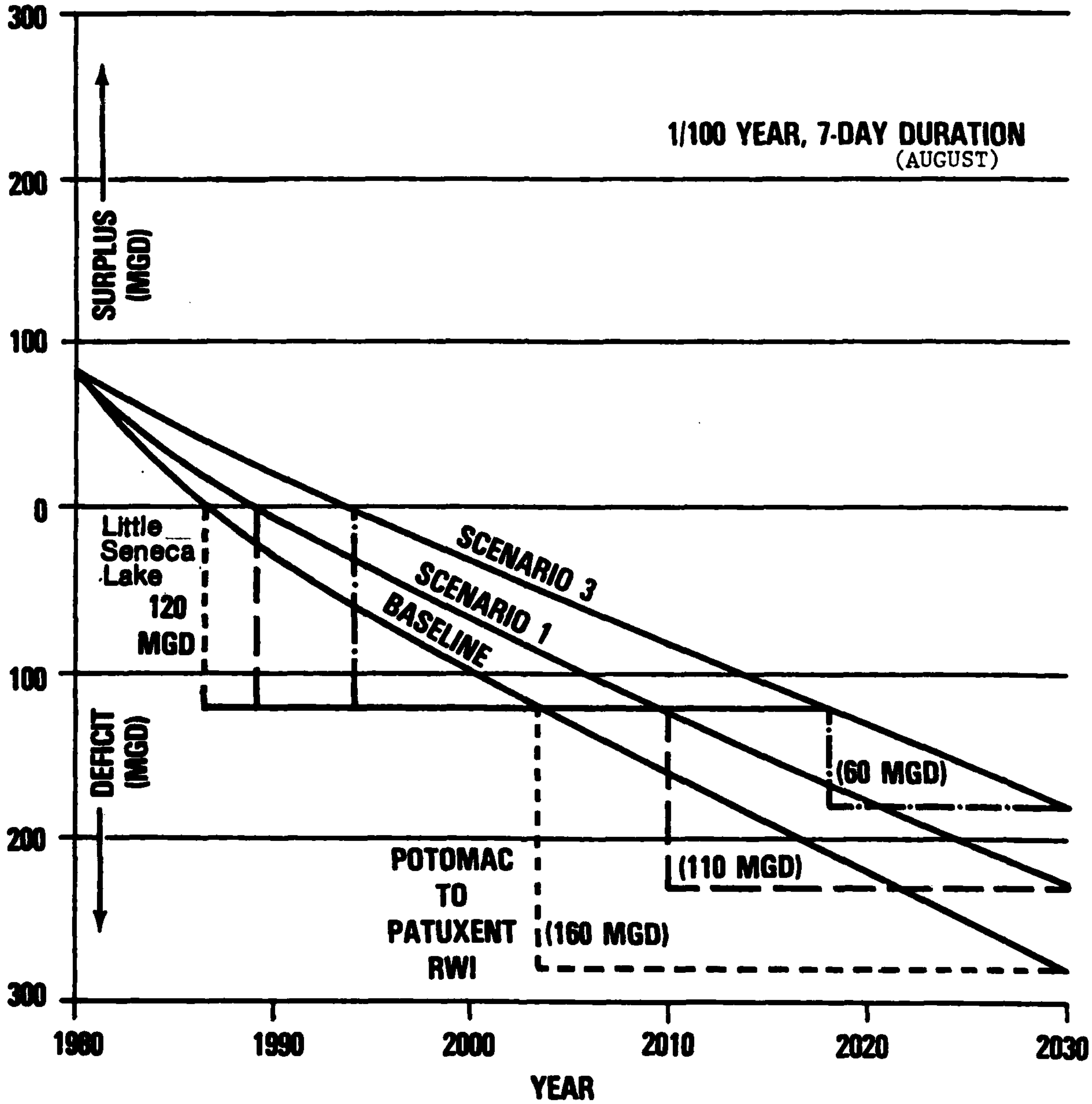
| CONSERVATION SCENARIO | COMPONENTS | FIRST SIZE (mgd) | PRESENT** WORTH OPERATION DATE | COST ($ mil) | 1980 ($ mil) |
|---|---|---|---|---|---|
| Baseline | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Patuxent-Potomac RWI | 160 | 2003 | 92.7 | 20.1 |
| | | | | 112.9 | 33.7 |
| One | Scenario I | | 1980-2030 | 7.6 | 3.3 |
| | Little Seneca Lake | 120 | 1988 | 20.2 | 11.9 |
| | Patuxent-Potomac RWI | 110 | 2010 | 76.2 | 10.4 |
| | | | | 104.0 | 25.6 |
| Three | Scenario III | | 1980-2030 | 9.1 | 3.7 |
| | Little Seneca Lake | 120 | 1994 | 20.2 | 8.0 |
| | Patuxent-Potomac RWI | 60 | 2017 | 54.3 | 4.6 |
| | | | | 83.6 | 16.3 |

* Uses Plan IV as the basis for comparison with 1/100 year risk level, 7-day August supplies and demands, 135 mgd from Bloomington, 100 mgd flowby, 95 mgd from Occoquan Reservoir, and 55 mgd from Patuxent Reservoirs.

** December 1978 price levels, 6-7/8 percent Federal discount rate, 1980 base year for planning.

FIGURE B-18

## PLAN IV CONSERVATION SENSITIVITY



## Duration

The sizing and operation of facilities was found to be directly related to the duration of the shortage to be met. Table B-22 and Figure B-19 present the effects on Plan IV for 30, 7, and 1-day shortages. Results indicated that planning to satisfy 7 and 1-day peak shortages requires larger facilites and hence, higher costs than plans to meet 30-day shortages. The basic question to be answered at this point was what duration of drought would the water utilites and public be willing to accept.

## Frequency of Occurrence

Most water supply facilites are designed to provide an adequate supply given the occurence of a certain critical event, for instance a once in 100-year drought (1 percent chance of occurence). In the Potomac River, the 1930 drought produced monthly average flows with a frequency of occurrence of about once in 100 years. The 1966 drought produced 7-day and 1-day flows with frequency of occurrence of about once in 100 years. As demonstrated in Figure B-20 and Table B-23, designing for more frequent droughts would result in smaller facilities, lower costs, and greater risks of shortage. Designing for less frequent droughts would result in larger facilities, higher costs, and smaller risks of shortages.

## Flowby

At the time of the early-action phase, the State of Maryland was conducting a study to determine an appropriate value of flow into the Potomac Estuary (flowby) for environmental purposes in coordination with the U.S. Fish and Wildlife Service. In the absence of a specific number, or range of numbers, from these agencies until the completion of their study, a 100 mgd value was assumed (as in the NEWS study) in all calculations. This value approximated the flow into the Potomac Estuary during the severe period of the 1966 drought. Figure B-21 demonstrates that increasing the flowby volume by 100 mgd increments for the 100-year, 7-day drought with Baseline Conservation increases the need for supply augmentation to the Potomac River service areas. Both project sizing and cost, particularly for raw water interconnections, would be very sensitive to flowby volume. This issue provided a basis for discussion in further plan formulation as discussed in a later section.

## PUBLIC INVOLVEMENT

The purpose of the public involvement program in this second iteration was to gain public input on the progress and direction of early-action plan for formulation and evaluation. This was accomplished through a series of meetings with representatives of various Federal, state, and local agencies as well as with members of the FISRAC.

The meeting with FISRAC members on 16 February 1979 was of particular importance to the MWA Study as it provided specific recommendations on critical issues that would guide plan formulation in the final iteration of the early-action phase. Prior to this meeting, an information packet was distributed to each of the FISRAC members, to familiarize them with important issues for discussion at the scheduled meeting. These critical issues included:

- flowby levels for planning purposes.

- appropriate conservation levels.

TABLE B-22

COST COMPARISON FOR DURATION*
ITERATION II

| DURATION | COMPONENTS | SIZE (mgd) | OPERATION DATE | FIRST COST ($ mil) | PRESENT** WORTH 1980 ($ mil) |
|---|---|---|---|---|---|
| 30-Day | Little Seneca Lake | 120 | 2005 | 20.2 | 3.8 |
| | Patuxent-Potomac RWI | 20 | 2027 | 32.5 | 1.4 |
| | | | | 52.7 | 5.2 |
| 7-Day | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Patuxent-Potomac RWI | 160 | 2003 | 92.7 | 20.1 |
| | | | | 112.9 | 33.7 |
| 1-Day | Little Seneca Lake | 120 | 1981 | 20.2 | 18.9 |
| | Patuxent-Potomac RWI | 160 | 1995 | 92.7 | 34.2 |
| | Occoquan-Potomac RWI | 70 | 2019 | 58.6 | 4.4 |
| | | | | 171.5 | 57.5 |

* Uses Plan IV as the basis for comparison with Baseline Conservation, 1/100 year risk level, August supplies and demands, 135 mgd from Bloomington, 100 mgd flowby, 95 mgd from Occoquan Reservoir, and 55 mgd from Patuxent Reservoirs.

** December 1978 price levels, 6-7/8 percent Federal discount rate, 1980 base year for planning.

FIGURE B-19

## PLAN IV DURATION SENSITIVITY

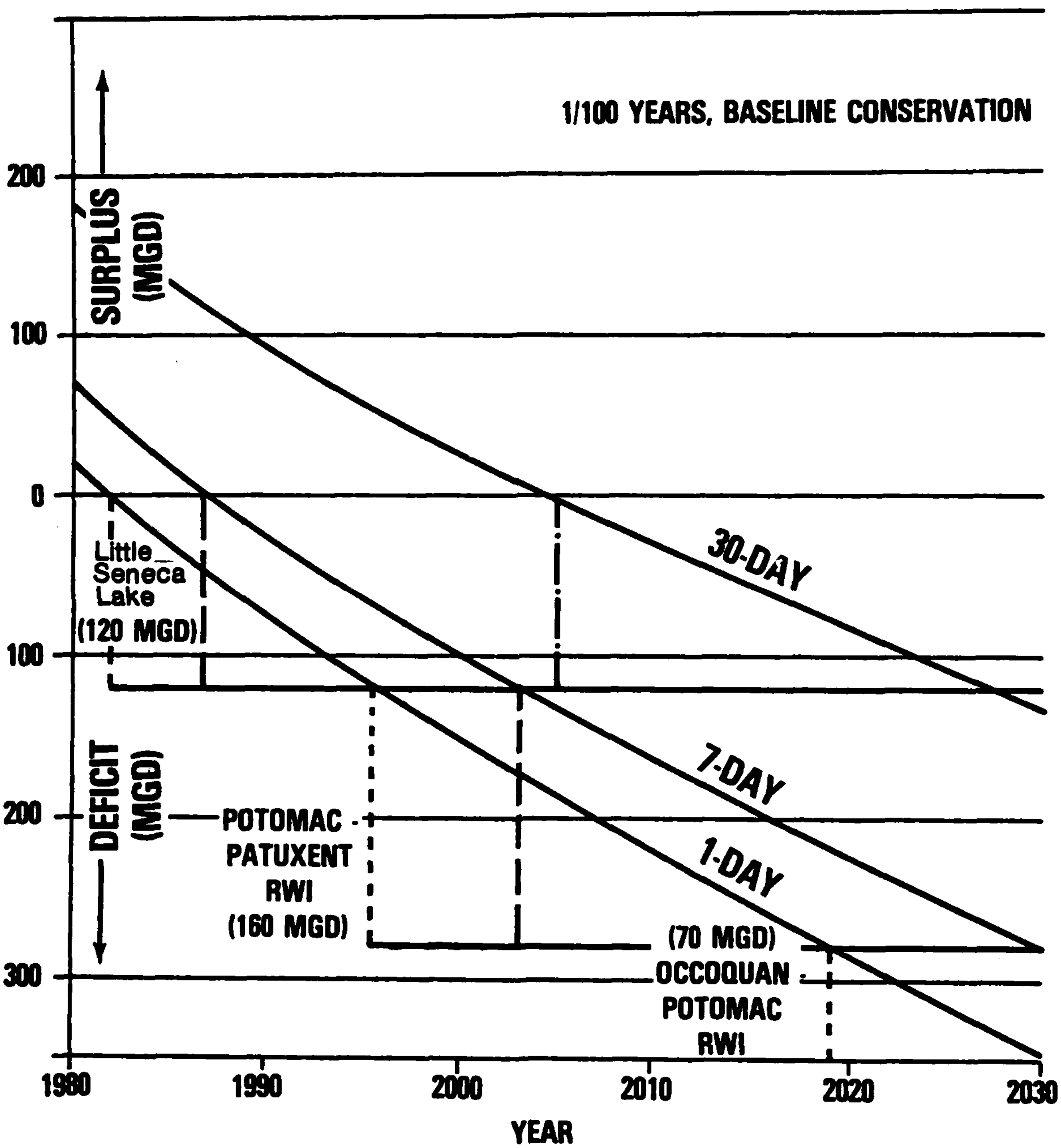


FIGURE B-20

## PLAN IV FREQUENCY SENSITIVITY

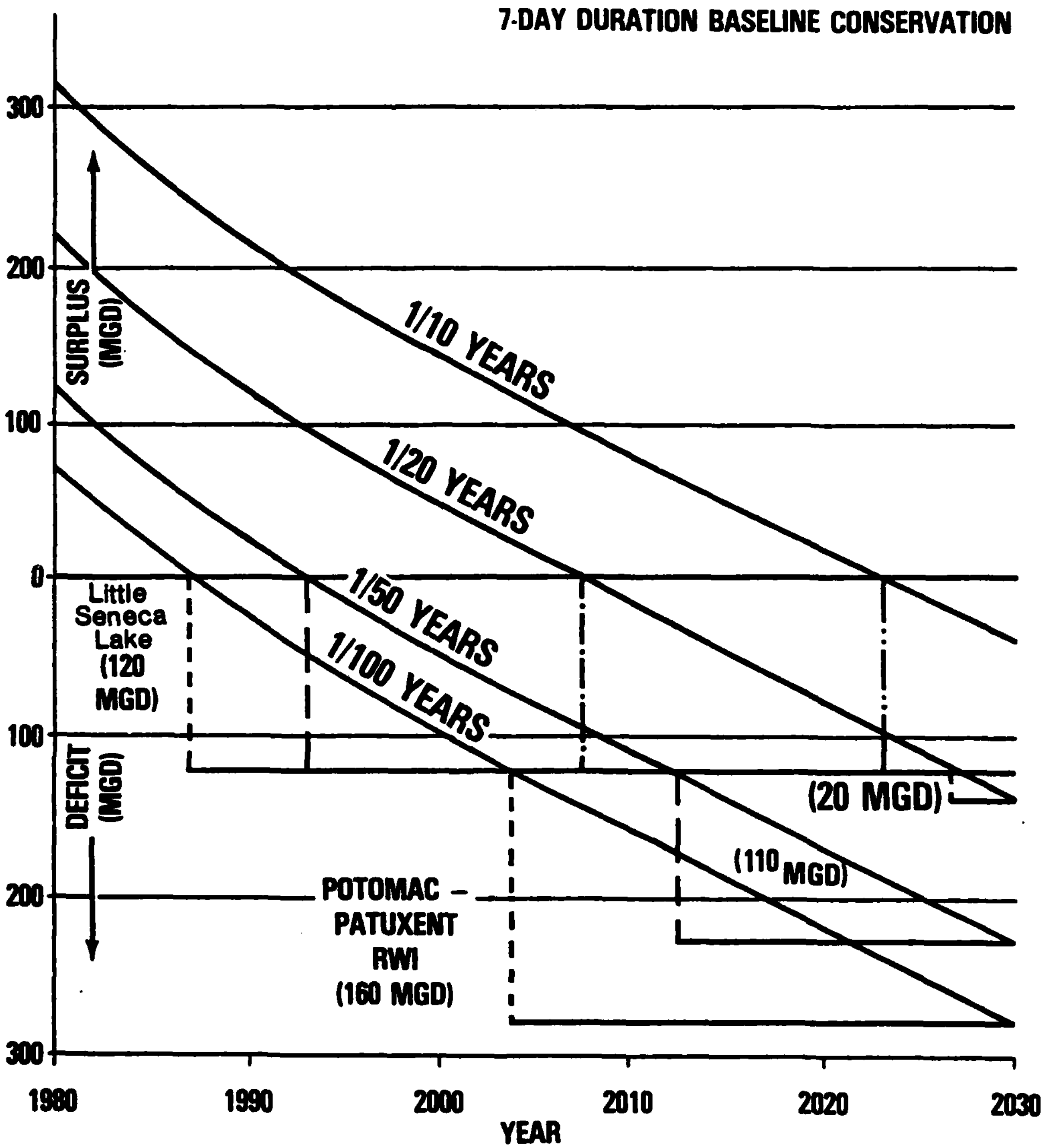


TABLE B-23

COST COMPARISON FOR RECURRENCE INTERVAL*
ITERATION II

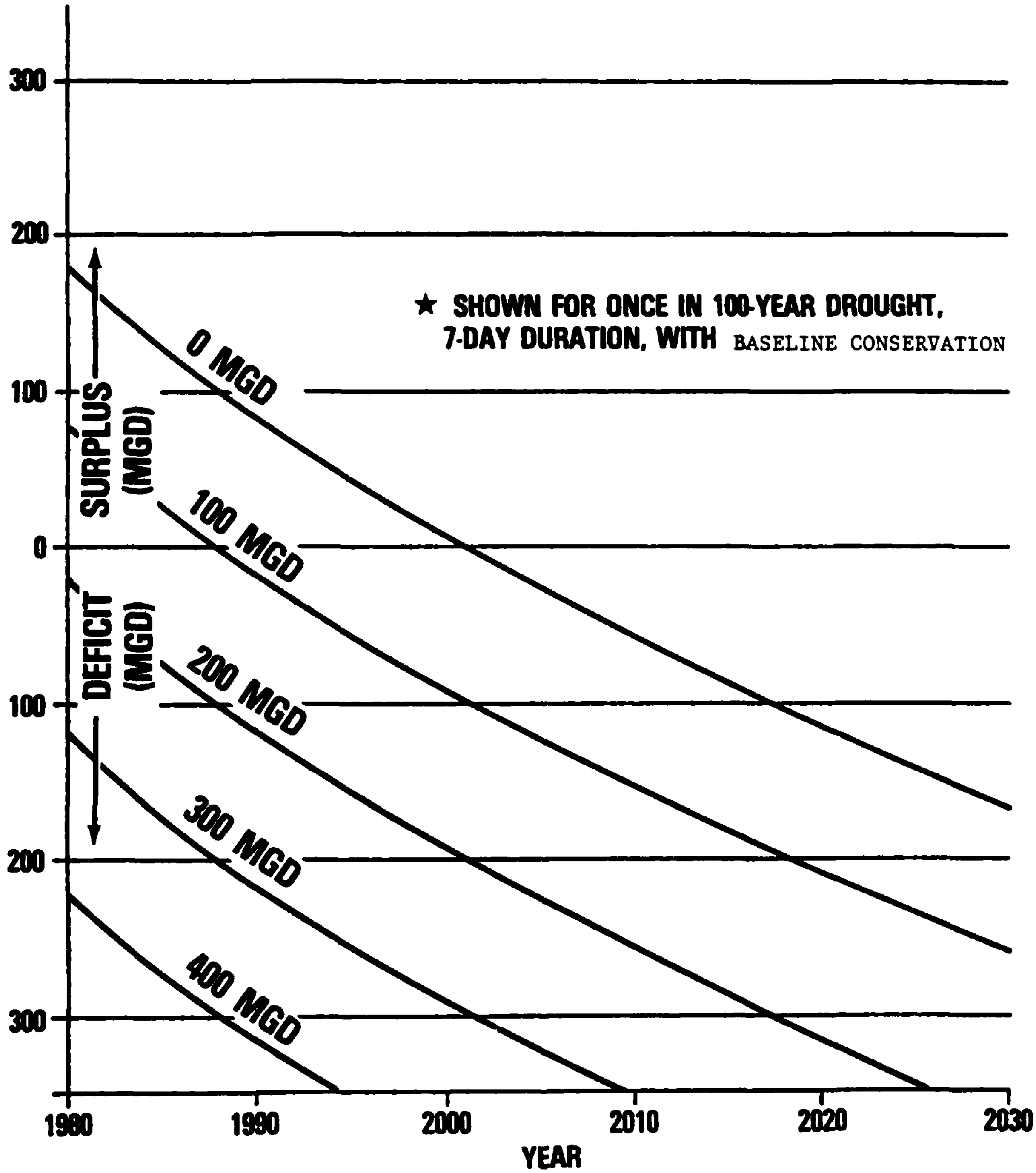
| RISK LEVEL | COMPONENTS | SIZE (mgd) | OPERATION DATE | FIRST COST ($ mil) | PRESENT** WORTH 1980 ($ mil) |
|---|---|---|---|---|---|
| 1/10 | Little Seneca Lake | 120 | 2023 | 20.2 | 1.2 |
| | | | | 20.2 | 1.2 |
| 1/20 | Little Seneca Lake | 120 | 2007 | 20.2 | 3.4 |
| | Patuxent-Potomac RWI | 20 | 2027 | 24.0 | 1.1 |
| | | | | 44.2 | 4.5 |
| 1/50 | Little Seneca Lake | 120 | 1993 | 20.2 | 8.5 |
| | Patuxent-Potomac RWI | 110 | 2012 | 76.2 | 9.1 |
| | | | | 96.4 | 17.6 |
| 1/100 | Little Seneca Lake | 120 | 1986 | 20.2 | 13.6 |
| | Patuxent-Potomac RWI | 160 | 2003 | 92.7 | 20.1 |
| | | | | 112.9 | 33.7 |

* Uses Plan IV as the basis for comparison with 7-day August supplies and demands, Baseline Conservation, 135 mgd from Bloomington, 100 mgd flowby, 95 mgd from Occoquan Reservoir, and 55 mgd from Patuxent Reservoirs.

** December 1978 price levels, 6-7/8 percent Federal discount rate, 1980 base year for planning.

FIGURE B-21

## COMPARISONS OF SHORTAGES FOR VARIOUS FLOW-BYS★



- acceptable drought duration for planning purposes.
- appropriate risk level (frequency of occurence).
- acceptable discharge points for raw water interconnections.
- regional coordination.

REFINEMENTS AND MODIFICATIONS

On the basis of the FISRAC review of the information packet containing the nine plans and the sensitivity data generated on the important decision variables, the number of plans was further reduced prior to subsequent planning in Iteration III. The following sections discuss the refinements and modifications of information developed during Iteration II.

Flowby

The general consensus of the FISRAC was that a 100 mgd flowby value was acceptable for planning purposes for the early-action phase. Since the results of the Maryland-USFWS flowby study were incomplete, sensitivity tests for flowby values other than 100 mgd showing effects on the timing and costs of projects would be appropriate. It was further recommended, however, that long-range efforts in the long-range phase of the study look at mechanisms such as reservoirs to supplement Potomac flows for flowby. This instruction meant that sizing the components in all of the subsequent plans would not violate, at the minimum, a 100 mgd flowby at all times into the Potomac estuary.

Water Conservation

The FISRAC members were of the opinion that 10 percent reduction in demand could reasonably be achieved by the major service areas and that Conservation Scenario 3 could be used for planning purposes.

As a consequence, Iteration III was directed at satisfying the shortages that would remain after Conservation Scenario 3 was implemented. This meant that projects could be slightly smaller, satisfy needs for longer periods of time, and thus achieve greater cost savings than otherwise anticipated if lesser conservation scenarios were implemented.

Duration and Frequency of Occurrence

After much discussion of the experiences and histories of facility designing for water supply in local studies, the FISRAC agreed that for the purposes of the MWA study's early-action phase, facilities should be sized for a 7-day duration, once in 100-year drought event. They suggested, however, that the trade-offs of costs and quantities of shortages be presented for more frequent events.

Appropriate Discharge Points for Raw Water Interconnections

Up to this point in the study, raw water interconnections had been designed with two operational options in mind. By virtue of their reversibility, each pipeline could discharge water into the reservoirs to maintain storage or to treatment facilities. It was pointed out, however, that reservoir levels in both the Patuxent and the Occoquan (when Potomac facilities were completed) Reservoirs could be manipulated through reregulation. Moreover, it would be likely that a National Pollutant Discharge Elimination System (NPDES) permit would be required to discharge Potomac water into either reservoir, possibly preceded by some type of treatment of Potomac River water prior to discharge. Because the direct transfer of water to the treatment plants could avoid potential water quality problems in the reservoirs, yet still have the same net effect of conserving reservoir storage and decreasing Potomac use, the FISRAC members recommended that Potomac water be transferred directly to the reservoir water treatment plants instead of to the reservoirs.

## Regional Coordination

Some degree of regional coordination was viewed as a prerequisite for any successful water supply plan in the MWA. Depending upon the approach used to solve the water shortage problem, the degree of regional coordination could vary. The basic question raised at the FISRAC meeting was to what extent would an individual supplier be willing to share both the costs and benefits of a particular project which had potential areawide water supply benefits.

It was the WSSC's contention that the Corps should investigate more strongly the "sub-regional" solutions because of the many implementation problems with a "regional" approach. Virginia also stated a preference for a sub-regional plan with individual solutions for individual service areas. Both agreed, however, that the benefits (cost savings) of a regional plan over a sub-regional plan should be displayed for evaluative purposes. However, it was pointed out that even with the sub-regional approach, WAD's demands wuld still be met by the sharing of Maryland and Virginia's projects. The suggestion was made that another alternative be developed where the WAD would be independent of solutions for either the WSSC or the FCWA.

After much discussion, a three-tiered approach was proposed by the FISRAC members, each of which represented an increasing level of cooperation. These were listed as follows:

1. A "local" approach where each service area provided a solution to meet their own problem. This would require minimal, albeit some, local cooperation among service areas. One possibility for the WAD would be to purchase and reserve the uncontracted portion of the Bloomington Reservoir for its exclusive use.

2. A "subregional" approach requiring greater cooperation than in the local approach based on the FCWA and WSSC solving their own shortages plus a share of WAD's shortage.

3. A "regional" approach with a project in one or more service areas which would meet the needs of all of the Potomac-based service areas. Thus, total cooperation would be the cornerstone of any regional plan.

## EARLY-ACTION PLAN FORMULATION - ITERATION III

Building on the data, refinements, and decisions developed during the first two iterations, Iteration III was concerned with the formulation, assessment, and evaluation of a final set of plans for the early-action phase. The following sections discuss the planning assumptions, the rationale which guided plan development including the study objectives, and the technical data relative to sizing, staging, and costs of the plans. Pertinent economic, social, environmental, and institutional effects are also discussed.

## ASSUMPTIONS

The important assumptions which were used as a basis for early-action plan formulation in Iteration III were the following:

- Reregulation would be initiated in both the FCWA and the WSSC to increase the storage availability for peak demand situations.

- Conservation Scenario 3 would be implemented to achieve an overall 10 percent reduction in water use by the end of the planning period.

- The 7-day duration, once in 100-hundred year occurence of low flow in the Potomac River during August would be used.

- A 100 mgd flowby to the Potomac Estuary would be maintained at all times.

- The maximum 7-day treatment rates at the Patuxent and Occoquan WTP's would be 55 and 95 mgd, respectively.

- A maximum 135 mgd release for the month of August would be used from Bloomington Lake.

- The Low Flow Allocation Agreement (LFAA) would be in effect.

- Local cooperation was assumed to effectively implement each of the above.

Given these assumptions, solutions to either one or all of the Potomac service area water supply needs to the year 2030 could be achieved by implementing a combination of the available components. Both reregulation and Conservation Scenario 3 would be basic elements in any action plan. The shortages remaining after the implementation of these two components could be made up by using some combination of: Little Seneca Lake, a Potomac to Patuxent raw water interconnection, or a Potomac to Occoquan raw water interconnection.

The reregulation component would be implemented to conserve storage in the Patuxent and Occoquan Reservoirs for use during peak demand periods. During a critical peak shortage period (i.e., 7-day), both the Occoquan and Patuxent water treatment plants would be operating at their maximum feasible rate, 95 and 55 mgd, respectively, per the LFAA and thus result in increased reliance and use of stored water.

Conservation Scenario 3 would provide a non-structural component for all of the plans. Although this scenario acting by itself would not provide for enough of a reduction in water use (approximately 100 mgd) to entirely eliminate the predicted shortages, it would contribute significantly in reducing the size and the need for structural projects.

The Little Seneca Lake project in Montgomery County, Maryland would be used to release water to the Little Seneca Creek which feeds directly into the Potomac River. Although the project was originally envisioned to provide water only to the WSSC, its storage could be used to serve other Potomac users as well. Thus, the project could have regional as well as service area water supply potential.

Similarly, the reversible Potomac River to Rocky Gorge Reservoir (Patuxent) raw water interconnection could be operated to maintain higher flows in the Potomac River by transferring stored water from local reservoirs to the Potomac River water treatment plants. This transfer would reduce the need for large Potomac withdrawals. The volume of water transferred could be varied to satisfy at least WSSC's needs, and at the maximum to satisfy regional needs. On the Virginia side of the Potomac River, the Potomac to Occoquan Reservoir raw water interconnection could be operated in the same manner.

## PLAN DESCRIPTION

Within the context of satisfying regional as well as service area needs, a series of five plans, as listed in Table B-24 were developed using National and study area objectives. Each of the components which comprised the five plans are listed in Table B-24 along with the estimated date of implementation. The four action plans were capable of meeting the four Potomac-dependent service area's (WAD, FCWA, WSSC, and Rockville) water supply needs through the year 2030, given the assumptions listed in the previous section.

Each of the action plans (Plans 2-5) was arranged in ascending order to regionalization or local cooperation that would be required to implement them effectively. Because local cooperation among the various parties was viewed as being critically important for any action plan, and because various levels of cooperation could potentially be achieved, the four action plans were arranged accordingly for comparative purposes. The Without Plan represented the level of cooperation that existed at the time and that would continue to exist through the year 2030 without the implementation of any of the action plans. The Local Plan (Plan 2) required slightly more cooperation and each following plan progressively required more.

### Plan 1 - Without Condition

The Without Condition Plan represented the most probable water supply, demographic, economic, social, and environmental conditions that were likely to exist without any future water supply project other than those which had already been planned locally. It was this condition which was used to define the planning objectives for the study and against which the four "action" plans were compared.

For the purposes of the early-action phase, the Without Condition (Plan 1) was represented by the water supply situation that would exist through the period 1980-2030 in the absence of implementation of any plan to alter the development or management of the region's water resources. Without any additional conservation measures implemented other than those which had already been planned, the maximum 7-day, once in 100-year shortage by the year 2030 was projected to be 279 mgd. Table B-25 summarizes the regional and service area surpluses and shortages by benchmark year. Additional information on the calculation of water supply shortages, including the application of the Potomac Low Flow Allocation Agreement is contained in Appendix D - Supplies, Demands and Deficits.

TABLE B-24

LIST OF EARLY-ACTION PLANS - ITERATION III

| PLAN | COMPONENTS | APPROACH |
|---|---|---|
| 1 | Without Condition<br>Purchase of unpaid portion of Bloomington Lake (1981) | |
| 2 | Reregulation (1980-2030)<br>Little Seneca Lake (1994)<br>Potomac-Occoquan RWI (1994)<br>Purchase of unpaid portion of Bloomington Lake (1981)<br>Conservation Scenario 3 (1980-2030) | Local |
| 3 | Reregulation (1980-2030)<br>Purchase of unpaid portion of Bloomington Lake (1981)<br>Little Seneca Lake (1994)<br>Potomac-Occoquan RWI (1994)<br>Conservation Scenario 3 (1980-2030) | Sub-regional |
| 4 | Reregulation (1980-2030)<br>Purchase of unpaid portion of Bloomington Lake (1981)<br>Little Seneca Lake (1994)<br>Potomac-Patuxent RWI (2017)<br>Conservation Scenario 3 (1980-2030) | Regional |
| 5 | Reregulation (1980-2030)<br>Purchase of unpaid portion of Bloomington Lake (1981)<br>Potomac-Patuxent RWI (1994)<br>Conservation Scenario 3 (1980-2030) | Regional |

TABLE B-25

EARLY-ACTION PHASE
SERVICE AREA SURPLUSES AND SHORTAGES* (MGD)

WITH AND WITHOUT CONSERVATION SCENARIO 3

| SERVICE AREA | YEAR 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) | -100(-28) | -159(-79) | -223(-133) | -279(-180) |

*Surplus 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 parenthesis indicate projected shortages (-) or surpluses (+) with Baseline demands; numbers inside parenthesis indicate projected shortages or surpluses with Conservation Scenario 3 demands.

Conservation Scenario 3 was implemented, it was estimated that the shortage by the year 2030 would reach only 180 mgd. The surpluses and shortages associated with Conservation Scenario 3 are also shown in Table B-25 by benchmark year, but in parenthesis. Because Conservation Scenario 3 was assumed to be a component of all of the action plans, the numbers in parenthesis in Table B-25 actually represented a revised "Without Condition" upon which the staging and design sizing of the structural plan components was based.

It is important to point out that with Plan 1 as well as the four action plans, Bloomington Reservoir was expected to contribute a maximum of 135 mgd to the Potomac during critical periods. Only a small portion of the water supply storage provided by this reservoir, however, had been contracted for at the time the early-action phase was being completed. For planning purposes, it was assumed that the remaining water supply storage in Bloomington Lake would be purchased by some user as part of the Without Condition Plan, but the user was unidentified. The action plans, however, investigated the consequence of assigning the uncommitted Bloomington storage to different users. These examinations are further discussed under the action plans.

<u>Plan 2 - Local Plan</u>

As suggested by the FISRAC, Plan 2 addressed the water supply problems by providing a separate and distinct source of water for each water service area. Even this type of "local" plan required some regional cooperation; however, the benefits of a single structural project would not be shared with more than one water supplier. Such a plan could be implemented by independent actions on the part of each water supplier.

In Plan 2, Conservation Scenario 3 would be implemented in all service areas. Reregulation would be applied in the WSSC and the FCWA. Plan 2 would provide water to WAD and Rockville by allowing them to purchase the uncontracted water supply storage in Bloomington Lake (almost 92 percent). Releases from Bloomington, then, would first be reserved for satisfying the shortages in WAD and Rockville. The WSSC and FCWA, on the other hand, would be receiving little or no benefit from Bloomington releases. Thus, their projects, namely Little Seneca Lake and the Potomac to Occoquan raw water interconnection, would be sized larger as their share of the Potomac River flows would be smaller. The use of Bloomington in the Local Plan differs from its use in Plans 3, 4, and 5 in that WAD and Rockville would be receiving the major portion of the flows from Bloomington rather than the flows being distributed uniformly among all users.

<u>Plan 3 - Subregional Plan</u>

A subregional plan was formulated similar to Plans II and III of Iteration II. The approach to the water supply problem in the subregional plan was to construct separate projects to satisfy shortages on either side of the Potomac River, i.e. Maryland and Virginia. Rockville and WAD, however, would have no structural project specifically for their use during low Potomac flows. To overcome this deficiency, these two service areas would share financially in the structural projects of both the FCWA and WSSC. By sizing the projects larger than for their indivisual needs, FCWA and WSSC could reduce withdrawals from the Potomac, thereby letting more flow in the river for Rockville and WAD. With the subregional plan, then, structural projects would be needed in both the FCWA and WSSC at the same time. The FCWA could not benefit from WSSC's project, or vice versa.

Reregulation was also considered to be operational in both the FCWA and WSSC for Plan 3. Conservation Scenario 3 would first be applied to each of the four Potomac service areas (WAD, WSSC, FCWA, and Rockville) through the planning period. Little Seneca Lake would then come on line to supplement flows in the Potomac River for use by the WSSC. During times of 7-day shortages in the WAD and Rockville Service area, 50 percent of their shortages would be provided from the flows released from Little Seneca Lake. On the other side of the river, a reversible Potomac to Occoquan raw water interconnection would operate to satisfy all of the FCWA's shortages and the other 50 percent of the WAD and Rockville shortages.

Plan 4 - Regional Plan 1

This plan provided a regional solution to the water supply problem. Plan 4 first provided for implementation of Conservation Scenario 3 in the four Potomac-based service areas followed by construction of the Little Seneca Lake project. Later in the planning period, a raw water interconnection between the Potomac River and the Rocky Gorge Reservoir would be implemented (this staging is discussed later). This plan takes Plan IV of Iteration II one step further by applying Conservation Scenario 3 to reduce water demand by about ten percent. This action reduced the size necessary for the Potomac to Rocky Gorge raw water interconnection and thus provided considerable cost savings. Because it is the lowest cost plan available, Plan 4 would be expected to have the least effect on the national economy in terms of cost of all of the available action plans. The cost-effectiveness of this plan was further achieved because: (1) it provided for the implementation of two of the lowest cost components; and (2) it was a regional plan which provided flexibility to construct the Potomac-Rocky Gorge interconnection at some point in the future. This made Plan 4, in terms of present worth, less costly.

Plan 5 - Regional Plan 2

Plan 5 represented the second regional approach for water supply. It would cause the least damaging effect to the environment of all of the plans considered.

Both Conservation Scenario 3 and reregulation would be implemented in this plan as well as in Plans 2, 3, and 4. As emphasized previously, the two structural mechanisms which were available to meet the water requirements through the year 2030 included raw water interconnection and Little Seneca Lake. The impact assessment highlighted the relative advantages of pipelines over reservoirs in environmental terms. As a result of these analyses, Plan 5 was designed to meet the regional needs without the development of a new reservoir. Thus, this plan was essentially a conservation plus raw water interconnection plan.

Before selecting the pipeline(s) which would be used for the plan, different combinations of raw water interconnections were tested using hydrologic simulation to determine adequate designs to satisfy the 7-day shortages. This analysis also provided a means to trace the effects of their operation on storage through a critical drought period.

On the basis of the environmental assessment, the least environmentally disruptive raw water interconnection, the Potomac to Patuxent (Rocky Gorge) raw water interconnection, was tested first. It was found that a large reversible pipe (180 mgd) from the Rocky Gorge Reservoir to the Potomac River in combination with the demand reduction achieved by Conservation Scenario 3, would be sufficient to meet the regional needs through the year 2030. Because the use of a large Occoquan raw water interconnection or combinations of smaller Patuxent and Occoquan interconnections would cause a greater net adverse impact on the environment, the large Potomac to Patuxent raw water interconnection was designated as part of this plan.

SIZING OF COMPONENTS

Having defined the Without Condition and outlined the formulation rationale for the five plans, the next step was to determine the capacity of the components to satisfy the projected year 2030 shortages. This component sizing was accomplished indivudually for each action plan. Different levels of regionalization (local, subregional, or regional) would require different component capacities even though the local shortage would be the same in each plan. The following section discusses the process whereby component capacities were determined for each of the four action plans. Not only was the total capacity of each component computed, but each user's share of the total capacity was determined for later use in cost apportionment.

Application of LFAA

An important issue was raised at this point in the plan formulation process regarding the application of the Potomac Low Flow Allocation Agreement (LFAA) formula for dividing Potomac River flows. (Appendix D contains the details about use of the LFAA.) The LFAA contained a clause which allowed the allocation ratios to be "frozen" anytime after 1988. It was noted that use of either the "frozen" or continuous rolling average ratios for allocating flows could alter the distribution of shortages among the various service areas. Using the continuous rolling average formula, more water would be allocated to the growing suburbs of the FCWA and WSSC progressively throughout the planning period with a reduction in the amount of water allocated to the Aqueduct. Freezing the ratio in 1988 would mean less water allocated to the WSSC and the FCWA and more for the Aqueduct. The City of Rockville would be only slightly affected by either method.

As a consequence of the two possibilities, the component capacities and each user's share of the total capacity would be affected. Due to the uncertainty regarding which set of allocation ratios would be applied, the 1979 Progress Report compared plans sized to meet either set of ratios to demonstrate the effect of the potential "freeze." Later modification of the LFAA in 1982 effectively eliminated the "freeze" possibility. (The reader is referred to a later section on results and status of the early-action phase for more information about the decision to eliminate the "freeze.") Hence, only the information reflecting the application of the continuous rolling average ratio is provided in the following text. Table B-25 already listed the service area surpluses and shortages computed according to the terms of the LFAA assuming the continuous rolling average ratios.

Component Capacities

The first set of data on Table B-26 shows the projected shortages for the Local Plan. The use of Bloomington releases deserves special mention at this point for two reasons. In dividing flow to calculate component capacity (and later for cost-apportionment), it was necessary to know the actual flow provided by Bloomington to each user under the terms of the LFAA. This was done by allocating flow with and without Bloomington as

## TABLE B-26

## SURPLUSES AND SHORTAGES IN MGD ACCORDING TO VARIOUS REGIONAL BREAKDOWNS

| | 1980 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|
| Local Plan 2 | | | | | | |
| Without Bloomington | | | | | | |
| WSSC | -20 | -51 | -70 | -91 | -112 | -131 |
| FCWA | +11 | -8 | -23 | -38 | -58 | -76 |
| WAD & Rockville | -21 | -55 | -70 | -85 | -98 | -108 |
| or | | | | | | |
| With Bloomington | | | | | | |
| WSSC | +88 | +20 | -18 | -53 | -87 | -113 |
| FCWA | +17 | +2 | -10 | -26 | -46 | -67 |
| WAD & Rockville | 0 | 0 | 0 | 0 | 0 | 0 |
| | +105 | +22 | -28 | -79 | -133 | -180 |
| Sub-regional Plan 3 | | | | | | |
| WSSC | +37 | +5 | -13 | -35 | -56 | -75 |
| FCWA | +11 | 0 | -12 | -22 | -35 | -47 |
| WAD & Rockville | +57 | +17 | -3 | -22 | -42 | -58 |
| or | | | | | | |
| WSSC + 1/2 (WAD & Rock) | +66 | +14 | -15 | -46 | -77 | -104 |
| FCWA + 1/2 (WAD & Rock) | +39 | +8 | -13 | -33 | -56 | -76 |
| | +105 | ±22 | -28 | -79 | -133 | -180 |
| Regional Plans 4 & 5 | +105 | +22 | -28 | -79 | -133 | -180 |

*Design conditions - 1/100 year recurrence, 7-day duration, reregulation, Conservation Scenario 3, 100 mgd flowby, 135 mgd from Bloomington, and August demands.

part of the Potomac base flow and then finding the difference. It should be noted that for the Local Plan, Bloomington water was reserved for the Aqueduct and Rockville before being divided among the remaining users. This was done because of the Aqueduct's and Rockville's lack of alternative supplies and the FISRAC's expressed desire at the completion of Iteration II to identify separate solutions for the Local Plan.

The next set of data on Table B-26 shows the surplus/shortage calculations for the subregional plan, Plan 3. By adding one-half of Rockville and WAD deficits to both FCWA and WSSC, shortages were computed for the subregional plan (FCWA and WSSC both furnishing some additional capacity to assist Rockville and WAD).

The regional surplus/shortage calculations for Plans 4 and 5 on Table B-26 show the availabilty of supplies without regard to areal distribution. Regional plans would have to furnish sufficient capacity to meet a total projected shortage of the four Potomac River service areas of 180 mgd in the year 2030.

Once the distribution of shortages within each action plan had been calculated in Table B-26, it was possible to determine the required capacity of each component within a plan as well as the capacity attributable to each user. Table B-27 calculates the required capacities by plan and by user for year 2030. The Bloomington release is tabulated as part of each plan as it contributes differently to the users in some instances (i.e., Local Plan).

For the regional plans, each user's share of capacity was calculated as its percentage of total regional shortage. If WSSC's shortage was 106 mgd of a total regional shortage of 180 mgd, then WSSC's share of a regional project would be 106/180 or 58.9 percent. Required user capacities for the Subregional and Local Plans were taken directly from Table B-26. The information in Table B-27 provided a basis for cost estimating for specific facilites in that it identified the required flow capacities, and thus the sizes, of the various components.

Hydrologic Simulation

Having calculated the sizes and required capacities of the components within each plan, it was then necessary to "test" the plans using hydrologic simulation. Tests were executed on both the Without Plan (Plan 1) with reregulation and conservation applied, as well as the four action plans. The summer period of June through September 1966 was selected as the supply simulation period which represented continuous low flow conditions in the Potomac. Within this interval, there were 11 consecutive 7-day periods in the Potomac River with average flows less than 1,000 mgd (the average yearly flow in the Potomac is over 7,000 mgd at the Little Falls gage). Likewise, the flows in the Patuxent, Occoquan and Seneca streams were very low. The 11th period, 7 through 13 September 1966, exhibited the lowest 7-day average flow (404 mgd) ever recorded at the Little Falls gaging station. The lowest daily average in the Potomac was recorded as 388 mgd on 13 September 1966, the last day of the 11th 7-day period.

With the 1966 supply information and projected year 2030 summer demands, it was then possible to trace the effects of inflows, releases, evaporation, and withdrawals from the reservoirs and the Potomac River during the critical summer period. Examination of reservoir storage was particularly important as these facilities would be depended on to furnish large quantities of water during low flow in the Potomac.

The first hydrologic simulation mathematically traced the effects of both Conservation Scenario 3 and reregulation on the Without Condition for the critical period from June through September 1966. Graphs were prepared which illustrated the remaining storage levels in the Occoquan and Patuxent Reservoirs, the remaining Potomac River flow, and the unsatisfied demand (maximum week = 186 mgd). Based on this Without Condition simulation, additional simulations were conducted to determine if the proposed facilities in the action plans were adequate to satisfy the projected shortages. All of the action plans, with components sized as calculated in Table B-27, were found to be adequate for satisfying the projected shortages. Table B-28 summarizes by plan the results of the hydrologic simulation for the June through September 1966 drought period.

COST COMPARISON

Once the components were sized to meet the projected year 2030 demands and the hydrologic simulation indicated that the proposed facilities were satisfactory, design and cost details were then developed for each component size. Both construction costs and average annual costs (including operation, maintenance, and replacement costs) were then estimated. The various technical appendices contain the details on the cost estimating methodologies.

As a sample of the information developed in the August 1979 Progress Report, Table B-29 lists the pertinent construction costs and average annual costs associated with each plan. (It should be noted that the cost data presented in Table B-29 differ slightly from the costs tabulated in the earlier 1979 Progress Report. These changes have been made to correct an error in the economic computation procedure used for the 1979 Progress Report. These changes do not affect the ultimate conclusion which was that a regional approach to water supply management would be the most cost-efficient). The Little Seneca Lake project was assumed to be built to the same size in any of the action plans as there were to be other secondary uses of the reservoir for flood control storage and recreation during non-drought periods . Table B-29 demonstrates the cost advantage of striving for regional management of the water supply system such as in Plan 4. A regional approach would allow the implementation of the most cost-effective projects no matter where they were located, and would also allow projects to be staged on an as-needed regional basis rather than a local basis. Significant cost savings could thus be achieved as shown for Regional Plan 4 in Table B-29.

The costs developed in Table B-29 were further apportioned to the different users. The underlying theme of the cost apportionment was to provide an equitable distribution of costs among plan beneficiaries. For the early-action phase, the "benefits" were determined to be the supplemental flows provided by any of the action plans to meet projected 2030 shortages for the design condition (7-day, once in 100-hundred year recurrence, August demands, 135 mgd from Bloomington, 100 mgd flowby, reregulation, and Conservation Scenario 3). Costs, of course were determined to be the cost of implementing any of the plans to provide the "benefits" (supplemental flow).

Based on the component sizes and cost just developed, costs for each component were apportioned to a user according to the ratio of that user's requirement (in terms of flow) to total project size (again in terms of flow). The logic of dividing costs according to the degree of project use was felt to be an equitable method of cost apportionment for the early-action phase, although certainly not the only method. Table B-30 shows a sample apportionment of construction costs according to the method just described. (Again, these numbers differ slightly from those tabulated in the 1979 Progress Report due to the correction of a computation error).

IMPACT ASSESSMENT

Concurrent with the development and comparison of plan costs, impacts were also assessed for social, environmental, and institutional parameters associated with each of

TABLE B-27

REQUIRED FLOW CAPACITY (MGD) BY WATER SUPPLIERS IN YEAR 2030

| Plans | Water Suppliers: WAD & Rockville | WSSC | FCWA | TOTAL |
|---|---|---|---|---|
| 1. No Action Plan | | | | |
| Required flow without Bloomington | 108 | 131 | 76 | 315 |
| Bloomington Addition | -50 | -56 | -29 | -135 |
| REMAINING SHORTAGE | 58 | 75 | 47 | 180 |
| 2. Local Plan | | | | |
| Little Seneca Lake | — | 113 | — | 113 |
| Pot/Pat RWI | — | — | — | — |
| Pot/Occ RWI | — | — | 67 | 67 |
| Subtotal | — | 113 | 67 | 180 |
| Bloomington Addition | 108 | 18 | 9 | 135 |
| TOTAL WATER SUPPLIED | 108 | 131 | 76 | 315 |
| 3. Subregional Plan | | | | |
| Little Seneca Lake | 1/2 x 58 = 29 | 75 | — | 104 |
| Pot/Pat RWI | — | — | — | — |
| Pot/Occ RWI | 1/2 x 58 = 29 | — | 47 | 76 |
| Subtotal | 58 | 75 | 47 | 180 |
| Bloomington Addition | 50 | 56 | 29 | 135 |
| TOTAL WATER SUPPLIED | 108 | 131 | 76 | 315 |
| 4. Regional Plan 1 | | | | |
| Little Seneca Lake | 58/180 x 120 = 39 | 75/180 x 120 = 50 | 47/180 x 120 = 31 | 120 |
| Pot/Pat RWI | 58/180 x 60 = 19 | 75/180 x 60 = 25 | 47/180 x 60 = 16 | 60 |
| Pot/Occ RWI | — | — | — | — |
| Subtotal | 58 | 75 | 47 | 180 |
| Bloomington Addition | 50 | 56 | 29 | 135 |
| TOTAL WATER SUPPLIED | 108 | 131 | 76 | 315 |
| 5. Regional Plan 2 | | | | |
| Little Seneca Lake | — | — | — | — |
| Pot/Pat RWI | 58/180 x 180 = 58 | 75/180 x 180 = 75 | 47/180 x 180 = 47 | 180 |
| Pot/Occ RWI | — | — | — | — |
| Subtotal | 58 | 75 | 47 | 180 |
| Bloomington Addition | 50 | 56 | 29 | 135 |
| TOTAL WATER SUPPLIED | 108 | 131 | 76 | 315 |

TABLE B-28

SUMMARY OF 7-DAY HYDROLOGIC SIMULATION FOR ALL PLANS
29 JUNE 1966 THROUGH 27 SEPTEMBER 1966*

| Plan | Total Storage at beginning of period - 29 Jun 66 | Releases from Little Seneca Lake | Raw Water Interconnection Pumpage | Total Additional Volume Supplied | Total Storage Remaining at End of Period 13 Sep 66 | Unmet Demands |
|---|---|---|---|---|---|---|
| 1. Without Condition | 18.3 | - | -- | -- | 11.2 | 12.5 |
| Without Condition plus reregulation | 18.3 | -- | -- | 2.4 | 10.1 | 10.1 |
| Without Condition plus reregulation & Cons. Scen. 3 | 18.3 | -- | -- | 4.6 | 10.7 | 5.5 |
| 2. Local | 21.9 | 3.6 | 1.9 | 5.5 | 9.1 | 0.0 |
| 3. Subregional | 21.9 | 3.4 | 2.1 | 5.5 | 8.8 | 0.0 |
| 4. Regional Plan 1 | 21.9 | 3.6 | 1.9 | 5.5 | 8.9 | 0.0 |
| 5. Regional Plan 2 | 18.3 | -- | 5.5 | 5.5 | 5.2 | 0.0 |

*7-day supplies at Little Falls gaging station and 7-day demands for 2030 based on 1966 peaking ratios.

TABLE B-29

EARLY-ACTION PLANS FOR CHOICE
COST COMPARISON*

| PLAN COMPONENTS | DATE OPERATIONAL | QUANTITY SUPPLIED (MGD) | DEMAND REDUCED (MGD) | CONSTRUCTION COST** ($1,000) | OPERATION MAINTENANCE & REPLACEMENT COSTS ($1,000/YEAR) | AVERAGE ANNUAL COSTS*** $1,000/YEAR) |
|---|---|---|---|---|---|---|
| **PLAN 1 - WITHOUT CONDITION** | | | | | | |
| Potomac Low Flow Allocation Agreement | 1980 | | | | | |
| Existing Coservation 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 - 44 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 |

TABLE B-29 (Cont'd)

EARLY-ACTION PLANS FOR CHOICE
COST COMPARISON*

| PLAN COMPONENTS | DATE OPERATIONAL | QUANTITY SUPPLIED (MGD) | DEMAND REDUCED (MGD) | CONSTRUCTION COST** ($1,000) | OPERATION MAINTENANCE & REPLACEMENT COSTS ($1,000/YEAR) | AVERAGE ANNUAL COSTS*** $1,000/YEAR) |
|---|---|---|---|---|---|---|
| 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 an d 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.

TABLE B-30

EARLY-ACTION PLANS FOR CHOICE
CONSTRUCTION COST APPORTIONMENT

| | WAD & Rockville | | WSSC | | FCWA | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | Flow (Mgd) | Cost ($1,000) | Flow (Mgd) | Cost ($1,000) | Flow (Mgd) | Cost ($1,000) | Flow (Mgd) | Cost ($1,000) |
| **PLAN 1 - WITHOUT CONDITION** | | | | | | | | |
| Bloomington Lake | 50 | 18,790 | 56 | 21,050 | 29 | 10,900 | 135 | 50,740 |
| **PLAN 2 - LOCAL PLAN** | | | | | | | | |
| Reregulation | | | | | | | | |
| Conservation Scenario 3 | 32 | 3,130 | 44 | 4,300 | 23 | 2,350 | 99 | 9,680 |
| Little Seneca Lake | | | 113 | 22,960 | | | 113 | 22,960 |
| Potomac to Occoquan RWI | | | | | 67 | 64,400 | 67 | 64,400 |
| Subtotal | 32 | 3,130 | 157 | 27,260 | 90 | 66,750 | 279 | 97,040 |
| Bloomington Lake | 108 | 40,590 | 18 | 6,770 | 9 | 3,380 | 135 | 50,740 |
| Total | 140 | 43,720 | 175 | 34,030 | 99 | 70,130 | 414 | 147,780 |
| **PLAN 3 - SUBREGIONAL PLAN** | | | | | | | | |
| Reregulation | | | | | | | | |
| Conservation Scenario 3 | 32 | 3,130 | 44 | 4,300 | 23 | 2,250 | 99 | 9,680 |
| Little Seneca Lake | 29 | 6,400 | 75 | 16,560 | | | 104 | 22,960 |
| Potomac to Occoquan RWI | 29 | 24,700 | | | 47 | 40,040 | 76 | 64,740 |
| Subtotal | 90 | 34,230 | 119 | 20,860 | 70 | 42,290 | 279 | 97,380 |
| Bloomington Lake | 50 | 18,790 | 56 | 21,050 | 29 | 10,900 | 135 | 50,740 |
| Total | 140 | 53,020 | 175 | 41,910 | 99 | 53,190 | 414 | 148,120 |
| **Plan 4 - REGIONAL PLAN 1** | | | | | | | | |
| Reregulation | | | | | | | | |
| Conservation Scenario 3 | 32 | 3,130 | 44 | 4,300 | 23 | 2,250 | 99 | 9,680 |
| Little Seneca Lake | 39 | 7,460 | 50 | 9,570 | 31 | 5,930 | 120 | 22,960 |
| Potomac to Patuxent RWI | 19 | 14,680 | 25 | 19,320 | 16 | 12,370 | 60 | 46,370 |
| Subtotal | 90 | 25,270 | 119 | 33,190 | 70 | 20,550 | 279 | 79,010 |
| Bloomington Lake | 50 | 18,790 | 56 | 21,050 | 29 | 10,900 | 135 | 50,740 |
| Total | 140 | 44,060 | 175 | 54,240 | 99 | 31,450 | 414 | 129,750 |
| **PLAN 5 - REGIONAL PLAN 2** | | | | | | | | |
| Reregulation | | | | | | | | |
| Conservation Scenario 3 | 32 | 3,130 | 44 | 4,300 | 23 | 2,250 | 99 | 9,680 |
| Potomac to Patuxent RWI | 58 | 33,460 | 75 | 43,260 | 47 | 27,110 | 180 | 103,830 |
| Subtotal | 90 | 36,590 | 119 | 47,560 | 70 | 29,360 | 279 | 113,510 |
| Bloomington Lake | 50 | 18,790 | 56 | 21,050 | 29 | 10,900 | 135 | 50,740 |
| Total | 140 | 55,380 | 175 | 68,610 | 99 | 40,260 | 414 | 164,250 |

the plans. This process of impact assessment relied heavily on aerial photo interpretation, field reconnaissance, coordination with the U.S. Fish and Wildlife Service, interviews, and literature searches conducted earlier. Suffiçent detail had been developed in the previous iterations of plan formulation and in the component analyses so little additional effort was required other than to group the impacts according to plan components. Table B-31 contains a summary of the significant impacts for each action plan.

In general terms, the most significant impacts of the Without Condition Plan were judged to be the consequences of potentially severe water shortages during occasional low flow years, with the likely severity increasing as water demands grow in future years. Expected environmental impacts included the likelihood of the Potomac River being at or near the minimum flowby level for much of the drought period with associated stresses on the aquatic system and excessive drawdowns in the offstream Patuxent and Occoquan reservoirs with possible carryover effects into the next year. Predicted social impact of the Without Condition Plan included probable restrictions on water use in every sector, possible taste and odor problems of the drinking water supply, and reduced system pressure and associated fire-fighting capability. Economic impacts would be felt by the commercial, industrial and governmental sectors as certain activities would be curtailed to conserve dwindling water supplies.

With any of the action plans, the aforementioned consequences of a severe water shortage could be avoided. However, other impacts related to new project construction and operation would be incurred. Generally, plans containing raw water interconnections would create significant short-term adverse environment and social impacts during the construction phase, but would result in relatively few long-lasting operational related impacts. Energy consumption would be high during drought periods when the interconnections would be used. Economic impacts, in terms of construction costs, would also be significant for plans containing the raw water interconnections. For plans using reservoir storage such as provided by Little Seneca Lake, significant short-term adverse environment and social impacts would also be incurred during the construction phase. Permanent long-term inundation of certain terrestrial and aquatic stream resources would occur over the life of the project, but the lake would also provide some beneficial long-term impacts in terms of a lake fishery and a recreational resource. Energy consumption would be low even during drought periods. Economic impacts of the reservoir construction cost would also be significant, but less than similar impacts for plans with raw water interconnections. Both reregulation and water conservation as embodied by Scenario 3, were judged to have overall positive environment, social, and economic impacts.

## PLAN EVALUATION

The following paragraphs provide evaluative statements regarding the five Plans for Choice which were formulated during the early-action phase. As discussed earlier in the appendix, the Water Resources Council's Principles and Standards were employed as the framework for plan evaluation. The Principles and Standards required the achievement of two National Objectives: National Economic Development (NED) and Environmental Quality (EQ). All plans were measured by the System of Accounts: the two objectives of NED and EQ plus Regional Development (RD) and Social Well-Being (SWB). Using these four public information accounts, the beneficial and adverse impacts of each plan were displayed for evaluation purposes.

TABLE B-31

IMPACT ASSESSMENT FOR PLANS FOR CHOICE

| IMPACT CATEGORIES | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|
| **Environmental** | | | | |
| Total Number of 100 Year Floodplain Crossings | 8 | 8 | 10 | 10 |
| Total Number of Stream Crossings | 49 | 49 | 27 | 27 |
| Total Miles of Pipeline Along Stream Valleys | 4 | 4 | 2 | 2 |
| Miles of Stream Valleys Inundated | 8 | 8 | 8 | N/A |
| Percent Storage Remaining in Reservoirs During 7-Day Drought Simulation (1966) | | | | |
| Occoquan | 32 | 26 | 48 | 48 |
| Patuxent | 57 | 57 | 40 | 6 |
| Potential for Critical Wildlife Affected | | | | |
| For Storage | Significant | Significant | Significant | Significant |
| For Interconnections | None | None | None | None |
| Effects on Threatened or Endangered Species | None | None | None | None |
| Acres of Agricultural Land Inundated | 212 | 212 | 212 | N/A |
| Miles Through or Adjacent to Agricultural Land | 10 | 10 | 14 | 14 |
| Acres of Forest-land Inundated | 235 | 235 | 235 | N/A |
| Miles Through or Adjacent to Forestland | 17 | 17 | 14 | 14 |

TABLE B-31 (Cont'd)

IMPACT ASSESSMENT FOR PLANS FOR CHOICE

| IMPACT CATEGORIES | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|
| **SOCIAL** | | | | |
| Meet Needs of MWA for 7-Day Shortages | Yes | Yes | Yes | Yes |
| Percent Reduction Water Use Achieved Through Conservation Program | 10 | 10 | 10 | 10 |
| Miles of Interconnection Along Roadways | | | | |
| Dual | 0 | 0 | 0 | 0 |
| Primary | 0 | 0 | 3 | 0 |
| Secondary | 8.1 | 8.1 | 0 | 4.5 |
| Others | .4 | .4 | 1.4 | 1.4 |
| Number of Major Roadway Interconnections | | | | |
| Dual | 5 | 5 | 7 | 7 |
| Primary | 0 | 0 | 5 | 5 |
| Secondary | 15 | 15 | 11 | 11 |
| Number of Road Relocations | 1 | 1 | 1 | N/A |
| Miles Along Existing Major Utilities Rights-of-Way | | | | |
| Gas | 11.3 | 11.3 | 2 | 2 |
| Electric | 10.3 | 10.3 | 4 | 4 |
| Number of Major Utility Interections | | | | |
| Gas | 6 | 6 | 2 | 2 |
| Electric | 5 | 5 | 3 | 3 |
| Number of Major Utility Relocations | 5 | 5 | 5 | N/A |

TABLE B-31 (Cont'd)

IMPACT ASSESSMENT FOR PLANS FOR CHOICE

| IMPACT CATEGORIES | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|
| Number of Known Cultural Resource Areas Affected | 13 | 13 | 11 | 4 |
| Potential for Cultural Resource Areas Being Affected | High | High | High | High |
| Miles Through or Adjacent to: | | | | |
| Agricultural Lands | 10 | 10 | 14 | 14 |
| Forest Lands | 17 | 17 | 14 | 14 |
| Commercial/Industrial | 0 | 0 | 2 | 2 |
| Public | .5 | .5 | .5 | .5 |
| Acres of Agricultural Lands Inundated | 212 | 212 | 212 | N/A |
| Acres of Forest-lands Inundated | 235 | 235 | 235 | N/A |
| Number of Recreational Areas Affected | 6 | 6 | 8 | 8 |
| Surface Acres Created for Recreation | 525 | 525 | 525 | N/A |
| Approximate Number of Residences Within 500 Feet of Right-of-Way | 750 | 750 | 3,000 | 3,000 |
| Approximate Number of Owners Affected by Construction | 250 | 250 | 150 | 150 |
| Ease of Implementation | Good | Fair | Poor | Poor |

Within the context of the two broad national objectives, certain study criteria were also established to judge the effectiveness of the early-action plans in satisfying the MWA's regional water supply problems. These criteria included the following: flexibility, limited environmental impact, ease of implementation, economic equity, low cost, low risk, planning compatibility, and effect on social cohesion. Table B-32 summarize the System of Accounts evaluation as applied to the five Plans for Choice. The following paragraphs elaborate on the plan evaluation in relation to the study criteria.

Flexibility

In all of the plans, flexibility within the existing water supply systems was ensured by applying reregulation to shift the supplies and demands within the region to conserve water in local reservoirs and to meet 30-day demands. The reversible raw water interconnections in each of the plans would add to this flexibility by providing the operational variability to draw from either the Potomac or the off-stream reservoirs to more efficiently utilize the existing regional water resources. Furthermore, Conservation Scenario 3 could be adopted for the region as well as individual service areas and could be called upon further to reduce demands in the most severe drought situations. Plan 5 (Regional Plan) was the least flexible Plan for Choice as it provided only projects on the Maryland side of the river. Therefore, should it be necessary to provide supplies to FCWA, no direct mechanism would be available. The incorporation of the Little Seneca Lake project in Plans 2, 3, and 4 provided added operational flexibility in cases where peak demands might exceed the design condition. Additional releases provided from this reservoir could help ameliorate shortages or more severe conditions.

Limited Environmental Impact

The potential effects of any given plan on the environment varied depending upon the perspective and time element that was considered. Over the long run, each of the plans would contribute a net positive effect on the environment. This was a result of over all-reduction in water use through implementation of Conservation Scenario 3 which, in effect, would allow more water to remain in the Potomac River and the offstream reservoirs year round. In addition, the reregulation schedule would balance flows in the river and storage in the offstream reservoirs even in times of normal flow conditions. This would contribute to higher volume and therefore healthier conditions in the reservoirs and in the Potomac River.

However, during critical shortages, reregulation would operate differently. In these cases, stored water that accumulated over time would be needed because of low flow conditions in the Potomac River. To offset this situation, reregulation would operate toward averting shortages and therefore drawdown the local reservoirs, in some cases greater than would otherwise be expected.

Plan 5 represented the least environmentally disruptive plan, particulary with respect to habitat loss, as it required no new reservoir project. Although the Patuxent reservoirs may suffer rapid drawdown using 1966 simulation conditions, the Occoquan reservoir, which in the past has suffered from water quality problems during drought periods, would maintain higher storage levels with implementation of this plan. Plans 2 and 3 would pose additional environmental disturbances with the implementation of the Potomac River to Occoquan raw water interconnection.

TABLE B-32
SYSTEM OF ACCOUNTS, PLANS FOR CHOICE

| | PLAN 1 WITHOUT CONDITION | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|---|
| A. DESCRIPTION | 100 mgd flowby Bloomington Lake; Average monthly releases-60 mgd July, 135 mgd August, Sep. Oct., 75 mgd Nov; Existing conservation programs utilized; WSSC & FCWA intakes functional; Raising Occoquan dam two feet; Potomac Low Flow Allocation Agreement. | 100 mgd flowby Bloomington Lake; Average monthly releases-60 mgd July, 135 mgd August, Sep. Oct., 75 mgd Nov; Existing conservation programs utilized; WSSC & FCWA intakes functional; Raising Occoquan dam two feet; Reregulation-FCWA, WSSC; Possible purchase of storage in Bloomington Lake by D.C.; Potomac Low Flow Allocation Agreement; Conserva. Scenario 3; Little Seneca Lake (113 mgd); Potomac-Occoquan Interconnection (67 mgd). | 100 mgd flowby Bloomington Lake; Average monthly releases-60 mgd July, 135 mgd August, Sep. Oct., 75 mgd Nov; Existing conservation programs utilized; WSSC & FCWA intakes functional; Raising Occoquan dam two feet; Reregulation-FCWA, WSSC; Potomac Low Flow Allocation Agreement; Conserva. Scenario 3; Little Seneca Lake (104 mgd); Potomac-Occoquan Interconnection (76 mgd). | 100 mgd flowby Bloomington Lake; Average monthly releases-60 mgd July, 135 mgd August, Sep. Oct., 75 mgd Nov; Existing conservation programs utilized; WSSC & FCWA intakes functional; Raising Occoquan dam two feet; Reregulation-FCWA, WSSC; Potomac Low Flow Allocation Agreement; Conserva. Scenario 3; Little Seneca Lake (120 mgd); Potomac to Patuxent Interconnection (60 mgd). | 100 mgd flowby Bloomington Lake; Average monthly releases-60 mgd July, 135 mgd August, Sep. Oct., 75 mgd Nov; Existing conservation programs utilized; WSSC & FCWA intakes functional; Raising Occoquan dam two feet; Reregulation-FCWA, WSSC; Potomac Low Flow Allocation Agreement; Conserva. Scenario 3; Potomac to Patuxent Interconnection (180 mgd). |

TABLE B-32 (Cont'd)
SYSTEM OF ACCOUNTS, PLANS FOR CHOICE

| | PLAN 1 WITHOUT CONDITION | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|---|
| B. IMPACTS | | | | | |
| NED | Is the least cost plan, but water supplies are not guaranteed. | Is the moderately priced plan that meets the water needs. | Is the moderately priced plan that meets the water needs. | Is the least cost plan that meets the water the water needs. | Is the most expensive plan that meets the the water needs. |
| EQ | Potomac River-during 7-day drought conditions would degrade habitat; Reservoirs-for the most part of the year, reservoirs and their levels would be lower than with any of the other plans. | Potomac River-during 7-day drought conditions would degrade habitat; Reservoirs - During most of the year, reservoirs will have more storage. During critical periods, significant withdrawals could be made with little damage to aquatic ecosystem. | Potomac River-during 7-day drought conditions would degrade habitat; Reservoirs - During most of the year, reservoirs will have more storage. During critical periods, significant withdrawals could be made with little damage to aquatic ecosystem. | Potomac River-during 7-day drought conditions would degrade habitat; Reservoirs - During most of the year, reservoirs will have more storage. During critical periods, significant withdrawals could be made with little damage to aquatic ecosystem. | Potomac River-during 7-day drought conditions would degrade habitat; Reservoirs - During critical periods significant withdrawls would have a damaging effect on the aquatic ecosystem. Does not require construction of Little Seneca. |
| SWB | Would eventually produce health and safety risks because of limited water supplies. | Does not impair health and safety of the area because water needs are met. | Does not impair health and safety of the area because water needs are met. | Does not impair health and safety of the area because water needs are met. | Does not impair health and safety of the area because water needs are met. |
| RD | Does not meet the local desires to provide adequate water supplies. | Meets the local desires of the planners as the projects are similar to the local plans for the area. | Meets the local desires of the planners as the projects are similar to the local plans for the area. | Meets the local desires of the planners as the projects proposed are similar to the local plans for the area. | Meets the local desires of the planners as the projects proposed are similar to the local plans for the area. |

TABLE B-32 (Cont'd)
SYSTEM OF ACCOUNTS, PLANS FOR CHOICE

| | PLAN 1 WITHOUT CONDITION | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|---|
| C. EVALUATION (NOTE: -= does not meet objectives. +=meets objectives partially. ++=totally meets objectives.) | | | | | |
| Flexibility | - | ++ | ++ | + | ++ |
| Limited Evntl Impact | - | + | + | - | ++ |
| Ease of Implementation | ++ | ++ | ++ | + | - |
| Economic Equity | - | - | + | ++ | ++ |
| Low Cost | - | + | + | ++ | + |
| Plng. Compatibilty | - | ++ | ++ | ++ | + |
| Social Cohesion | ++ | + | + | + | ++ |

TABLE B-32 (Cont'd)
SYSTEM OF ACCOUNTS, PLANS FOR CHOICE

| | PLAN 1 WITHOUT CONDITION | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|---|
| D. RESPONSE TO: | | | | | |
| (NOTE: ++= responds highly += does respond -= response likely --= does not respond.) | | | | | |
| Acceptability | + is acceptable now but in future deficits will occur | ++ most easily accepted | + has possibility for acceptance | - may not be politically favored | -- is the least acceptable |
| Completeness | -maintains fragmented planning | ++incorporates all forms of planning | ++incorporates all forms of planning | ++incorporates all forms of planning | ++incorporated all forms of planning |
| Effectiveness | -not a coordinated approach | -is not most coordinated approach | +does coordinate planning efforts | ++is a coordinated approach | ++is a coordinated approach |
| Efficiency | -does not meet needs in best way | -meets needs however effort may be fragmented | +meets needs in a less fragmented way | ++meets needs in least fragmented way | ++meets needs in least fragmented way |
| Certainty | ++is being implemented now | +most likely to be implemented | -not too good for implementing | --difficult to implement | --difficult to implement |
| Geographic Scope | -not regional in perspective | -not the most regional in scope | ++is regional in perspective | ++is regional in perspective | ++is regional in perspective |

TABLE B-32 (Cont'd)
SYSTEM OF ACCOUNTS, PLANS FOR CHOICE

| | PLAN 1 WITHOUT CONDITION | PLAN 2 LOCAL PLAN | PLAN 3 SUBREGIONAL PLAN | PLAN 4 REGIONAL PLAN | PLAN 5 REGIONAL PLAN |
|---|---|---|---|---|---|
| E. RANKINGS<br>1=best<br>2=good<br>3=fair<br>4=poor | | | | | |
| NED | 4 | 3 | 2 | 1 | 3 |
| EQ | 4 | 3 | 3 | 3 | 3 |
| SWB | 4 | 2 | 2 | 2 | 3 |
| RD | 4 | 2 | 2 | 2 | 2 |

Plans 2, 3, and 4 represented different alternatives with the development of the Little Seneca Lake site. No significant effects to the Patuxent resesrvoirs would be expected with respect to the Without Plan. A slight improvement during the early spawning period would occur with all of the plans, although Plan 5 would have the least detrimental effect. Both Regional plans would also improve conditions in the Occoquan reservoir.

Ease of Implementation

As stressed earlier, the effective implementation of any of the Plans for Choice would require varying levels of regional cooperation among the implementing agencies. None of the plans would meet the design condition without the cooperation that is necessary to design, operate, and manage the plans and their components.

The most difficult plans to implement would be Regional Plans 4 and 5; because they were comprised of projects located in two service areas (the FCWA and WSSC), but would be operated to meet the needs of a third (the Aqueduct) party as well.

Economic Equity

Each of the plans was judged to be equitable from an economic viewpoint, insofar as the basis for cost apportionment was that each user would share in the cost of the plan components according to the degree of water supply benefits derived. Plan 4 would be the least expensive plan from a regional viewpoint; however, it would not be least expensive for all of the service areas - most notably - WSSC. Given these differences, perceptions of economic equitability depend upon the particular plan and the particular service area.

Low Cost

Plan 4, the Regional Plan, represented the lowest cost plan to meet the 2030 demands among the four actions plans considered. This plan would provide the means for the region to solve its water supply probably in the most affordable way available. Plans 2, 3, and 5 each represented plans which did not vary significantly in cost among themselves, but which were considerably more expensive than Plan 4.

Low Risk

From a standpoint of design, the action plans were developed to meet the risk associated with the 7-day, once in 100-year frequency low flow condition. Based on meetings with the local water suppliers, these conditions represented a publicly acceptable risk level given the monetary resources and water supply capabilities of the local utilities.

Plan 5 represented the highest risk plan insofar as it relied on only one project (raw water pipeline) to meet the regions needs. At the end of the severe drought this plan would probably carry forward the least amount of storage of the four action plans. In the event that pumps should fail for this plan, no other facilities would be available to meet water shortages.

On the other hand, each raw water interconnection decreased the risk to public safety and health should the Potomac River become contaminated or unfit for drinking purposes for a short period of time. Should this unlikely event occur, off-Potomac supplies could be made readily available to the region via reversible pipelines. Plans 2 and 3 would particularly provide overall benefits to the entire region by diluting Potomac River flows with water from the Little Seneca Lake and providing an offstream source to FCWA.

Planning Compatibility

All of the early-action water supply plans were in general agreement with local and regional development goals because they assured a safe and dependable water supply to meet the region's needs through the year 2030.

All of the action plans required the implementation of Conservation Scenario 3, which was consistent with local perceptions and preferences for using conservation as a means to conserve water in the MWA.

Each plan was comprised of at least one component which was actively being pursued by local water suppliers as a potential water supply project to meet water shortages in their respective service areas. The Subregional and Local Plans specified projects consistent with local plans. Plan 5 conflicted the most with local planning initiatives because it did not consider construction of the Little Seneca Lake, which was a high priority project for the WSSC.

The extensive use of utility rights-of-way for the raw water interconnection projects of Plans 2, 3, 4, and 5 reduced the total amount of land that would be needed for project implementation and thus was most consistent with local land use development plans. Plans 2 and 3 did so particularly because they contained the Potomac to Occoquan raw water interconnection, which followed existing utilities for almost 70 percent of its length. In attempting to coordinate planning attempts, all of the raw water interconnections utilized existing intakes on the Potomac River and existing WTP's.

Social Cohesion

None of the action plans was projected to create any widespread long-term adverse effects on the social cohesion of local communities within the region. The only serious disruption to the patterns of life would be felt in the established areas inundated by the waters of Little Seneca Lake in rural Montgomery County (Plans 2, 3, and 4). Although disruption to daily communication and transportation activities of urban and suburban communities would likely result from the construction of pipeline projects for all of the action plans, these would be temporary in nature and normal activities should resume, relatively unchanged from the pre-pipeline condition.

## RESULTS OF EARLY-ACTION PLANNING

### AUGUST 1979 PROGRESS REPORT

The final product of the Corps' early-action phase was a 10-volume Progress Report published in August 1979 which documented study activities up to that date. The Progress Report concentrated primarily on the formulation, assessment, and evaluation of the five early-action Plans for Choice for the four Potomac service areas through the year 2030. (It is important to remember that the early-action phase, although originally intending to formulate plans to satisfy needs through the year 2000, actually investigated plans capable of carrying the region through the year 2030.) The Progress Report was distributed to affected Federal, interstate, state, county and local governments, water supply agencies, citizens groups, industries, and other interested parties for review and comment.

The document was prepared to provide a wide base of information, from a regional perspective, so that local experts could further evaluate the data and choose the best course of action to meet the Potomac service area's water supply needs. No recommendations for Federal involvement were made in the Progress Report, however, as water supply development was viewed as a total non-Federal cost category in accordance with the terms of the Water Supply Act of 1958. This approach placed the responsibility for any initiative to solve the potential water supply problems squarely in the hands of local and regional decison-makers.

## PUBLIC INVOLVEMENT

During the preparation and distribution of the Progress Report, two additional Water Forum Notes were published. Water Forum Note 6 (June 1979) briefly described the screening of the nine plans in Iteration II to the five Plans for Choice in Iteration III. Water Forum Note 7 (September 1979) presented a comparison of plan costs as apportioned to different users and an estimate of per capita plan costs by service area. Many positive comments were received on the entire series of Water Forum Notes, especially in regard to the simple overview they provided on the MWA's complex water supply situation.

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. Generally unfavorable comments were received on the method of cost apportionment (especially 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 projects which were based on Round I and not Round II growth forecasts by MWCOG.

Written comments were also received from numerous sources concerning the Progress Report. Samples of some of these letters are contained in Annex C - VIII - Background Correspondence. Most of the written comments reflected the same concerns and issues raised at the workshops and public meeting.

## NAS/NAE MEETING AND REPORT

Additionally, the NAS/NAE Committee for the MWA Water Supply Study met on 27 and 28 September 1979 to review the Corps' Progress Report. This meeting resulted in a letter report from NAS/NAE dated 11 December 1979 both complimenting and criticizing certain aspects of the report. This letter report was followed by a more comprehensive review report prepared by NAS/NAE and transmitted to the Corps on 1 October 1980. Both the letter report and the review report are contained in Annex C-IX - Coordination with National Academy of Sciences - National Academy of Engineering.

## FISRAC MEETING

Recognizing that the impetus for any early-action plan would likely come from a consensus of the affected states and water supply utilites, the Corps convened a meeting of its Federal-Interstate-State-Regional Advisory Committee (FISRAC) in December 1979. This committee had met several times before December 1979 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 related both to the study in particular and the water supply problem in general. First, the FISRAC 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 anyway. 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. (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 or adequate land to develop them. Some form of regional cooperation 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 narrowed in on Plan 4 as providing the basis for a cost-effective and acceptable framework for any regional plan.

Finally, these three conclusions led naturally and directly 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 and cooperation already initiated through the signing of the Potomac Low

Flow Allocation Agreement in 1978 and the creation of a "Section" in November 1979 by the Interstate Commission on the Potomac River Basin to develop Cooperative Water Supply Operations on the Potomac (CO-OP).

CREATION OF REGIONAL TASK FORCE

Having reached these conclusions at the FISRAC meeting, the participants asked Mr. Robert S. McGarry, General Manager of WSSC, to form a Washington Metropolitan Regional Water Supply Task Force of local elected officials to further develop and implement a regional management strategy. The Regional Task Force first met in January 1980, and worked through the summer of 1982 on devising and implementing a regional water supply plan. The Regional Task Force was assisted by both a Technical Advisory Group and a Citizens Advisory Group. The Regional Task Force and its associated support groups made exceptional progress in their deliberations, aided primarily by the growing spirit of cooperation among the various jurisdictions and the recognition of the significant advantages to be gained by approaching the water suppy problem from a regional management viewpoint.

Using the Corps' August 1979 Progress Report as a starting point, the Regional Task Force proceeded to develop its own regional plan amenable to timely local implementation without direct Federal involvement. The Regional Task Force's plan included components such as water conservation, reregulation, and Little Seneca Lake which were examined in the Progress Report. Additionally, the Regional Task Force incorporated the findings of the CO-OP modelling efforts performed in 1980 and 1981 by ICPRB to establish formal regional regulation guidelines for coordinating reservoir releases and utilities' water withdrawal (As these modelling efforts were conducted after completion of the Progress Report, they were considered in the Corp's long-range phase of study and are further described in a later section.) The Regional Task Force plan, like the Corps' early-action plans, were estimated to satisfy the water supply needs in the four Potomac service areas until at least the year 2030. In concept, the Regional Task Force plan was very similar to Plan 4 formulated by the Corps of Engineers with the exception that a Potomac to Patuxent raw water interconnection was not included. Optimum regional management of the water supply system, as outlined during the CO-OP modelling efforts, would negate the need for this additional structural project prior to the year 2030.

The most important accomplishments of the Regional Task Force, however, were not in selecting technical components for the plan but in negotiating the numerous agreements and contracts which would be necessary to implement the plan. Such institutional arrangements were originally viewed as nearly insurmountable obstacles blocking any move toward regional water supply management. To the credit of the Regional Task Force, though, it was able to use the Corp's Progress Report, the mathematical modelling efforts of the CO-OP program, and its own work to convince others of the significant advantages of such regional cooperation. Furthermore, the Regional Task Force took the initiative to negotiate the necessary institutional arrangements so that implementation of the plan could proceed expeditiously.

STATUS OF EARLY-ACTION PLANNING

By early 1982, the Regional Task Force had reached general agreement on the technical components of its plan and the necessary institutional arrangements. A significant milestone was subsequently achieved on 22 July 1982 when the responsible Federal, state and local officials gathered to sign the final agreements and contracts to implement the regional plan. Taken together, the six signed agreements and contracts created a unified "package" which formalized the MWA's future commitment to regional water supply management. This commitment took the following forms:

- A contract by which WSSC, FCWA, and WAD/DC will purchase all water supply storage (both initial and future) in Bloomington Lake. Yearly repayments to the Corps for capital and O&M cost allocated to water supply are to be shared among WSSC (50 percent), FCWA (20 percent), and WAD/DC (30 percent). See Annex H - IX for a copy of the contract.

- A novation agreement between the Corps of Engineers and the Maryland Potomac Water Authority terminating the original contract for initial water supply storage repayment for Bloomington Lake. See Annex H-X for a copy of the novation agreement.

- An agreement between WSSC, WAD/DC, and FCWA to share the capital and O&M costs of the water supply portion of Little Seneca Lake, with WSSC assuming a 50 percent share, WAD/DC assuming a 40 percent share, and FCWA assuming a 10 percent share. (The cost of land for the buffer zone and for recreation is not to be shared). See Annex B-II for a copy of the cost-sharing agreement.

- An agreement among WSSC, FCWA, WAD/DC, and Allegany County, Maryland to share the O&M costs of Savage River Reservoir, presently borne entirely by Allegany County, because Savage River Reservoir releases will be necessary to neutralize acidic releases from Bloomington Lake. Annual shares are to be repaid by WSSC (40 percent), FCWA (16 percent), WAD/DC (24 percent), and Allegany County (20 percent). See Annex B-III for a copy of this agreement.

- Modification to the existing LFAA to eliminate the provision that freezes the computation of each jurisdiction's low flow share after 1988 and to include Little Seneca Lake releases as flow subject to the allocation formula. This modification is to become effective only when Little Seneca Lake is operational and the regional operating agreement is in place. See Annex D-IV for a copy of the LFAA and the modification.

- An agreement among WSSC, WAD/DC, and FCWA to use ICPRB's CO-OP program to achieve the regional operational water supply objectives stated below. See Annex B-I for a copy of the Water Supply Coordination Agreement.

(1) Maintain the risk of invoking the Potomac Low Flow Allocation Agreement (LFAA) at less than five percent during the repeat of any historical drought.

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

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

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

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

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

- An agreement to share the construction and O&M costs of any further MWA water supply project after Little Seneca Lake among the parties in accordance with the formulas below. Further, water from such a project would be subject to allocation according to the LFAA. The terms of this arrangement were also included in the Water Supply Coordination Agreement (see Annex B-I).

DC's Share $\% = \frac{(A-B)}{(A-B) + (C-D) + E-F)} \times 100$

FCWA's Share $\% = \frac{(C-D)}{(A-B) + (C-D) + (E-F)} \times 100$

WSSC's Share $\% = \frac{(E-F)}{(A-B) + (C-D) + (E-F)} \times 100$

Where:

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 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 substitute the number of gallons of process water pumped daily.

D = Same as B, except subsititue 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 processed water pumped daily by the WSSC.

With these agreements and contracts in place, WSSC is now proceeding with construction of Little Seneca Lake, a key element of the regional plan. All of the necessary State and Federal permits have been obtained, the design phase has been completed, and financing has been arranged. Ground breaking ceremonies were held in September 1982.

In a related matter, proposed legislation has been submitted to the U.S. Congress to permit the sale of water from the Federally owned Washington Aqueduct directly to authorities in the State of Maryland in a manner similar to the sale of water to Virginia communities authorized under existing legislation. This authorization would allow the construction of finished water interconnections between the Washington Aqueduct Division and the Washington Suburban Commission 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.

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 local implementable solutions with the MWA boundaries. The findings of the Progress Report, along with the CO-OP modelling program by ICPRB, provided both the background information and the necessary incentive for local jurisdictions to proceed toward a regional solution for the water supply problem.

A fundamental objective of the Corps' early-action program was therefore achieved by means of the Progress Report: i.e., to enable decisions and implementation of high priority water supply plans in a timely fashion.

## LONG-RANGE PHASE

### OVERVIEW

As originally envisioned, the long-range phase of the MWA Water Supply Study was to consider the water supply needs beyond the year 2000, and focus attention on a full range of water supply alternatives in addition to those considered in early-action planning. However, the actions of the MWA water utilities since the 1979 Progress Report drastically altered the water supply situation. First, as a result of the planned construction of the new supply source (Little Seneca Lake) and the implementation of regional management of the supply system, the water supply base condition (the "without" condition) changed significantly, necessitating a redefinition of the water supply problem for this portion of the study. In addition, the full implementation of these programs would probably satisfy the MWA water supply demands through the year 2030. Therefore, the purpose and scope of the long-range phase was modified in part to reflect these changes.

Subsequently, the long-range phase of the MWA Water Supply Study concentrated on four points. First, the supply and demand conditions were redefined, taking into account the recent regional developments. Then, the capability of the existing system (the "without" condition) was reevaluated using a simulation model developed specifically for the MWA system. Next, the system's response to large changes in the supply and demand conditions was investigated, in order to ascertain the sensitivity of the system. Lastly, the full range of water supply alternatives was evaluated in the context of the redefined system's capability and sensitivity.

PROBLEM REDEFINITION

After the Progress Report was published in 1979, it was recognized that there were several shortcomings in the definition of the MWA water supply problem as stated in the early-action planning phase. First, the early-action supply was based mainly on the 7-day and 30-day system capacities and statistical flow duration data. It did not address low flow periods of longer duration or the flexibility of a regional system which can trade off between upstream and local impoundments, nor did it examine the benefits to be derived from this type of system operation. (A regionally managed system also has the advantage of allowing the water utilities to choose between reservoir and river withdrawals, to best meet their demands.)

Second, the early-action analysis, which assumed a continuous release of 135 mgd from Bloomington Lake, did not consider variable Bloomington water supply releases to satisfy fluctuating regional needs. Consequently, the operation of the Bloomington project assumed in the early-action analysis was inefficient and not fully representative of its supply potential.

Third, the early-action analysis did not thoroughly examine the effects of the low flow period on all of the system's reservoirs. Specifically, it did not evaluate the effects of long-term droughts on the reservoirs' capability to deliver adequate quantities of water throughout the drought. This was a serious shortcoming because the availability of storage would most likely be the limiting constraint of the supply system in a long-term drought.

In addition to these major shortcomings, the early-action supply base did not include regional management of the Savage River Reservoir nor did it account for travel time and flow losses between Bloomington Lake and the MWA's Potomac intakes, which could be significant during low flow periods.

Recognizing these inadequacies of the early-action phase, the study team decided to re-evaluate the supply base methodology. This review process culminated in the establishment of several analytical goals for the long-range supply base. These goals were:

(1) to examine Bloomington Lake and Savage River Reservoirs, in detail, as well as to the other local reservoirs,

(2) to analyze the effects of several months of flow as well as shorter periods, such as seven days,

(3) to incorporate the LFAA provisions and the reregulation plans for the Occoquan and Patuxent distribution facilities,

(4) to include the effects of transit losses and time between Bloomington and the MWA intakes.

(5) to evaluate the trade-offs between upstream and downstream (local) storage and between reservoir and river withdrawals,

(6) to examine the utility of regional cooperation by simulating the system's reservoirs for maximum, efficient use on a regional level,

(7) to investigate more effective release strategies for Bloomington, and

(8) to include flexibility in the supply parameters for additional analyses.

At the same time that the early-action methodology was being reviewed, research work at the Johns Hopkins University (JHU) was exploring state-of-the-art techniques for defining the MWA water supply problems. Toward this end, JHU researchers had investigated mathematical hydrologic models; however, these models were unable to incorporate some important system constraints, such as the LFAA and reregulation. These models were also limited in time scale, using time intervals of one month or longer. As such, they masked more frequent fluctuations in streamflow which are critical in the Potomac River Basin. Therefore, the JHU investigators turned to site-specific simulation modelling.

Simulation modelling describes the changes in a supply system caused by user actions and decisions and provides a record of how the system reacts to a sequence of flow data and needs. By their nature, simulation models can incorporate many site-specific elements. Consequently, simulation modelling could address the important institutional constraints (e.g., the LFAA) where other techniques could not.

Additionally, the recent developments in the MWA water supply situation changed the character of the supply and demand problem. In the early-action analysis, the emphasis was on a comparison of the rate (mgd) of supply (Potomac flow and reservoir withdrawals) versus demand. The realization of reregulation plans, Little Seneca Lake, Bloomington water supply storage, and regional cooperation effectively reduced the short-term water supply flow problems. The remaining constraint in the supply situation was then the volume of storage available in a long-term drought. This volumetric supply and demand relationship became the major aspect of the problem to be addressed in the long-range planning phase. This type of problem lent itself easily to a simulation type of analysis.

In late 1979, the JHU efforts had advanced to the point where they had a working MWA simulation model. Since this new tool was available, the Corps of Engineers contracted with the model developer to adapt the Hopkins simulation model to the MWA Water Supply Study needs for the long-range planning phase. In addition, the Corps' study team further modified the model to specifically address the analytical goals stated earlier. This model, named the Potomac River Interactive Simulation Model (PRISM/COE) was then used extensively in the long-rang phase for both redefinition of the MWA problem and evaluation of the supply effectiveness of different operating strategies and supply alternatives.

The PRISM/COE model was designed to simulate the operation management of the MWA multi-reservoir and river system on a weekly basis for the 50 years of flow record be record between October 1929 and September 1979. The model incorporates the major supply elements of the MWA system: Bloomington Lake, Savage River Reservoir, Triadelphia and Rocky Gorge Reservoirs, Occoquan Reservoir, and the Potomac River. At the time of the PRISM/COE development in the late 1970's, the construction of Little Seneca Lake did not appear imminent; therefore, the reservoir was not included in the model. However, Little Seneca Lake was simulated separately. Details of the calculations can be found in Appendix D, Supplies, Demands, and Deficits.

The PRISM/COE simulation model is able to monitor the storage levels and releases of all of the reservoirs as well as flows in the major streams. The model also accounts for the effects of reregulation throughout a drought, as well as the travel time between the upstream reservoirs and the MWA. Important system constraints such as Bloomington flood control and water quality operations and the LFAA are defined in the model programming. The model also provides a detailed accounting of Bloomington storage and releases, charactistic of the probable regulation of the project. Full details of the PRISM/COE simulation model are described in Annex H-III - PRISM/COE Development and Application.

As a result of its unique capabilities, the PRISM/COE model played an important role in redefining the MWA problems by simulating the new "without" condition for the Potomac users as well as by testing potential operating schemes. In conjunction with other technical analyses, the model was able to identify a good operating policy for regional management of the system from a water quality as well as a water supply perspective. This policy, in turn, was included in the "without" condition analysis, since it represented how the system would most likely be operated. In addition, the model also formed the basis for the supply analysis in the Bloomington Lake Reformulation Study since its structure was designed to evaluate the Bloomington storage in detail.

The selected baseline regional operation strategy as well as the other supply and demand assumptions for the long-range phase are outlined below. Many of them were specifically developed for the PRISM/COE model analysis. These assumptions were then used to evaluate the capability of the existing system without further action by the water suppliers (the "without" condition).

## DEMAND

In the early action phase of the MWA Water Supply Study, the deficit analysis for the Potomac service areas used the Conservation Scenario 3 demands, based on MWCOG Round I population forecasts. For the long-range planning phase, these demands were reevaluated in the context of the current available information. The results of this reevaluation are presented below.

In 1980, MWCOG published its Round II forecasts for population in the MWA. These projections were not significantly different from the Round I forecasts. The Round II intermediate projections showed a total population in the Washington, D.C. SMSA of about 8 percent less than the Round I forecasts. However, most of the differences between Round I and Round II were reflected in the outlying service areas, with only minor decreases in the Potomac River users' jurisdictions. Furthermore, the Round I population projections and subsequent water demands had been accepted by several local groups, including CO-OP and the Regional Task Force, as the basis for their water supply planning efforts. For these reasons, the Round II population projections were not pursued further in the demand analysis for the Potomac users. The Round II projections, however, were used for the outlying areas as described in Appendix I.

In the past few years, the water supply utilities in the MWA have continued their efforts in water conservation. Reconfirming their decision in the early-action phase, the Potomac users still felt that the 10 to 11 percent damand reduction by 2030, represented by the conservation measures contained in Scenario 3 demands, would be reasonable and attainable. Therefore, Conservation Scenario 3 demands were assumed in the long-range planning phase.

Based on the existing planning conditions and the early-action demand assumptions, the Conservation Scenario 3 and Round I population forecasts were considered appropriate for the long-range planning. As in the earlier analysis, monthly demand variations were recognized. However, the weekly demand peaks of the early-action phase were not used in the long-range deficit analysis for several reasons. First, the PRISM/COE simulation model which was used in the long-range deficit analysis showed that weekly demand peaks had little or no impact on the overall supply availability in a long-term drought. Second, emergency conservation measures, such as those required by the Metropolitan Washington Water Supply Emergency Agreement, would be capable of controlling large fluctuations in demand. Additionally, the Round II population forecasts indicated less future growth in the Potomac dependent service areas which was not reflected in the Round I monthly average demands. As a result, the Round I demands were considered conservative from a deficit point of view. The set of 2030 demands for WSSC, WAD, and FCWA services areas, which were used in the long-range phase formulation, are tabulated in Table B-33. These monthly demands are identical to those developed in the early-action phase.

SUPPLY

The supply base for the MWA was expanded to include Little Seneca Lake and regional reservoir operations in the long-range planning phase. In addition, the available storages as well as the withdrawal capacities for the system's reservoirs were used as constraints. The available storage for each reservoir was determined by simulating inflows and outflows (evaporation releases and withdrawals) on a weekly basis using the PRISM/COE model.

For the offstream reservoirs, a conservation capacity of 10,300 million gallons (mg) for the Occoquan Reservoir, and a total conservation capacity of 10,100 mg for both WSSC reservoirs on the Patuxent River, were assumed. The Occoquan storage capacity included the two-foot extension to the dam by the addition of a poured in place concrete cap. The water supply withdrawals from these offstream reservoirs were limited by the maximum weekly treatment capacities of their systems. For the Occoquan (FCWA), this value was 95 mgd, while WSSC could only treat a maximum of 55 mgd, on a weekly basis which was the basic time unit used in PRISM/COE. Additionally, the treatment facilities at the reservoirs require a constant minimum flow for operational reasons, so minimum reservoir withdrawals of 30 mgd (Occoquan) and 20 mgd (Patuxent) were assumed.

TABLE B-33

LONG-RANGE MWA WATER SUPPLY DEMANDS
2030, CONSERVATION SCENARIO 3

Demand (mgd)

| Month | WSSC | WAD | FCWA | TOTAL |
|---|---|---|---|---|
| January | 224 | 199 | 115 | 538 |
| February | 224 | 198 | 115 | 537 |
| March | 225 | 193 | 116 | 534 |
| April | 235 | 202 | 126 | 563 |
| May | 263 | 212 | 138 | 613 |
| June | 291 | 238 | 150 | 679 |
| July | 304 | 259 | 163 | 726 |
| August | 290 | 256 | 154 | 700 |
| September | 290 | 239 | 146 | 675 |
| October | 251 | 219 | 130 | 600 |
| November | 233 | 206 | 123 | 562 |
| December | 229 | 201 | 121 | 551 |

The conservation storage capacity of Little Seneca Lake was defined as 4,020 mg. Water supply releases from Little Seneca Lake were assumed to flow without loss to the MWA intakes within a day. The timing and magnitude of the releases were based on deficit conditions in the MWA. The water supply releases were restricted to the maximum outlet capacity of 275 mgd. The assumed release policy was not necessarily the optimal strategy for regional management; however, with eventual regional management of the supply system, a day-to-day operational model will be able through CO-OP to better maximize the use of the system elements, including Little Seneca Lake.

For the "without" condition, Bloomington Lake's conservation capacity was set at the authorized level of 30,000 mg (92,000 acre-feet), of which 13,370 mg (41,000 acre-feet) was allocated to water supply storage for non-Federal users, and 16,630 mg (51,000 acre-feet) to water quality storage controlled by the Federal government. The available Savage conservation storage was defined as 5,900 mg since about 600 mg of Savage's 6,500 mg conservation capacity is set aside for water supply for the Town of Westernport.

The operation of the two upstream reservoirs within the regional supply system was very important to the supply base in the long-range planning phase. Consequently, it was studied in great detail with the PRISM/COE model as part of the Bloomington Lake Reformulation Study. Many of the decisions used in this supply analysis were derived from the investigations in that study, and are detailed in Appendix H, Bloomington Lake Reformulation Study. For the upstream regulation, both reservoirs were assumed to follow their existing rule curves, drawing down the pools in winter for flood control and bringing them back up in late spring. Water quality releases were made from each reservoir based on meeting a flow target of 78 mgd (120 cfs) at Luke, Maryland, and maintaining acceptable water quality in the North Branch Potomac River. This minimum flow value was the result of detailed reservoir and stream water quality modelling, as described in Annex H-II, Water Quality Investigations. Also, the modelling indicated that the proportion of Savage to Bloomington releases should vary depending on the time of the year and the total flow at Luke. This was taken into consideration in the scheduling of water quality releases for the long-range supply and demand analysis.

Water supply storage in Bloomington was released to meet downstream MWA needs when the Potomac River flow declined to low levels; at the same time, a proportional Savage release was made to dilute the acidic Bloomington release. The volume of upstream water supply release varied with time, as the need for extra supply arose. The timing of releases was a key factor in the supply scenario, and as such was the subject of intensive investigations using the PRISM/COE model.

With regional management of the system, the balance between upstream reservoir usage and downstream reservoir usage became quite important to the overall MWA supply base. Releasing large volumes of upstream (Bloomington) storage allowed large Potomac withdrawals, thereby preserving the downstream reservoir storage. However, this strategy quickly depleted the Bloomington water supply storage and proved to be a great risk in a long-term drought. A large degree of reliance on the Occoquan and Patuxent reservoirs drained their storages rapidly, but maintained a large supply in Bloomington. This policy could prove ineffective if the Potomac flows dropped off quickly and upstream releases were not made in time. The balance between the two sets of reservoirs essentially became a fine tuning of the system supply network. During the long-range planning analysis, this balance was studied intensively and a proper balance was selected, taking into account environmental, water quality, and water supply concerns. This was then the basis for the regional reservoir management strategy. The particulars of this investigation can be found in Appendix H.

In addition to these reservoirs, the MWA supply base also consisted of the Potomac River source. For the long-range phase, the Potomac River flows were simulated from historical flow records. The natural Potomac River flow was then adjusted for the Bloomington and Savage reservoir-controlled areas. The Potomac River flow which was available to the MWA users was then this natural base flow plus any releases (water quality or water supply) from the upstream reservoirs. About 47 percent of the upstream release was assumed to arrive within the actual week of release, and the remaining 53 percent in the following week. These travel times and volumes were the results of low flow modelling by the USGS in their travel time study which is discussed in Annex H-V - USGS Flow Loss and Travel Time Studies. On top of these releases, would be any Little Seneca Lake releases.

The Potomac River supply was allocated to the three major Potomac users (FCWA, WSSC, and WAD) according to the allocation formula set forth in the LFAA and described in the early-action portion of this appendix. For the long-range analysis, the potential freeze option of the LFAA was not invoked because the LFAA signatories had modified the LFAA to eliminate the freeze provision once Little Seneca construction was completed. The final Potomac withdrawal of each utility was limited by this allocation, the demand that could be supplied by its Potomac facility, and the capacity of its intake facility. For FCWA, WSSC, and WAD, the Potomac intake capacities were set at 200, 400, and 650 mgd, respectively. These values are identical to those assumed in the early-action supply evaluation.

The Potomac River water supply withdrawals were also limited by the designated estuary flowby minimum. For the long-range "without" condition, this value was defined as 100 mgd as recommended by the state of Maryland in their report, The Potomac River Environmental Flowby Study. This study, an outgrowth of the LFAA negotiations, was an assessment of the effects of low flows on the Potomac River ecosystem. The executive summary of the study is contained in Annex D-V.

These elements and considerations, thus formed the water supply base for the long-range phase. A comparison of the analytical elements for the supply and demand analyses of the early-action phase and the long-range phase is presented in Table B-34. This table demonstrates that the long-range phase devoted considerably more analysis to reservoir storage and regional management of the MWA system than did the early-action phase. This was the result of using simulation modelling as the major analytical tool.

## SYSTEM EVALUATION

Using the redefined supply and demand base, a PRISM/COE simulation was performed for the 50 years of historical flow data between 1929 and 1979. This simulation established the "without condition" for the long-range phase. The input data for this simulation are summarized in Table B-35. The simulation results for the 1930-31 and 1966 flows are presented in Table B-36.

TABLE B-34

COMPARISON OF WATER SUPPLY BASE
AND DEMAND ASSUMPTIONS
EARLY-ACTION VS. LONG-RANGE

| Description | Early-Action | Long-Range Planning |
|---|---|---|
| MWA Demands | Round I forecast<br>Conservation Scenario 3*<br>Weekly peaks | Round I forecast<br>Conservation Scenario 3<br>Monthly Average |
| Potomac Withdrawal Capacity | | |
| FCWA | 200 mgd | 200 mgd |
| WSSC | 400 mgd | 400 mgd |
| WAD | 650 mgd | 650 mgd |
| Occoquan Max. Withdrawal | 95 mgd | 95 mgd |
| Patuxent Max. Withdrawal | 55 mgd | 55 mgd |
| Occoquan Storage | Not Addressed** | 10,300 mg |
| Patuxent Storage | Not Addressed** | 10,100 mg |
| Bloomington Storage, Total | Not Addressed** | 30,000 mg |
| Water Quality | Not Addressed | 16,630 mg |
| Water Supply | Not Addressed | 13,370 mg |
| Bloomington Release | 135 mgd | Regional Need-Dependent |
| Travel Time of U/S Release | Not Addressed | 47% 1st Week, 53% 2nd Week |
| Little Seneca Lake Storage | Not Addressed*** | 4,020 mg |
| Little Seneca Lake Release | Not Addressed*** | Offset Potential Deficits |
| Regional Management | Not Addressed | Systems Approach |
| Flow Data | Frequncy-Duration | Recorded Drought Simulation |

* Although not truly part of the demand base, Conservation Scenario 3 was considered as an element in all of the proposed plans of the early-action phase.

** The storages in these reservoirs were not analyzed in detail in the early-action analysis; however, their storage was considered as a supply source via their release capacity.

*** Little Seneca Lake was considered in the plan formulation aspect, rather than the supply base.

TABLE B-35

SUPPLY AND DEMAND
WITHOUT CONDITION FOR LONG-RANGE PHASE

| Assumption | 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 |
| Water Supply Release | variable |
| Seasonal Drawdown for Flood Control | yes |
| Savage River Reservoir | |
| Available Storage | 5,900 mg |
| Minimum Release | 13 mgd |
| Seasonal Drawdown for Flood Control | yes |
| Flow Target at Luke, Maryland | 78 mgd |
| Bloomington: Savage Release Ratios | time-dependent, flow-dependent |
| Water Supply Target Factor | 0.6 |
| Transit Factor, First Week | 47% |
| Transit Factor, Second Week | 53% |
| Flow Loss Between Luke and MWA Intakes | 0 mgd |
| Occoquan Reservoir | |
| Water Supply Storage | 10,300 mg |
| Environmental Flowby | 0 mgd |
| Minimum Withdrawal | 30 mgd |
| Maximum Withdrawal | 95 mgd |
| Patuxent Reservoirs (Triadelphia & Rocky Gorge) | |
| Water Supply Storage | 10,100 mg |
| Environmental Flowby | 10 mgd |
| Minimum Withdrawal | 20 mgd |
| Maximum Withdrawal | 55 mgd |
| Little Seneca Lake | |
| Water Supply Storage | 4,020 mg |
| Environmental Flowby | 1.12 mgd |
| Minimum Withdrawal | 0 mgd |
| Maximum Withdrawal | 275 mgd |
| Potomac Withdrawal Capacity | |
| WAD | 650 mgd |
| WSSC | 400 mgd |
| FCWA | 200 mgd |
| Potomac Estuary Flowby | 100 mgd |
| LFAA provisions | No Freeze |
| | |
| Demand Year | 2030 |
| Level of Conservation | Scenario 3 |

TABLE B-36

SUMMARY OF SIMULATION RESULTS FOR LONG-RANGE PHASE
WITHOUT CONDITION - 100 MGD FLOWBY

| | 1930-31 | 1966 |
|---|---|---|
| Maximum Deficit, mgd | | |
| WSSC | 0 | 0 |
| FCWA | 0 | 0 |
| WAD | 0 | 0 |
| Region | 0 | 0 |
| Cumulative Deficit, mg | | |
| WSSC | 0 | 0 |
| FCWA | 0 | 0 |
| WAD | 0 | 0 |
| Total | 0 | 0 |
| Available Storage Remaining, mg | | |
| Water Supply | | |
| Bloomington | 11,822 | 12,255 |
| Occoquan | 1,780 | 6,181 |
| 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 | 13 | 7 |

The "without condition" simulation for the long-range phase showed that the MWA supply system, as it currently is projected, could satisfy 2030 demands (Conservation Scenario 3) without difficulty. For the longest historical drought (1930-31) as well as the severest low flow occurrence (1966), the system would experience no deficits. A key to the system's operation without deficits is the availability of Little Seneca Lake releases on short notice. On some occasions, unpredicted sudden drops in Potomac River flow could cause deficits if releases from Little Seneca Lake are not immediately available.

For the 1930-31 drought, the simulated system operated for 13 weeks at the minimum flowby level as depicted in the Potomac River hydrograph in Figure B-22. For the remaining simulated periods in the 50 years of flow record, the minimum flowby of 100 mgd was reached in a total of 11 weeks of system operation: 7 weeks during 1966, 2 weeks during 1964, and 2 weeks during 1932. Otherwise, the system passed higher flows into the Potomac Estuary.

SENSITIVITY OF SUPPLY AND DEMAND BASE

Noting that the PRISM/COE simulations indicated the system could easily handle historical droughts with the 100 mgd flowby target, a sensitivity analysis using higher estuary flowby levels was performed. Additional 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 additional system demands on the Potomac River source or as lower Potomac base flows. The additional Potomac demands could be the result of (1) population growth higher 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 offstream source, such as the Occoquan or Patuxent Reservoirs. In addition, the higher Potomac demand could conceptually represent a lower base river flow than recorded in the past 50 years. Therefore, the analysis of several flowby levels was structured to evaluate how sensitive the MWA system was to higher demands or lower supply conditions than those in the "without condition" analysis which formed the basis for the long-range phase.

The simulation results for the flowby targets of 100, 300, and 500 mgd are tabulated in Tables B-37 and B-38 for two major historical low flow periods, the 1930-31 and 1966 droughts. In all other years of simulation, Little Seneca Lake releases were needed with a flowby target of 500 mgd in only three years. Otherwise, the system managed easily and Little Seneca releases were not required to maintain an adequate supply. For these other years, any Little Seneca Lake drawdowns were due to net evaporation losses.

With the 300 mgd estuary flowby target, system deficits occurred only for the 1930-31 flow simulation. The 500 mgd flowby target resulted in a severe MWA deficit in 1930-31, a moderate deficit in 1966, and an insignificant deficit in 1963. The extent of the deficits and flow conditions during the 1930-31 drought is clearly depicted by the simulated Potomac River hydrographs in Figures B-23 and B-24.

In these hydrographs, the estimated regional deficit is graphed for each week as the shaded bars below the designated flowby level. The sum of these bars (the area) is the cumulative deficit which would be experienced if that level of flowby was enforced.

FIGURE B-22

SIMULATED POTOMAC RIVER HYDROGRAPH
WITHOUT CONDITION, 100 MGD FLOWBY

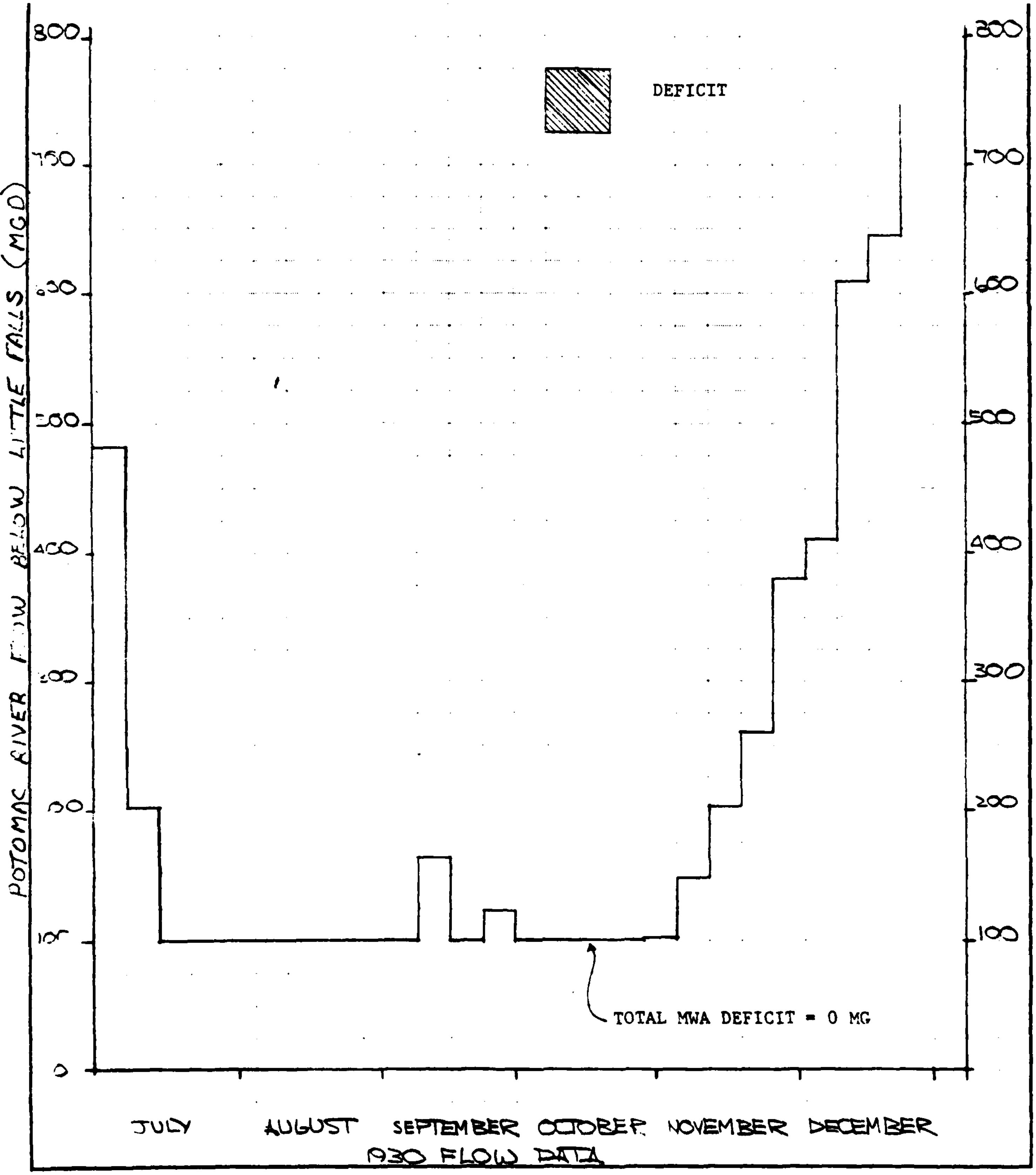


TABLE B-37

SUMMARY OF SIMULATION RESULTS FOR LONG-RANGE PHASE
WITHOUT CONDITION
1930-31 FLOWS

| | Flowby Level, mgd | | |
|---|---|---|---|
| | 100 | 300 | 500 |
| Maximum Deficit, mgd | | | |
| 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 Total Capacity (60,320 mg) | 66.7% | 16.7% | 13.5% |
| Weeks at Minumum Flowby Level | 13 | 18 | 21 |

TABLE B-38

SUMMARY OF SIMULATION RESULTS FOR LONG-RANGE PHASE
WITHOUT CONDITION
1966 FLOWS

| | Flowby Level, mgd | | |
|---|---|---|---|
| | 100 | 300 | 500 |
| Maximum Deficit, mgd | | | |
| WSSC | 0 | 0 | 235 |
| FCWA | 0 | 0 | 51 |
| WAD | 0 | 0 | 203 |
| Region | 0 | 0 | 487 |
| Cumulative Deficit, mg | | | |
| WSSC | 0 | 0 | 2,802 |
| FCWA | 0 | 0 | 713 |
| WAD | 0 | 0 | 2,343 |
| Total | 0 | 0 | 5,858 |
| Available Storage Remaining, mg | | | |
| Water Supply | | | |
| Bloomington | 12,225 | 862 | 0 |
| Occoquan | 6,181 | 6,163 | 5,764 |
| Patuxent | 7,033 | 7,171 | 6,789 |
| Little Seneca | 3,082 | 3,942 | 0* |
| Total | 28,551 | 18,138 | 12,553 |
| % of Capacity (37,790 mg) | 75.6% | 48.0% | 33.2% |
| Non-Water Supply | | | |
| Bloomington | 13,645 | 13,344 | 13,234 |
| Savage | 4,731 | 1,797 | 1,194 |
| Total | 18,376 | 15,141 | 14,428 |
| % of Capacity (22,530 mg) | 81.6% | 67.2% | 64.0% |
| Total Storage Remaining | 46,927 | 33,279 | 26,981 |
| % of Total Capacity (60,320) | 77.8% | 55.2% | 44.7% |
| Weeks at Minimum Flowby Level | 7 | 6 | 8 |

* This 1966 simulation started with the Little Seneca pool partially drawn down, due to 1965 releases.

FIGURE B-23

SIMULATED POTOMAC RIVER HYDROGRAPH
WITHOUT CONDITION, 300 MGD FLOWBY

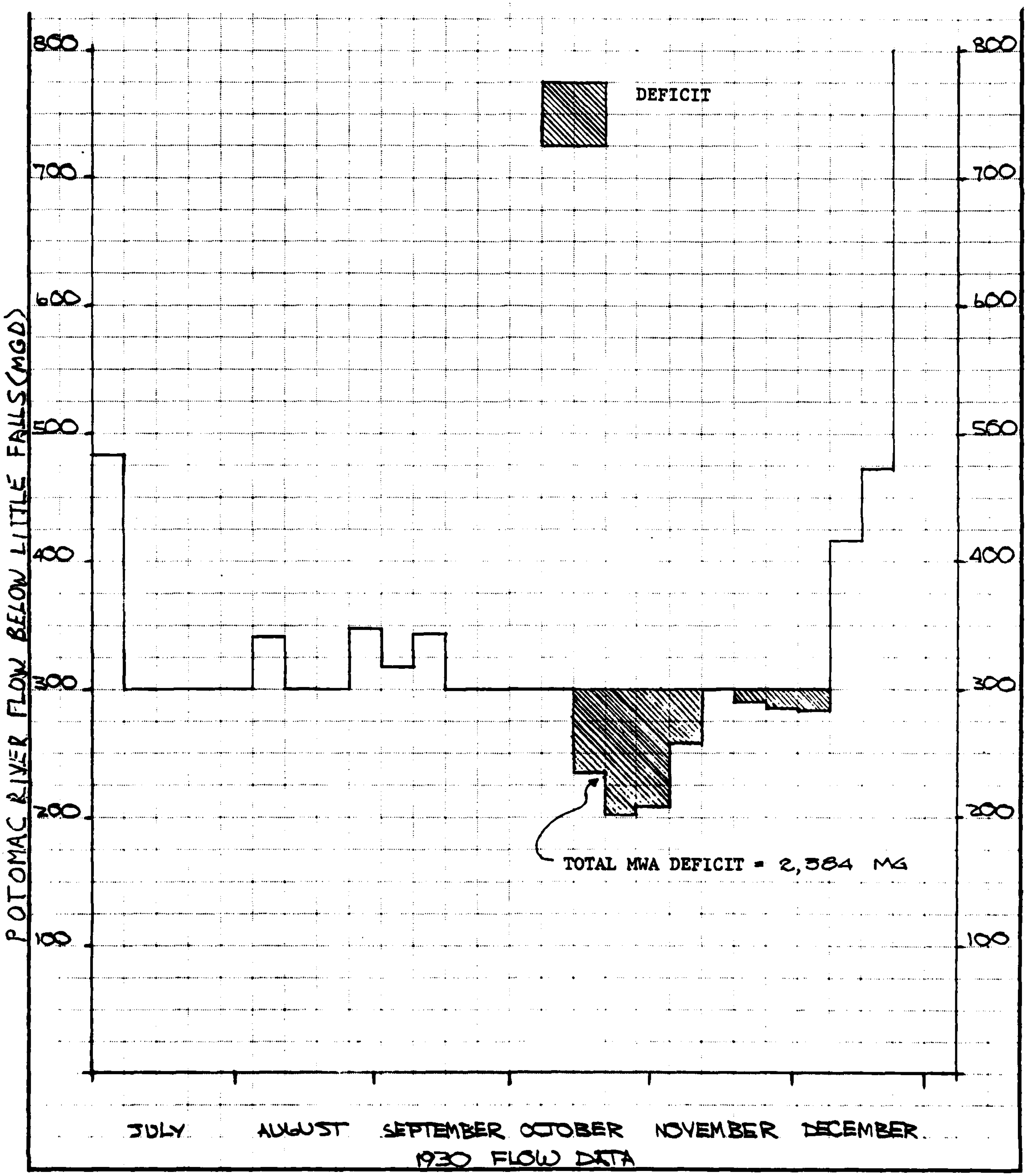
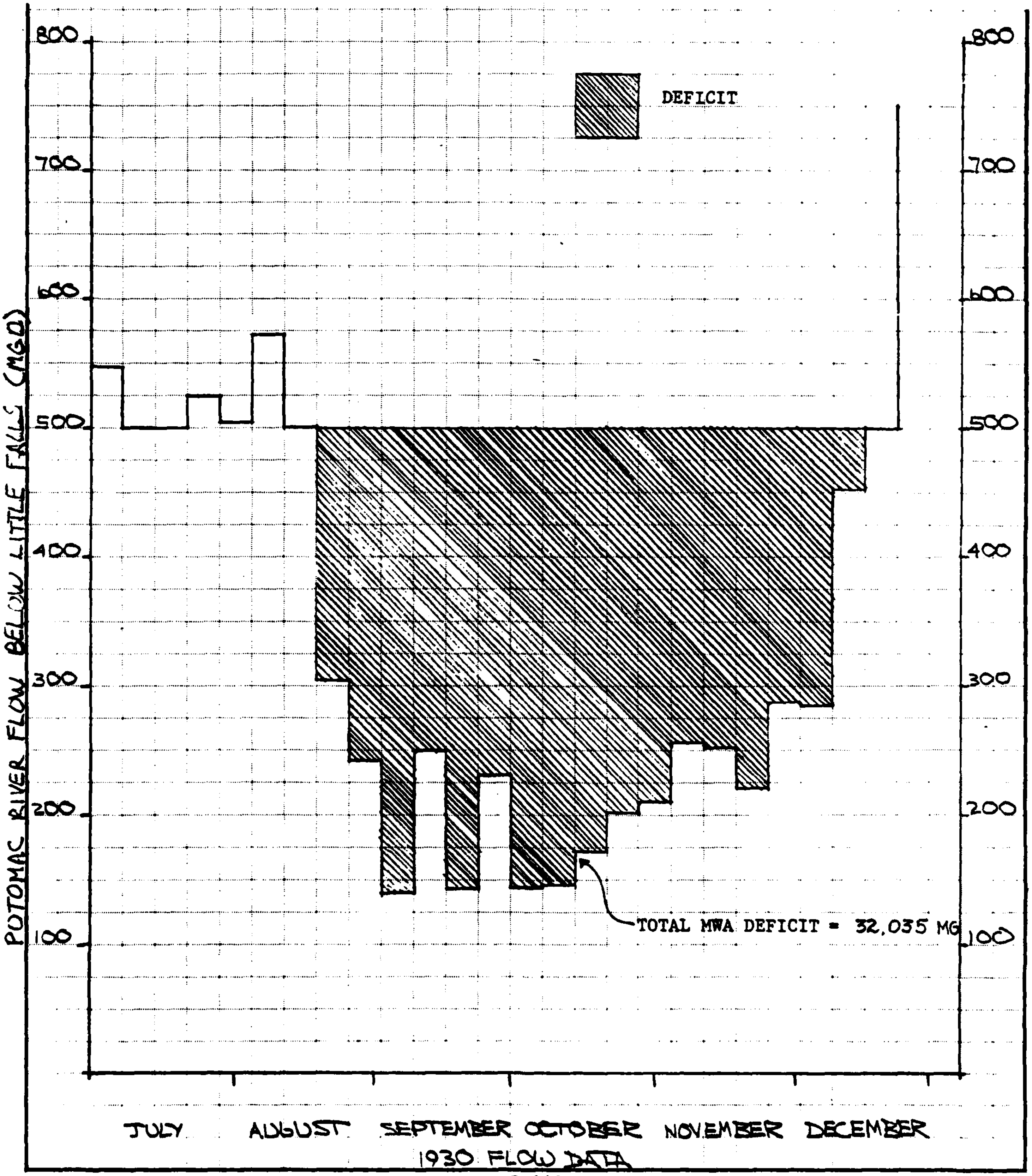


FIGURE B-24

SIMULATED POTOMAC RIVER HYDROGRAPH
WITHOUT CONDITION, 500 MGD FLOWBY



CONCLUSIONS

The recent developments in the MWA water supply situation have changed the character of the supply vs. demand problem. In the early-action analysis, the emphasis was on a rate of supply (Potomac flow and reservoir withdrawals) versus demand. This analysis concluded that there was potential for short-duration water supply shortages within the 50-year planning period. However, the realization of reregulation plans, Little Seneca Lake, Bloomington water supply storage, conservation plans and regional cooperation, have effectively (eliminated) any short-term water supply problems given 100 mgd flowby. The remaining limitation of the supply base is the volume of storage available in a more severe, extended drought with higher flowby values. This volumetric supply and demand relationship was the nature of the problem to be addressed in the long-range planning phase.

Based on the fifty years of historical flows, the current storage facilities (including the proposed Little Seneca Lake) can easily provide an adequate supply to the MWA through the year 2030, under the "without condition." Under the worst simulated conditions (the 1930-31 drought), only about one-third of the system's storage was required to meet the system's demand, indicating that under even lower base flows, the system should be adequate for the projected demands, and potentially higher flowbys.

With an increase in the level of flowby to 300 mgd (or an increase in demand and reduction in supply) the MWA system would severely tax its storage resources in a serious, long-term drought. The PRISM/COE simulations indicated that for 1930-31 drought condition the system's water supply storage would be reduced to only 7 percent of its capacity. In addition, the system would experience nearly 2,400 million gallons in deficit. For a 150-day drought, this deficit would average about 16 million gallons per day.

Much larger increases in demand or reductions in supply from the "without" condition would have even more significant effects. Assuming a flowby of 500 mgd (a change of 400 mgd) would result in 32,000 million gallons of regional deficit over a five-month period during a recurrence of the 1930-31 drought, or an average of 210 mgd. The system storage would be reduced to about 4 percent of its capacity. In addition, the system would experience a moderate deficit under the 1966 flow conditions, and would start to have shortages under even less severe flows.

APPROACH TO LONG RANGE FORMULATION

The preceding sections dealing with problem redefinition using PRISM/COE model simulations demonstrated that local actions would essentially eliminate water supply shortages under the projected supply, demand, and flowby conditions. In addition to this major conclusion, it was also demonstrated that additional demands placed on the system would result in regional deficits varying in magnitude depending upon the timing and volume of additional demand. These deficits might arise from a variety of circumstances such as a higher desired level of environmental flowby, higher than anticipated rates of population growth, and/or the reduction or failure of the available supply base.

Given the charge by the authorizing legislation of the study to evaluate a full spectrum of water supply alternatives available to the MWA and considering the sensitivity of the new "without condition" to variations in the supply or demand base, the objective of the long-range phase of the study then became to develop, evaluate, and present additional information on alternatives for the region which could produce additional volumes of supply over and above that which would be required given the base condition. In this way, the report would provide new information to area planners as to the technical feasibility and impact of water supply alternatives such as pricing, use of the Potomac Estuary, wastewater reuse, and groundwater use from the Coastal Plain aquifiers.

Unlike the early action phase of the study which presented "plans for choice," the long-range phase was not directed towards offering any additional plans. Rather, the long-range portion of this report is intended to serve as an information document, displaying the preliminary costs, and discussing the technological feasibility, impacts, and implementability of each of the components considered. This should provide a base of important information for local planners to consider should they wish to develop a program for meeting needs above the base condition. It will also provide new data and add to the wealth of knowledge on less traditional methods of supply augmentation and demand reduction which, at some point in the future, may prove to be more palatable to local decisionmakers.

## COMPONENT DEVELOPMENT

Ten components were identified for investigation in the long-range planning phase of the study. Table B-39 list these components and references the appendices of the report in which complete technical documentation appears for each. The first three components listed in Table B-39 were examined in the early-action phase of the study. These were reintroduced into the long-range phase of the study to determine the extent to which their full development could meet long-range objectives and the degree to which they would be applicable given the redefined "without condition." Reregulation was not included since it had been adopted locally as an operational practice and had become part of the existing conditions. The remaining six components represented new alternatives which were not considered in the early-action phase. These components served to broaden the realm of possibilities for providing more water or reducing the use of water within the region and represented, with some exceptions, less traditional water supply projects. In April 1980, a Stage II report on the Outlying Service Areas and Long Range Alternatives for the MWA Water Supply Study was published which documented the progress on the technical work underway at that time. This Appendix documents the completion of those long range studies. Appendix I deals with the Outlying Service Areas. The appropriate technical appendices contain the completed technical work for each component and that information in turn was drawn upon in the long-range formulation exercise. The following sections summarize the technical findings for each component studied.

### WATER CONSERVATION

Five water conservation scenarios were developed in the early-action planning phase and are summarized in Table B-15 presented earlier in this Appendix. The scenarios vary according to the user classes targeted for reduction and the degree and type of user participation. The scenarios are cumulative in their effect. Figure B-16 illustrates the range of their effectiveness from a 7 percent reduction by Scenario 1 to a 27 percent reduction by Scenario 5 in the year 2030. Water conservation programs capable of achieving levels of reduction comparable to Conservation Scenario 3 are now being implemented in the MWA and therefore have been assumed to be part of the new baseline condition which was redefined in earlier sections.

TABLE B-39

COMPONENTS FOR LONG-RANGE STUDY

| COMPONENT | REPORT REFERENCE FOR TECHNICAL DOCUMENTATION |
|---|---|
| Water Conservation | Appendix G |
| Raw Water Interconnections | Appendix E |
| Finished Water Interconnections | Appendix E |
| Pricing | Appendix G |
| Groundwater | Appendix F |
| Reservoirs | Appendix F |
| Potomac Estuary | Appendix F |
| Wastewater Reuse | Appendix G |
| Bloomington Reservoir Storage Reallocation | Appendix H |

Consequently, Conservation Scenarios 4 and 5 were available for further consideration at the outset of the long-range planning exercise. Conservation Scenario 4 accomplishes an additional level of reduction in the unaccounted for water use category by minimizing the amount of water lost from leaks through system improvements. This amounts to an additional 2% reduction over Conservation Scenario 3 or an overall 13% reduction based on the combined average annual demand figures for the year 2030 for WSSC, WAD and FCWA. These figures may vary slightly from service area to service area. Conservation Scenario 5 incorporates the savings achieved by Scenario 4 as well as providing an additional 16 percent savings over Scenario 3, or an overall reduction of 27 percent from the baseline. This is accomplished by achieving the most efficient use of available low water use fixtures for indoor new residential and non-residential water users and securing progressively greater levels of user implementation for more water efficient fixtures such as siphon jet toilets and shower controls.

Inspection of the demand reduction figures which appear in Table B-40 reveals that Conservation Scenarios 4 and 5 can achieve an additional 2 percent and 16 percent level of reduction, respectively, over and above Scenario 3 demands. Because of the relatively small reduction associated with Scenario 4, only Scenario 5 was selected to be investigated further for long-range planning.

Table B-41 provides a breakdown of the capital costs required to implement Scenario 5 in the major Potomac service areas both individually as well as in combination. Based on the data provided in this table a total cost of approximately $92.5, $28.4 and $61.4 million would accrue to the residents of the WSSC, WAD, and the FCWA service areas, respectively, by the year 2030. It is noted that siphon-jet toilets which represent a proto-type fixture of extremely high efficiency represents over ninety percent of the total cost of this scenario.

Of all the Conservation Scenarios originally considered, Scenario 5 would probably have the greatest impact on the MWA water user. Because of the severity in water use reduction, Scenario 5 may create several social and institutional impacts. For example, the implementation of the siphon-jet toilet in all new residential construction may create a very strong negative impact on residential users. Consumers may not be willing to use a toilet which does not operate exactly in the same manner as toilets have for years. People will not refrain from buying new homes just because of the siphon-jet toilets, but they may let their contractor know how displeased they are which may in turn be passed on to the institutions who requested the plumbing code changes.

Overall, the primary impact of Scenario 5 will be on the existing water use habits of residential and nonresidential sectors alike. Behavior modification will be the main force affecting the habits of water users. Initial distaste will arise but will be only temporary as new habits quickly replace the old.

## FINISHED WATER INTERCONNECTIONS

Finished water interconnections consist of pipelines which convey treated or "finished" water between separate water distribution systems. In the early-action phase of the study, reversible interconnections were investigated between the Aqueduct and the

TABLE B-40

LEVELS OF WATER DEMAND
REDUCTION - CONSERVATION
SCENARIOS 4 AND 5

| Major Potomac User Demands 1/ | % Reduction Above Scenario 3 Level | Total Level of Reduction From Baseline (686 mgd) | |
|---|---|---|---|
| Scenario 3 | 609 | 0 | 11 |
| Scenario 4 | 598 | 2 | 13 |
| Scenario 5 | 500 | 16 | 27 |

1/ Represents average annual demands (mgd) projected for the year 2030 for the WSSC, FCWA and WAD.

TABLE B-41

CAPITAL COSTS FOR CONSERVATION SCENARIO 5
($000)

| Conservation Measure | WAD | FCWA | WSSC | TOTAL |
|---|---|---|---|---|
| PRV's | ---------------N/A--------------- | | | |
| Insulation | 0 | 0 | 0 | 0 |
| Toilet Modifications | 802.2 | 472 | 807.7 | 2081.9 |
| Shower Modifications | 242.2 | 141.7 | 240.8 | 624.7 |
| Indoor Behavoir Mod. | 0 | 0 | 0 | 0 |
| Outdoor Behavoir Mod. | 0 | 0 | 0 | 0 |
| Non-Residential Behavoir Mod. | 0 | 0 | 0 | 0 |
| Siphon-Jet Toilets | 22,690 | 57,487.9 | 86,258.7 | 16,643.6 |
| Shower Controls | 1,281.1 | 3,243.2 | 4,865.5 | 9,389.8 |
| Leak Repair | 3,386.3 | 78.4 | 313.7 | 3,778.4 |
| Total Oct 81 $ | 28,402 | 61,423 | 92,486 | 182,311 |

WSSC, the Aqueduct and the FCWA, and between separate portions of the Aqueduct system (refer to Figure B-12). As part of this effort, pipeline alignments were identified and hydraulic studies were conducted to determine the full potential of finished water interconnections and their associated costs. An impact assessment was also conducted for each route alignment.

In recognition of some of the benefits possible from finished water interconnections, a finished water main was recently constructed between the Dalecarlia Water Treatment Plant of the Washington Aqueduct and the WSSC System in Montgomery County which was modelled after the WAD-WSSC Route #1 originally investigated during the early-action planning effort for this study.

Because of the potential benefits which could be realized from finished water interconnections, detailed design and cost data were developed for the major routes considered and are provided in Appendix E, Raw and Finished Water Interconnections and Reregulation. A summary of the capital costs for the four remaining finished water interconnections considered is reproduced in Table B-42.

TABLE B-42

TOTAL COSTS FOR FINISHED WATER INTERCONNECTIONS
($1,000,000 - October 1981 Prices)

| LINE | PIPELINE | PUMP STATION | LAND | TOTAL | O&M* |
|---|---|---|---|---|---|
| DESTINATION | | | | | |
| WAD-WSSC #6 | 1.9 | 2.2 | 6.7 | 10.8 | 0.09 |
| WAD-FCWA #8 | 2.4 | - | 6.1 | 8.5 | - |
| WAD-FCWA #4 | 20.0 | 3.0 | 11.4 | 34.4 | 0.13 |
| WAD-WAD #7 | 0.07 | - | - | 0.07 | - |

*Based on pump station operation of 30 days @ 24 hours per day continuously.

RAW WATER INTERCONNECTIONS

As discussed earlier and as depicted in Figure B-9, raw water interconnections permit a water supply system with the appropriate components (river source, reservoir storage, water treatment plants at both river source and reservoir, and a pipeline and pump system connecting the two sources and the treatment facilities) to conserve stored water during high flow periods for use during low flow periods. Implementation of raw water interconnections enable more efficient use of both the river water supply source and reservoir storage.

During the early-action phase of planning, several raw water interconnections were identified between the Potomac River and the Patuxent Reservoirs operated by the WSSC, the Potomac River and Occoquan Reservoir operated by the FCWA, as well as others. An optimization analysis was undertaken to determine the best combination of interconnections to satisfy the needs during critical drought periods. In addition to this, an impact assessment was done to determine the effects of these potential pipelines within the proposed pipeline corridors. After several iterations of optimization, impact assessment, and screening, it was determined that two of the interconnections schemes would best serve the needs of the major Potomac users. These were the Potomac River to Rocky Gorge Reservoir Route #1 and the Potomac River to Occoquan Reservoir Route #3 (see Figures E-7 and E-12 in Appendix E for detailed route alignments). These alternatives were chosen over the others based upon their relative cost-effectiveness, the flexibility they provided in taking advantage of the existing treatment capacity at both ends of pipeline, and their ability to allow for storage of excess Potomac flows.

Based on the merits of these projects, each of the "Plans for Choice" developed for the early-action report contained either a Potomac-Patuxent or Potomac-Occoquan raw water interconnection as an integral component. Although these projects have not been implemented in the MWA as have some other components studied in early-action planning, they merit further consideration in the long-range planning because of their ability to conserve and transport water rapidly.

Table B-43 presents the updated summary costs for several pipeline size classes for both pipeline alternatives. The flow design chosen would vary depending upon the design drought and level of additional flow desired. From a cost-effectiveness and overall impact viewpoint, the Potomac-Rocky Gorge Reservoir interconnection would be preferable to the Potomac-Occoquan Reservoir interconnection primarily because of its shorter length. Regardless of the route considered, it is noted that raw water interconnections would represent relatively expensive projects which would generate disruptive impacts during construction. Impacts would be minimal during the operation stage, however.

## PRICING

In addition to other "non-structural" approaches to demand reduction such as water conservation and wastewater reuse, the effects of water pricing were also investigated as part of the MWA Water Supply Study. The key question posed at the outset of the work conducted on water pricing was: Would adjustments in the price of water charged to consumers be an effective way of reducing the overall demand for water in the MWA?

To answer this and other pertinent questions, the firm of Jack Faucett Associates, Inc. was contracted during the long range planning phase to conduct a pricing study (The contractor's report is presented in Annex G-II). In developing a general scope of work for the pricing study, several broad purposes were established, recognizing that many factors would come to bear on the feasibility of pricing as a demand reduction tool in the MWA. These purposes included:

1) developing concepts for better pricing and for measuring impacts of price changes;

2) determining the effectiveness of prices and pricing (rate) strategies in reducing demand;

3) evaluating impacts of alternative pricing strategies; and

4) determining the feasibility of implementing various pricing strategies; that is, identifying practical and political constraints.

TABLE B-43

RAW WATER INTERCONNECTION PROJECT COSTS ($1,000)
(October 1981 Prices in $1,000)

| Cost Item | Potomac River-Rocky Gorge Reservoir 60 mgd 54" | 90 mgd 66 | 180 mgd 96" | Potomac River-Occoquan Reservoir 65 mgd 60" | 75 mgd 60" | 90 mgd 66" | 180 mgd 96" |
|---|---|---|---|---|---|---|---|
| Pipeline | 38,138 | 52,475 | 95,928 | 56,486 | 56,486 | 65,984 | 118,767 |
| Pump Stations | 3,270 | 4,350 | 7,560 | 3,970 | 4,440 | 4,990 | 7,690 |
| Land | 14,100 | 14,100 | 14,100 | 14,100 | 14,100 | 14,100 | 14,100 |
| Final Design, P&S, Const S&I | 4,441 | 5,674 | 9,407 | 5,964 | 6,002 | 6,806 | 11,245 |
| Total Capital Costs | 59,949 | 76,599 | 126,995 | 80,520 | 81,028 | 91,880 | 151,802 |
| Daily Potomac Pump Station O&M Costs | 6.6 | 9.7 | 19.2 | 7.1 | 8.3 | 9.8 | 19.5 |
| Daily Reservoir Pump Station O&M Costs | 5.3 | 7.8 | 15.4 | 8.0 | 9.5 | 10.9 | 21.9 |
| Annual Pipeline O&M costs | 38 | 53 | 96 | 56 | 56 | 66 | 119 |
| Annual Major Replacement Costs | 8 | 10 | 12 | 10 | 10 | 11 | 13 |

## Study Methodology

The concept of marginal cost peak period pricing was used as the evaluative standard in the study. Marginal cost peak period pricing can be defined as the opportunity cost of the resources used to provide water during peak periods. The "marginal cost" is the cost to produce the last unit at the peak period level of output. This approach was used because, from an economic theory viewpoint, it best assures efficiency in the use of the resource and equity in the distribution of costs between users of the resource. Although, it was recognized that other forms of pricing were available, it was felt that marginal cost peak pricing represented the most optimum and "fair" method available and it was therefore the focus of investigation.

With marginal peak cost pricing serving as a theoretical "best method" for pricing, the contractor undertook several tasks which are summarized below:

a) the development of a data base of cost information relative to source development, treatment, transmission, O&M, fixed costs, etc., for both water and sewer;

b) the reorganization of the information developed in item a above in terms of peak and non-peak use;

c) development a 3-tiered rate structure including a fixed charge, commodity charge, and peak use charge based on the data organized in item b, above; and

d) the development of future water costs in terms of the newly developed 3-tiered structure. Information provided by the utilities formed the basis for these costs.

Since the tasks above were geared towards developing estimates of the marginal cost for utilities in the MWA, considerable effort was involved in securing base data regarding rate structures and capital improvement plans. Ten individual water/wastewater billing agencies which represent the major or portions of the major Potomac River users in the MWA were analyzed (Table B-44) as well as others in the outlying service areas. The data are provided in Annex G-II and Appendix I. Because water billing in the MWA is also influenced by wastewater use and billing, wastewater costs were also analyzed as part of the study. Figure B-25 illustrates the complex inter-relationships between water sources, water treatment, wastewater treatment, and the water and wastewater billing agencies for the major systems in the MWA.

In addition to the four step approach outlined earlier, the contractor closely monitored the progress of the major Potomac service areas in negotiating the institutional agreements which would provide for sufficient supplies to meet the areas needs to the year 2030. These agreements had a bearing on some of the pricing study findings and recommendations as discussed in the following sections.

## Study Findings and Conclusions

Results of the pricing study were quite different from original expectations. The major finding in response to the question posed at the outset of the study was that demand forecasts would not be further reduced by implementation of better pricing policies, at least in the immediate future. This conclusion was reached in view of the recent progress made in the study area in terms of supply management which would have the

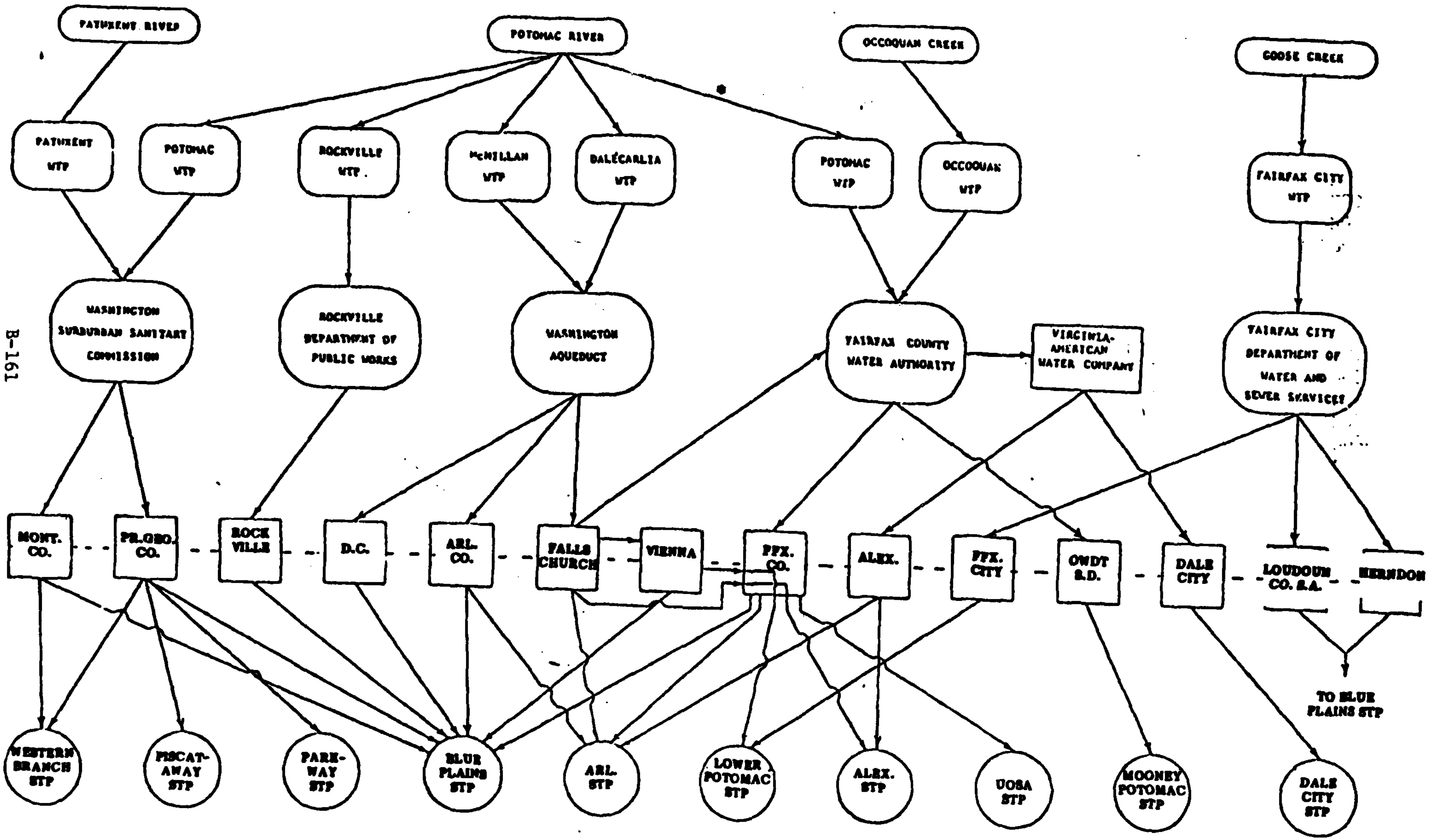
TABLE B-44

POTOMAC RIVER WATER AND WASTEWATER BILLING
AGENCIES SURVEYED IN THE
PRICING STUDY

District of Columbia/WAD
Washington Suburban Sanitary Commission
Fairfax County
City of Alexandria
City of Falls Church
City of Rockville
Arlington County
Town of Vienna
Dale City
Occoquan-Woodbridge-Dumfries-Triange Sanitary District

FIGURE B-25

INTER-RELATIONSHIP OF WATER AND WASTEWATER SYSTEMS
IN THE METROPOLITAN WASHINGTON AREA



effect of making new increments of capacity so inexpensive over the near-term that prices high enough to depress demand could not be justified on the basis of marginal costs. In addition to this major finding, other findings are noteworthy insofar as they further clarify the study conclusions as well as provide much broader information regarding the implications and role of pricing in the study area. Other important findings are listed below:

1) A high proportion of fixed costs to total costs in the major Potomac utilities (approximately 42%) has the effect of keeping marginal cost peak period rates below rates from present pricing. Because "fixed" costs are unavoidable and do not vary with consumption, the high percentage of these costs to total costs contributes to the ineffectiveness of marginal peak cost pricing to further decrease demand (see Figure B-26). These fixed costs are especially hard to offset where water and sewer are billed as a single combined charge.

2) Although marginal cost peak pricing does not appear useful to reduce demand at the present time because of supply management, it is possible at some future date that additional supply projects may be deemed desirable. At that point in time, the benefits from supply management will be lessened as the cost for new supplies increase considerably. Marginal peak cost pricing in this potential situation could be more effective in reducing the demand for water.

3) Moreover, with respect to item 2 above, the recent revisions to the LFAA provide strong incentives to participating utilities to reduce peak demands. In the sense of economic theory, this new agreement would have optimal characteristics, if new projects are developed, because by its very nature it will keep attention focused on pricing policy and reward pricing practices that approximate an optimal economic approach.

4) Marginal peak cost pricing can provide a true measure of benefit-cost ratio of additional supply and therefore play a major role in the theoretically optimal schedule of regional water supply development.

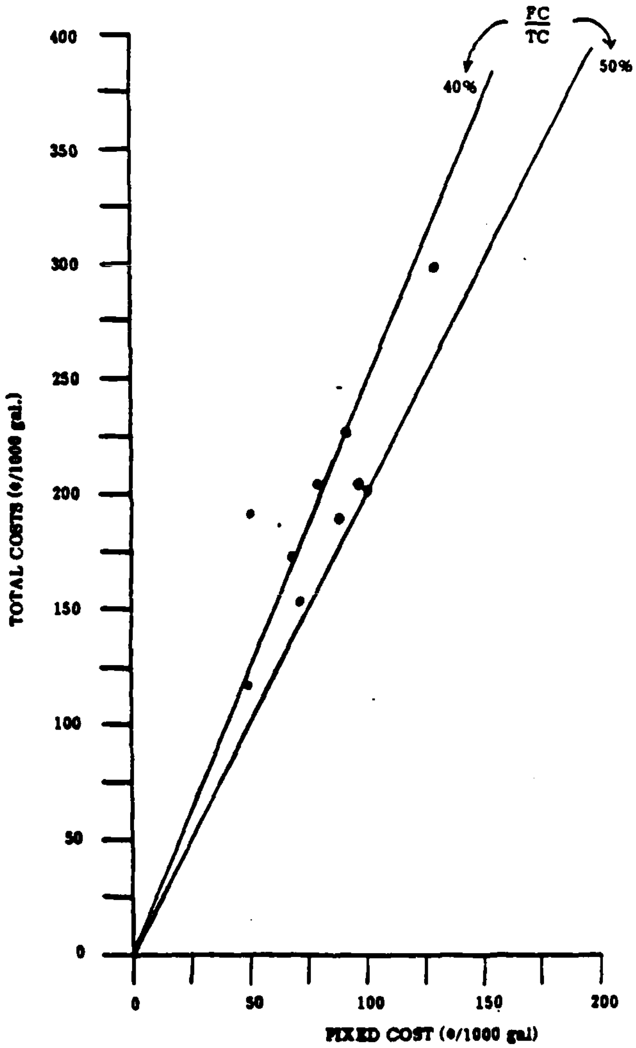
5) While there exist other forms of pricing strategies (i.e., declining block rates, flat rates, etc.) which could be used to depress demand, by their very nature they produce a loss of economic efficiency and equity from an economic viewpoint and therefore do not achieve the benefits of marginal peak cost pricing.

## GROUNDWATER

Within the geographical boundaries of the major Potomac service areas the potential for groundwater development is rather limited due to the underlying geology. Immediately, to the east and south of these areas, however, the potential groundwater reserves increase considerably due to the vast water bearing capacity of the Atlantic Coastal Plain aquifiers. In order to determine the true capacity of these aquifers and their ability to supplement the water supply base for the MWA, a groundwater study was undertaken with assistance from the U.S. Geological Survey (USGS).

FIGURE B-26

FIXED COSTS AS A PROPORTION OF TOTAL COSTS
FOR THE POTOMAC RIVER UTILITIES IN THE MWA



In its original scope, the groundwater study was to have investigated the development of well fields in the carbonate rocks of the Hagerstown Valley to the west of the MWA in addition to the Coastal Plain Aquifers. Strong public opposition to the study of groundwater in the Hagerstown Valley voiced early in the study process prompted the decision to consider only the Atlantic Coastal Plain Aquifers. Furthermore, it was felt that the increased reliability, greater hydraulic potential, and proximity of the Atlantic Coastal Plain to the MWA were important factors which favored the study of these aquifers over the Hagerstown sites. At the outset of the groundwater effort, however, it was cautioned by the FISRAC and the State of Maryland that use of the southern Maryland groundwater resource for the MWA would be acceptable only if it were demonstrated that the local groundwater users would not be adversely affected by the groundwater development and transfer schemes. The study which ensued was therefore sensitive to these concerns as will be discussed in the following sections.

Geology of Study Area

This study focused on the aquifers within the Potomac Sediment group of Cretaceous Age and within an area limited to a 30 mile radius of Washington, D.C. (Figure B-27). The Coastal Plain consists of numerous layers of unconsidated sediments which increase in thickness from a feather edge at the Fall Line to about 2400 feet in southern Prince Georges County (Figure B-28).

Within the study area, there are four major formations which serve as aquifers. The aquifers include, in ascending order, the Patuxent, the Patapso, the Magothy, and the Aquia Formations. These aquifer consist typically of sand layers of varying thickness interbedded with clays. The general thickness of the Patuxent, Patapsco, Magothy and Aquia in the study area are 250, 500, 50 and 80 feet, respectively. Major pumping occurs at various points within all of the aquifers in the study area with the exception of the Aquia which is penetrated by smaller domestic type wells less than 0.1 mgd in capacity.

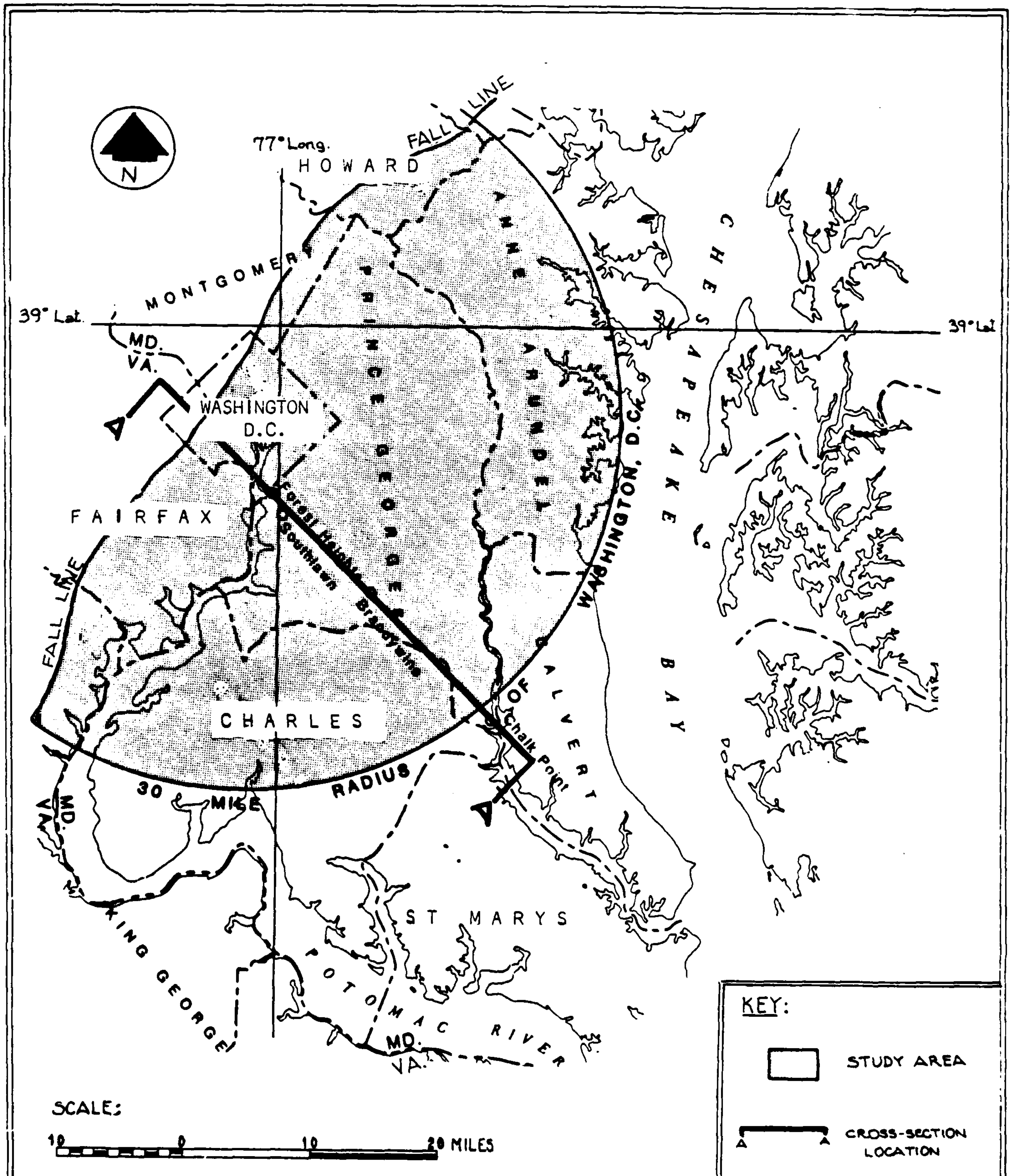
Groundwater Modelling

As part of the groundwater investigations, the USGS performed detailed studies of the groundwater availability and drawdown effects of large scale pumping from the Coastal Plain Aquifers. This was accomplished using a digital simulation model originally developed by the USGS for the Magothy Aquifer. The model uses a finite difference numerical approach to solve a set of partial differential equations which describe groundwater flow over a grid area encompassing about 5100 square miles. Existing data available for the study area including aquifer depth, thickness, hydraulic conductivity, storage coefficients, and groundwater pumpage served as the basic input to the model. Using this data for all four aquifers in question, the model was reconstructed, calibrated, and tested.

After the model calibration was completed, the model was used to simulate pumping from the Magothy, Patapsco, and Patuxent aquifers individually and in combinations. The resultant drawdowns in those three aquifers and in the overlying Aquia aquifer were estimated and used to formulate groundwater supply schemes for the MWA Water Supply Study.

FIGURE B-27

LOCATION OF THE GROUNDWATER STUDY AREA



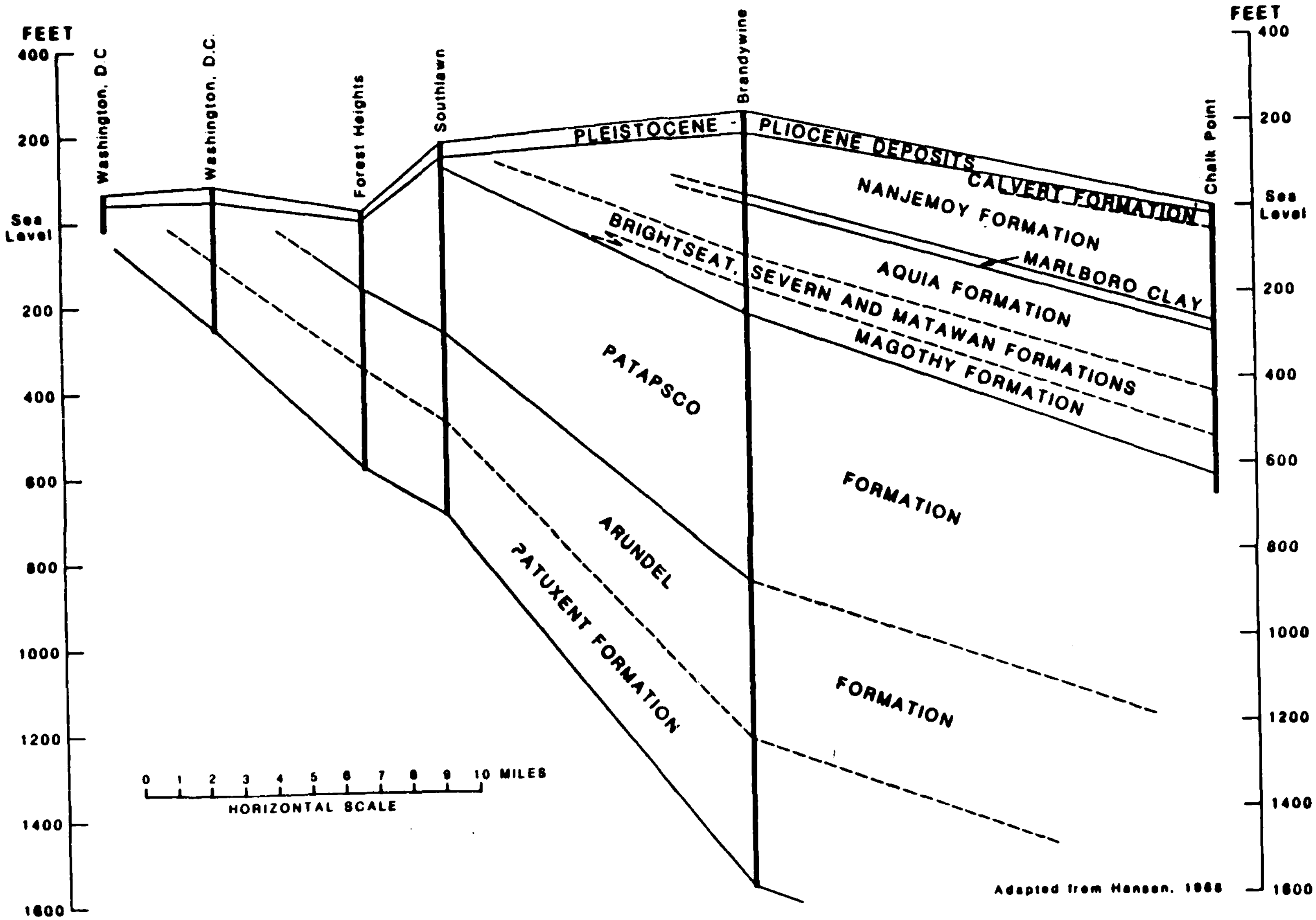



FIGURE B-28

GENERALIZED GEOLOGIC CROSS-SECTION OF THE COASTAL PLAIN SEDIMENTS

Fourteen tentative sites in the study area were initially selected and tested preliminarily for groundwater development. From this group of 14 locations, four locations were chosen for detailed model and cost analysis. The four sites were selected with consideration given to the location of present pumpage, so that interference effects with those wells would be minimized. In addition, the sites were selected such that four counties within the 30 mile radius in Mayrland were represented. The proposed sites are located in southeastern Prince Georges County, eastern Charles County, southern Anne Arundel County, and northern Calvert County as shown in Figure B-29.

For planning purposes, the model simulation tested a two-year drought sequence. During this time, the aquifers were pumped for five months from July through November, then not utilized until the following July, at which time they were pumped for five more months.

The groundwater simulations revealed several relationships. Pumping the Magothy aquifer at any of the three available sites produces much smaller drawdowns than the same pumpage from either the Patapsco or the Patuxent aquifers. However, pumping the Magothy aquifer also results in the greatest drawdown of the overlying Aquia aquifer, by a large margin. The model indicated that the recovering time of the Aquia aquifer in the vicinity of the well would be three to six months. Similar results would apply for the other three sites.

Of the four sites, Site 1 shows the greatest potential for groundwater development from a supply point of view, followed in order by Site 2, Site 3, and Site 4. Sites 1, 2, and 3 should be able to produce 50 to 60 mgd individually with proper design and management. However, Site 4 is limited to its potential yield and development at that site should be restricted to 20 to 30 mgd total. From the entire Coastal Plain Aquifer system, a total yield of 100 mgd is considered a safe limit. Due to the large drawdowns with using only one aquifer, multi-aquifer screening was recommended.

Formulation, Design and Cost of Groundwater Schemes

Using the USGS results, the Baltimore District developed preliminary design and cost estimates for a series of alternative groundwater development schemes. The general groundwater scheme consisted of development of a wellfield at one or more of the four selected sites, pumping the groundwater to a water treatment plant near Upper Marlboro in Prince Georges County, Maryland, and then final transmission of the treated water to the WSSC finished water system near Largo, Maryland. A schematic of the proposed groundwater scheme is shown in Figure B-30. The groundwater scheme was sized for yields of 25, 50, and 100 mgd. The assumption was made that up to 100 mgd would be available to replace other WSSC supplies in the central and southern Prince Georges County areas.

The costs for the wellfield, pump stations, pipelines and water treatment plants were estimated using the Methodology for Area-wide Planning Studies (MAPS) computer program developed by the U.S. Army Corps of Engineers' Waterways Experiment Station.

Alternative pipelines, pumping stations, and a water treatment plant were sized according to the various well fields considered: 25, 50, 75, and 100 mgd. For the proposed groundwater scheme, at least two pumping stations would be required, one at the wellfield, and one at the water treatment facility. For schemes involving a combination of wellfields, additional pumping stations would be needed.

FIGURE B-29

LOCATION OF THE FOUR GROUNDWATER DEVELOPMENT SITES

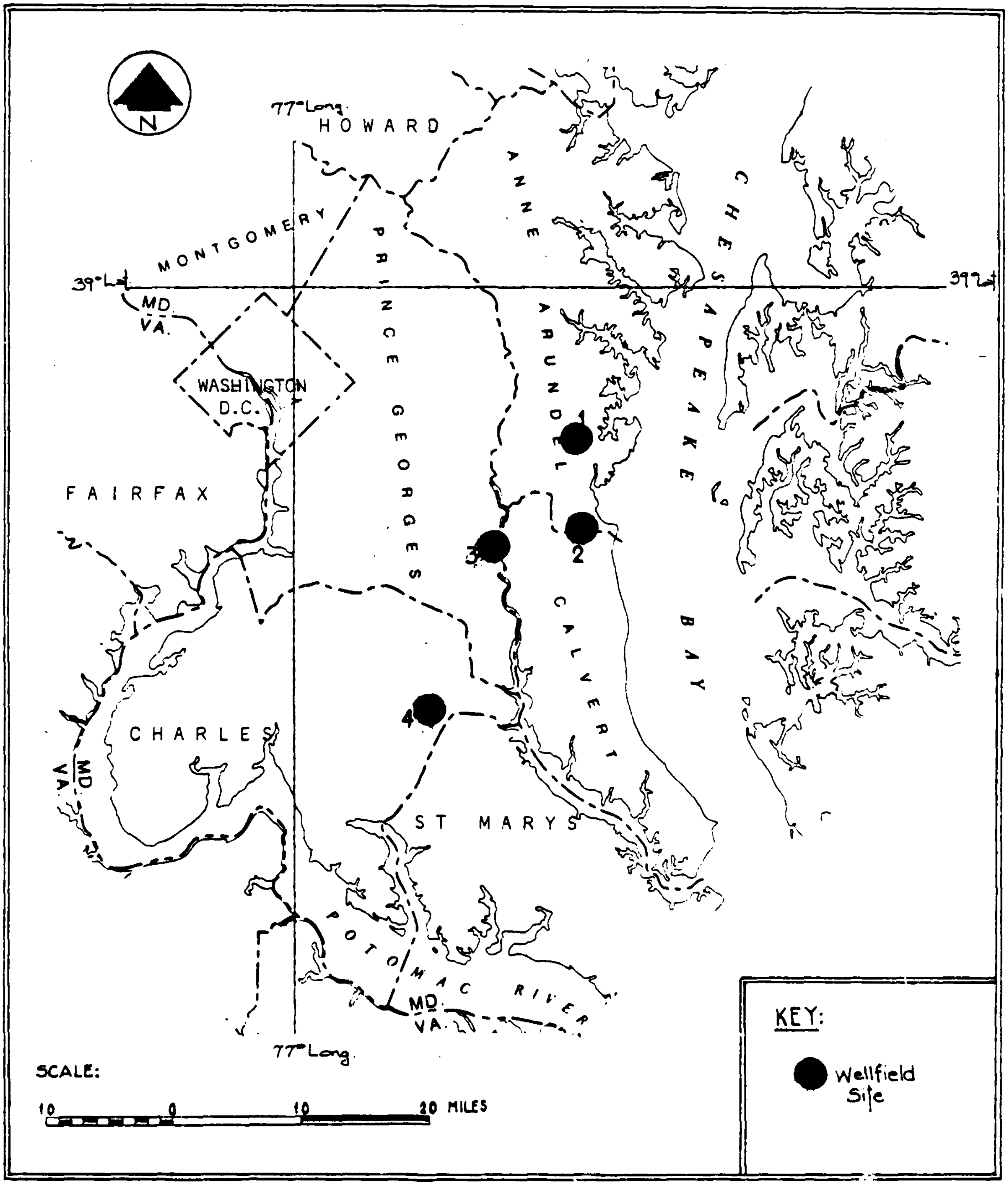
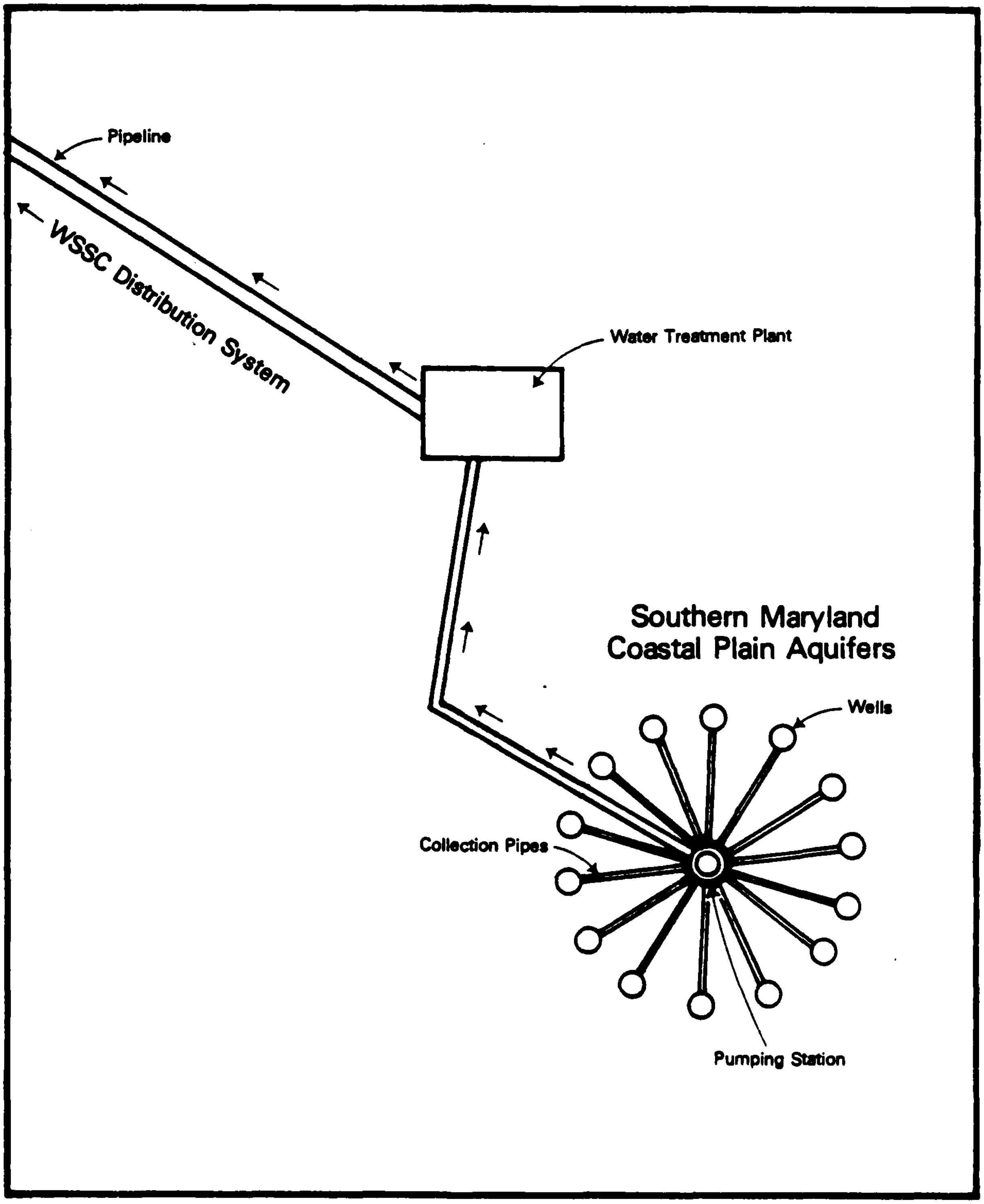


FIGURE B-30

GENERALIZED GROUNDWATER PUMPING STATION



The groundwater supply in the study area would most likely require some treatment prior to use in the MWA system, although the water quality data indicates that the Coastal Plain aquifers are of high quality. To estimate the costs of a treatment plant for groundwater supply alternatives, a similar neighboring facility was chosen as a design example. The basic processes included in design of the plant included pre-aeration, prechlorination, filtration iron removal, and disinfection.

The various component costs developed by MAPS were grouped to form alternatives for 25, 50 and 100 mgd levels of supply. Table B-45 and B-46 summarize the alternative costs for a 100 mgd development scheme which represent the highest practical level achievable based on the USGS Study. It is noted that development at the Charles County Site (Site 4) was not included here due to its relatively poor development potential, distance from MWA, and excessive drawdown characteristics. For the 100 mgd development scheme, it was determined that a combination of Sites 1 and 3 were the most cost effective of those examined.

It was determined further that only screening of the Patuxent and Patapsco formations would be prudent. This was because of the close hydraulic relationship determined to exist between the Magothy and the Aquia formations which, as demonstrated by the USGS, would result in significant drawdowns in the Aquia as a result of pumping in the Magothy formation. All groundwater schemes tested therefore did not include screening of the Magothy or the Aquia formations. Further details of the wellfield design are documented in Appendix F.

Impact Assessment

Both operational as well as construction impacts of each groundwater development scheme were considered in the impact assessment. Construction impacts were assessed based upon review of 1:24000 aerial photography available for the area as well as from existing reports and publications. The environmental analysis indicated that the four groundwater sites have very similar land use patterns (agriculture and forest land with stream valleys) and therefore similar environmental impacts. Bottomland hardwood habitat would be especially sensitive to construction activities as would the area in and around Site 3 which has been designated as a future environmental study area by the State of Maryland. Recreation or open space planning could help mitigate environmental losses on the rather large tracts of land which would be needed for the wellfields. With respect to the pipeline components, the use of highway rights-of-way would generally result in minimal impacts on the environment.

Potentially adverse environmental and social impacts of large scale pumping could include localized land subsidence, saltwater intrusion, effects on surface streams, and adverse effects on existing groundwater users. Based on the pumping rates and duration of pumping studied, it does not appear that the drawdowns would be significant enough to cause problems in the Aquia Formation which is used largely by smaller domestic users. This was due largely to the design scheme developed which eliminated using the Magothy and Aquia Formations as a potential source. It is noted however, the significant drawdowns would likely occur (20 -25 feet) in the Patuxent and Patapsco formations themselves given the pumping scenarios tested (see Figure B-31). At the present time, neither the Patapsco nor the Patuxent formations are major sources of supply in the

TABLE B-45

CAPITAL COSTS OF ALTERNATIVE GROUNDWATER SCHEMES[1]

| Component | Site 1 (50)[2] and Site 2 (50) | Site 2 (50) and Site 3 (50) | Site 1 (50) and Site 3 (50) | Site 1 (50) Site 2 (25) and Site 3 (25) |
|---|---|---|---|---|
| Wellfield at Site 1 | $11,980,000 | — | $11,980,000 | $11,980,000 |
| Wellfield at Site 2 | 12,300,000 | $12,300,000 | — | 5,060,000 |
| Wellfield at Site 3 | — | 12,200,000 | 12,200,000 | 4,960,000 |
| Wellfield at Site 4 | — | — | — | — |
| Water Treatment Plant | 9,080,000 | 9,080,000 | 9,080,000 | 9,080,000 |
| Pipe A | 10,600,000 | — | 10,600,000 | 10,600,000 |
| Pipe B | 15,200,000 | 15,200,000 | — | 8,730,000 |
| Pipe C | — | 18,700,000 | 18,700,000 | 10,700,000 |
| Pipe D | — | — | — | — |
| Pipe E | 7,560,000 | 2,440,000 | 2,440,000 | 5,970,000 |
| Pipe F | 38,200,000 | 38,200,000 | 38,200,000 | 38,200,000 |
| Pumping Station at Site 1 | 4,220,000 | — | 4,220,000 | 4,220,000 |
| Pumping Station at Site 2 | 4,510,000 | 4,510,000 | — | 2,840,000 |
| Pumping Station at Site 3 | — | 4,340,000 | 4,340,000 | 2,720,000 |
| Pumping Station at Site 4 | — | — | — | — |
| Pumping Station at WTP | 10,700,000 | 10,700,000 | 10,700,000 | 10,700,000 |
| TOTAL | $124,350,000 | $127,670,000 | $122,460,000 | $125,760,000 |
| Total Cost per Mgd | $1,240,000 | $1,280,000 | $1,220,000 | $1,260,000 |
| Total Cost per MG (150-Day Supply) | $ 8,300 | $ 8,500 | $ 8,200 | $ 8,400 |

1 Costs are based on October 1981 price levels, and screening of the Patapsco and Patuxent aquifers.

2 Numbers in parenthesis represent wellfield capacity developed at each site in mgd.

TABLE B-46

OPERATION AND MAINTENANCE COSTS FOR ALTERNATIVE GROUNDWATER SCHEMES[1]
$/YEAR

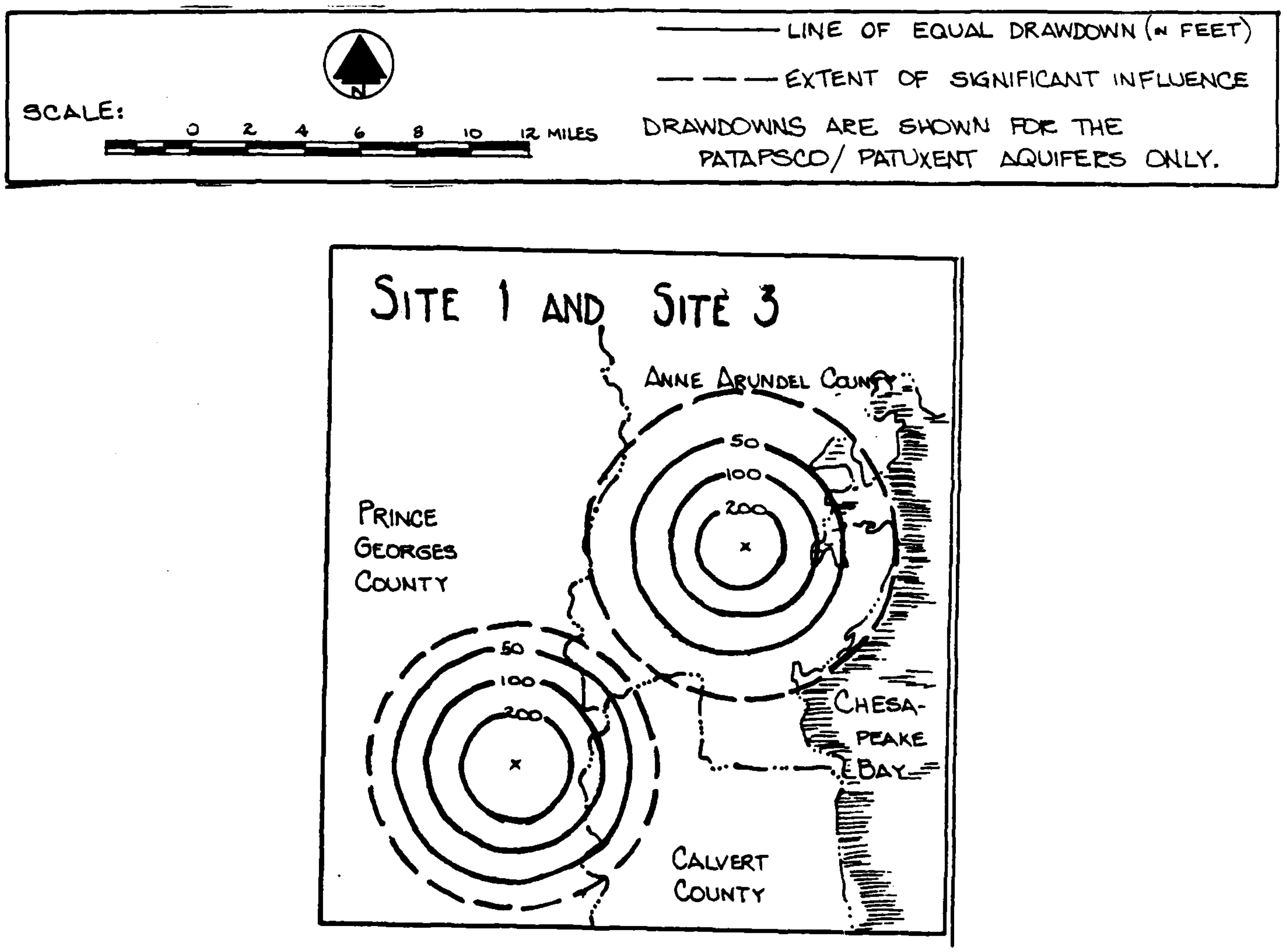
| Component | Site 1 (50)[2] and Site 2 (50) | Site 2 (50) and Site 3 (50) | Site 1 (50) and Site 3 (50) | Site 1 (50) Site 2 (25) and Site 3 (25) |
|---|---|---|---|---|
| Wellfield at Site 1 | $507,000 | — | $507,000 | $507,000 |
| Wellfield at Site 2 | 595,000 | $595,000 | — | 217,000 |
| Wellfield at Site 3 | — | 608,000 | 608,000 | 204,000 |
| Wellfield at Site 4 | — | — | — | — |
| Water Treatment Plant | 608,000 | 608,000 | 608,000 | 608,000 |
| Pipe A | 18,200 | — | 18,200 | 18,200 |
| Pipe B | 26,100 | 26,100 | — | 15,600 |
| Pipe C | — | 32,000 | 32,000 | 19,100 |
| Pipe D | — | - | - | - |
| Pipe E | 12,500 | 6,800 | 6,800 | 10,000 |
| Pipe F | 63,100 | 63,100 | 63,100 | 63,100 |
| Pumping Station at Site 1 | 38,300 | — | 38,300 | 38,300 |
| Pumping Station at Site 2 | 38,300 | 38,300 | — | 22,400 |
| Pumping Station at Site 3 | — | 47,900 | 47,900 | 31,400 |
| Pumping Station at Site 4 | — | — | — | — |
| Pumping Station at WTP | 1,100,000 | 1,100,000 | 1,100,000 | 1,100,000 |
| TOTAL | $3,006,000 | $3,125,000 | $3,029,000 | $2,854,000 |
| Total Cost per Mgd | $ 30,000 | $ 31,000 | $ 30,000 | $ 29,000 |
| Total Cost per MG, 150-Day Supply | $ 200 | $ 210 | $ 200 | $ 190 |

[1] Costs are based on October 1981 price levels, wellfield operation during five months of the year, and screening of the Patapsco and Patuxent aquifers.

[2] Numbers in parenthesis represent wellfield capacity at each site in mgd.

FIGURE B-31

DRAWDOWN LEVELS IN PATUXENT AND PATAPSCO FORMULATIONS
FOR MOST FAVORABLE GROUNDWATER PUMPING SCHEME



vicinity of the tested sites. Future local development of these aquifers however would have to been carefully evaluated if the potential schemes studied here were implemented.

Summary and Conclusions

Based on the foregoing analysis, several broad conclusions can be made regarding the potential for tapping groundwater reserves in southern Maryland for use in the MWA during drought periods. These are:

1) Based on the results of the USGS modeling efforts about 100 mgd could be available from the Coastal Plain Aquifers within 30 miles of the Washington, D.C. area.

2) Screening of the Magothy Formation under the prescribed pumping schemes would cause unacceptable levels of drawdown in the Aquia Formation. Therefore, the potential schemes developed for maximum development should only consider screening the Patuxent and Patapsco formations.

3) Based on a pumping, treatment, and wellfield developed scheme developed by the Corps of Engineers, a cost-effective maximum sized 100 mgd wellfield system could cost approximately $122,500,000 or about $8,200 per million gallons.

4) For the scheme referenced in item 3 above, drawdowns in the Patuxent and Patapsco would be considerable. This factor would have to be evaluated further if local jurisdictions use these aquifers more extensively in the future in the vicinity of the modelled sites.

5) The Charles County wellfield site (Site 4) was considered to be too costly to develop relative to the other sites considered and had the greatest potential for affecting nearby wells. It was not included in the final analysis because of these reasons.

6) Environmental impacts during construction in the vicinity of the wellfield site would generally be temporary in nature. Site 3 represented the most sensitive of the wellfield sites considered, however, impacts could be mitigated with proper development and management.

7) To improve the reliability of the results of the USGS modelling effort, particularly for the deep aquifers where input data was least available, test drilling would be necessary to obtain more accurate information.

RESERVOIRS

Providing additional water supply storage through development of new impoundment sites or the expansion of the water supply capability at existing sites represents an alternative method of augmenting water supply for the MWA.

The concept of providing additional reservoir storage for the MWA is not a new one. Several studies conducted by the Corps of Engineers and others have proposed reservoir projects with the purpose of water supply included at various locations within the Potomac Basin. Few of the projects originally proposed have been constructed; however by way of introduction the history of the development of the same key projects which have been constructed is worthy of a brief summary.

Construction of the Bloomington Lake Project was completed in 1981 and was a direct result of the North Branch Potomac River Study conducted by the Corps of Engineers in the late 1950's. In addition to this study, the 1963 Potomac River Basin Report also studied the Bloomington project as well as numerous additional multi-purpose reservoir projects in the Upper Potomac Basin, none of which have been authorized for construction at this date (a complete discussion of these project is contained in Appendix F).

Construction of the Little Seneca Lake project located in Montgomery County, Maryland began in September, 1982. This project, which was originally envisioned by the WSSC as a water supply project for Montgomery and Prince Georges Counties, will be shared on a regional basis by the WAD, WSSC and FCWA. Other projects close to the MWA have been studied by the local water utilities; however, none have been constructed with the exception of the expansion of the Occoquan Reservoir. The storage capacity of this project has been increased by 1 billion gallons by adding a two-feet addition to the height of the existing structure. Other sites which have been studied include many in the western portion of the MWA which were analyzed, in most cases, as high flow skimming projects by Black and Veatch in 1974 for the FCWA, WAD and the WSSC. In addition to these projects, the Cedar Run project was also originally studied by Prince William County to meet its future needs.

Past experience suggests that water supply reservoirs can provide a relatively efficent and economical means of providing large volumes of water when needed. Despite these advantages, public support for reservoir projects has been generally lacking based on the impacts which occur at the project site. Because of the inherent utility of reservoirs to provide additional supply and given the fact the many years have elapsed since studies have been undertaken of many of the sites discussed in the studies noted above, it was concluded that a review of potential sites was again in order for the present study to determine their present day viability in terms of social, economic and environmental conditions.

## General Description

The potential sites under study were organized into three broad categories to include: 1) upstream reservoirs, located in the Upper Potomac Basin; 2) local reservoirs, located in the western portion of the MWA, principally in Loudoun County, and 3) modification or expansion of existing reservoir storage which included the Occoquan Reservoir. Reallocation of storage within Bloomington Reservoir also falls into this category but deserves special attention because of the scope and breadth of the Bloomington Lake Reformulation study. This is discussed separately in a later section and in its entirety in Appendix H.

Twenty-one upstream reservoirs were reviewed. Sixteen of these were those were originally recommended in the Corps 1963 Potomac River Basin report and two additional sites, Sideling Hill and Little Cacapon were added during the review of that report. Table B-47 summarizes the physical characteristics and costs of these projects in October 1981 dollars. The location of these projects are identified in Figure B-32. During coordination with the USFWS for the MWAWSS, 3 additional sites in the upper basin were identified based on USFWS recommendations. These included Mt. Storm, Laurel Run and Abrams Creek, all located in the North Branch Potomac River. At these locations, the USFWS perceived that the greatest need for aquatic resource restoration and enhancement was apparent and could potentially be addressed by these three projects.

With respect to local reservoirs, 21 sites originally studied by Black and Veatch were also reviewed. These project sites are located in most cases on small tributaries to the Potomac River and, because of insufficient flows were originally designed as high flow skimming projects involving pipelines and pump stations. Table B-48 summarizes some of the important water supply characteristics and costs for these 21 projects. It is noted that the costs for these projects are rather high due the pumping which would be required to utilize their full storage capability.

In addition to these sites two additional local sites were considered. The FCWA requested that the Corps review a potential impoundment site located on an unnamed tributary to the Potomac River in Loudoun County, Virginia. Cedar Run reservoir, originally studied by Prince William County was also included as potential source of additional water supply. (Data developed for these two sites are also included in Table B-48.) The location of all the local reservoir sites considered are shown in Figure B-33.

Impact Assessment and Screening

Each of the sites within the three categories of reservoirs (upstream, local and modified existing) were reviewed based on their potential yield, cost, environmental impacts and institutional concerns. The environmental impact assessment for local reservoirs was based on the characteristics of the watersheds and site visits, whereas the upstream reservoir assessment was based on area visits by the USFWS as well as information from existing reports. Field reconnaissance of the Occoquan and Cedar Run reservoirs were also conducted.

For the local reservoirs, it was possible to categorize the impoundment alternatives into three groups according to the level of impact as follows:

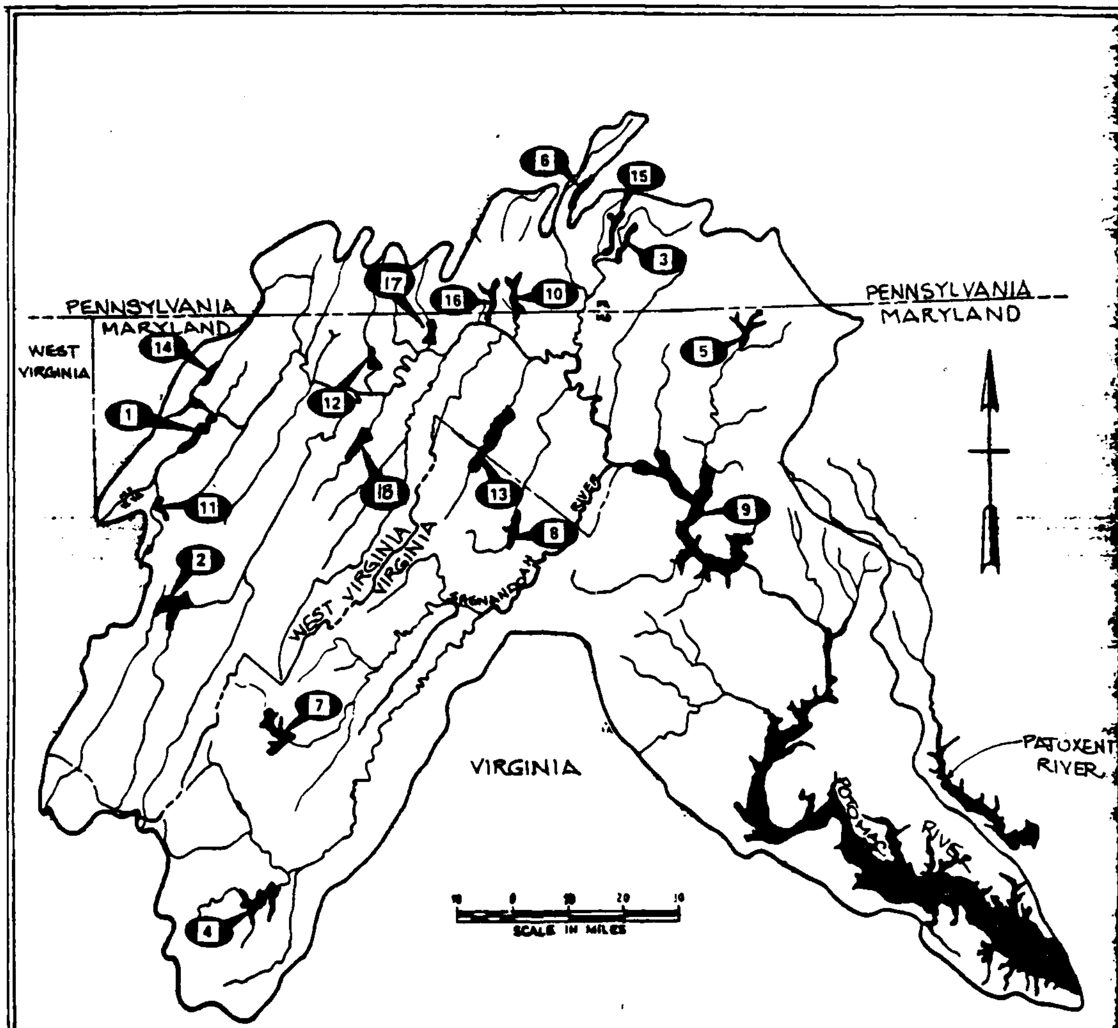
TABLE B-47

SELECTED CHARACTERISTICS - UPSTREAM RESERVOIR SITES

| Project | Stream or River | Drainage Area | Estimated Increase in Dependable Flow (MGD) | Conservation Storage (Acre-Feet) | Total Storage (Acre-Feet) | Allocated Water Supply Cost ($1,000) | Total Cost $1,000 |
|---|---|---|---|---|---|---|---|
| Royal Glen | South Branch Potomac River | 640 | 312 | 228,000 | 338,000 | 14,563 | 131,202 |
| Chambersburg | Conococheague Creek | 141.5 | 40 | 28,000 | 42,300 | 4,413 | 53,179 |
| Verona (Staunton) | Middle River | 325 | 110 | 104,000 | 143,000 | 77,071 | 152,616 |
| Sixes Bridge | Monocacy River | 308 | 85 | 63,000 | 103,000 | 37,790 | 65,836 |
| West Branch | West Branch Conococheague Creek | 77.9 | 42 | 45,000 | 77,500 | 1,796 | 49,895 |
| Brock Gap | North Branch Shenandoah River | 213.5 | 95 | 120,800 | 187,000 | 3,382 | 70,458 |
| Winchester | Opequon Creek | 120.5 | 30 | 28,300 | 77,000 | 2,165 | 47,061 |
| Seneca | Potomac River | 11,400 | 900 | 460,000 | 1,193,000 | 68,066 | 436,322 |
| Licking Creek | Licking Creek | 158 | 89 | 82,100 | 120,500 | 9,785 | 48,442 |
| Mount Storm | Stony River | 49 | 32 | 27,000 | 43,500 | 13,641 | 41,845 |
| Town Creek | Town Creek | 144.5 | 63 | 57,500 | 96,800 | 6,695 | 41,845 |
| North Mountain | Back Creek, WV | 231 | 89 | 95,500 | 195,000 | 10,852 | 70,019 |
| Savage II | Savage River | 48 | 37 | 39,000 | 50,000 | 32,940 | 56,308 |
| Back Creek | Back Creek, PA | 62.3 | 18 | 19,700 | 46,900 | 2,435 | 31,630 |
| Tonoloway | Tonoloway Creek | 112 | 54 | 50,000 | 88,000 | 11,136 | 59,234 |
| Sideling Hill Creek | Sideling Hill Creek | 104 | 61 | 54,500 | 75,000 | 3,841 | 47,778 |
| Little Cacapon | Little Cacapon River | 101 | 59 | 53,000 | 82,500 | 5,305 | 51,357 |

FIGURE B-32

LOCATION OF THE POTOMAC RIVER BASIN
SITES STUDIED IN 1963 REPORT




POTOMAC RIVER BASIN SITES

1. Bloomington*
2. Royal Glen
3. Chambersburg
4. Verona (Staunton)
5. Sixes Bridge
6. West Branch
7. Brocks Gap
8. Winchester
9. Seneca
10. Licking Creek
11. Mount Storm
12. Town Creek
13. North Mountain
14. Savage II
15. Back Creek
16. Tonoloway Creek
17. Sideling Hill Creek
18. Little Cacapon

* Constructed.

LOCATION OF THE POTOMAC RIVER BASIN
RESERVOIR SITES STUDIED IN THE
1963 REPORT

TABLE B-48

SELECTED WATER SUPPLY DATA FOR LOCAL RESERVOIR SITES

| Influent Stream | Site Number | Drainage Area Sq. Mi. | Water Supply Storage MG | Yield mgd | Cost* $\$x10^6$ | Cost per mgd $\$x10^6$ |
|---|---|---|---|---|---|---|
| Catoctin Creek | L-1 | 91.5 | 12,400 | 50 | 61.54 | 1.23 |
| Tributary of South Fork, Catoctin Creek | L-4 | 1.8 | 1,210 | 4 | 25.31 | 6.33 |
| Limestone Branch | L-5 | 1.2 | 1,710 | 4 | 23.94 | 5.99 |
| South Fork, Limestone Branch | L-6 | 2.3 | 3,100 | 9 | 26.60 | 2.96 |
| Tuscarora Creek | L-7 | 4.5 | 1,650 | 7 | 44.68 | 6.38 |
| North Fork, Goose Creek | L-8 | 23.6 | 9,630 | 31 | 94.09 | 3.03 |
| Beaverdam Creek | L-9 | 22.4 | 7,790 | 24 | 81.58 | 3.40 |
| Beaverdam Creek | L-11 | 38.4 | 7,140 | 21 | 76.0 | 3.62 |
| Cromwell Run | L-15 | 18.1 | 5,030 | 18 | 66.82 | 3.71 |
| Beaverdam Creek | L-18 | 5.9 | 1,890 | 7 | 39.44 | 5.63 |
| North Fork, Goose Creek | L-20 | 95.0 | 39,100 | 125 | 187.74 | 1.50 |
| Goose Creek | L-21 | 268.0 | 62,100 | 220 | 295.92 | 1.35 |
| Upper Bull Run | L-24 | 22.8 | 5,390 | 17.5 | 73.55 | 4.20 |
| Goose Creek | L-25 | 375.0 | 5,720 | 20 | 114.71 | 5.74 |
| Piney Run | L-26 | 12.4 | 2,810 | 10 | 26.03 | 2.60 |
| Dutchman Creek | L-27 | 12.9 | 3,610 | 12.5 | 34.60 | 2.77 |
| Little Monocacy River | M-3 | 3.3 | 10,650 | 32 | 64.33 | 2.01 |
| Tenmile Creek | M-5 | 6.1 | 9,810 | 28 | 65.29 | 2.33 |
| Hookers Branch, Seneca Creek | M-6 | 28.1 | 4,460 | 20 | 68.90 | 3.45 |
| Muddy Branch | M-7 | 3.0 | 1,660 | 6 | 42.91 | 7.15 |
| FCWA Proposed Site | — | 1.85 | 3,310 | 12 | 27.54 | 2.30 |
| Cedar Run Site | — | 197.0 | 89.60 | 25 | 23.04 | 0.92 |

*Based on October 1981 Prices. Includes cost of reservoir project and high flow skimming pipelines.

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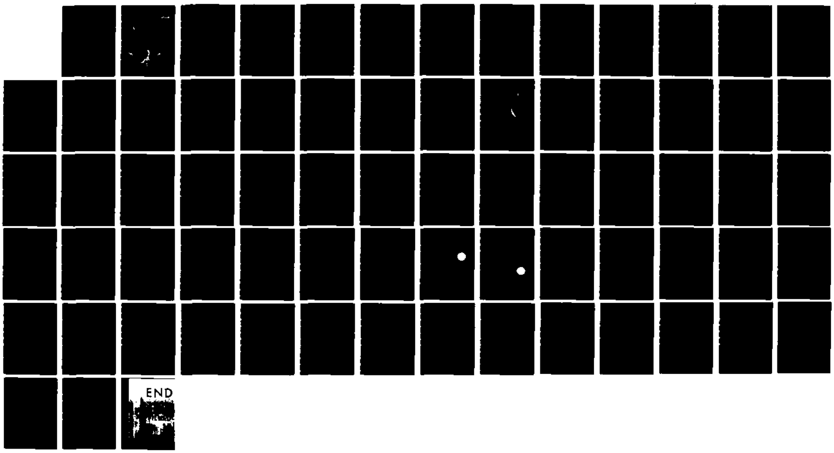
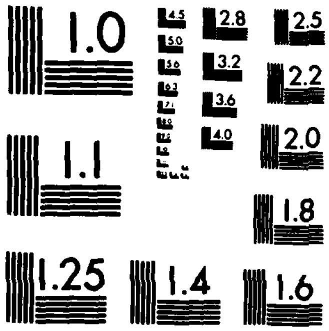





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

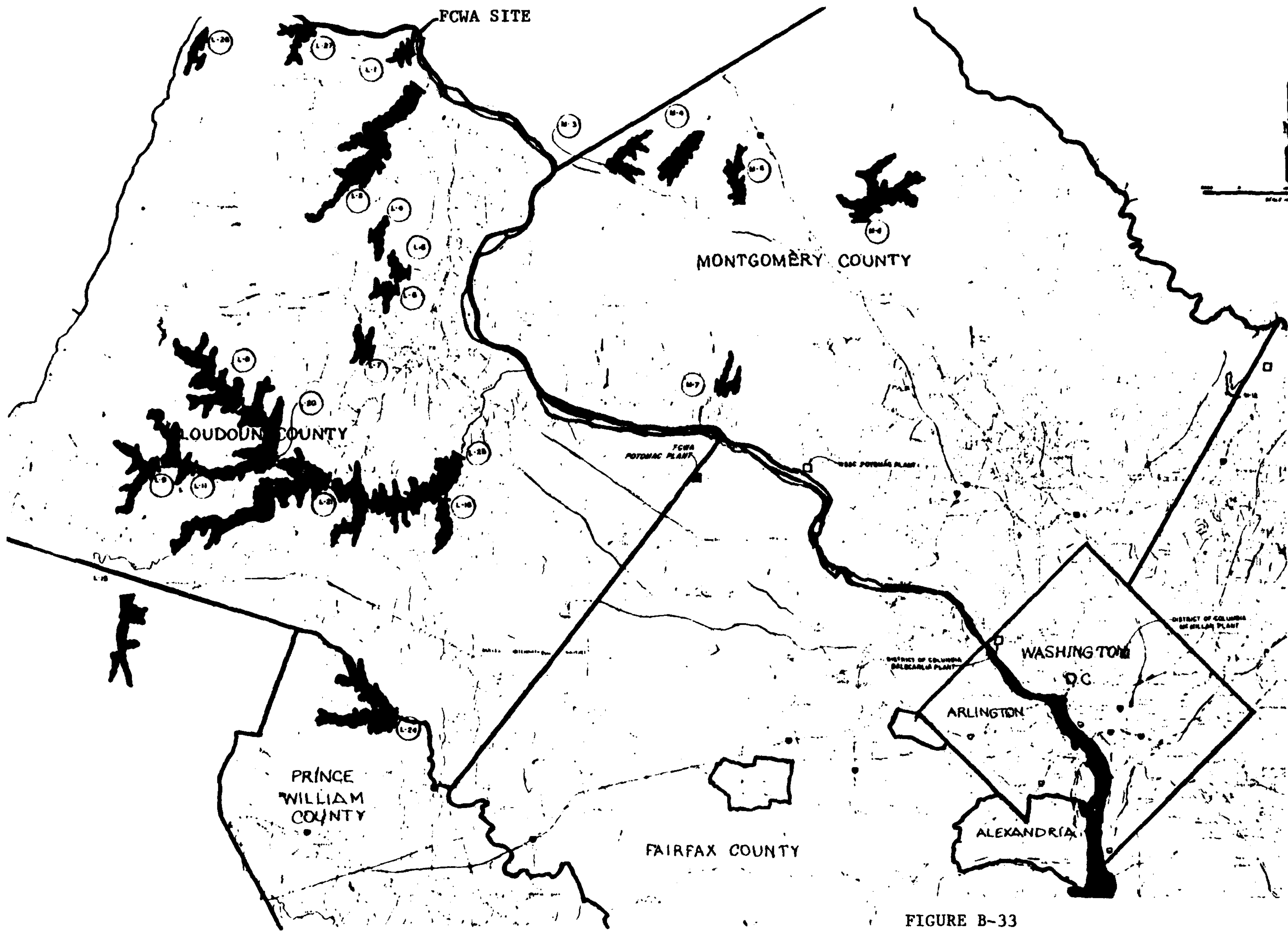



FIGURE B-33

LOCATION OF SITES SELECTED IN THE BLACK AND VEATCH REPORT

| | |
|---|---|
| High Impact: | L-1, L-20, L-21, L-25 |
| Medium Impact: | L-8, L-9, L-11, L-15, L-24, M-5, M-6 |
| Low Impact: | FCWA site, L-4, L-5, L-6, L-7, L-26, L-27, M-3, M-4, M-7 |

The alternatives in the high impact group are located on designated State scenic rivers or on streams which are closely associated with them. Also, the proposed dams in the high impact group are located on the larger streams in the area and would create the largest impoundments. The amount of loss of free-flowing streams, riparian habitat, and upland habitat would be greatest with these sites. As these larger stream reaches are relatively uncommon compared to the number of smaller streams in the medium and low impact groups, their loss would be all the more damaging.

The reservoir sites in the medium impact group tend to be located on intermediate-sized stream reaches. The area which would be inundated at maximum storage ranges between 570 and 1,220 acres. The environmental impact of these alternatives would be substantial, but not as great as those in the high impact group.

The sites in the low impact group tend to be located on small streams. Such reservoirs are relatively small, ranging from 138 acres to 375 acres (except for M-4). In most cases, the dam sites would be close to the Potomac River, so adverse effects on downstream reaches would be minimized. A full discussion of the environmental impacts associated with the local reservoirs is contained in Appendix F.

Based on a trade-off analysis considering the impacts, yields, and costs associated with these projects, a few were identified from each impact category for further consideration. These projects include raising the Occoquan reservoir, Cedar Run Reservoir, the FCWA Site and Sites M-4, L-8, L-9 and L-20. Any individual project or combination of these projects could prove to be more favorable from the various viewpoint considered than the other sites evaluated and could serve as a potential "base" of projects to choose from if local reservoirs were to be considered further to augment existing supplies.

With respect to the upstream reservoirs it was determine that little change in site conditions such as land use and development would likely cause significant modifications to the design of the reservoir projects and therefore the original cost estimates could be readily updated. In addition, reexamination of the original environmental assessment data and field investigation of the project sites revealed that the types of terrestrial, aquatic, and cultural resources had not changed considerably in the twenty years since the original assessment. The environmental reevaluation concluded that the relative impacts originally identified by earlier studies were still applicable. Because both the impacts and costs were still valid, it was concluded that the six sites originally recommended by the Chief of Engineers in 1969 were still in a relative sense, the most optimum projects to consider, if in fact, upstream reservoirs were to be considered further for providing additional water supply to the MWA. Whereas, it was recognized that the remaining projects also had some merit in providing additional water, it was concluded that six recommended projects present a more preferable set of reservoir sites which balanced environmental, social, economic and physical characteristics. These projects include: Sixes Bridge, Verona, Town Creek, North Mountain, Sideling Hill, and Little Cacapon.

It is further noted that with respect to the upstream reservoir sites recommended for study by the USFWS, that only the Mt. Storm project represented a favorable project because of its potential for improving substantially the water quality in the Stony River. The remaining USFWL sites were unfavorable based on their limited storage capability and their minimal ability to improve downstream water quality.

Table B-49 summarizes the upstream and local reservoir sites which have merit for providing additional water supply in a manner which in most cases minimizes impacts and in some cases has the potential to enhance the environment. Should further consideration at the local level be given toward securing additional supplies at some future date, the projects listed in Table B-49 represent some of the more preferable projects that should be considered in further detail.

## USE OF THE POTOMAC ESTUARY

One of the alternatives which has long been considered as a means to alleviate projected water supply shortages in the MWA is use of the Potomac Estuary. The use of estuary water, although abundant, has always been questionable because of its unknown composition, complex biological and chemical interactions, and the unknown environmental impacts of freshwater withdrawals on salinity regimes. Because of the potential which exists and because of the many questions which needed to be answered before the estuary can be used, Section 85b(2) of PL 93-251 specifically authorized an investigation and study of the use of the Potomac Estuary. The authorization provided for the construction, operation, and evaluation of a Potomac Estuary Experimental Water Treatment Plant (EEWTP) to assess the treatability of Estuary water.

In response to these charges, a EEWTP was constructed near the Blue Plains Water Pollution Control Plant in the District of Columbia (Figure B-34). The plant was designed for a 1.0 mgd maximum flow rate with unit processes that, based on the present knowledge, would produce potable water. In order to properly assess the use of the estuary, three years of project investigation were scheduled, including approximately six months of plant start-up, two years of plant operation, and six months of plant deactivation and preparation of a final report. The two years of plant operation were accomplished between March 1981 and March 1983. A separate document has been prepared which is independent of the final MWAWSS report and which contains the full documentation of the findings of the EEWTP testing program. This final report for the EEWTP was also submitted to a review committee of by the National Academy of Sciences - National Academy of Engineering which was reponsible for evaluating the scientific and engineering validity of the investigation.

Appendix F of this report contains a discussion of the scope and findings of the EEWTP Studies. The following sections serve to summarize this discussion as well as present the findings of related studies pertaining to the Potomac Estuary.

## TABLE B-49

### SUMMARY LISTING OF FAVORABLE RESERVOIR SITES FOR CONSIDERATION IN LONG-RANG PLANNING

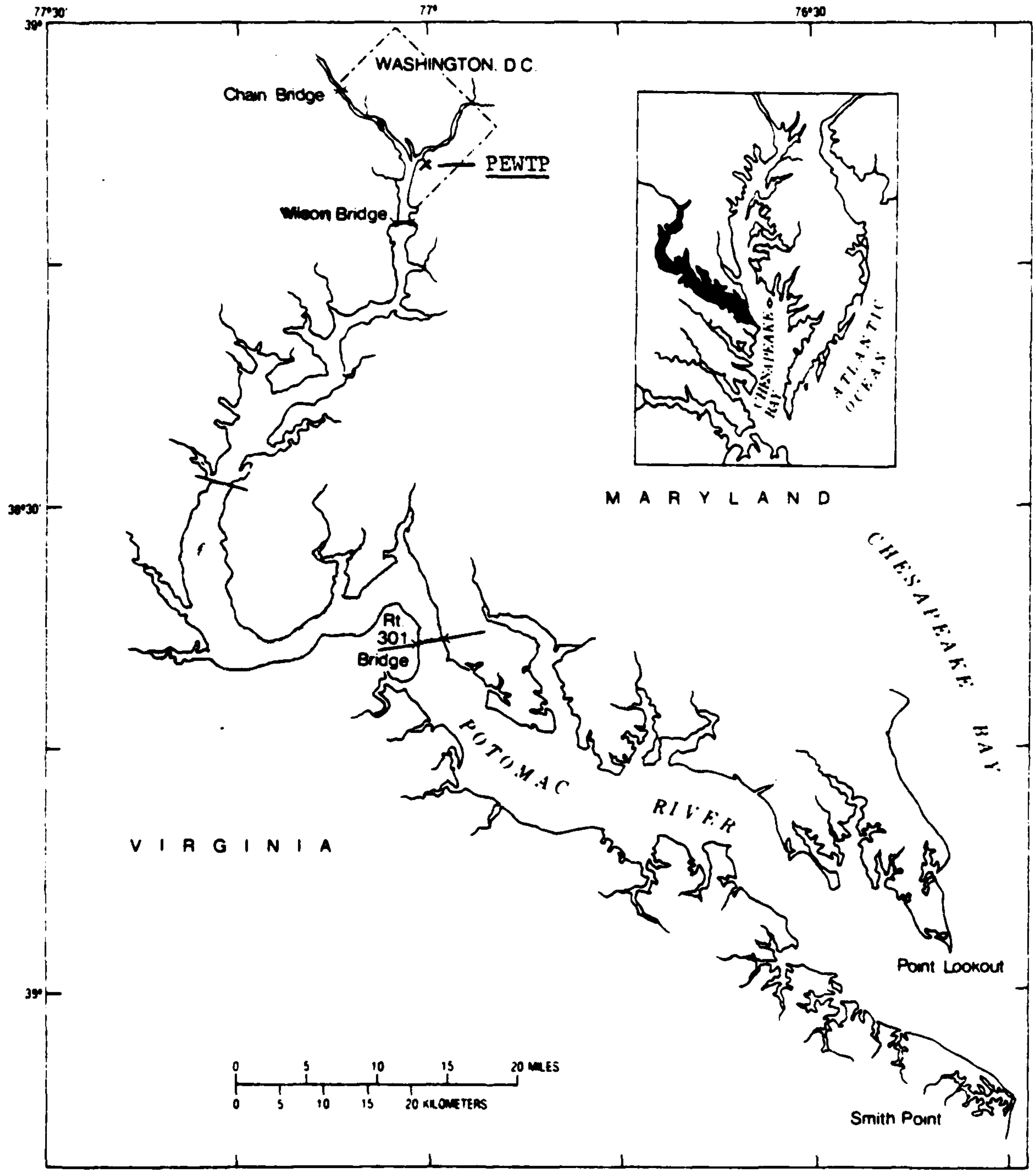
| Upstream Sites | Water Supply Storage(MG) | Additional Yield(MG) | Environmental Impact[1] | Total Cost[2] ($mill) | Water Supply Cost/mgd ($mill) |
|---|---|---|---|---|---|
| Sixes Bridge | 20,500 | 85 | — | 37.79(65.84) | 0.44 |
| Verona | 33,900 | 110 | — | 77.07(152.62 | 0.70 |
| Town Creek | 18,700 | 63 | — | 6.70(41.84) | 0.11 |
| North Mountain | 31,100 | 89 | — | 10.85(70.02) | 0.12 |
| Sideling Hill | 17,800 | 61 | — | 3.84(47.78) | 0.06 |
| Little Cacapon | 17,300 | 59 | — | 5.30(51.36) | 0.09 |
| Mt. Storm | 8,800 | 32 | — | 13.64(41.84) | 0.43 |
| **Local Sites** | | | | | |
| Little Monacacy Tributary (M-4) | 16,650 | 32 | LOW | 64.33 | 2.01 |
| Unnamed Potomac Tributary (FCWA) | 3,310 | 12 | LOW | 27.54 | 2.30 |
| Cedar Run | 8,220 | 12.5 | MEDIUM | 23.04 | .84 |
| North Fork Goose Creek (L-8) | 9,630 | 31 | MEDIUM | 94.09 | 3.03 |
| Beaverdam Creek (L-9) | 7,790 | 24 | MEDIUM | 81.58 | 3.40 |
| North Fork Goose Creek (L-20) | 39,100 | 125 | HIGH | 187.84 | 1.50 |
| **Modified Existing Site** | | | | | |
| Occoquan Reservoir 3 foot addition | 2,200 | 12.5 | LOW | 1.98 | 0.16 |

[1] Upstream reservoirs were not reevaluated as to high, medium, low impacts.

[2] Number in parenthesis are total project costs for all purposes. Numbers not in parenthesis represent water supply storage costs only. Only upstream sites are multi-purpose.

FIGURE B-34

THE POTOMAC ESTUARY AND LOCATION OF THE EEWPT



## EEWTP Project Objectives

The overall objective of the EEWTP project was to determine the technical and economic feasibility of using the Potomac River estuary as a supplemental source of potable water in the MWA. Achieving these objectives required the answer to a number of key questions.

1. Using the best available analytical techniques, what quality of water can be produced by commonly used water treatment processes?

2. Was the water produced by the demonstration plant of potable quality?

3. What were the optimum process combinations which would ensure production of potable water at a minumum cost?

4. What was the operational feasiblity and reliability of a water treatment plant that would be operated only intermittently?

5. Finally, what were the estimated costs of such a water treatment plant with a hydraulic capability of 200 mgd?

## EEWTP Description

The EEWTP utilized three systems dealing with the water treatment processes (both the main processes and total dissolved solids (TDS) sidestream processes), the sludge handling and chemical recovery processes, and the chemical handling systems.

A flow schematic of unit processes used to accomplish the water treatment processes is illustrated in Figure B-35. These included a combination of physical-chemical unit operations designed to produce potable water from a highly contaminated source. Contaminants which could be removed included suspended material (particulates), heavy metals, organic contaminants, inorganic dissolved solids, and pathogenic microorganisms.

The unit processes for solids handling and chemical recovery included sludge thickening, sludge acidulation, centrifugation, and sludge disposal via truck transport to disposal or (possibly) incineration. The concentrate was recirculated to the rapid mix tank or aeration basin, depending upon which centrifuge and sludge disposal technique was in use. Chemical handling processes for the various dry and wet chemicals were also used at the EEWTP.

## Water Quality Goals

As part of the overall testing program, water quality goals were established for the finished water produced by the EEWTP for the majority of parameters which were being tested. In developing water quality goals, a number of factors were considered. As a minimum, the goals proposed for the EEWTP matched existing drinking water standards promulgated by the EPA. Other standards developed by the World Health Organization (WHO) European Standards, the National Academy of Sciences, the Office of Water Planning and Standards of the EPA, and the American Water Works Association (AWWA) were also consulted. This was done so that parameters not currently regulated by the

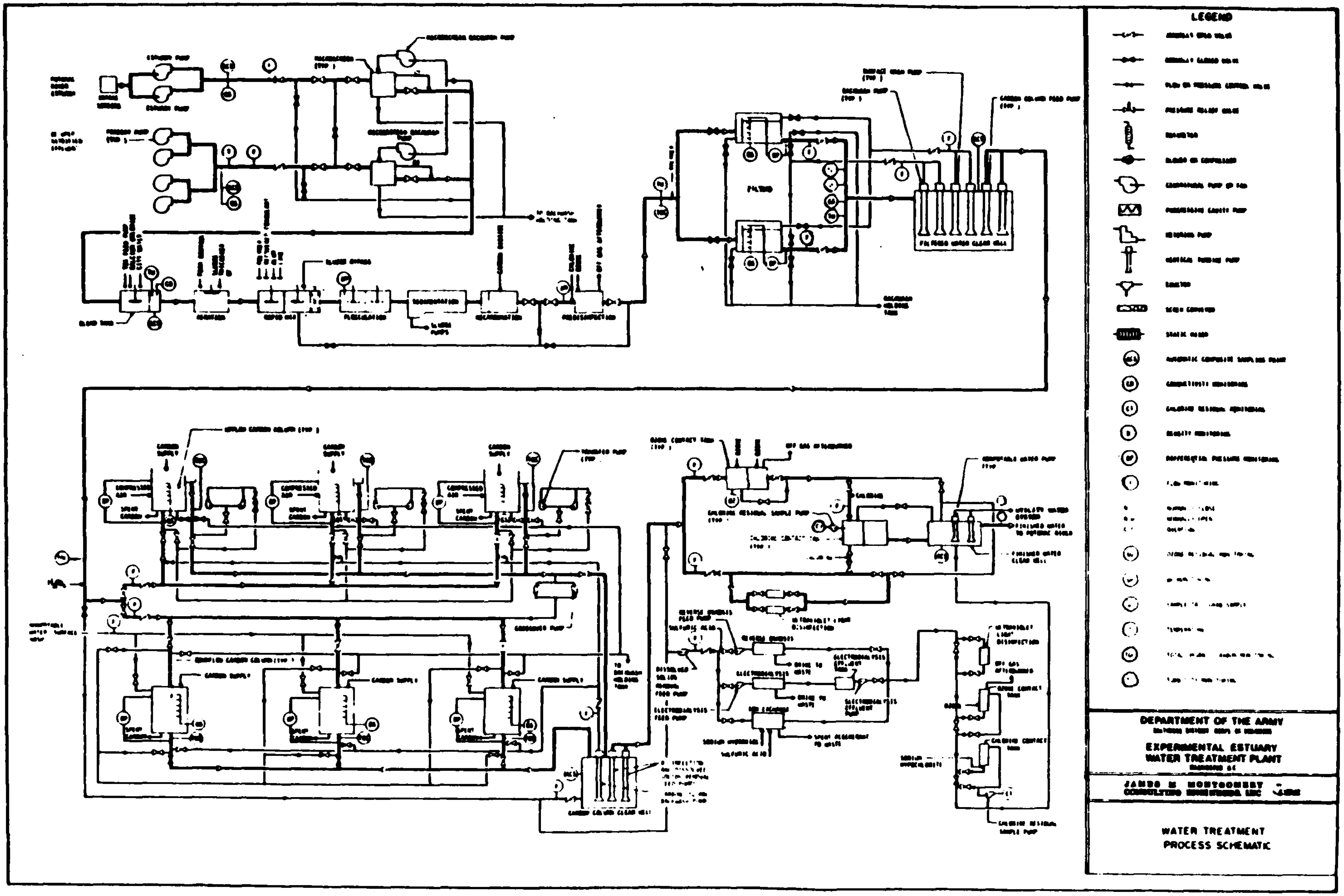



FIGURE B-35

SCHEMATIC OF THE UNIT PROCESSES - EEWPT

EPA or by state health departments could be considered given the unconventional blend of estuary water and nitrified effluent from the Blue Plains Wastewater Treatment Plant which was being treated by the EEWTP.

The following decisions were developed for selecting water quality goals for the finished water from the EEWTP:

1. The goal was to at least comply with current applicable EPA regulations.

2. The water quality goals should be acceptable to consumers.

3. Treated water quality for regulated parameters should be equivalent in quality to levels achieved by current practice in well-operated water treatment plants.

4. Health risks should be minimal or negligible. Where data was available on health effects, negligible health risks were defned as follows: (1) for carcinogens, a 1 in 1,000,000 incremental lifetime cancer risk and (b) for non-carcinogens, a safety factor of 100 using the acceptable daily intake.

The goals which were selected for water quality monitoring purposes are summarized in Table B-50. The reader is referred to Appendix F for details on the source for each goal selected.

Selection of Influent Conditions for the EEWTP

In order to determine the effectiveness as well as technical and economic feasibility of using the Potomac Estuary as a potable source of water during periods of severe and sustained drought, it was necessary to design the EEWTP with facilities using two influent sources to simulate projected water quality levels which might be reached. One source was the estuary, the other, nitrified, unchlorinated effluent from the adjacent Blue Plains Wastewater Treatment Plant.

Numerical modelling efforts were undertaken to determine the mix of nitrified effluent and estuary water which would best simulate future water quality characteristics. Conditions to consider which could potentially affect this future condition included: flowby conditions, hydraulic conditions equivalent to the worst drought on record, water supply withdrawals, estuary withdrawal rates, drought duration, and expected water quality levels in the estuary intake and the Blue Plains nitrified effluent.

Based on the results of the numerical modelling, a 50:50 blend ratio of estuary water to Blue Plains effluent was selected as the most representative water quality mixture for use during the two year EEWTP testing period.

Water Quality Testing Program

The overall water quality testing program was subdivided into three parts:

a. The Routine Water Quality Testing Program (RWQTP).

b. The Testing Program for Process Adjustment and Modification (TPPAM).

TABLE B-50

LISTING OF SELECTED WATER QUALITY GOALS

| Parameter | Units | Goal |
|---|---|---|
| Microbiological | | |
| Total Coliform | org/100 m | 0.1 |
| S.P.C. | org/ml | 50 |
| Ent. Virus | pfu/l | 0.01 |
| Inorganics | | |
| Arsenic | mg/l | 0.01 |
| Lead | mg/l | 0.025 |
| Cadmium | mg/l | 0.01 |
| Mercury | mg/l | 0.002 |
| Nitrate | mg/l | 5 |
| Asbestos | Mf/l | 0.1 |
| Chromium | mg/l | 0.05(VI) |
| Physical | | |
| Turbidity | T.U. | 0.2 |
| Particulates (≥ 22.5 microns) | No./ml | 50 |
| Corrosivity (gen'l) | | - |
| Lang. Indx (LI) | pH.U | -0.1 LI 0.3 |
| Cooper | mpy | 0.2 |
| Galv | mpy | 2.0 |
| Iron | mpy | 6.0 |
| Color | a.c.u. | 3 |
| Organics | | |
| TOC | mg/l | 3.0 |
| TOX | μg/l | 150 |
| TTHM's | μg/l | 50 |
| PCE | μg/l | 4 |
| TCE | μg/l | 4.5 |
| DDT | μg/l | 50 |
| Lindane | μg/l | 0.05 |

c. The Operator Data Collection System (ODCS).

The purpose of the RWQTP was to develop baseline information on influent quality and EEWTP process performance and to produce a catalogue of water quality data on the product water from the EEWTP and three local water treatment plants. This catalogue of quality data on effluents was used to assist in evaluating the potability of the EEWTP's product and the standard treatment process train.

The principal objective of the TPPAM was to determine the optimum process combination and design criteria for a future 200 mgd estuary water treatment plant. This plant should be capable of producing a potable water at minimum cost, consistent with requirements for process reliability.

The ODCS was a computerized system to monitor the operational data base which would serve as recorded values on the process parameters.

Estimated Costs of a Full Scale Plant

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 met 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.

Cost estimates were developed for a 200 mgd Estuary water treatment plant for both process configurations. For comparison, a 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 B-51 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 B-51 are similar estimates for a conventional plant indicating such a plant would be about one-half the cost of an estuary-type plant. Due to the unknown exact location and operating philosophy of a full-scale Estuary plant, certain important facilities were excluded from the cost estimates. These facilities, which would substantially increase the cost of a complete water treatment plant, were the following: intake structure, 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.

Findings

Based on the two-year operational phase of the EEWTP project, the overall quality of the finished water produced by the EEWTP was characterized as satisfactory and generally suitable for human consumption. The finished water was compared to existing water quality standards and to water produced by other major water treatment plants in the MWA. Physical, aesthetic, radiological, toxicological, and microbiological parameters were evaluated as well as maximum contaminant levels for anions, cations, nutrients, metals, and organics. The main parameters of concern were nitrate-nitrogen level (which was below but consistently close to the maximum contaminant level of 10 mg/l established by EPA) and the odor level (which frequently exceeded the allowable

TABLE B-51

PRELIMINARY COST ESTIMATES
200 MGD POTOMAC ESTUARY PLANT*

| | ALUM/CHLORINE PROCESS | LIME/OZONE 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

maximum contaminant level). Further information concerning the EEWTP testing program and its results are contained in Appendix F- Structural Alternatives. The data are contained in the separate report for the EEWTP.

Related Studies

In connection with the EEWTP, the Corps of Engineers Chesapeake Bay Model was used to obtain a better understanding of the estuary's hydrodynamics under various flow regimes. Based on the completion of a series of hydraulic model tests which assumed a severe drought condition (1964) and a 100 mgd inflow to the estuary, it was determined that salinity levels reaching 1 ppt could be present at the head of the Potomac Estuary near Chain Bridge (see Appendix F for complete discussion on testing program). It should be noted that Congress has not funded further use of the hydraulic model and therefore a more refined estimate of the extent and duration of the salinity intrusion plus the impacts of various levels of esturary pumping could not be developed at this time. It would appear from the preliminary hydraulic model test results, however, that the salinity levels projected could pose problems for an expanded estuary plant given the drought conditions which were assumed. Further hydraulic and numerical modelling should be considered prior to any recommendation for use of the estuary as a future source of supply, particularly under extreme drought conditions.

WASTEWATER REUSE

The reclamation of wastewater, regardless of how it is implemented, can provide a source of water that can delay or negate the need for supplies from conventional sources. Wastewater reclamation can be used in combination with other methods of balancing the supply and demand for water and thus increase the efficiency of the present use of water in growing areas.

As early as 1965, the Water Resources Planning Act required that reuse be considered one of the alternative methods for meeting future water demand. In 1973, the U.S. National Water Commission in its publication "Water Policies for the Future", gave the concept of reuse further impetus by recommending that it". . . should occupy a permanent spot in future planning for overall water resources utilization."

Various wastewater reclamation approaches were examined for their application to the MWA for the long-range phase. These included land application of wastewater and subsequent recovery as well as other forms of reuse, particularly, recharge of the Potomac River. Use of the Potomac Estuary as a direct source of supply also represents wastewater reuse because of the wastewater component contained within the estuary. The potential for using the estuary as a potable source is considered fully in the previous section dealing with the EEWTP. The following sections review the investigations completed for the several other forms of reuse considered for this study.

Land Application

Land application is the treatment of wastewater using plants, the soil surface, and the soil matrix to remove certain wastewater constituents. Traditionally, this mechanism has been used as a means to treat wastewater; however, for this study this method was also examined as to its feasibility in reclaiming water for supply purposes.

In recent years, there has been a growing interest in land application of municipal wastewater throughout the United States. This interest has been spurred in part by the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) which encourages that land treatment of wastes be considered along with other forms of treatment to help meet national water quality goals. Land application of secondary effluent in combination with a recovery system and in conjunction with groundwater recharge were the primary schemes considered to augment available water supplies. Several criteria were used to evaluate the feasibility of land application within the MWA including climate, soil, land, and the proximity of sources of effluent and points of discharge.

Limitations

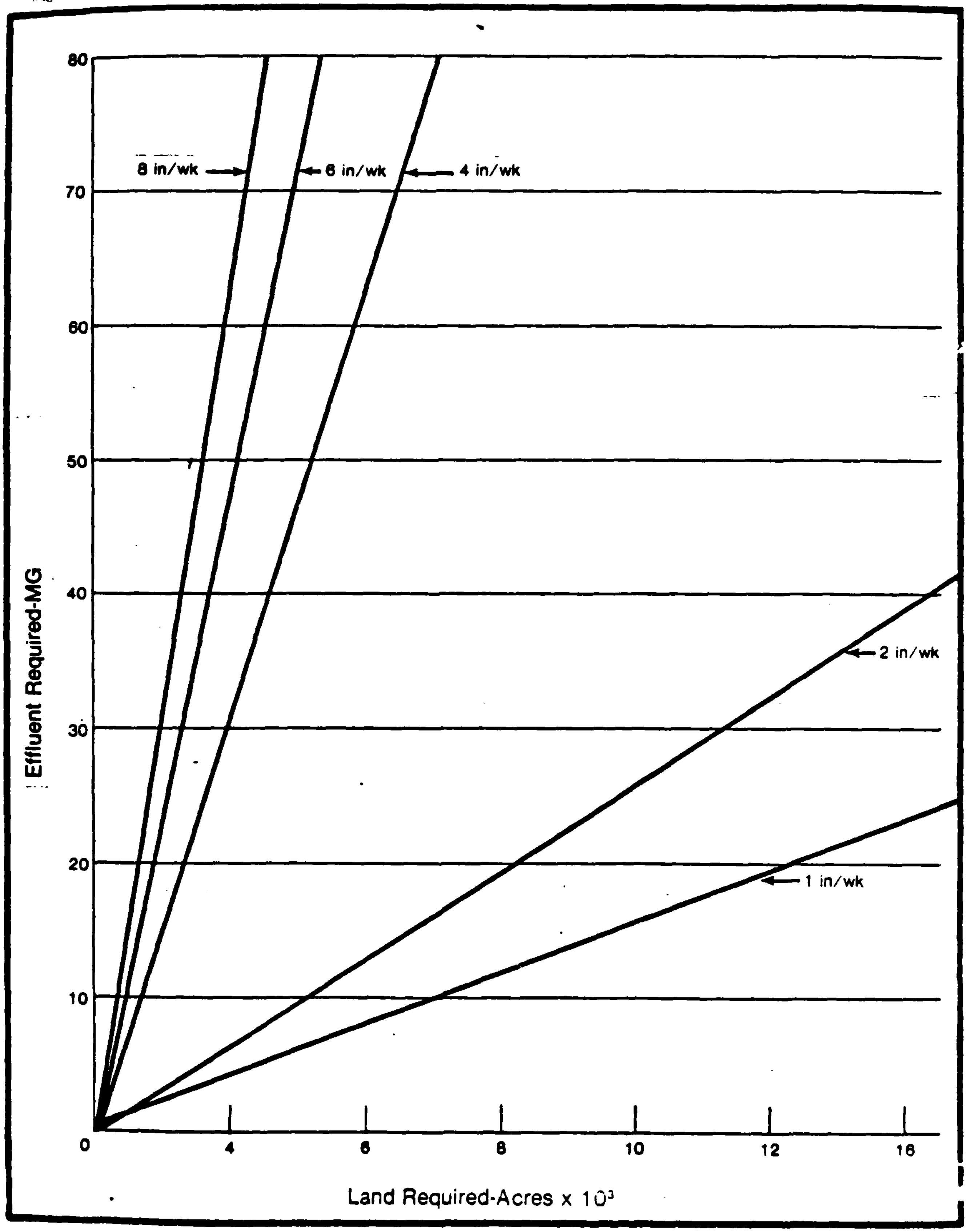
It was determined that serious practical limitations would limit the potential for use of land application to supply water on a large scale. Figure B-36 illustrates the interrelationship between the land requirements and effluent recoverable for a range of wastewater loadings. These relationships were developed for a hypothetical land application site based on a generalized equation taken from the NEWS Study. From this figure it was concluded that: 1) land application requires substantial land area which increases significantly with the higher yields desired and, 2) when possible, higher loading rates can greatly reduce the land required for a given yield desired.

Based on an average cost of $3,000 and $1,500 for farmland and forestland, respectively, it is evident that a land application site would involve a large cost. For example, for a 50 MGD agricultural site, land cost alone may range from $15 to $80 million dollars. Although a wide range of costs are possible, it is likely that the costs would tend to fall on the higher side of the cost curve where the lower loading rates are more realistic for the MWA. Additional costs relating to construction of the application facilities, storage facilities and collection system would make large scale land application an extremely expensive alternative.

Another limiting factor which was found to limit the viability of land application for water supply was the location of the source of available effluent with reference to a potential site, and in a scheme involving augmenting flows in the Potomac, the distance to an appropriate discharge point. These factors would both affect the length and therefore the cost and impact of transmission facilities. It was observed that upstream sites closest to the Potomac River would appear to be desirable provided large enough tracts of suitable land could be secured.

FIGURE B-36

LAND REQUIREMENTS VS. FLOW RECOVERY
LAND APPLICATION SYSTEMS



A third important limitation for the use of land application as a source of supply for the MWA is public acceptability. There has been general public rejection of land application as a means of waste disposal, particularly in heavily developed urban areas. Although increased public understanding of the principles of land application could mitigate this attitude, it is likely that more conventional systems for water supply which are less expensive and involve less of a perceived risk to health and the environment will be more palatable to the public. This perception however, could change in the future as conventional sources become more scarce and as more technical information becomes available regarding the true health risk associated with the product water.

With respect to environmental impacts it was concluded that the impacts would vary based on the type of system selected, the location, and management and mitigation techniques that were applied. Areas of concern which would require monitoring and attention include: groundwater contamination given a recharge mode, long term effects on soil chemistry due to build up of toxic chemicals, vegetation enhancement with increased nitrogen levels, effects on available open space, control of odors, and beneficial and adverse effects on terrestrial and aquatic species.

Conclusions

Based on these observations, it was apparent that a large scale, land application/water supply system has limited feasibility in the MWA. Although land application sites might be useful on a limited basis to produce water for non-potable uses, these uses are considered minor and would not appreciably change the overall water picture for the region. Because of these shortcomings, land application was not further considered in long-range planning.

Other Forms of Reuse

Several additional wastewater reuse strategies were reviewed for their applicability to the MWA. A cursory review of a wide range of options indicated that only a few had some potential given the study area's characteristics. These included strategies for agriculture, industry, groundwater recharge and surface water recharge. It was found further that even for these remaining strategies the potential for reuse was in most cases, minimal.

It was determined that reuse for both agriculture and industry would be marginally beneficial in terms of providing a significant amount of additional supply. Agriculture represents a very minor fraction of the total water use of the MWA and does not figure to increase significantly because of the urban character of the region. With respect to industrial use, a greater portion of all large industrial users (industrial use is expected to grow from from 11 percent to 14 percent of the total water use by the year 2030) are food-processing related operations which require water of a potable quality. This also limits the applicability of this form of reuse.

With respect to groundwater it was concluded that the recharge potential is greater for jurisdictions located beyond the boundaries of the major Potomac River users such as Prince William, Loudoun, and Charles County. This is true from hydrogeologic standpoint because of the greater groundwater reserves which underlie these areas, particularly within the Atlantic Coastal Plain. It is noted in Appendix I - Outlying Services Areas, however, that even in these areas, high quality secondary effluent or advanced wastewater treatment effluent would most likely be required to protect those groundwater reserves which are heavily used. Potential health risks are significant, making this approach highly unlikely.

The concept of recharge of the Potomac River with AWT effluent had some merit which made it worthy of further consideration. Two strategies were considered for low flow augmentation of the Potomac River and are depicted in Figure B-37. One reuse scheme proposed the pumping of 100 to 200 mgd of highly treated effluent from the Blue Plains Wastewater Treatment Plant to a discharge point immediately downstream from the Little Falls intake. This discharge would provide the desired flowby on an as-needed basis, while permitting the Potomac River users to benefit from an equal level of increased withdrawal from the Potomac River. A similar scheme was also developed involving a point of discharge about 21 miles upstream from the Blue Plains wastewater treatment facility.

Using the MAPS computer program developed by the Corps of Engineers, a preliminary cost estimate of each of the two options for 100 mgd and 200 mgd pipelines was developed. Table B-52 contains the design parameters, capital, and O&M costs for these alternatives.

Several major difficulties were noted with respect to the proposed recharge schemes. These included:

a) Major social and cultural impacts which could be expected along the pipeline corridors because of the high level of urbanization as well as park areas of national significance.

b) Potential conflict of operation with the Emergency Estuary Pumping station at the Little Falls discharge location.

c) State of Maryland review and approval regarding discharge location. This would be particularly critical in the case of the upstream discharge location because of the Maryland Environmental Health Administration's sensitivity to discharges above water supply intakes.

d) General public acceptance of any scheme where there is a perceived risk of water supply degradation or contamination.

Based on these observations it would appear that the option involving discharges below the MWA water supply intakes would be preferable because it would eliminate the problems of reuse that would otherwise result with the upstream location. Nonetheless, reuse in any form would receive close public scrutiny given other alternative supply sources which may be available.

BLOOMINGTON RESERVOIR STORAGE REALLOCATION

As discussed in the problem redefinition section for long-range formulation, the PRISM/COE model was used to evaluate numerous Bloomington operating strategies designed to improve the regional management of the MWA's existing water supply system. In doing so, a number of important operating assumptions were made relative to the flow target achievable at Luke, Maryland, preferability of a seasonal versus year round flood control pool and travel time release functions. The product of this

FIGURE B-37

SCHEMATIC OF POTOMAC RIVER RECHACE OPTIONS

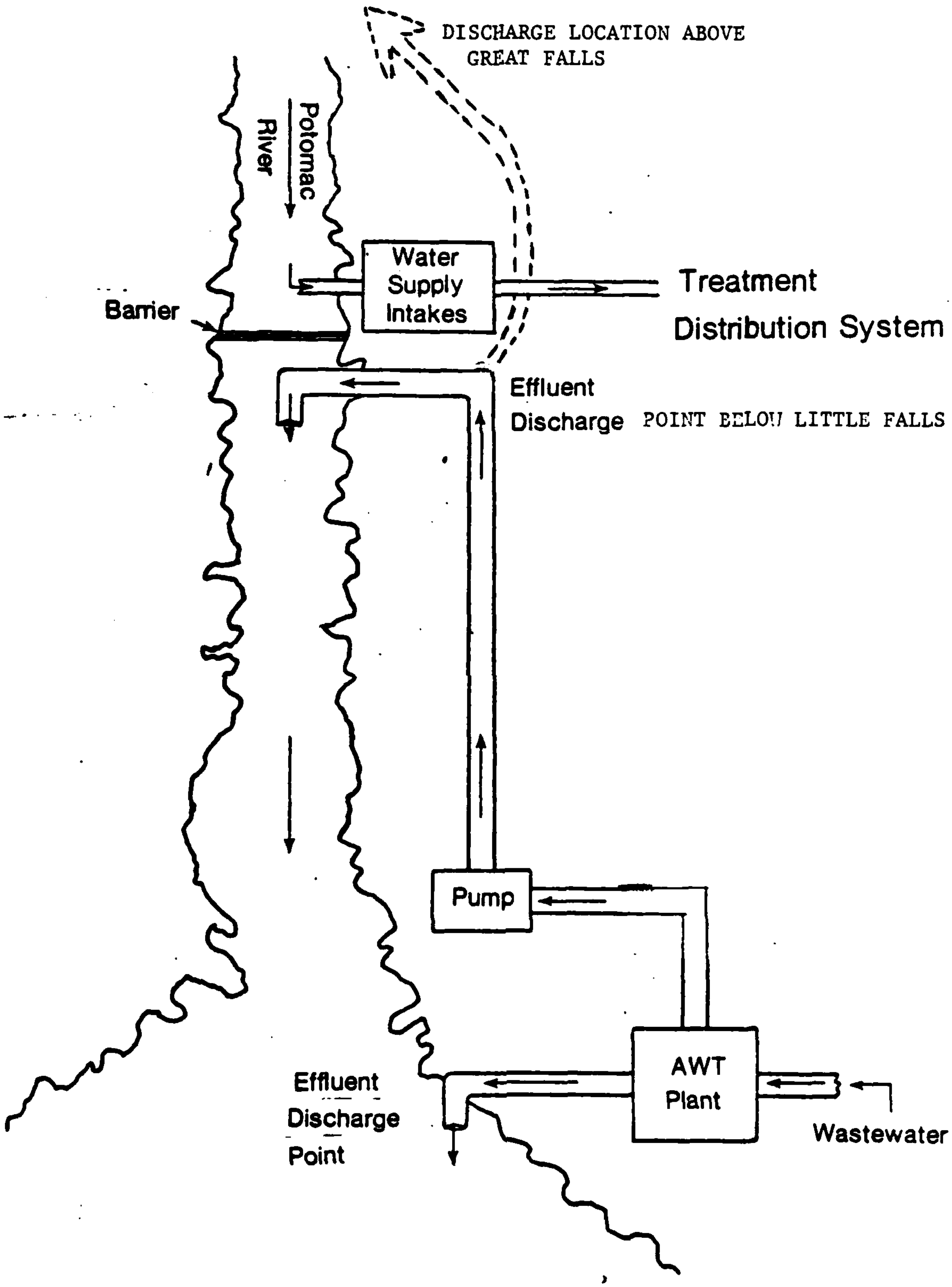


TABLE B-52

COST SUMMARY OF POTOMAC RIVER RECHARGE SCHEMES

| | BLUE PLAINS TO LITTLE FALLS | | BLUE PLAINS TO GREAT FALLS | |
|---|---|---|---|---|
| | 100 MGD | 200 MGD | 100 MGD | 200 MGD |
| Pipe Diameter (inches) | 66 | 96 | 72 | 108 |
| Length (miles) | 12.9 | 12.9 | 20.8 | 20.8 |
| Pipeline Capital Cost | 40,900,000 | 76,000,000 | 71,400,000 | 131,000,000 |
| Pump Station Capital Cost | 5,100,000 | 8,630,000 | 5,830,000 | 9,940,000 |
| Total Capital Cost | 46,000,000 | 78,630,000 | 77,230,000 | 140,940,000 |
| O&M Total Cost ($/YR) | 527,100 | 730,000 | 853,000 | 1,304,000 |

Costs were based on October 1981 values, and an interest rate of 7.625 percent.
Total O&M cost include pipe O&M plus pump station O&M.

evaluation was the establishment of a new baseline condition for the MWA Potomac users which indicated that the regulation of the present 13,370 mg (41,000 acre-feet) of Bloomington Lake water supply storage could, in conjunction with the other actions instituted in the MWA (such as Conservation Scenario 3, Little Seneca Lake, and the water supply agreements recently entered into by the major uses pertaining to regional sharing of supplies) be used to effectively satisfy downstream water supply needs given a 100 mgd flow to the Potomac Estuary.

In addition to developing more efficient regulation schemes for the existing Bloomington project, two forms of reservoir storage reallocation were considered: reallocation of varying portions of both water quality storage and flood control storage to water supply. Each were tested using the PRISM/COE model.

Reallocation of Water Quality Storage

Based on water quality investigations (Annex H-II) conducted for the Bloomington Lake Reformulation Study coupled with PRISM/COE runs, it was determined that the existing project allocation could easily meet a minimum flow target of 120 cfs (78 mgd) at Luke, Maryland which was determined to be adequate to maintain an acceptable water quality in the North Branch Potomac River. It was further determined from the water quality analysis that 5000 acre-feet (1,630 mg) of the total 51,000 acre-feet (16,630 mg) of water quality storage in Bloomington Lake represented storage capacity in excess of that needed to maintain acceptable water quality conditions. This storage represented potential additional water supply which could be used to augument Potomac River flows when needed. PRISM/COE runs further demonstrated that if the 5000 acre-feet of water quality storage were reallocated to water supply it could reduce the regional deficits under higher flowby assumptions - 300 and 500 mgd, respectively. It is noted that in the former case, deficits (maximum weekly deficit of 67 mgd, total of 800 mg for drought) would persist with the 5000 acre-feet reallocation, whereas in the later case even more significant deficits would occur which would be minimally lessened by the reallocation. It was concluded that the 5000 acre-feet of water quality storage should not be reallocated because of its marginal potential to appreciably increase Potomac flows when needed. Furthermore, this storage could best serve the purpose of ensuring that 100 mgd flowby could be met in the rare instances that this minimum target could not be achieved at Washington, D.C., given the existing system. For these reasons the reallocation of water quality storage was not further investigated.

Reallocation of Flood Control Storage

Three seasonal pool elevations were originally considered for the flood control storage reallocation analysis. These were 1474, 1485 and 1492 which represented corresponding storage reallocations of 9,000 acre-feet, 18,000 acre-feet, and 27,000 acre-feet, respectively.

Table B-53 summarizes the consequences of these reallocations in terms of reduction in flood control benefits, downstream water quality impacts, and water supply deficits.

With respect to the effect of flood control reallocation on flooding it was found that there would be no effects at any upstream damage center resulting from raising the Bloomington Lake normal pool elevation. To determine the effects on flood control benefits downstream from the project, a survey and reinventory of the current floodplain development was conducted which was in turn related to new stage-discharge frequency

TABLE B-53

EFFECTS OF
FLOOD CONTROL REALLOCATION, BLOOMINGTON LAKE

| Reservoir Pool Elevation (msl) | Storage Reallocated (Acre-Ft) | Percent of Flood Control Storage | Reduction in Flood Control Benefits | Downstream Water Quality Impacts[2] | Total Deficit (MG) at 300 flowby | Total Deficit (MG) at 500 flowby |
|---|---|---|---|---|---|---|
| 1474 | 9000 | 25 | 3% ($49,000) | Reduced control of pH | 0 | 28 |
| 1485 | 18,000 | 50 | 7% ($108,000) | Reduced control of pH | 0 | 25 |
| 1492 | 27,000 | 75 | 31% ($467,000) | --- | --- | --- |

[1] Number in parenthesis represent average annual damages foregone. Further analysis of 1492 pool level was not undertaken due to unacceptable reduction in flood control benefits.

[2] These impacts would be limited to the infrequent occurrence of a long term drought and would vary with the magnitude of water supply releases made.

curves associated with the reallocated flood control storage levels. The important impact centers which were evaluated include Luke, Westernport, Cumberland, South Cumberland and Oldtown, Maryland as well as Keyser, Ridgely, and Greenspring, West Virginia. Figure B - 38 schematically shows the generalized impact of flood control reallocation to other purposes on the discharge frequency and hence damage frequency relationships which would likely to be expected. Loss of flood control storage generally results in a greater probability of the occurrence of high flood flows and thus greater damages associated with the higher frequency of these events.

The analysis of flood control reallocation on downstream damage centers concluded that a 75 percent 50 percent, and 25 percent transfer of flood control storage would result in approximately a 31, 7, and 3 percent reduction in flood control benefits, primarily in the more rural reaches. Because of the high level of flood control benefit reduction associated with a 75 percent level of storage reallocation, this alternative was not further considered.

Reallocation of flood control storage in itself would have minimal effects on the reservoir and on downstream areas. Impacts would be created however with the concomitant water supply releases that would be made to make use of the reallocated water supply storage. The environmental assessment conducted for the 300 mgd and 500 mgd flowby targets which would require joint Bloomington and Savage flow releases indicated that the higher water supply releases would progressively be characterized by poorer water quality from a pH standpoint. This would be due to reduced averaging effect within the reservoir itself as well as the increased likelihood that Savage Reservoir storage might be insufficient to dilute the releases from Bloomington. In this respect, it is noteworthy that water supply releases in the order of magnitude of 300 to 500 mgd would be extremely infrequent and therefore the environmental consequences of such releases are not considered significant for the North Branch.

With respect to water supply capability given the demand for an assumed additional 300 and 500 mgd of additional flow, the COE/PRISM runs demonstrated that a 25 percent reallocation was adequate to meet the 300 mgd level, however both reallocations schemes were insufficient to meet the needs at a 500 mgd level (See Table B-54). Furthermore, in all cases considered, the available water supply storage in Bloomington Reservoir would be depleted. In the most extreme flow requirement scenario of 500 mgd, all available water supply storage in the system with the exception of the Patuxent was depleted for both the 25 and 50 percent reallocation conditions. Annex H-III, PRISM Development and Application provides the complete documentation of all the flow conditions tested using PRISM/COE.

Two costs would be incurred given the 1475 pool and 1484 pool flood control storage reallocation schemes. The cost of structural changes associated with flood control reallocation cited in Table B-54 are associated with spillway and intake modifications, further reservoir clearing and relocation of the Howell Run boat ramp facilities to accommodate higher summer pool levels. Further studies would be required with respect to corrosivity on the tainter gates given higher pool levels, the effects of more frequent releases on the tainter gates themselves as well as the stability of the fill areas immediately downstream of the project and, possible enlargement of the air vents in the intake structure for higher pool levels. In addition to the investment costs for structural modifications, a portion of the original project cost would be reallocated to water supply and would also have to be paid by a non-Federal buyer. The cost of this storage was determined by its share of the original project's cost using the "Use of Facilities" method, which is a cost allocation formula developed by the Corps of Engineers. This costs for the two schemes investigated are included in Table B-55.

FIGURE B-38

EFFECTS OF RESERVOIR FLOOD CONTROL STORAGE REALLOCATION

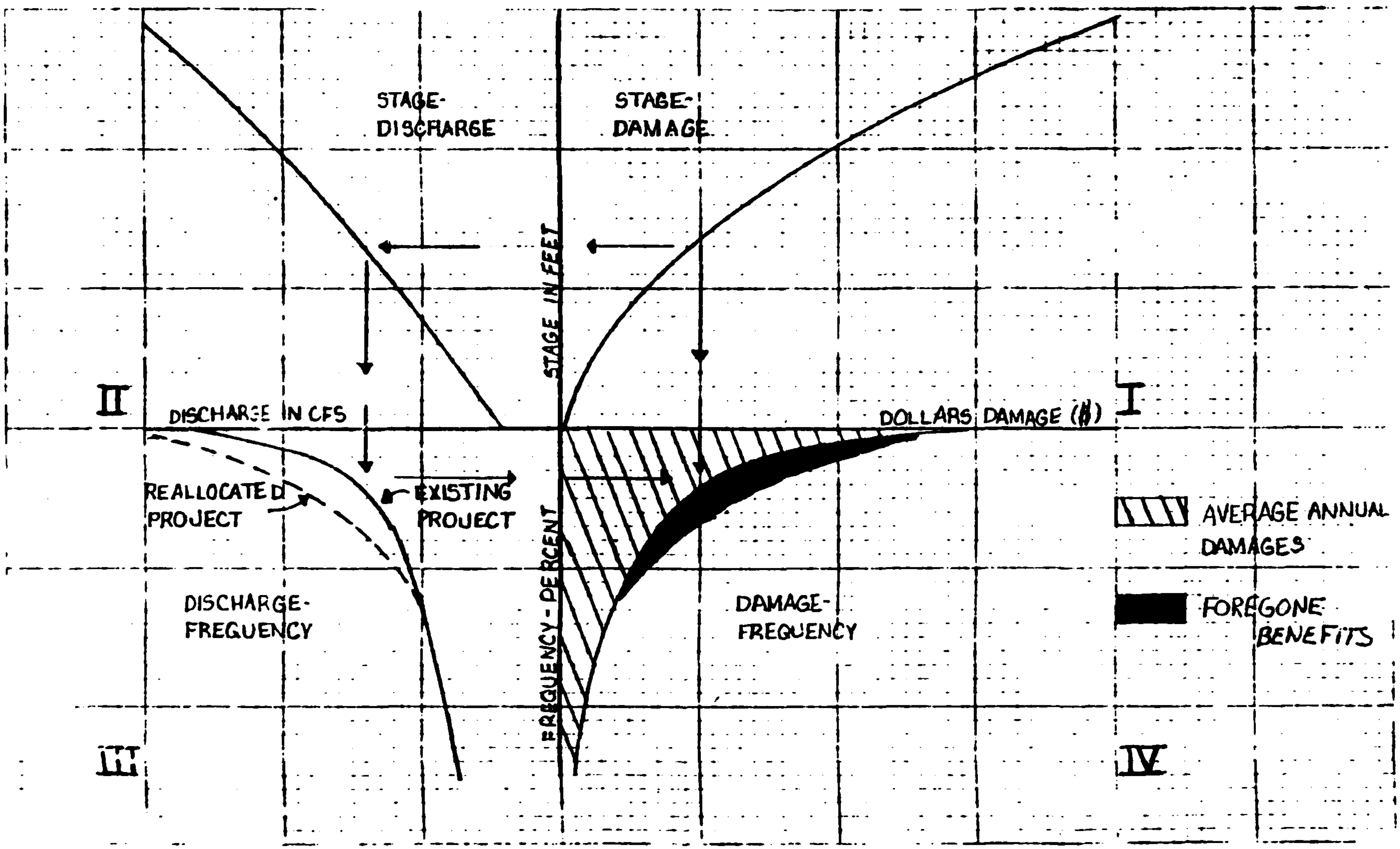


TABLE B - 54

INTERRELATIONSHIP OF DEMAND, DEFICIT, AND RESERVOIR STORAGE REALLOCATION

| | 25% Flood Control Storage Reallocation (9,000 acre-feet) | | 50% Flood Control Storage Reallocation (18,000 acre-feet) | |
|---|---|---|---|---|
| | 300 mgd Add'l Demand | 500 mgd Add'l Demand | 300 mgd Add'l Demand | 500 mgd Add'l Demand |
| Maximum Regional Deficit (MGD) | 0 | 355 | 0 | 354 |
| Cumulative Regional Deficit (MG) | 0 | 27,947 | 0 | 24,650 |
| Available Water Supply Storage Remaining (MG) | | | | |
| Bloomington | 0 | 0 | 0 | 0 |
| Occoquan | 150 | 0 | 823 | 0 |
| Patuxent | 2,934 | 1,570 | 3,386 | 1,730 |
| Little Seneca | 1,230 | 0 | 3,432 | 0 |
| Total | 4,314 | 1,570 | 7,641 | 1,730 |
| Percent of total system water supply storage capacity remaining | 10.4 | 3.8 | 17.1 | 3.9 |

TABLE B-55

SUMMARY OF COSTS ASSOCIATED WITH A
REALLOCATION OF FLOOD CONTROL AT BLOOMINGTON LAKE*

| | 1475 pool | 1484 pool |
|---|---|---|
| Investment costs for modifications | 2,100,000 | 3,337,000 |
| Cost of Reallocated Storage | 20,179,000 | 41,736,000 |
| Total Investment Costs | 22,279,000 | 45,073,000 |
| Reallocated Water Supply Storage (MG) | 2,900 | 5,900 |
| Cost/MG of Additional Water Supply | 7,680 | 7,640 |

*Oct 1981 dollars

## Conclusions

In terms of storage reallocation for the purposes of water supply in Bloomington Lake, the following conclusions can be drawn from the evaluation and analyses which were undertaken:

1) Reallocation of approximately 5,000 acre feet of water quality storage to water supply can be achieved without compromising acceptable water quality in the North Branch. Only marginal water supply benefits however, could be obtained in this manner. Use of this storage could be put to best use as a "safety factor" to ensure a minimum flow of 100 mgd in the Potomac River in the rare event the existing system failed to maintain this minimum established flow requirement. Reallocation of water quality storage to water supply was therefore not viewed as a favorable reallocation alternative.

2) A 75 percent reallocation of flood control storage to water supply would be unacceptable as it results in a 31 percent decrease in flood damage reduction capability.

3) Reallocation of 25 and 50 percent of flood control storage to water supply improves the water supply capability of the system, however, in both cases water supply deficits would not be eliminated entirely in the MWA under 500 mgd flowby requirements.

4) Reallocation of flood control storage to provide large water supply releases reduces the pH control capability of the Savage/Bloomington Reservoir system for the North Branch. Since large releases would likely be infrequent, these impacts are not considered significant.

5) Reallocation of flood control storage to water supply would require combined structural modifications and reallocated project costs of approximately $22.3 million and $45.1 million for a 1475 and 1484 pool, respectively. Reallocated original project costs represent the largest portion of these costs.

## LONG RANGE EVALUATION

Given the technical information presented for each of the long range components, several steps were taken leading to the presentation of long range planning options available to the MWA. First, a series of planning criteria were developed to facilitate an analysis and a uniform comparison of the advantages and disadvantages of the components. Next, an evaluation matrix was constructed displaying the components and criteria with which they were to be evaluated. Using these criteria, a component by component evaluation was conducted by an interdisciplinary planning team using a set of performance indicators which were developed to gauge each component's ability to meet the criteria which were set. Following this procedure, some of the more salient and broader observations were made based upon a review of the completed evaluation table. This revealed some of the more obvious comparisons that could be made concerning the components investigated. The evaluation was concluded with a presentation of long range planning options for consideration which was presented from the viewpoint of the various needs and concerns which would likely affect local decision-making in the future. The following discussion traces in detail this methodology.

## LONG RANGE CRITERIA

Each of the eight water supply or demand reduction components previously described were evaluated using planning criteria developed specifically for the long-range planning exercise. These criteria included:

- Degree of additional water supply provided or reduction in demand
- Cost per million gallons of supply or demand reduction
- Minimize cost
- Minimize adverse impacts
- Maximize ease of implementation
- Maximize dependability of supply
- Minimize use of energy intensive projects
- Maximize flexibility

These planning criteria were developed independently from those for the early-action phase of the study. It was presumed at the initiation of long-range planning that the water supply needs of the major Potomac dependent users in the MWA would be met given local actions to implement water supply plans. Each of the long-range components were therefore presented assuming that, at some future date, consideration would be given to providing additional water supply under a variety of circumstances. In view of this, it was necessary to develop a set of long range planning "criteria for further action" which would enable local decision makers to evaluate the relative merits of the components investigated. It is recognized that differences of opinion will exist over what should be the key factors in decision-making, depending upon the point of view and vested interests that the affected parties would bring to the decision table. Certainly, the first five criteria listed above would be of primary importance to all of those concerned. The remaining criteria were also considered important and worthy of consideration.

The first two criteria listed display in simple terms a unit measure of accomplishment in terms of the quantity and cost of water provided or demand reduced. These units of measurement were also important to consider along with the other criteria. The following sections provide definitions and explanations for all of the planning criteria considered.

### Degree of Additional Water Supply Provided or Reduction in Demand

Each of the components have differing capabilities of either increasing the available supply or decreasing the demand for water. Their relative capabilities which are measured by flow values were categorized according to the following class intervals: not effective, 0 to 100 mgd, 100 to 300 mgd and greater than 300 mgd. The designation of components to a given class interval was based on the maximum flows evaluated in the technical studies for each component.

Cost per Million Gallons of Water Provided or Demand Reduced

This measure represents the capital cost in thousands of dollars per million gallons of supply increased or demand reduced. To provide a uniform basis for comparison, where applicable, flow rates were converted to volume assuming a 5-month (150 day) duration of project operation. This duration closely approximates the duration of the most critical period during the most severe drought on record in the early 1930's. For example, use of a 200 mgd EEWTP would correspond to 30,000 mg for a 5-month period. Using a preliminary capital cost of $98,500,000 for a 200 mgd EEWTP plant, the cost per thousand gallons is approximately $3300. These values do not represent the operating costs of the project, but rather give only a relative indication of the capital investment required to supply or reduce the demand for water based on a critical drought.

Minimize Cost

This category qualifies from a relative point of view among components, the cost/million gallons of supply provided or demand reduced specified by the second listed objective. Those projects or programs which result in a high return at a low cost are preferable to those which represent high unit costs per volume provided or reduced.

Minimize Adverse Impacts

Relates to the relative degree by which a component produces negative impacts on the existing and projected future natural, social, and cultural environment. This criteria measures the degree the effects are minimized and the potential for enhancement in these categories. Impacts include those which can occur during project or program construction or operation and may be site specific or secondary in nature.

Maximize Ease of Implementation

Because of the multiplicity of political authorities, governmental agencies, and other vested interests that exist in the MWA, the financial, organizational, and political influences often represent the overriding factors which determine the success or failure of any proposed plan of action. Public acceptability also exerts a great deal of influence on the feasibility of any component. Because of these realities, the practicability or ease of implementation figures prominently among the criteria being considered.

Maximize Dependability of Supply

Relates to the ability of a given component to assure an adequate quantity of water or reduce demand when it is required. Factors important in this determination are reliability of the source and the degree of certainly that a given project or program will function at the level it is designed for.

Minimize Use of Energy Intensive Projects

In view of past energy crises, and the rapidly growing cost of energy in the United States, the energy requirements for the operation of projects may represent a significant component of their overall cost, particularly in the future. Clearly those projects or programs which are less energy intensive than others in their operation offer distinct monetary advantages over the more energy intensive projects.

Maximize Flexibility

The capability of components to achieve multiple use (i.e., flood control, wastewater treatment, instream flow improvement) as well as to accomodate changing conditions that can or cannot be predicted over the planning period increases their viability for implementation. The potential for incremental staging of project capacity, the ability to activate and deactivate projects or programs in an expeditious fashion, and the ability to operate a given project or program to the benefit of one or more service areas adds to its flexibility.

PERFORMANCE INDICATORS

A set of performance indicators was developed to evaluate the relative degree of success that each of the components could have in meeting the stated criteria. These indicators were used to fill out the evaluation material represented by Figure B-39. As noted earlier, the first two criteria relating to supply, demand, and cost could be readily quantified. Numerical ranges were therefore developed for these categories and each components ability to satisy the criteria within a given range was noted by an "X". A more qualitative set of performance indicators was needed to gauge each components ability to satisy the remaining criteria which were subjective in nature. These were represented by the following symbols:

N/A -Not Applicable. The component cannot be evaluated by the stated criteria.

O -The component does not meet the stated criteria.

◔ - The component has a relatively low level of achievement in meeting the stated criteria.

◑ - The component has partial ability to meet the stated criteria.

◕ - The component has considerable ability to meet the stated criteria.

● - The component fully meets the stated criteria.

FIGURE B-39

LONG RANGE PLANNING COMPONENT EVALUATION MATRIX

| PLANNING COMPONENTS | DEGREE OF ADDITIONAL WATER SUPPLY PROVIDED OR DEMAND REDUCTION (MGD) | | | | COST/MILLION GALLONS PROVIDED OF 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: Increase 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

* See text p 210

An interdisciplinary study team from the Baltimore District with considerable experience with regard to the water supply situation in the MWA and the components investigated evaluated each component and assign the performance indicators as appropriate. The following sections discuss the evaluation and the rationale used for designating the performance indicators on a component by component basis.

## COMPONENT EVALUATION

### Conservation Scenario 5

Using average annual projected demands for the year 2030 for the WAD, WSSC, and FCWA service areas, it was calculated that an additional 109 mgd of reduction could be achieved by Conservation Scenario 5 over and above the redefined baseline (Scenario 3) projected demand levels. Based on an incremental cost of Scenario 5 over Scenario 3 of $183,311,000 based on Table B-41, a rather high unit cost of about $11,200/million gallons of reduction achievable was calculated based on a 5 month (150 day) drought. It is emphasized that this cost may be significantly overstated because it does not reflect the year round cost savings that would also be associated with conservation. These include reduction in water treatment plant operating costs, reduction in wastewater treatment plant costs, and reduction in pumping costs at both the raw water intakes and within the finished water distribution system.

Because Conservation Scenario 5 is essentially a non-structural component, little adverse impact would be expected in almost all of the listed accounts. Some minor social impacts might be associated with the leak repair program of this scenario as well as the degree by which the public would be expected to participate in the program.

Although adverse environmental, social, and cultural impacts would be expected to be minor or absent entirely, there exists other constraints on the ease of implementing Conservation Scenario 5. These relate to the fact that a large part of the program is based on the introduction of a proto-type toilet fixture which has not been traditionally used in the area. Furthermore, it may be reasoned by the public and the utilities that a sufficient level of long term reduction (about an additional 11%) has already been achieved or is planned to be achieved. The additional (16%) level of reduction represented by Scenario 5 might be considered execessive in view of the conservation efforts already under taken. Based on early action planning, the public utilities indicated that a 11 percent level of reduction appeared to reasonable and was achievable.

Conservation not only minimizes use of energy, it also involves energy savings by reducing the energy requirements associated with water treatment, wastewater treatment, pumping, and the use of hot water heating in the domestic sector. Furthermore, unlike many structural alternatives, parts of the conservation program such as the educational programs can be started and stopped depending on need. This adds to its flexibility. By reducing wastewater flows, conservation indirectly results in a multi-purpose benefit.

## Raw Water Interconnections

The raw water interconnection evaluation was based on two potential projects; a reversible Potomac River - Occoquan Reservoir interconnection and a reversible Potomac River - Patuxent Reservoir interconnection. It was assumed that the 65 mgd Potomac - Occoquan interconnection and the 60 mgd Potomac - Patuxent interconnection represented the most reasonable design size for consideration since larger capacity pipelines would most likely be oversized for the water supply storage that would be likely available in these reservoirs given the current regional operating agreements.

Based on the capital cost data summarized in Table B-43 given a 150 day drought, the average cost/million gallons of supply provided was determined as approximately $7,500 per thousand gallons for both interconnections.

With respect to adverse environmental impacts it was felt that in general the impacts would be minor; however, from an operational standpoint this would include the rapid drawdown of the Patuxent and Occoquan Reservoirs during droughts which could adversely affect the fisheries in the reservoir. This would be expected to occur infrequently and therefore long-lasting and irreversible impacts would not be anticipated. Adverse environmental impacts associated with pipeline construction would be temporary, and restricted to the pipeline corridors which mostly follow existing rights-of-way. Although social impacts would also be temporary, in most cases the potential for disruption would be greater than in the case of the natural environment because of the numerous properties which would either be traversed or paralleled by the pipeline right-of-way. Some minor changes in land use would therefore likely result. Although both pipelines are routed through highly disturbed areas and areas of low potential from a cultural resources viewpoint, several small archaeological finds were recorded in these corridors, primarily in the stream valleys.

The primary constraints to implementing raw water interconnections would likely be the high costs associated with their construction and operation; the perceived negative impact on reservoir levels which not only affects the natural environment but also the recreational opportunities and aesthetic appeal at both reservoirs; and the fact that numerous property owners along the length pipeline routes would have to be dealt with on a property-by-property basis which would make the real estate acquisition process a very complicated and lengthy one and could generate appreciable public resistance.

Once constructed, raw water interconnected would likely be reliable if properly maintained. An extremely long and severe drought, though, could reduce storage capacities in the reservoirs to the point where interconnections were rendered useless. Similar limitations, however, could hold true for all structural alternatives which draw on natural sources of supply.

The use of energy for raw water interconnections would be infrequent and limited to use during droughts. As with other structural projects that require pumping, raw water interconnections were considered to be relatively energy-intensive in comparison to the other non-structural or gravity type projects such as reservoirs.

Raw water interconnections exhibit flexibility in a number of ways. From an operational viewpoint, water may be pumped in both directions; from the Potomac River to both the river and reservoir treatment plants as well as from the reservoir back to either treatment plant. The primary benefit would be the ability to make the most efficient use of reservoir storage. Phased installation of pumping capacity also adds to the flexible operation ability of this project; however it would not be cost-effective nor practical to phase capacity of the pipeline itself. In the event of an emergency stemming from the contamination of the principle source of the supply for the region, the Potomac River, raw water interconnections may serve as a useful emergency supply back-up. Once in place, the new pipeline rights-of-way may offer multi-use potential in terms of open space and green belts and possibly recreation. Furthermore, pipeline corridors may represent significant buffer areas between communities.

## Finished Water Interconnections

Finished water interconnections are unlike all of the long-range alternatives insofar as they cannot increase the supply available to the region. As such, the evaluation for finished water interconnections was based on their utility as an emergency measure which is their most favorable attribute.

Because finished water interconnections would be implemented in highly developed urban areas, adverse impacts would be restricted largely to disruption to traffic, residences, and business during construction. Once in place, these impacts would be eliminated. It is unlikely that emplacement of finished water interconnections would face major public resistence since they do not involve the securing of new lands or the conversion of land to new uses.

Finished water interconnections require little additional pumping since they function largely from the pressure differences which exist between adjacent systems. They involve therefore, minimal use of additional energy. Some flexibility is offered by finished water interconnections because they may be operated in a reversible fashion to the benefit of both interconnected systems.

## Pricing

It is noted that the contractual work on pricing did not specify a precise level of reduction achievable by implementing marginal cost peak pricing. This was due primarily to the fact that the projected most likely future would not generate increased project costs at the levels at which this preferable method of pricing would be most successful. Nonetheless, it was pointed out the effectiveness of pricing would be contigent upon the future scenario projected and that only with higher cost projects would the effectiveness of pricing as a demand reduction tool be realized. Given the uncertainty in the long range of what projects would be needed and when these projects would be implemented it was not possible to develop a definitive level of reduction at which marginal cost peak pricing would be effective. However, it was reasoned by the study team that the maximum limit for reduction of demand due to marginal peak cost pricing could probably fall above 100 mgd but would unlikely reach as high as 300 mgd. Furthermore, there would be relatively little cost incurred to implement pricing. Some administrative costs would have to borne by the utilities related to changes in meter reading and billing however these were considered to be relatively minor. Pricing therefore represents a minimal cost component.

With respect to environmental and cultural impacts, pricing generally results in minimum adverse effects because it does not involve construction. Some adverse social impacts could be expected due to changes in user consumption of water which at the individual level may be undesirable. It can also be argued that the economically equitable cost allocation resulting from marginal peak cost pricing adversely affects low income groups by forcing them to pay a summer premium for water whereas "rich" people are able to indulge in the excesses of water use with little economic discomfort. While this may occur, it must also be realized that this situation probably reflects a much larger problem related more to income distribution than to pricing policy in itself.

There are both positive and negative aspects of pricing with respect to ease of implementation. On the positive side, marginal peak cost pricing represents a fair and equitable method of recouping the cost of improvements from those who seek to benefit from them. Furthermore, because implementation of this form of pricing would have the indirect effect of delaying the need for projects (or allowing projects to be built when needed, from an economic viewpoint), it would appear as if the general public would be receptive to its implementation. On the other hand, as mentioned earlier the problem of high costs for those who are in low income groups represents a retarding factor with respect to implementation of pricing. Moreover, the utilities would have to make a concerted effort to implement pricing by increasing the internal administrative steps to insure its effectiveness and, if necessary, as by seeking the approval of rate changes through the Public Service Commission in Maryland and the State Corporation Commission in Virginia. The latter step might prove to be a long and arduous task if the rate changes are perceived to be controversial by the public.

Unlike major structural projects which can store or provide a tangible supply of water, the effects of pricing are less tangible and less certain which reduces its dependability considerably. Though it can be said that at a maximum and under ideal conditions, pricing is capable of reducing demand in a range between 100 and 300 mgd, it is not possible to be as confident that the proper conditions and consumer reaction to price change will be at the level that desired and be persistent over time. The existing data base available for the MWA with respect to elasticity of demand does little to add confidence for estimates of reliability.

Pricing can, as can conservation, indirectly reduce the energy costs associated with water and wastewater treatment operation and distribution by reducing the use of water. Another parallel that can drawn between these two components is that both can be initiated or retracted as needed which increases their flexibility. No direct multipurpose uses can be obtained from pricing.

Groundwater

Based on a capital cost of $1,220,000 per mgd to construct wellfields at site 1 and 3, and to treat, and convey groundwater from these sites to the WSSC System a rather high unit cost of about $8,200/million gallons was estimated based on a 150 day drought. These costs make groundwater one of the highest costs components available.

Most of the environmental and social impacts associated with the groundwater development schemes would be temporary and related to construction, at the well sites which are located in or near stream valleys. Since the pipeline routes follow the rights-of-way of major roadways, little if any impacts would be expected from these portions of the overall groundwater development scheme. Based on the pumping schemes evaluated, the projected pumping levels of 100 mgd would not severely impact upon surrounding wells given the current level of development.

The concept of development of groundwater in southern Maryland for the expressed purpose of augmenting supply for the MWA has been met with strong resistance in the past and is likely to face strong opposition in the future. Representatives of the southern Maryland area who are members of the Citizens Task Force for the MWA Water Supply Study have strongly indicated that the citizens of southern Maryland would fight the exportation of groundwater which represents their sole source of water supply. Furthermore, the State of Maryland as well as the FISRAC cautioned the Corps at the outset of the groundwater study that development of this source would not be acceptable unless it were demonstrated that in doing so, the adjacent water sources would not be adversely affected. Based on the location and intensity of local pumping levels at the present time, and the frequency at which additional large scale pumping would be required, it appears that little adverse impact would result. However, the degree to which local wells will be expanded in the future is uncertain. Certainly no other local sources of supply are available to these areas and deep aquifers represent a likely supply source. It is expected that additional information available from a test drilling program will be needed to verify some of the findings of the USGS work and well as alleviate some of the local and state concerns regarding the further use and transfer of this valuable source of water. For these reasons, groundwater does not appear to be a readily implementable component at this time.

As noted earlier, based on the USGS estimates of groundwater reserves and the pumping schemes developed by the Baltimore District, all of which were conservative, 100 mgd appears to be a dependable yield for the groundwater schemes which were developed. The uncertainty which does exist is related to the sufficiency of the actual data used for the groundwater modelling which reduces the confidence in the dependability of the schemes developed. The unknown extent of future pumping from the surrounding areas adds to this uncertainty.

The proposed groundwater sites 1 and 3 require approximately 2400 acres of land (two 1200 acre tracts) to allow adequate spacing of individual wells and minimal well interference. These sizeable tracts of land represent a significant potential for multiple use public use (i.e., parkland). The wellfields would further be flexible because each individual well could be separately drilled and staged depending upon need.

Reservoirs

The reservoir evaluation was completed considering the seven upstream sites and the six local sites (excluding modification of the Occoquan Reservoir) as separate reservoir groupings with distinct characteristics. Based on the aggregate water supply storage and the safe yields calculated for each of the upstream reservoirs, approximately 500 mgd of flow is achievable from these projects. Given a total cost of about $155.2 million for the water supply storage and a total storage of approximately 148,100,000 gallons, the cost per million gallons of storage provided by these reservoirs was approximately $1050. These costs are considered relatively low given the large storage reserves that these upstreams sites represent. However, it is further noted that these costs represent only the water supply costs and not the entire project costs. Additional costs related to other project purposes might be required to be cost shared with non-Federal entities based on the current multi-purpose design of these projects.

The costs per unit volume of storage for the local reservoirs were calculated to be considerably higher than the upstream reservoirs because of the pumpover pipelines which would be required to ensure their effectiveness. Given a total project cost of approximately $478,300,000 for the six local sites considered and an aggregate water supply storage of approximately 70,750 mg about a $6,700 cost per million gallons of supply was calculated. Local reservoirs and their attendant pumpover facilities represent a considerably higher cost/unit volume components compared to upstream reservoirs.

Environmental impacts were considered to be significant for both the upstream and local reservoir sites due to the loss of free flowing streams and the riparian and upland habitat which exist at all of the sites considered. Since most of the upstream areas are sparsely developed social impacts would not be great; however, the likelihood for development at the local sites is much greater due to the proximity of these sites to the MWA. While it is unlikely that highly unique cultural resources would be found at either the upstream or local sites, the potential for cultural resources would be greatest in the stream valleys and these sites would need to be surveyed further so that these resources could be properly documented.

In the past, there has been little support for the construction of large reservoirs upstream of the Washington, D.C. area. As noted, earlier, Bloomington Reservoir represents the only reservoir that was constructed as a result of various planning studies which have recommended reservoirs over the past 25 years. Most recently, the withdrawal of support for the Verona project by the Commonwealth of Virginia and the deauthorization of the Sixes Bridge project bears testimony to the lack of citizen and political interest in seeing these projects to construction. At the local level, there has been some progress made as evidenced by the construction of Little Seneca Lake. However it is safe to say, particularly for those projects located in the Goose and Catoctin Creek basins of Virginia that are valued for the scenic and environmental qualities, that a strong sentiment against reservoirs persists. This sentiment is likely to continue particularly in view of the recent advances in regional water supply management.

It was reasoned that both the local and upstream projects would equally provide a sound and dependable supply of water based on their design.

Whereas the upstream reservoirs would be gravity controlled structures, most of the local reservoirs would require occassional pumping for refilling over extended droughts which would add to their energy costs.

Both upstream and local reservoirs exhibit some flexibility for different reasons. Multiple project purposes have been planned for many of the upstream projects including flood control, water quality control, and recreation. Though there exists some recreation potential at the local sites which were considered, this potential is more limited due to the smaller size of these sites and the large drawdowns that would likely occur during drought events. At the downstream or local sites, the pumpover lines would add some flexibility for filling these reservoirs during high flows in the Potomac River. Furthermore, it may be easier to stage the construction of these smaller sites over time (barring implementation limitations) than the much larger reservoir projects considered in the upper basin.

Modification of Existing Reservoirs

It was determined that the cost of modification of existing reservoirs to increase their water supply capability differed considerably for the Occoquan Reservoir and Bloomington Reservoir. This is due to the fact that relatively little construction would be required to make the necessary modifications at the Occoquan Reservoir whereas considerable costs associated with reallocated project purposes would result in the case of flood control storage reallocation at the Bloomington project. In the case of the Occoquan three foot addition it was estimated that approximately $2,000,000 would be required to increase the storage volume by 2200 mg. About a $900/mg cost would be associated therefore with this addition. For the Bloomington Reservoir flood control reallocation of 18,000 acre feet (5865 mg), to water supply approximately a $45,100,000 cost would be associated with permanent modifications to the project and the costs associated with reallocated water supply storage. This would result in about a $7,640 per million gallon cost.

Modification of the Occoquan Reservoir and the Bloomington Reservoir would cause little adverse environmental impacts. However, additional land may have to be acquired for flooding easements at the Occoquan Reservoir, and this may present adverse social and institutional impacts.

Adverse impacts would be slightly greater at the Bloomington site. These impacts would be related to the decreased ability to dilute acid flows from the reservoir during infrequent drought events and the perceived risk by downstream property owners of the decreased flood control protection associated with flood control reallocation. Despite the fact that damage surveys have indicated that only minor losses of flood control benefits would result from the reallocation, it was felt that the public would still be wary of any changes in protection which were being contemplated.

Reservoir modification generally fairs favorably with respect to the criteria relating to implementability, dependability and energy intensiveness. Since little additional land would be required in these instances, adverse impacts would be minimized, and from this viewpoint, reservoir modification would appear to be attractive to the implementing agencies and public alike. The adverse effects associated with the loss of flood control benefits at the Bloomington reservoir cited in the previous section could reduce this attractiveness. Because the Bloomington Reservoir is already on line and there exists institutional mechanisms in the MWA capable of purchasing and using this storage in an efficient manner, its attractiveness is greatly enhanced. Each modification scheme is likely to be dependable given the water supply they will be anticipated to be able to provide. Neither involve pumping and therefore energy requirements will be minimal during their operation.

The added water supply capability provided through modification would result in little additional flexibility at either project. No additional project purposes would result from these changes and it is possible, particularly in the case of Bloomington Reservoir, that higher fluctuating pool levels would diminish the recreation experience at the reservoir somewhat. Structural changes to the project would most practically be completed in one construction period and the potential for adding water supply capacity at a future data would be minimal.

Experimental Estuary Water Treatment Plant

Given the findings from the EEWTP testing program, an evaluation of future use of the Potomac Estuary through consideration of an expanded version of the pilot EEWTP was undertaken.

Using the data developed by Montgomery Engineers, Inc. for an expanded Potomac Estuary treatment plant of 200 mgd, a cost per unit volume of water was estimated. Based on a capital cost of $122,000,000 for an alum-chlorine process, a cost per million gallons of about $4,100 was calculated assuming 150 days of plant operation. These costs are conservative insofar as they do not reflect land costs, intake costs, and piping to the treatment plant which would vary depending upon the site chosen.

The primary adverse environmental impact associated with operation of a 200 mgd estuary treatment plant would be the secondary effects of higher salinity concentrations on the [illegible]ta in the upper estuary. Although this concentration and its attendant effects [illegible] been fully quantified, test results from the Chesapeake Bay Hydraulic Model [illegible] that salinity levels could appreciably increase given the level of withdrawals [illegible]water inflow conditions assumed under drought conditions. Decreased levels of [illegible]ved oxygen also could have adverse impacts on fish populations. From a social viewpoint, negative public reaction regarding the use of the Estuary as a potable source would likely be experienced given the commonly held perceptions by local residents of the poor water quality in the Potomac Estuary, particularly as it relates to the Blue Plains Wastewater Treatment Plant. An expanded plant constructed anywhere near the historic areas which surround virtually all parts of the upper estuary would also likely be adversely affected.

The general public's reluctance toward acceptance of estuary water as a potable source of water supply transcends many of the technical findings regarding the potability of this source. Whereas the technical data has shown that the mix of Estuary water and treated Blue Plains effluent can be treated within the acceptable health standards set by the EPA and others, it is another matter to conclude from this that the negative sentiment regarding use of this perceived "polluted" source will dissipate as a result of imparting these technical findings. Certainly, a well organized and widespread public education program will be required to gain further acceptance of this component.

Based on the design and technology which would be envisioned for an expanded plant, it appears as if the Estuary would provide a dependable source of supply. It is further noted however, that based on the results of the hydraulic model testing studies high salinity concentrations could be found at the end of a drought period in the upper Estuary which could affect the treatability of this source.

Although pumping requirements were not developed for the EEWTP, it was concluded that in a relative sense, the EEWTP could be categorized along with the other structural projects which require energy to render them operational such as raw water interconnections, local reservoirs and the wastewater reuse pumpovers. The treatment process, withdrawal, and distribution would each have its own energy requirements for an expanded plant.

Finally some flexibility could be attributed to an expanded EEWTP in terms of staging of treatment capacity.

Wastewater Reuse

Supply estimates for the reuse evaluation were based on the Potomac River recharge scheme which was studied. No costs were developed for a land application system because it was not considered to be a viable alternative in a water supply recovery mode. Given a 200 mgd pumpover to both Great Falls and to Little Falls considering 150 days of operation, a cost of $4700/mg and $2600/mg was estimated, respectively. These estimates can be considered somewhat conservative because of the additional costs associated with constructing the pumpover pipeline across the Potomac River. Despite these additional costs it would appear that wastewater reuse in the form of recharging the Potomac River represents one of the less costly long range components considered.

However, many of the significant impacts of reuse are likely to affect almost all of the criteria considered which poses serious constraints on the viability of reuse as a source of supply for the MWA. Significant adverse environmental and primarily social impacts would be associated with developing a 13 or 21 mile pipeline corridor for an eight or nine foot diameter pipe through the highly developed national capital area. This would especially be troublesome in areas close to the Potomac River of high national and cultural significance. From a social viewpoint, it would also appear that discharges of wastewater effluent upstream of the MWA water supply intakes, regardless of the level of treatment, would be unacceptable because of the perceptions regarding reuse of wastewater as a potable supply. The State of Maryland's procedure for granting permits for wastewater discharges would be exercised especially carefully in view of the potential perceived health risk of water supply degradation, particularly during periods of low Potomac river flows. In the case of a discharge location downstream from the Potomac intakes, potential conflicts exist with the safe use of the Emergency Estuary Pumping Station. In view of all of these problems, chances for public and institutional acceptance of the pumpover scheme would be extremely low.

As far as dependability is concerned, the Blue Plains Wastewater Treatment Plant would be a fairly dependable and continuous source of effluent which could be used as needed. As with all of the pumping related components, additional energy requirements would be added to the overall annual cost of operation. Only slight flexibility benefits could be derived from a pumpover scheme and these would be related primarily to staging of pumping capacity.

EVALUATION SUMMARY

The preceding discussions revealed that the long range components which were considered are rather diverse in their approach and level of technological development. As anticipated, many of the components widely differed in their ability to meet the planning criteria which were set. Several broad observations, however, were possible which serve to summarize some of the basic conclusions regarding these components. These observations complement many of the technical findings which were developed and presented earlier in the component development sections. The broad observations are as follows:

1. Upstream reservoirs have the greatest potential for providing large volumes of additional supply at low cost. Their major drawbacks are potential adverse impacts at the sites under consideration and difficulties in implementation.

2. Modification of the storage capacity at the Occoquan Reservoir represents a relatively inexpensive and low adverse impact method of providing additional water to the region among those components investigated in long range planning. The major limitation of this component is that only a relatively small increase in flow can be achieved given the project storage involved, and the possible difficulty in acquiring the necessary land for flooding easements.

3. Reallocation of flood control storage to water supply storage in Bloomington Lake is more costly than modification of the Occoquan Reservoir due to the fact that it is a multi-purpose project whereby the reallocated cost of the reservoir project attributable to water supply must also be paid in addition to the costs for the structural modifications. Because Bloomington Reservoir is already in place and is part of the regional system for water supply, any increase in project storage could be readily used to the benefit of the region. Moreover, a combination of Occoquan Reservoir expansion and Bloomington Reservoir storage reallocation could greatly add to the flexibility to the regional system because they can be operated conjunctively.

4. Among the structural components investigated, groundwater from the Atlantic Coastal Plain ranks as the most expensive per unit volume provided. Furthermore, only a maximum of 100 mgd is achievable given the results of the USGS modelling studies. Since the State of Maryland and the Coastal Plain residents have taken a very "guarded" posture regarding this source, it will take considerable effort to secure this form of supply, even on an emergency basis, for the benefit of the MWA.

5. Conservation Scenario 5 has many positive attributes, among them, minimum adverse effects in all impact categories. This component however, is a very costly one given the highly efficient water saving devices it employs. Furthermore, it may be difficult to achieve further reductions in the order of magnitude possible through conservation Scenario 5 given the levels of reduction that have already been achieved in the MWA through local conservation efforts.

6. Finished water interconnections are incapable of providing additional water to the MWA, however, they can provide valuable emergency capability in the event of a failure in an interconnected portion of the system.

7. The structural components investigated were considered more reliable that the non-structural components because of their ability to deliver the additional supplies when needed. Whereas pricing and Conservation Scenario 5 could potentially provide comparable volumes of supply, their ability to do so is contingent upon numerous assumptions which are highly sensitive to variances in human behavior and consumer preferences. For these reasons, the non-structural components represent a less certain means of providing additional supply when needed.

8. Based on the preliminary findings, it would appear that treatment of water from the Potomac Estuary represents a less costly alternative that many of the other structural alternatives which were considered. Their remains however, significant questions as to acceptability of this water as a potable supply. The same limitations hold true for the Potomac River recharge scheme which was also considered.

## LONG RANGE PLANNING OPTIONS

It merits reemphasis at this point that the need to develop long-range plans for the Potomac users has been obviated because of the actions taken by local decision-makers to implement projects and agreements which enables them to meet their projected water supply needs during the entire planning period (1980-2030). The scope and focus of the long range study therefore was different than that which was originally intended. The purposes of the long-range study were modified to: 1) respond to the study authorization by presenting the technical findings of various studies of specific methods to provide additional water to the MWA and, 2) provide a range of options for the local decision-makers and the public to consider if additional water is desired in the MWA over and above current planning targets.

As noted earlier, the willingness of the public to support the implementation of any of the long range components which were studied will depend upon the degree to which these components satisfy their needs, desires, concerns, and the degree to which it affects others who do not directly benefit from these actions. Building upon this presupposition, a series of premise sets were developed to display the preferences of various segments of the public with respect to the long range components. Table B-56 contains these premise sets. The table lists seven representative sets of needs and concerns or "perspectives" from which the various segments of the public in and around MWA would likely base their decisions with regard to water supply development in the Potomac Basin. Based on these needs and concerns, the study team identified the likely long-range components which would most closely satisfy the needs and desires which were specified. That is not to say that additional points of view do not exist nor does it mean that segments of the public which would support certain components would not support others from those listed.

However, based on the study team's familiarity with the study area it was felt that the projects listed represented those more likely to be favored by representative points of view which exist in the region.

In addition to a list of preferred projects, Table B-56 identifies the limitations, or shortcomings, of these projects and the negative factors or conditions which one would have to accept if in fact he or she was willing to implement the project or program. Table B-56 therefore, serves as an aid to decision makers, listing the range of choices most amenable to various points of view, as well as the drawbacks associated with making these choices. It also points out the inherent conflicts which exist and must be dealt with in arriving at any decision involving the development of water resource projects or programs in the region. For example, thte desire to develop additional sources which have a minimum impact on the environment, such as pricing or groundwater, also may represent those which are less dependable in providing the volumes of supply needed or perhaps involve costs which the public are unwilling to bear. Conversely, highly dependable and relatively inexpensive sources of supply such as upstream reservoirs may produce unacceptable environmental impacts or may be vehemently rejected by those directly affected by these projects in the upper basin. These conflicts, which are likely to exist before any decisions are made, require a careful consideration of trade-offs and eventually compromise to arrive at the most acceptable course of action. In the event that additional water is sought at some future date, the information contained in this Appendix may serve as a foundation from which to base decisions or undertake further study.

TABLE B-56
LONG-RANGE PLANNING OPTIONS

| 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.<br>-Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH levels 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 those affected in the upper basin.<br>-Must also accept removal of land areas and environmental habitat from present conditions.<br>-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 minimal adverse environmental impacts at or near the site of development and would have a potential to enhance the environment. | a) Modification of existing reservoirs including expansion of the Occoquan and reallocation with Bloomington Reservoir | -These alternatives have a limited storage potential and could not provide more than 100 mgd each during a prolonged drought.<br>-Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH levels on infrequent basis. |
| | b) Conservation Scenario 5 | -High relative cost. Higher degree of cooperation required of public to reduce use. |
| | c) Pricing | -Reduced degree of certainty to achieve desired levels of reduction. |

TABLE B-56

## LONG-RANGE PLANNING OPTIONS

| Needs and Concerns | Individual Would Likely Favor | Limitations or Factors Individual Would Have to Accept |
|---|---|---|
| | d) Raw Water Interconnections | -Would have to accept infrequent but rapid draw-downs of Occoquan and Patuxent Reservoirs.<br>-Relatively high cost component. |
| | e) Groundwater | -Have to accept using considerable land area (acres) for maximum development.<br>-Potential exists to preclude development of future supplies by locals.<br>-Limited supply potential (100 mgd) at a 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.<br>-Must be willing to accept reduced flood protection below Bloomington Reservoir and decreased control of pH levels on infrequent basis. |
| | b) Upstream Reservoirs | -These alternatives would result in high public resistance from those affected in the upper Potomac Basin.<br>-Must also accept removal of land areas and environmental habitat from present conditions.<br>-Must be willing to accept travel time associated with releases from reservoirs (Reduced daily control). |

TABLE B-56

**LONG-RANGE PLANNING OPTIONS**

| Needs and Concerns | Individual Would Likely Favor: | Limitations or Facotrs Individual Would Have to Accept |
|---|---|---|
| Preservation of land and water quality in the upper Potomac Basin. Regional economic growth. | a) All components with the exception of upstream upstream reservoirs and reallocation of Bloomington Reservoir flood control storage. | -Could lose recreational opportunities and water quality improvements associated with upstream reservoir sites.<br>-Lose opportunity to "buy into" water supply storage at these sites.<br>-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 | -Reluctance on the part of the public to accept estuary water as a potable source.<br>-Potential environmental impacts of large withdrawals from the upper Potomac Estuary.<br>-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.<br>-Significant social disruption during and possibly after, pipeline construction. |

TABLE B-56

**LONG-RANGE PLANNING OPTIONS**

| Needs and Concerns | Individual Would Likely Favor | Limitations or Factors Individual Would Have to Accept |
|---|---|---|
| | c) Conservation Scenario 5 | -High relative cost. Higher degree of coopera-tion required of public 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 coopera-tion required of public 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.<br>-Must be willing to accept reduced flood pro-tection below Bloomington Reservoir and decreased control of pH levels on infrequent basis. |
| | d) Potomac River Recharge | -Endangering the safety and potability of supply if discharge point is above MWA water supply intakes.<br>-Conflict with Emergency Estuary Pumping Station operation if discharge point is below the MWA water supply intakes.<br>-Significant social disruption during and possibly after pipeline construction. |

ANNEX B-I

**WATER SUPPLY**

**COORDINATION AGREEMENT**

## WATER SUPPLY COORDINATION AGREEMENT

THIS AGREEMENT, dated for convenience of reference as the _____ day of _____________, 1982, made and entered into by and among the UNITED STATES OF AMERICA acting through the Baltimore District, Corps of Engineers, U.S. Army, functioning through the Washington Aqueduct Division (hereinafter called the "Aqueduct"); the FAIRFAX COUNTY WATER AUTHORITY (hereinafter called the "Authority"); the WASHINGTON SUBURBAN SANITARY COMMISSION (hereinafter called the "Commission"); the DISTRICT OF COLUMBIA (hereinafter called the "District"); and the INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN SECTION FOR COOPERATIVE WATER SUPPLY OPERATIONS ON THE POTOMAC (hereinafter called the "CO-OP").

### WITNESSETH

WHEREAS, the Chief of Engineers is charged with the operation and maintenance of the Washington Aqueduct for the purpose of providing an adequate supply of potable water for distribution to and consumption by the agencies and instrumentalities of the Federal Government situated in the District and its environs, and of providing a public water supply for the inhabitants of the District, and certain communities in northern Virginia; and

WHEREAS, the Authority is an authority established pursuant to the laws of the Commonwealth of Virginia charged with responsibility for providing a safe and adequate public water supply within certain geographic areas of northern Virginia, and is also authorized to enter into agreements to purchase and provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, the Commission is a public authority established pursuant to the laws of Maryland, is charged with the responsibility of providing a safe and adequate water supply within the Counties of Montgomery and Prince George's, Maryland and is also authorized to enter into agreements to purchase and provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, the District is authorized and empowered to contract to provide a safe and adequate water supply to the inhabitants and entities within its jurisdiction and accomplishes this purpose through cooperation with the Washington Aqueduct Division, Corps of Engineers, United States Army, and is also authorized to contract for the purposes described herein; and



WHEREAS, the Interstate Commission on the Potomac River Basin (ICPRB) has created CO-OP devoted to forecasting demand and supply in the Washington Metropolitan Area; and

WHEREAS, CO-OP has developed a program for optimal utilization of all available water supply facilities in the Washington Metropolitan Area, particularly during drought periods; and

WHEREAS, the Aqueduct, the Authority, and the Commission (hereinafter called the "suppliers") now have in place, on the Potomac River, water intakes installed in accordance with appropriate Federal and state laws; and

WHEREAS, the suppliers are governed by the provisions of the Potomac River Low Flow Allocation Agreement, dated January 11, 1978, which is hereby incorporated by reference into this agreement and made part thereof; and

WHEREAS, it is in the mutual benefit of the suppliers to manage Potomac River flows, reservoir releases, and water supply withdrawals so as to reduce or eliminate the possibility that the Emergency Stage of the Low Flow Allocation Agreement will ever be reached or that the allocation formula set forth therein becomes operative.

NOW, THEREFORE, in consideration of the mutual covenants herein contained the parties hereto do hereby agree as follows:

ARTICLE 1. - The suppliers agree to operate their respective water supply systems in a coordinated manner so as to provide the optimal utilization of all available water supply facilities for the benefit of the inhabitants of the Washington Metropolitan Area.

ARTICLE 2. - The Authority and the Commission agree to operate their non-Potomac water supplies (Occoquan River and Patuxent River) so as to maximize the availability of reservoir storage associated therewith for use during periods of low flows in the Potomac River.

ARTICLE 3. - The District, the Authority, and the Commission agree that, notwithstanding the extent to which they each may participate in the cost of construction, operation and maintenance of Bloomington Lake, and the proposed Little Seneca Lake and in the operation and maintenance costs of the Savage Reservoir, releases of water from Bloomington Lake water supply storage and Little Seneca Lake shall be made as provided by this agreement.

ARTICLE 4. - The suppliers agree that all available water supply facilities shall be managed and operated as provided in the attached Drought-Related Operations Manual for the Washington Metropolitan Area Water Suppliers (hereinafter called the "Operations Manual"), which manual is hereby made part of this agreement.

**ARTICLE 5a.** - CO-OP agrees to provide the administrative, technical, supervisory and managerial services set forth in the attached Operations Manual and the District, the Authority, and the Commission agree to pay the costs thereof in the following proportions: District-30%, Authority-20% and Commission-50%.

**ARTICLE 5b.** - The District shall take all necessary actions to procure the required appropriations to meet its cost sharing obligations hereunder; provided, however, that no payments shall be made by the District until appropriations for such purposes have been made pursuant to the requirements of the Budget and Accounting (Anti-Deficiency) Act of 1921 (31 U.S.C. 665) as amended.

**ARTICLE 6.** - The parties agree that the services to be provided by CO-OP may be terminated at any time either by the unanimous agreement of the District, the Authority and the Commission or by CO-OP, in which event CO-OP shall deliver to the suppliers all computer hardware and software, equipment, supplies, records, etc., which may have been acquired or developed at the expense of the District, the Authority, and the Commission and thereupon the suppliers shall make appropriate arrangements for continuing the functions, duties and responsibilities theretofore performed by CO-OP. The District, the Authority, and the Commission agree to pay necessary termination expenses incurred by CO-OP.

**ARTICLE 7.** - The suppliers do hereby establish an Operations Committee which shall comprise a representative of each supplier. The Committee shall be responsible for overseeing implementation of this agreement and the Operations Manual and shall be empowered, upon unanimous agreement, to revise the Operations Manual as circumstances may require. The Operations Committee shall:

(a) as necessary, review decisions of the Director of CO-OP and by unaminous agreement, change such decisions and so inform the Director of CO-OP,

(b) monitor compliance with the terms of this agreement and the Operations Manual,

(c) provide executive support to the Director of CO-OP within their agencies,

(d) approve expenditures of CO-OP relevant to the terms of this agreement,

(e) establish joint and coordinated operating procedures for use by the suppliers to monitor supply (including rainfall forecasts) and demand during emergencies and droughts, and

(f) establish CO-OP as the agency responsible for executing the procedures in 7(e) above and for the establishment and maintenance of a system for monitoring supply and demand and performing drought management analysis.



**ARTICLE 8.** - The consideration for this agreement is the promises herein exchanged based upon the premises above mentioned and the public and governmental interests deemed necessary and desirable by the parties to this agreement.

**ARTICLE 9.** - It is agreed that the waters released from Bloomington Lake water supply storage and Little Seneca Lake are to be utilized to achieve the objectives of this agreement without regard to any cost-sharing by the District, the Authority, and the Commission in Bloomington Reservoir and Little Seneca Lake.

**ARTICLE 10.** - In April 1990 and in April of each fifth year thereafter during such time as this agreement is in effect and the proposed Little Seneca Lake has been constructed and is operational, the Aqueduct, the Authority, the Commission and the District shall review and evaluate the adequacy of the then available water supplies to meet the water demands in the Washington Metropolitan Area which may then be expected to occur during the succeeding twenty year period. If as a result of any such review and evaluation it is determined that additional water supplies will be required to meet the expected demands, the Aqueduct, the Authority, the Commission and the District shall undertake negotiations to provide the required additional water supplies and, when provided, water from such additional water supplies shall be included as water subject to the allocation formula under the terms of the Potomac River Low Flow Allocation Agreement. Such facilities shall be operated under the terms of this agreement. The District, the Authority, and the Commission agree that the costs of construction, operation and maintenance of such additional water supplies shall be shared among these parties in accordance with the following formulae:

$$\text{District's Share} \quad -\%= \frac{(A-B)}{(A-B)+(C-D)+(E-F)} \times 100$$

$$\text{Authority's Share} \quad -\%= \frac{(C-D)}{(A-B)+(C-D)+(E-F)} \times 100$$

$$\text{Commission's Share} \quad -\%= \frac{(E-F)}{(A-B)+(C-D)+(E-F)} \times 100$$

Where:

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 substitute the number of gallons of processed water pumped daily by the Authority.

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

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

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

Whenever application of the above formulae results in a negative amount for any one of these parties, such party's share of the costs shall be zero. Thereupon, the formulae applicable to the other two parties shall be revised by eliminating therefrom the term which relates to the party with zero cost share (e.g., if the District's share is zero, the term (A-B) shall be eliminated; if the Authority's share is zero, the term (C-D) shall be eliminated; and if the Commission's share is zero, the term (E-F) shall be eliminated) and the revised formulae shall be applied to determine the respective shares of costs to be borne by the other two parties. Whenever application of the above formulae results in negative amounts for any two of these parties, their respective shares of the costs shall be zero and the entire costs shall be borne by the third party.

ARTICLE 11. - The suppliers, the District and CO-OP agree to utilize their best efforts to resolve any disputes which arise under this agreement or the Operations Manual by informal negotiation, the resolution of which shall require unanimous agreement of the suppliers, and the District. However, any party may initiate litigation, the purpose of which is to construe a provision of or resolve a dispute that arises under this agreement or the Operations Manual. The parties to this agreement hereby agree the issues to be litigated may be litigated in any court of competent jurisdiction sitting in Maryland, Virginia, or the District of Columbia and consent to venue in any such court and to the service of all papers and pleadings related thereto. Pending final resolution of any dispute, the provisions of this agreement and the Operations Manual shall continue in effect.

ARTICLE 12. - The effective date of this agreement shall be the date on which the last party executes the same.

ARTICLE 13. - Unless sooner terminated by unanimous agreement of the suppliers, and the District, this agreement shall continue in effect for as long as the water systems of the suppliers remain in existence and operation.



IN WITNESS WHEREOF, the parties have caused this Agreement to be executed as of the date which appears with their respective signatures.

| Approved in form and in legal sufficiency: | |
|---|---|
| | UNITED STATES OF AMERICA |
| | By: District Engineer, Baltimore District, Corps of Engineers, U.S. Army |
| Date: 22 July 1982 | Date: 22 July 1982 |
| | FAIRFAX COUNTY WATER AUTHORITY |
| | By: Chairman |
| Date: July 22, 1982 | Date: July 22 '82 |
| | WASHINGTON SUBURBAN SANITARY COMMISSON |
| | By: General Manager |
| Date: July 22, 1982 | Date: 22 Jul 82 |
| | THE DISTRICT OF COLUMBIA |
| | By: Mayor |
| Date: July 22, 1982 | Date: 7-22-82 |
| | INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN SECTION FOR COOPERATIVE WATER SUPPLY OPERATIONS ON THE POTOMAC |
| | By: |
| Date: July 22, 1982 | Date: July 22, 1982 |



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I, Henry P. Stetina, of Bethesda, Maryland, General Counsel to the Interstate Commission on the Potomac River Basin make oath and say that I, in the presence of the Executive Director, affixed the Common Seal of the Commission to the annexed Water Supply Coordination Agreement dated July 22, 1982, A.D., 1982, and that I saw the Chairman of CO-OP sign, execute and deliver said Contract as and for the act and deed of the CO-OP Section of the Commission and that I countersigned the said Contract to complete the due execution thereof. And further that the seal affixed and impressed at the foot or end of the said Contract is the Common Seal of the Commission and was affixed and impressed thereto by myself by a resolution adopted on the 29th day, of June A.D., 1982 and with the authority of the Commissioners of CO-OP and in conformity with procedures required for the authentication of the Contract.

Henry P. Stetina
General Counsel

Paul W. Eastman
Executive Director
(Witness)





Drought-Related Operations Manual
for the Washington Metropolitan Area Water Suppliers

(Attachment to Water Supply Coordination Agreement,
dated ______________, 1982)

I. Introduction

This manual details operations rules and procedures for reducing the impacts of severe droughts in the Potomac River Basin. Although the primary emphasis is on water supply for the Washington Metropolitan Area, the rules and procedures are consistent with maintaining instream flow and water quality in both upstream and downstream portions of the basin.

II. Objectives

A. Make the most efficient use of all water supply facilities, including but not limited to the Potomac River, Bloomington Lake, Occoquan Reservoir, Triadelphia Reservoir, Duckett Reservoir, and the proposed Little Seneca Lake to meet all water supply needs for the Washington Metropolitan Area.

B. Maintain the probability of invoking the Restriction Stage of the Potomac River Low Flow Allocation Agreement at less than 5 percent during a repeat of the historical streamflow record.

C. Maintain the probability of entering the Emergency Stage of the Potomac River Low Flow Allocation Agreement at less than 2 percent with full reservoirs on June 1 of any year.

D. Maintain the probability of not refilling any reservoir used for Washington Metropolitan Area water supply to 90 percent of useable capacity by the following June 1 at less 5 percent during a repeat of the historical streamflow record.

E. Maintain flows in the Potomac River below Seneca Pool as agreed to by the signatories to the Potomac River Low Flow Allocation Agreement.

F. Minimize conflict between normal utility operations and drought operations.

G. Provide consistency with the requirements of the Potomac River Low Flow Allocation Agreement.

III. Facilities and Operations Directly Affected.

A. Potomac River facilities of the Washington Aqueduct Division, U.S. Army Corps of Engineers, Washington Suburban Sanitary Commission, and the Fairfax County Water Authority.

B. Washington Suburban Sanitary Commission water supply facilities on the Patuxent River.



C. Fairfax County Water Authority water supply and power generating facilities on the Occoquan River.

D. Finished water interconnections between the Fairfax County Water Authority and the Washington Aqueduct Division, U.S. Army Corps of Engineers supplied water utilities in Virginia, subject to the approval of Arlington County and/or the City of Falls Church.

E. Water supply releases from the proposed Little Seneca Lake.

F. Water supply releases from water supply storage in Bloomington Lake.

IV. Implementation

A. Whenever gauged flows at Point of Rocks are below 2000 cfs, CO-OP will compute flows in the Potomac River at Little Falls Dam, including all prior water supply withdrawals for the Washington Metropolitan Area on a daily basis.

B. CO-OP will issue long-range water supply outlooks on a monthly basis from May through October. Additional outlooks will be issued as needed. These outlooks will contain estimates of the probability of meeting long-range unrestricted demands from current storage, and then refilling every reservoir to at least 90 percent of useable capacity by the following June 1.

When computing probabilities, CO-OP shall consider gross storage in all local reservoirs, less the following allowances for unuseable storage: a) Occoquan - 1 billion gallons; b) Patuxent (Triadelphia plus Duckett) - 2 billion gallons; and c) Little Seneca Lake - .5 billion gallons.

C. The rules set forth in Section V. shall take effect when one or both of the following conditions exist.

(1) The probability of meeting all unrestricted demands and refilling all reservoirs to 90 percent of useable capacity by the following June 1 is less than 98 percent.

(2) Flow in the Potomac as computed in IV-A above, less the amount required for flow-by over Little Falls Dam is projected to be less than twice the projected withdrawals for any of the next five days.

V. Operating Rules

A. During such time as the rules are in effect (per IV-C above) each supplier shall report daily to CO-OP, no later than 8:30 A.M., its 24 hour demand ending at 6:00 A.M. on that day.



B. During such times as these rules are in effect, the Director of CO-OP shall, following the objectives outlined in II above, and using techniques approved by the Operations Committee:

(1) Consult with the suppliers and the U.S. Army Corps of Engineers as required and direct the appropriate releases from water supply storage in Bloomington Lake and Little Seneca Lake.

(2) Prior to 10:00 A.M. daily set withdrawal rates from the Potomac for the Authority and the Commission for the 24 hour period beginning at 6:00 A.M. on that day.

C. As early as practicable during each day, the Director of CO-OP shall revise the Authority's and the Commission's Potomac withdrawal rates in light of actual river flow and water demands.

D. Whenever the Aqueduct declares the Restriction or Emergency Stage of the Potomac River Low Flow Allocation Agreement to be in effect, the allocation provisions of the Potomac River Low Flow Allocation Agreement shall determine Potomac withdrawals.

E. During such times as these rules are in effect power generation at the Occoquan River shall cease.

F. Should the probablity of meeting unrestricted demand with existing storage fall below 95 percent, each supplier agrees to so advise the governing bodies of the jurisdictions which they serve and to recommend restrictions on water use.

G. Raw water released from Lake Manassas and reimpounded in the Occoquan Reservoir shall be treated as Occoquan storage under these rules.

VI. Review by Operations Committee

A. The Operations Committee shall be responsible for overseeing the administration and implementation of this manual and, by unanimous agreement, shall be empowered to overrule or modify any action taken, or proposed to be taken, hereunder by the Director of CO-OP.

ANNEX B-II

## LITTLE SENECA LAKE
## COST SHARING AGREEMENT

LITTLE SENECA LAKE
COST SHARING AGREEMENT



## LITTLE SENECA LAKE
## COST SHARING AGREEMENT

THIS AGREEMENT, dated for convenience of reference as the 1st day of , 1982, is made and entered into by and among the DISTRICT OF COLUMBIA (hereinafter called the "District"), the FAIRFAX COUNTY WATER AUTHORITY (hereinafter called the "Authority") and the WASHINGTON SUBURBAN SANITARY COMMISSION (hereinafter called the "Commission").

W I T N E S S E T H

WHEREAS, the District is authorized and empowered to contract to provide a safe and adequate water supply to the inhabitants and entities within its jurisdiction and accomplishes this purpose through cooperation with the Washington Aqueduct Division, Corps of Engineers, United States Army, and is also authorized to contract for the purposes described herein; and

WHEREAS, the Authority is an authority established pursuant to the laws of the Commonwealth of Virginia charged with the responsibility of providing a safe and adequate public water supply within certain geographic areas of Northern Virginia, and is also authorized to enter into agreements to purchase and provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, the Commission is a public authority established pursuant to the laws of Maryland, is charged with the responsibility of providing a safe and adequate water supply within the counties of Montgomery and Prince George's, Maryland, and is also authorized to enter into agreements to purchase and provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, each of these parties believe it is desirable and necessary to their respective functions and authorized activities that a dam and reservoir, hereinafter referred to as the project, be constructed to insure that the inhabitants and entities for which they provide service are assured of an adequate supply of potable water now and far into the next century; and

WHEREAS, the Commission will construct the project, which is to be known as the Little Seneca Lake; and

WHEREAS, the parties desire to fix their obligations and responsibilities with respect to sharing the costs of construction, and the operation and maintenance of the project.

NOW, THEREFORE, in consideration of the mutual covenants herein contained, the parties do hereby agree as follows:

ARTICLE 1. Consideration

The consideration for this agreement is the promises herein exchanged based upon the premises above mentioned and the public and governmental interests deemed necessary and desirable by the parties to this agreement.

ARTICLE 2. Construction, operation and maintenance of the Project.

The Commission agrees to construct, operate and maintain a dam and all containment facilities, structures and a





reservoir necessary to provide an adequate supply of water which will be located in Boyds, Maryland on Little Seneca Creek, substantially as described in the plans, specifications and contract documents, prepared for the Commission by Black & Veatch, Consulting Engineers. The site shall be acquired by the Commission in conjunction with the Maryland-National Park and Planning Commission.

ARTICLE 3. Financing - Project Costs

A. *Sale of Commission Bonds.*

The Commission agrees to finance the construction of the project by the issuance and sale of its water supply bonds. The parties agree that the Commission subject to the provisions contained in Article 6 of this Agreement shall have the sole discretion to determine the manner in which these bonds will be sold.

B. Obligations to share the cost of the project.

The Authority and the District agree to share the project costs defined in subsection 4 of this Section as follows:

1. Estimated cost of construction.

The project costs that will be shared have been estimated to be Thirty Million, Five Hundred Thirty Thousand Dollars and No Cents ($30,530,000.00). Each party agrees that this estimate is fair and reasonable. The parties also agree that the Commission shall have the sole discretion to decide whether to construct the project. If in the Commission's opinion, the bids received for the construction of the project are not reasonable, the Commission shall have no obligation or duty to proceed with construction.

2. Obligation of the Authority to pay project costs.

The Authority shall be obligated to pay to the Commission ten percent (10%) of the project costs under either of the following options:

OPTION "A"

To pay the sum of $153,000.00 on or before the 30th day of the month in which construction of the project is commenced and to pay the sum of $100,000.00 on or before the 30th day of each of the succeeding twenty-nine (29) months.

Not later than six (6) months after the Commission completes payment of all project costs, the Commission shall furnish to the Authority a statement of actual project costs incurred and of the amount due and payable by the Authority. If the amount due and payable by the Authority is less than the aggregate of the monthly payments theretofore made by the Authority, the Commission shall promptly refund the difference to the Authority. If the amount due and payable by the Authority is greater than the aggregate of the monthly payments theretofore made by the Authority, the Authority shall promptly pay the difference to the Commission, but in no event shall the total amount to be paid by the Authority to the Commission exceed the sum of $3,350,000.00.





OPTION "B"

To pay, on or before December 31st of the year in which the Commission first issues and sells bonds to finance the project costs and in each year thereafter, an amount equal to ten percent (10%) of the total annual debt service cost (principal and interest payments) incurred on account of any and all bonds issued and sold by the Commission to finance the project costs which are outstanding and unpaid as of December 31st of each such year.

Not later than six (6) months after the Commission completes payment of all project costs, the Commission shall furnish to the Authority a statement of actual project costs incurred and of the amount due and payable by the Authority. The Authority's obligation for the payment of the principal portion of annual debt service cost shall be limited to ten percent (10%) of the project costs, not to exceed the sum of $3,350,000.00, and upon determination of the actual project costs, an appropriate adjustment shall be made to either increase or decrease future annual debt service payments to be made by the Authority on account of the actual project costs to be assumed by the Authority. Such adjustment shall take into account any underpayment or overpayment of annual debt service cost theretofore made by the Authority on account of estimated project costs.

The Authority shall be permitted, as of December 31st of any year, to pay, in full and without penalty, to the Commission its share of the principal amount of any and all bonds theretofore issued and sold by the Commission on account of project costs which are then outstanding and unpaid, and thereupon, the Authority shall be relieved of any obligation to make future annual debt service payments to the Commission.

Not later than thirty (30) days following receipt of notification of the Commission's intent to advertise for the first sale of bonds to finance the project costs, as provided in Article 6 hereof, the Authority shall advise the Commission of its determination to proceed under either Option "A" or Option "B" above.

3. Obligation of the District to pay project costs.

The District shall be obligated to pay to the Commission forty percent (40%) of the project costs under either of the following options:

OPTION "A"

To pay the sum of $612,000.00 on or before the 30th day of the month in which construction of the project is commenced and to pay the sum of $400,000.00 on or before the 30th day of each of the succeeding twenty-nine (29) months.

Not later than six (6) months after the Commission completes payment of all project costs, the Commission shall furnish to the District a statement of actual project costs incurred and of the amount payable by the District. If the amount due and payable by the District is less than the aggregate of the monthly payments theretofore made by the District, the Commission shall promptly refund the difference to the District. If the amount due and payable by the District is greater than the aggregate of the monthly payments theretofore made by the





District, the District shall promptly pay the difference to the Commission, but in no event shall the total amount to be paid by the District to the Commission exceed the sum of $13,425,000.00.

OPTION "B"

To pay, on or before December 31st of the year in which the Commission first issues and sells bonds to finance the project costs and in each year thereafter, an amount equal to forty percent (40%) of the total annual debt service cost (principal and interest payments) incurred on account of any and all bonds issued and sold by the Commission to finance the project costs which are outstanding and unpaid as of December 31st of each such year.

Not later than six (6) months after the Commission completes payment of all project costs, the Commission shall furnish to the District a statement of actual project costs incurred and of the amount due and payable by the District. The District's obligation for the payment of the principal portion of the annual debt service cost shall be limited to forty percent (40%) of the project costs, not to exceed the sum of $13,425,000.00, and upon determination of the actual project costs, an appropriate adjustment shall be made to either increase or decrease future annual debt service payments to be made by the District on account of the actual project costs to be assumed by the District. Such adjustment shall taken into account any payment or overpayment of annual debt service cost theretofore made by the District on account of estimated project costs.

The District shall be permitted, as of December 31st of any year, to pay, in full and without penalty, to the Commission its share of the principal amount of any and all bonds theretofore issued and sold by the Commission on account of project costs which are then outstanding and unpaid, and thereupon, the District shall be relieved of any obligation to make future annual debt service payments to the Commission.

Not later than thirty (30) days following receipt of notification of the Commission's intent to advertise for the first sale of bonds to finance the project costs, as provided in Article 6 hereof, the District shall advise the Commission of its determination to proceed under either Option "A" or Option "B" above.

4. Definition of project costs.

The parties agree that the project costs shall include but not be limited to the cost of planning studies previously completed, design activities, future construction inspection, acquisition of the land at the dam site and land within the 100 Year Flood Plain of the reservoir, actual construction of all facilities envisioned by the design upon which all permits will be based, construction contract administration including paid claims, all necessary utility relocation, relocation but not future expansion of the sewage pump station that will be inundated if not relocated and engineering, testing, start-up and preliminary operation procedures related to permits which will be issued for the facility. Further, the project costs shall include the cost of interest during construction if and to the extent that



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interest during construction is capitalized and funded from the proceeds of any bonds issued and sold by the Commission to finance the project costs. Any interest received by the Commission from the investment of bond proceeds during construction of the project pending the application of such proceeds to the project costs and any contributions received by the Commission on account of the project shall be applied as credits to reduce the project costs. In this regard, the Commission agrees to maintain books, accounts, records, documents and to follow accounting procedures and practices which are sufficient to show these costs. These books, accounts and records shall be open to inspection by the Authority and the District upon reasonable notice. The parties also agree that the cost of constructing water mains underneath the reservoir shall be borne solely by the Commission.

ARTICLE 4. <u>Financing</u> - <u>Cost of operation *and maintenance*</u>

A. Obligation to pay.

The Authority agrees to pay ten percent (10%) of the annual cost of the operation and maintenance of the project. The District agrees to pay forty percent (40%) of the annual cost of the operation and maintenance of the project.

B. Definition of cost of operation and maintenance.

The cost of operation and maintenance of the project shall include but not be limited to the necessary and reasonable cost of equipment calibration, repair, replacement and maintenance, salaries, fringe benefits, office expenses, equipment rental, insurance, training and other expenses deemed proper in the discretion of the Commission to be attributable to the sound and economical operation of the project. To this end, the Commission agrees to maintain books, accounts, records and documents, and to follow accounting procedures and practices sufficient to show properly the actual maintenance and operation cost incurred and billed by the Commission. These books, accounts and records shall be open to inspection by the Authority and the District upon reasonable notice.

C. Method of payment of operation and maintenance cost

The Authority and the District agree to pay their respective shares of the annual operation and maintenance cost within thirty (30) days of presentation of an invoice from the Commission. The District and the Authority each agree to hold harmless and indemnify the Commission for all expenses incurred by the Commission in covering any monetary shortages which result from their respective refusal or failure to timely pay such invoice.

D. Economical operation

The Commission shall, at all times after the project is placed in operation, operate the project in a sound and economical manner and in accordance with all applicable local state and federal laws, regulations and performance standards; shall keep it in good repair; and shall make all necessary repairs and replacements to its facilities and equipment. The Commission further agrees to operate the project in conformity with the provisions of the separate Water Supply Coordination Agreement which it shall execute simultaneously herewith.



E. Agreement to review obligations to pay the costs of operation and maintenance

The parties acknowledge that in the future there may be a need to adjust their respective obligations to pay the costs of operating and maintaining the project. To this end, and without intending to impair or affect the provisions of Article 9 or Article 10 of this agreement, the parties, for themselves, their successors and assigns, now agree to meet during the month of April in the year 2000 for the purpose of reviewing the equity of continuing to share the costs of operation and maintenance in the percentages that are defined in Section "A" of this Article. In the event these parties unanimously agree at that time that the percentages that are defined in Section "A" of this Article should be changed, they shall commence negotiations to effect such a change, provided, however, that no change in these percentages shall be effective unless there is unanimous agreement between these parties.

ARTICLE 5. District Compliance With the Anti-Deficiency Act

The District shall take all necessary actions to procure the required appropriations to meet its cost sharing obligations hereunder, provided, however, that no payments shall be made by the District until appropriations for such purposes have been made pursuant to the requirements of the Budget and Accounting (Anti-Deficiency) Act of 1921 (31 U.S.C. §665) as amended.

ARTICLE 6. <u>Financing - Effective date of obligation for payment of project cost obligations</u>

The Authority and the District agree that their respective obligations to pay the Commission their share of the project costs as defined in Article 3 will become a debt owed to the Commission as of the date of the first sale of bonds for construction of the project. The Commission agrees, however, that at least forty five (45) days prior to the advertisement for the sale of bonds, it will notify the Authority and the District of its financing plan and obtain written concurrence of the elements of the plan, including but not limited to the amount and timing of sale and anticipated interest rates.

ARTICLE 7. <u>Liability for payments by the Authority and the District</u>

The Authority and the District hereby agree that, in the event that any portion or all of the project is rendered partially or totally non-useful or non-usable during the term of this agreement, by reason of some natural or other circumstance which prevents the Commission from performing any or all of its obligations hereunder, the payments required to be made by the Authority and the District to the Commission under Articles 3 and 4 hereof shall nevertheless continue to be made as though no such event had occurred.

The Commission hereby agrees that it will use its best efforts to restore the project to full usefulness by making necessary repairs or providing adequate replacements and to resume the performance of its obligations hereunder as quickly as may be possible following such an event.



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If the cost of making necessary repairs or providing adequate replacements is estimated to be $100,000 or less, the Commission shall proceed therewith and such cost shall be considered an element of the cost of operation and maintenance of the project in the year(s) in which expenditures are made on account thereof. If such cost is estimated to be more than $100,000 and prior to the making of necessary repairs or providing adequate replacements, the Commission shall enter into negotiations with the Authority and the District for the purpose of establishing the respective portions of such cost, if any, which shall be contributed by the Authority and the District or assumed by the Authority and the District and added to their respective future annual payments hereunder. As used herein, the cost of making necessary repairs or providing adequate replacements shall mean the total cost minus any contribution of grants-in-aid or reimbursements received by the Commission from any parties which are not parties to this agreement.

ARTICLE 8. <u>Non-ownership of facilities by the Authority or the District</u>

The terms and conditions of this agreement shall not create or constitute any ownership interest or title by the Authority or the District in or to any part of the project.

ARTICLE 9. <u>Disputes</u>

The parties agree to utilize their best efforts to resolve any disputes which arise under this agreement by informal negotiation, the resolution of which shall require unanimous agreement of the partiês. However, any party may initiate litigation, the purpose of which is to construe a provision of or resolve a dispute that arises under this agreement. The parties agree that any action to construe this agreement or resolve a dispute thereunder as well as such actions and suits as are authorized by Article 11 of this agreement may be brought in any court of competent jurisdiction sitting in Maryland, Virginia or the District of Columbia, and the parties consent to venue in such courts and to the service of all papers and pleadings related thereto.

ARTICLE 10. <u>Obligation to pay continues during disputes; Severability of contract obligations</u>

In the event the parties to this agreement are in dispute as to their obligations relating to other agreements involving waters in the Potomac Basin, it is agreed that such disputes shall be considered as being severed from any connection to this agreement and the obligations under this agreement shall continue in full force and effect. Portions of this agreement which may be in dispute shall also be considered separate and removed and such other obligations to perform shall in no way be waived, delayed or impaired.

ARTICLE 11. <u>Remedies upon default</u>

If the Authority or the District fail to make any payment required under this agreement when due, such obligation shall bear interest at twenty percent from the due date, and the parties agree that any party which is in default in payment shall have no right to share in the use and benefit of water stored in or released from Little Seneca Lake until such default is cured, and the Commission





may proceed by an action at law to recover judgment for such amount together with reasonable attorney's fees and by injunction or otherwise to restrict or prohibit the defaulting party from using or benefitting from such water storage or release.

ARTICLE 12. <u>Further assurances</u>

The parties agree to use their best efforts to cause to be passed, authorized, executed, acknowledged and delivered all resolutions, ordinances, appropriations, conveyances and assurances as may be necessary for the purpose of giving effect to the intents expressed in this agreement.

ARTICLE 13. <u>Non-assignability</u>

No party to this agreement may assign any interest herein to any person or governmental entity without the consent of the other parties. Nothing contained in this article, however, shall be construed to prevent the reorganization of any party hereto or to prevent any other body, corporate or politic from succeeding to the rights, privileges, powers, functions and duties of a party as may be authorized or required by law.

ARTICLE 14. <u>Execution of documents</u>

This agreement may be executed in several counterparts, any of which shall be regarded for all purposes as an original and all of which shall constitute but one and the same instrument.

ARTICLE 15. <u>Waiver</u>

No waiver by any party of any term of this agreement shall constitute a waiver of any other term nor shall a waiver of any breach be deemed to constitute a waiver of any subsequent breach whether of the same or of a different article or section. All waivers must be made in writing.

ARTICLE 16. Entirety

This agreement constitutes the entire agreement between the parties, merges and supersedes all prior negotiations, representations and agreements on the subject matter of this agreement.

ARTICLE 17. Severability

The provisions of this agreement shall be severable and if any phrase, clause, sentence or provision of this agreement is declared unconstitutional or the applicability thereof to any party is held invalid, the remainder of this agreement shall not be affected thereby.

ARTICLE 18. Term of Agreement

In the event that the Commission does not award a contract for the construction of the project on or before June 30, 1987, the parties hereto shall undertake negotiations either to extend this agreement or to formulate a new agreement. In the event that the parties hereto fail either to agree upon an extension of this agreement or to formulate a new agreement on or before December 31, 1987, this agreement shall automatically be terminated on December 31, 1987. Unless so terminated, this agreement shall continue for as long as the project remains in existence and operation.



5-II-9

IN WITNESS WHEREOF, the parties have caused this agreement to be executed as of the date which appears with their respective signatures.

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| | DISTRICT OF COLUMBIA |
| Approved in form and legal sufficiency. | MARION BARRY, JR., MAYOR |
| Date: July 22, 1982 | Date: 7-22-82 |
| | FAIRFAX COUNTY WATER AUTHORITY |
| Approved in form and legal sufficiency. | FRED C. MORIN, CHAIRMAN |
| Date: July 22, 1982 | Date: July 22 '82 |
| | WASHINGTON SUBURBAN SANITARY COMMISSION |
| Approved in form and legal sufficiency. July 23, 1982 | ANDREW M. VISLOSKY, CHAIRMAN |
| Date: | Date: July 23, 1982 |

ANNEX B-III

SAVAGE RESERVOIR MAINTENANCE AND
OPERATION COST SHARING AGREEMENT

## SAVAGE RESERVOIR MAINTENANCE AND OPERATION COST SHARING AGREEMENT

**THIS AGREEMENT**, dated for convenience of reference as the first day of ____________, 1982, is made and entered into by and among the District of Columbia (hereinafter called the "District"), the Fairfax County Water Authority (hereinafter called the "Authority"), the Washington Suburban Sanitary Commission (hereinafter called the "Commission"), Allegany County (hereinafter called the "County") and the Upper Potomac River Commission (hereinafter called the "UPRC").

W I T N E S S E T H

WHEREAS, the District is authorized and empowered to contract to provide a safe and adequate water supply to the inhabitants and entities within its jurisdiction and accomplishes this purpose through cooperation with the Washington Aqueduct Division, Corps of Engineers, United States Army, and is also authorized to contract for the purposes described herein; and

WHEREAS, the Authority is an authority established pursuant to the laws of the Commonwealth of Virginia charged with responsibility of providing a safe and adequate public water supply within certain geographic areas of Northern Virginia, and is also authorized to enter into agreements to purchase and provide water and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and





WHEREAS, the Commission is a public authority established pursuant to the laws of Maryland, is charged with the responsibility of providing a safe and adequate water supply within the counties of Montgomery and Prince George's, Maryland, and is also authorized to enter into agreements to purchase and provide water, and for that purpose is operating and maintaining water treatment facilities and a water distribution system; and

WHEREAS, the County is a political subdivision established pursuant to the laws of the State of Maryland, appoints a commissioner to the UPRC and is responsible for the payment of the operation and maintenance costs associated with dams and reservoirs owned by the UPRC in accordance with Section 611(b) of the Code of Public Laws for Allegany County; and

WHEREAS, the UPRC is an authority established pursuant to the laws of the State of Maryland with the power and authority to regulate the flow in the Upper Potomac River and its tributary rivers and streams within certain geographic areas within the counties of Allegany and Garrett, Maryland, and is also authorized to enter into agreements for the purpose of maintaining and operating its facilities; and

WHEREAS, the UPRC owns and operates a dam and reservoir located in the southeast portion of Garrett County on the Savage River known as the Savage Reservoir, which facility is referred to below as "the project"; and

WHEREAS, the Potomac River is a source of water used by the District, the Authority and the Commission for public water supply purposes; and

WHEREAS, the Corps of Engineers, United States Army, maintains and operates a water impoundment facility known as the Bloomington Reservoir; and

WHEREAS, it is anticipated that releases of water from the Bloomington Reservoir will be necessary to provide an adequate supply of water to the Washington Metropolitan Area during periods of extreme low flow in the Potomac River; and

WHEREAS, the water which will be released from the Bloomington Reservoir may be acidic; and

WHEREAS, releases of water from the Savage Reservoir will be necessary so that these releases can mix with and thereby reduce the acidity of water released from the Bloomington Reservoir; and

WHEREAS, these parties agree that such releases of water from the Savage Reservoir will be an indispensable part of a regional plan to provide an adequate quantity of water to the inhabitants and entities for which they must provide service during periods of extreme low flow; and

WHEREAS, the District, the Authority and the Commission, in view of the above stated premises, desire to share the cost of operating and maintaining the Savage Reservoir with the County in exchange for the UPRC's obligation to release water from the Savage Reservoir as directed by the Corps of Engineers, United States Army.

NOW THEREFORE in consideration of the mutual covenants herein contained, the parties do hereby agree as follows:



ARTICLE 1. <u>Consideration</u>

The consideration for this agreement is the promises herein exchanged based upon the premises above mentioned and the public and governmental interests deemed necessary and desirable by the parties to this agreement.

ARTICLE 2. <u>Operation and Maintenance of the Project</u>

The UPRC agrees to operate and maintain the project in a sound and economical manner and in accordance with all applicable local, state and federal laws, regulations and performance standards; to keep it in good repair; to make all necessary repairs and replacements to its facilities and equipment; and to release water from the project as directed by the Corps of Engineers.

ARTICLE 3. <u>Financing</u> - <u>Operation and Maintenance</u>

A. Definition of Operation and Maintenance Cost

The cost of operating and maintaining the project shall include but not be limited to the necessary and reasonable cost of the equipment calibration, repair, replacement and maintenance, salaries, fringe benefits, office supplies, equipment rental, insurance, training and other expenses deemed proper in the discretion of the County to be attributable to the sound and economical operation of the Reservoir. To this end, the UPRC agrees to maintain books, accounts, records and documents and to follow accounting procedures and practices sufficient to show properly the actual maintenance and operation cost incurred by it. These books, accounts, records and documents shall be open to inspection by any of the parties upon reasonable notice.

B. Obligations to pay

1. Subject to the provisions of Article 5, the Authority, the District, the Commission and the County agree to share payment of the annual cost of operation and maintenance of the project in the following proportions:

Authority - Sixteen percent (16%)

District - Twenty-four percent (24%)

Commission - Forty percent (40%)

County - Twenty percent (20%)

The District shall take all necessary actions to procure the required appropriations to meet its cost sharing obligations hereunder, provided, however, that no payments shall be made by the District until appropriations for such purposes have been made pursuant to the requirements of the Budget and Accounting (Anti-Deficiency) Act of 1921 (31 U.S.C. §665) as amended.

2. Immediately following adoption by the County of each annual budget of the estimated annual cost of operation and maintenance of the project, the County shall forward a copy thereof to the Authority, the District and the Commission, together with invoices covering the respective portions



of the estimated annual cost of operation and maintenance to be paid to the County by the Authority, the District and the Commission, as provided in Article 3-B-1 hereof.

3. Within ninety (90) days following the close of each fiscal year, the County shall forward a statement of the actual cost of operation and maintenance of the project incurred during such fiscal year to the Authority, the District and the Commission. In the event that the actual cost of operation and maintenance of the project incurred during such fiscal year shall have been greater than the estimated cost as provided by the adopted budget for such fiscal year, the County shall render supplemental invoices to the Authority, the District and the Commission covering the respective portions of the excess cost to be paid by the Authority, the District and the Commission, as provided in Article 3-B-1 hereof. In the event that the actual cost of operation and maintenance of the project incurred during such fiscal year shall have been less than the estimated cost as provided by the adopted budget for such fiscal year, the County shall reimburse the Authority, the District and the Commission for the difference between the estimated cost and the actual cost in accordance with the proportions provided in Article 3-B-1 hereof.

4. The County agrees to forward to the UPRC in a timely fashion all payments received by it from the Authority, the District and the Commission on account of the annual operation and maintenance cost of the project.

ARTICLE 4. Financing - Effective date of obligation to pay for operation and maintenance.

The Authority, the District and the Commission agree that their respective obligations to pay to the County their share of operation and maintenance costs defined in Article 3 will become a debt owed to the County as of the date upon which an invoice for payment is submitted by the County. The District, the Authority and the Commission each agree, for themselves, their successors and their assigns, to pay their respective shares of these costs within thirty (30) days of the presentation of such invoice. The Authority, the District and the Commission each agree to hold harmless and to indemnify the County for all expenses incurred by the County in covering any monetary shortages which result from their respective refusal or failure to timely pay each invoice.

ARTICLE 5. Liability for Payments

A. Non-usability of the Project

The parties agree that in the event the project is rendered totally non-useful or non-usable during the term of this agreement, by reason of some natural or other circumstance which prevents the UPRC from performing its obligations hereunder, the other parties shall be relieved of their obligations to make payments to the County under Article 3 until such time as the UPRC resumes its obligations hereunder.



B. Partial Non-usability of the Project

The parties hereby agree that in the event that any portion of the project is rendered partially non-useful or non-usable during the term of this agreement, by reason of some natural or other circumstance which prevents the UPRC from performing any or all of its obligations hereunder, the payments required to be made by the Authority, the District and the Commission to the County under Article 3 hereof shall nevertheless continue to be made as though no such event had occurred. The UPRC agrees that it will use its best efforts to restore the project to full usefulness after such event by making necessary repairs or providing adequate replacements and to resume the performance of its obligations hereunder as quickly as may be possible following such an event. If the cost of making necessary repairs or providing adequate replacements is estimated to be $100,000 or less, the UPRC shall proceed therewith and such cost shall be considered an element of the cost of operation and maintenance of the project in the year(s) in which expenditures are made on account thereof. If such cost is estimated to be more than $100,000 then prior to the making of necessary repairs or providing adequate replacements, the UPRC and the County shall enter into negotiations with the other parties for the purpose of establishing the respective portions of such cost, if any, which shall be contributed by the other parties or assumed by the other parties and added to their respective future annual payments hereunder.

ARTICLE 6. Disputes

All parties agree to utilize their best efforts to resolve any disputes which arise under this agreement by informal negotiation, the resolution of which shall require unanimous agreement of the parties. However, any party may initiate litigation, the purpose of which is to construe a provision of or resolve a dispute that arises under this agreement. The parties to this agreement agree the issues to be litigated may be litigated in any court of competent jurisdiction sitting in Maryland, Virginia or the District of Columbia, consent to venue in such court and consent to the service of all papers and pleadings related thereto.

ARTICLE 7. Obligation to pay continues during disputes; Severability of Contract Obligations.

In the event the parties to this agreement are in dispute as to their obligations relating to other contracts involving waters in the Potomac Basin, it is agreed that such disputes shall be considered as being severed from any connection to this contract and the obligations under this contract shall continue in full force and effect. Portions of this contract which may be in dispute shall also be considered separate and removed and such other obligations to perform shall in no way be waived, delayed or impaired.



ARTICLE 8. Control of Releases

The parties acknowledge that releases of water from the project are done in accordance with the provisions of the Savage River Dam Regulation Manual which document is part of an agreement between UPRC and the Corps of Engineers. It is agreed that releases of water shall be made by the UPRC at the direction of the Corps of Engineers, United States Army, and made in accordance with the provisions of the Manual as it may be revised from time to time.

ARTICLE 9. Further Assurances

The parties agree to use their best efforts to cause to be passed, authorized, executed, acknowledged and delivered all resolutions, ordinances, appropriations, conveyances and assurances as may be necessary to give effect to the intents expressed in this agreement.

ARTICLE 10. *Non-assignability*

No party to this agreement may assign any interest herein to any person or governmental entity without the consent of the other parties. Nothing contained in this Article, however, shall be construed to prevent the reorganization of any party hereto or to prevent any other body, corporate or politic, from succeeding to the rights, privileges, powers, functions and duties of the party as may be authorized or required by law.

ARTICLE 11. <u>Execution of Documents</u>

This agreement may be executed in several counterparts, any of which shall be regarded for all purposes as an original and all of which shall constitute one and the same instrument.

ARTICLE 12. <u>Waiver</u>

No waiver by any party of any term of this agreement shall constitute a waiver of any other term nor shall a waiver of any breach be deemed to constitute a waiver of any subsequent breach whether of the same or different article or section. All waivers must be made in writing.

ARTICLE 13. <u>ENTIRETY</u>

This agreement constitutes the entire agreement between the parties, merges and supersedes all prior negotiations, representations and agreements on the subject matter of this agreement.

ARTICLE 14. <u>Severability</u>

The provisions of this agreement shall be severable and if any phrase, clause, sentence or provision of this agreement is declared unconstitutional or the applicability thereof to any party is held invalid, the remainder of this agreement shall not be affected thereby.

ARTICLE 15. <u>Term of Agreement</u>

The effective date of this agreement and the date on which the parties shall be obligated to commence cost sharing hereunder shall be July 1, 1982. This agreement shall continue for so long as the project remains in existence and cperation.



ARTICLE 16. <u>Invoices for Payment</u>

Invoices for payment required under this agreement shall be delivered to:

1. Engineer-Director
   Fairfax County Water Authority
   8560 Arlington Boulevard
   P. O. Box 1500
   Merrifield, Virginia 22116

2. Director
   Department of Environmental Services
   5000 Overlook Avenue, S. W.
   4th Floor
   Washington, D. C. 20032

3. Treasurer
   Washington Suburban Sanitary Commission
   4017 Hamilton Street
   Hyattsville, Maryland 20781

IN WITNESS WHEREOF, the parties have caused this agreement to be executed as of the date which appears with their respective signatures.

ALLEGANY COUNTY

Approved in form and in legal sufficiency:

[signature]

Date:

[signature]
Arthur T. Bond, Commissioner

Date:

FAIRFAX COUNTY WATER AUTHORITY

Approved in form and in legal sufficiency:

Ralph W Church

Date: July 22, 1982

Fred C. Morin
Fred C. Morin, Chairman

Date: July 22 '82

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|---|---|
| | DISTRICT OF COLUMBIA |
| Approved in form and in legal sufficiency: | |
| ______________________ | Marion Barry, Jr., Mayor |
| Date: July 22, 1982 | Date: 7-22-82 |
| | WASHINGTON SUBURBAN SANITARY COMMISSION |
| Approved in form and in legal sufficiency: | |
| ______________________ | Andrew M. Vislosky, Chairman |
| Date: 7-22-82 | Date: 7/22/82 |
| | UPPER POTOMAC RIVER COMMISSION |
| Approved in form and in legal sufficiency: | |
| ______________________ | John J. McMullen, Chairman |
| Date: | Date: July 1?, 1982 |