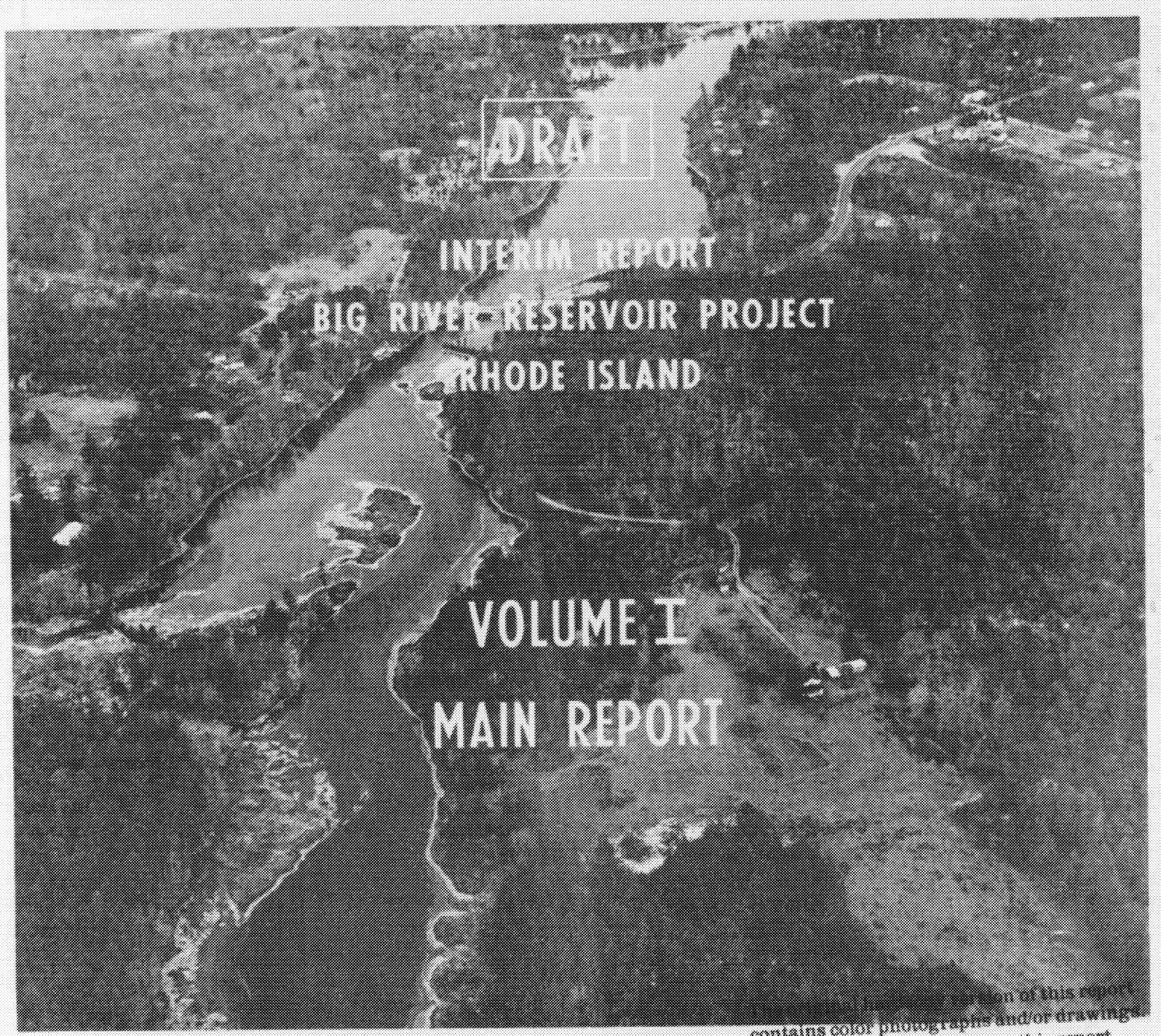
PAWCATUCK RIVER AND NARRAGANSETT BAY

DRAINAGE BASINS

WATER AND RELATED LAND RESOURCES STUDY



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JULY 1980

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14. ABSTRACT
The Big River Reservoir feasibility study focused on the water supply, flood damage and recreational problems in the study area. The study evaluated all feasible alternative plans for providing adequate water supplies to the region, protecting flood-prone areas and preventing flood damages, and meeting the recreational needs of the study area. Costs, benefits and environmental impacts of the various alternatives were investigated leading to tentative selection of a plan that would most effectively meet the identified needs.
Detailed investigations were limited to the communities within the Pawtuxet River Basin and for water supply planning to the legislated service area of the Providence Water Supply Board. Not all areas were investigated to the same level of detail but only were improvements warranted detailed study.

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Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

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DRAFT

MAIN REPORT

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1980

MAIN REPORT

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INTRODUCTION

This report attempts to summarize the efforts contained in the Big River Reservoir feasibility study. To familiarize the reader with the aims of the feasibility study and the resources utilized in the study, introductory and background information is provided herein, and in the section following.

STUDY AUTHORITY

The Big River Reservoir feasibility study is authorized under seven Congressional resolutions which were combined under one resolve and adopted by the Committee on Public Works of the United States Senate. These resolves authorized the Pawcatuck River and Narragansett Bay (PNB) study, of which this report is a part. The proposed Big River Reservoir site is located in the Pawtuxet River Basin which is included under the PNB authority.

SCOPE OF THE STUDY

The Big River Reservoir feasibility study focused on the water supply, flood damage and recreation problems in the study area. The study evaluated all feasible alternative plans for providing adequate water supplies to the region, protecting flood-prone areas and preventing flood damages, and meeting the recreational needs of the study area. Costs, benefits and environmental impacts of the various alternatives were investigated leading to the tentative selection of a plan that would most effectively meet the identified needs.

Detailed investigations were limited to the communities within the Pawtuxet River Basin and for water supply planning to the legislated service area of the Providence Water Supply Board. Not all areas were investigated to the same level of detail but only where improvements warranted detailed study.

Proposals have been evaluated using economic, engineering, social and environmental criteria. To aid in the evaluation of alternatives, detailed investigations have been made on geotechnical, hydrologic and engineering aspects of the proposed Big River Reservoir. Inventories of aquatic and terrestrial ecosystems, as well as historic and archaeological features of the site, were undertaken to better assess associated environmental and social impacts of the proposed reservoir.

The Big River Reservoir feasibility study is a survey level study, the findings of which will be reported in a feasibility report, the culmination of an approximately two and one-half year effort. The findings of this report could lead to implementation of any recommended projects with congressional and local approval.

The other areas of the PNB study region not addressed by this study are the focus of other studies being conducted by the Corps of Engineers in total response to the authorizing resolutions.

STUDY PARTICIPANTS AND COORDINATION

The U.S. Army Corps of Engineers was given the responsibility for conducting and coordinating the Pawcatuck River and Narragansett Bay Drainage Basins (PNB) study, of which this interim report is a part. The preparation of this report has utilized information developed in other Corps investigations and studies conducted by other agencies.

The studies and investigations for this report were prepared with the cooperation of a large number of agencies. Included in these agencies were the following:

Federal Agencies

U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency

State Agencies

Rhode Island Governor's Office
Rhode Island Water Resources Board
Rhode Island Office of State Planning
Rhode Island Department of Environmental Management
Rhode Island Department of Transportation
Rhode Island Department of Health

Local Interests

Providence Water Supply Board
Bristol County Water Company
Kent County Water Authority
Audubon Society of Rhode Island
Rhode Island League of Women Voters
Ecology Action for Rhode Island

The study effort provided the opportunity for direct participation and coordination by Federal, State and local agencies as well as interested citizens groups. As a means of encouraging full participation by all sectors of the public, several series of formal public workshops, public meetings and informational meetings were held throughout the study area to discuss alternative plans.

A series of three workshop sessions were held in September 1978 to obtain public input on problems, needs and issues surrounding the Big River Reservoir project. A further set of workshops were held in June 1979 to present the preliminary results of plan formulation and to obtain input on detailed water resources plans for the study area. Informal meetings were also conducted during the summer months of 1979 with various interest groups and members of the Project Working Committee, a group set up to facilitate the exchange of information and ideas between the Corps and the general public. Several briefing sessions were held on specific issues surrounding the study, as a further aid in informing the public and coordinating study efforts. The public participation and coordination structure of the study is shown on Plate 1.

STUDY PARTICIPANTS AND COORDINATION

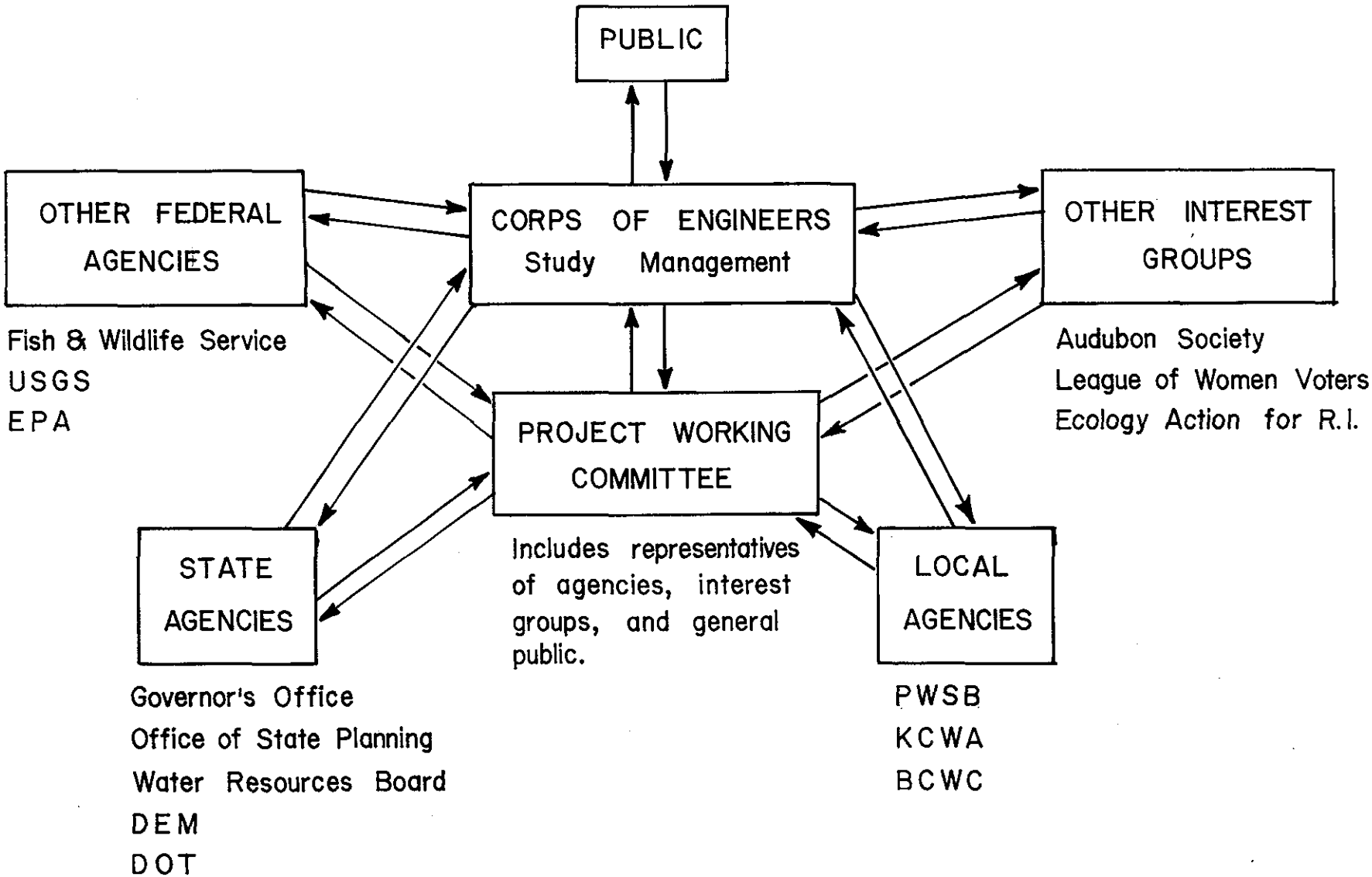

PLATE 1

Public involvement efforts regarding possible flood damage reduction plans for the Pawtuxet River Basin began in May 1969 with the start of the PNB study. Four public meetings were held at that time to gather information about problems and needs. In May 1975, two public meetings were held to present alternative plans and incorporate public desires into the most desirable alternative. At this time the Natick Diversion proposal received public support, although further environmental studies were requested.

In October 1976 a further public meeting was held to present the study findings. The recommended plan was now found unacceptable by the public, due to high construction costs and fear of environmental harm to Greenwich Bay. Redirection of the study efforts was accomplished with meetings held between October 1976 and May 1977. The resulting local flood management measures were discussed with State and local interests in March and May 1979, to come up with present alternatives.

Further information regarding public involvement efforts during the study can be found in Appendix C, "Public Participation," and in "Attachment 1."

STUDIES OF OTHERS

There have been many water resource related studies conducted in the State of Rhode Island in the past 20 years. A complete listing of these reports along with a brief summary of each can be found in the Problem Identification Appendix. A number of these reports have considered the proposed Big River Reservoir as a source for additional water supply to the Providence metropolitan area as well as an aid in flood control. Those reports specifically mentioning the Big River Reservoir are listed below:

1952 C.A. Maguire and Associates recommended several reservoir sites, including Big River and Nooseneck River, as sources of water supply for Providence, in a report to the R. I. Water Resources Commission (now the Water Resources Board).

1957 Metcalf and Eddy, Inc., in a report to the Water Resources Board recommended construction of Big River Reservoir and the Wood River diversion.

1967 In another report to the Water Resources Board, Metcalf and Eddy, Inc. again recommended development of Big River Reservoir and flood skimming from the Flat River Reservoir.

1968 C. A. Maguire and Associates recommended development of Big River and Wood River reservoirs to the Providence Water Supply Board.

1969 The Northeastern United States Water Supply (NEWS) Study by the Corps of Engineers proposed development of Big River Reservoir and flood skimming from the Flat River Reservoir.

1971 A flood control reconnaissance report on the Pawtuxet River Basin by the Corps of Engineers recommended detailed study of floodwater storage at the proposed Big River Reservoir.

1976 The Southeastern New England (SENE) report by the New England River Basins Commission (NERBC) recommended construction of Big River Reservoir.

1979 The PNB "Water Supply Alternatives" by the Corps of Engineers again recommended development of the Big River Reservoir.

1980 The Section 208 water quality management plan for Rhode Island establishes management strategies for the control of point and nonpoint sources of pollution, and includes an analysis of the impact of the proposed Big River Reservoir on water quality and wastewater generation in the Pawtuxet Basin.

This report is an interim report of the PNB urban study which addresses flood control and floodplain management, water supply, coastal restoration and protection and navigation. Drainage basins reported on in the PNB study include the Pawtuxet River, Taunton River, Pawcatuck River, Narragansett Bay Local Drainage and the Providence River Group, comprised of the Blackstone, Woonasquatucket, Moshassuck and Ten Mile River Basins. An interim report is scheduled for release in FY 1981 on the Blackstone River Basin. Investigations of the other basins are being completed this year, with findings and recommendations due to be included in the overall PNB report scheduled for publication in FY 1981.

THE REPORT AND STUDY PROCESS

In the interest of clarity of presentation, this report has been arranged into a main report, including a draft environmental impact statement, and eleven technical appendices.

The Main Report is the basic document which presents a summary of the overall planning process and study results for the benefit of both general and technical readers. It includes a description of problems and needs, plan formulation procedures and an assessment and evaluation of each plan's social, economic and environmental impacts. It also contains study findings, conclusions and recommendations.

The draft Environmental Impact Statement (EIS), included in the Main Report, consists of a description of the existing environmental baseline conditions and expected impacts resulting from the final detailed water resources plans. The draft EIS contains sufficient detail of the selected plan to permit an unbiased assessment of potential environmental impacts and issues by appropriate Federal, State and municipal agencies and the concerned public. All pertinent correspondence and evaluated input generated by this draft document is assimilated into the final EIS.

The technical appendices present supporting data and specific details of various elements of the study. Also included as an attachment to this report is a report documenting the detailed flood damage reduction investigations for the Pawtuxet River Basin. The report is contained in a total of seven volumes as follows:

Volume I - Main Report (including DEIS and Section 404 Evaluation)

Volume II - Appendix A - Problem Identification
Appendix B - Plan Formulation
Appendix C - Public Participation

Volume III - Appendix D - Hydrologic Analysis
Appendix E - Water Quality
Appendix F - Geotechnical Investigations
Appendix G - Design and Cost Estimates

Volume IV - Appendix H - Recreation and Natural Resources
Section 1 - Recreation Impact Analysis
Section 2 - Aquatic Ecosystem Assessment
Section 3 - Terrestrial Ecosystem Assessment
Section 4 - Fish and Wildlife Management Plan (including U.S. F & WS Report)

Volume V - Appendix I - Social and Cultural Resources
Section 1 - Social Resources
Section 2 - Cultural Resource Reconnaissance

Volume VI - Appendix J - Economics
Appendix K - Institutional Analysis

Volume VII - Attachment 1

The study process that culminates in the feasibility report is divided into three stages: Stage 1 - Reconnaissance Study, Stage 2 - Development of Intermediate Alternatives, and Stage 3 - Development of Detailed Plans and Publication of a Feasibility Report.

Each of the three planning stages incorporates four functional planning tasks which become progressively more detailed. The tasks are problem identification, formulation of alternatives, impact assessment and evaluation.

Problem Identification entails several procedures. Identifying public concerns, analyzing resource management problems, defining the study area, describing the base conditions, projecting future conditions, and establishing planning objectives are all elements which are addressed to determine the range of water resources problems a study will investigate.

The second planning task, formulation of alternatives, involves developing different resources management plans comprehensive enough to address the planning objectives and to satisfy future water-related requirements.

Impact Assessment identifies and measures the types of impacts caused by various alternatives and estimates the incidence of these impacts.

The fourth planning task, evaluation, is undertaken to analyze the impacts. Evaluation criteria such as public acceptability, completeness, effectiveness, efficiency and benefits versus costs are established, and an analysis is performed to determine each alternative's total impact as well as possible trade-offs among alternatives.

The results of these planning tasks are reviewed to determine if another iteration is needed; if not, the next planning stage is entered. The culmination of the three stages of the planning process is a feasibility report to Congress detailing the recommended plan and asking for authorization for Corps of Engineers implementation, if applicable.

PROBLEM IDENTIFICATION

In this section, background information about existing conditions is presented along with a scenario of conditions expected to occur without any Federal action. This information is analyzed to identify problems, needs and opportunities for the study area, from which national objectives can be set. Planning objectives and constraints then follow from the problems, conditions, and goals identified.

A more detailed description of the information in this section is given in Appendix A, "Problem Identification."

NATIONAL OBJECTIVES

National objectives for water resources planning have been defined in the Principles & Standards as achievement of National Economic Development (NED) and Environmental Quality (EQ). NED is to be achieved by increasing the value of the nation's output of goods and services and by increasing the national economic efficiency. EQ is to be achieved by the management, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The NED objective can be achieved by various project purposes in the study area. Flood control measures can improve the area economy by reducing flood damages and the resulting costs to businesses in the area's floodplains. Solving water supply problems allows residential, commercial and industrial growth in the study area to continue as projected. Water using industries will not be forced to relocate, and new residential and commercial developments will not be restricted by lack of water. Achievement of these projections can lead to increased growth in the work force and per capita income of the area.

The EQ objective can be achieved by the same project purposes, if properly applied. Flood control measures that include or allow preservation of ecologically valuable wetland areas could be adopted. Watershed management measures can increase ecological diversity and productivity of fish and wildlife in the area surrounding surface water development, as well as improving water quality in the impoundment. Recreational development at surface water sites can achieve both EQ and NED aims by increasing or preserving the aesthetic and cultural resources, and by providing recreational opportunities allowing relaxation and increasing worker productivity.

EXISTING CONDITIONS

Physical Conditions

Study Area. The Big River Reservoir study area comprises 469.1 square miles in north central Rhode Island. It is bounded on the west by Connecticut, on the north by Burrillville, North Smithfield, and Lincoln, and on the south by Exeter and North Kingstown. The study area covers almost the entire Pawtuxet River Basin as well as parts of the Providence River Group and the Narragansett Bay Local Drainage area.

There are 17 communities within the study area. Providence, North Providence, Cranston, Johnston, East Providence, Smithfield, Warwick, West Warwick, and Coventry receive water from the Providence Water Supply Board system's source, Scituate Reservoir. Foster, Glocester, Scituate, Bristol, Barrington, and Warren do not currently receive their water from Scituate Reservoir but are within the legally mandated service area of the Providence Water Supply Board. These communities are expected to turn to the Providence system in the future for supply augmentation. The two remaining towns, East Greenwich and West Greenwich, are included because of the proposed site's location in or near them and because they are logical recipients for any surplus water from Big River Reservoir.

Providence is the largest city in the study area, more than half of which is undeveloped and forested. The study area is shown on Plate 2.

Climate. The usually harsh extremes of New England weather are tempered in the study area by the moderating effects of Narragansett Bay. The area has a moderately cool and humid climate with an average annual temperature of 50 degrees Fahrenheit throughout the year. Monthly average temperatures range from a high of 73° F in July to a low of 29° F in January. Average precipitation is about 48 inches per year in the vicinity of the Big River Reservoir site. The precipitation is fairly uniformly distributed throughout the year with some occurring during the winter as snowfall.

Floods. Flooding can occur in the Pawtuxet River basin at any time of the year as a result of intense rainfall or in the winter or spring due to rainfall combined with snowmelt. Flood damage potential is concentrated along the lower mainstem areas of the Pawtuxet River where development is most dense. Flood damage surveys have shown that heaviest flood losses would occur in Warwick, Cranston and West Warwick. Some of the most severe floods that have occurred in the last century were in November 1927, March 1936, July 1938, September 1938, August 1954, March 1968 and March 1979.

Droughts. When rainfall is below average for a period of time, the area experiences what is referred to as drought conditions. A drought is defined as a prolonged period of precipitation deficiency which seriously affects both river flows and groundwater supplies. The 1961-1967 drought in southeastern New England was one of the greatest ever experienced, the last comparable drought to it was in 1914-1916. The 1960's drought is considered to have a probability of around 1 to 2 percent of occurring in any year.

Detailed hydrological information is contained in Appendix D, "Hydrologic Analysis," and in "Attachment 1," which presents specific information on flood hazard areas in the Pawtuxet River basin.

Topography. The land surface of the study area is about 60 percent forested with the cleared lands in various types of agricultural, residential, commercial and industrial development.

PAWCATUCK RIVER AND NARRAGANSETT BAY
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STUDY AREA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 2

The topography has been modified by glacial forces which eroded hills and filled in valleys. The highest point in the Pawtuxet River Basin (and in Rhode Island) is Jermoth Hill, with an elevation of 812 feet above mean sea level, on the basin divide in Foster.

In the western sections of the study area there are low to moderate size hills with a generally decreasing relief to the east.

Geology. In the Pawtuxet River Basin, Scituate Granite Gneiss is the most prevalent bedrock type. There are also sedimentary and metamorphic formations present consisting of sandstones, slates, conglomerates, graywacke, schists and gneiss. The unconsolidated overlaying deposits are predominantly of glacial origin. Post-glacial deposits occur as alluvium on riverbanks and floodplains and as swamp deposits of silts, fine sands and muck. Till deposits of varying thicknesses cover much of the hillside bedrock. Further details are contained in Appendix F, "Geotechnical Investigations."

Seismic Activity. Most of the study area is classified as an area of minor damage potential. The Northernmost section may undergo moderate damage. The potential for earthquakes has been evaluated and appropriate factors will be applied to any structural designs. For further information see Appendix F, "Geotechnical Investigations."

Natural Resources

Air. Based on 1977 air quality sampling data, most of the Big River Reservoir study area, except Providence, is able to meet current State and Federal ambient air quality standards. Over the last few years there has been a general improvement in air quality in the area. Providence, however, has recorded levels of carbon monoxide and total suspended particulates in excess of those allowable under State and Federal standards. During the summer months, some rural as well as urban sections of the study area have experienced temporary air quality problems.

Soils. The principal soil type found in the study area is Glocester stony fine sandy loam. There are, however, many other soil types represented in the area. Alluvial soils are found along many streams, Whitman stony loam in wetlands and Hinckley loamy sand is frequently associated with kames. Merrimack fine sandy loam is found in the lowlands of Cranston and Warwick and many low hills are blanketed with Narragansett stony fine sandy loam.

Forests. The forests in the Big River Reservoir study area are characterized by a predominance of oak, hickory and yellow poplar trees. Wetlands, consisting mainly of wooded swamps, are habitat for red maple, elm and ash.

Fish and Wildlife. All of the alternative reservoir sites in the study area have been identified as inhabited by a similar proportional distribution of wildlife species. Actual population size is dependent on the acreage of the habitats within the sites. Among the species indigenous to the study area are a variety of game birds and animals, waterfowl, song birds, shore and wading birds, fur bearing animals, raptors and rodents.

The numerous streams, ponds and lakes in the study area are well known for the excellent fishing they support. Bucks Horn Brook, Flat River and Wood River produce some of the best cold freshwater fishing in Rhode Island. Flat River Reservoir and Big River are classified as warm water fishing areas which are inhabited by such warm water species as large mouth bass and pickerel.

A detailed look at various aspects of fish and wildlife in the Big River Reservoir study area can be found in Appendix H, "Recreation and Natural Resources."

Surface Water. Investigations for flood control and recreation focus on the Pawtuxet River Basin, while the water supply study area includes small portions of several other drainage basins. The Pawtuxet basin is the major watershed in the water supply study area, with a drainage area of 230 square miles. Thus the Pawtuxet River Basin, shown on Plate 3, is the focus of this discussion.

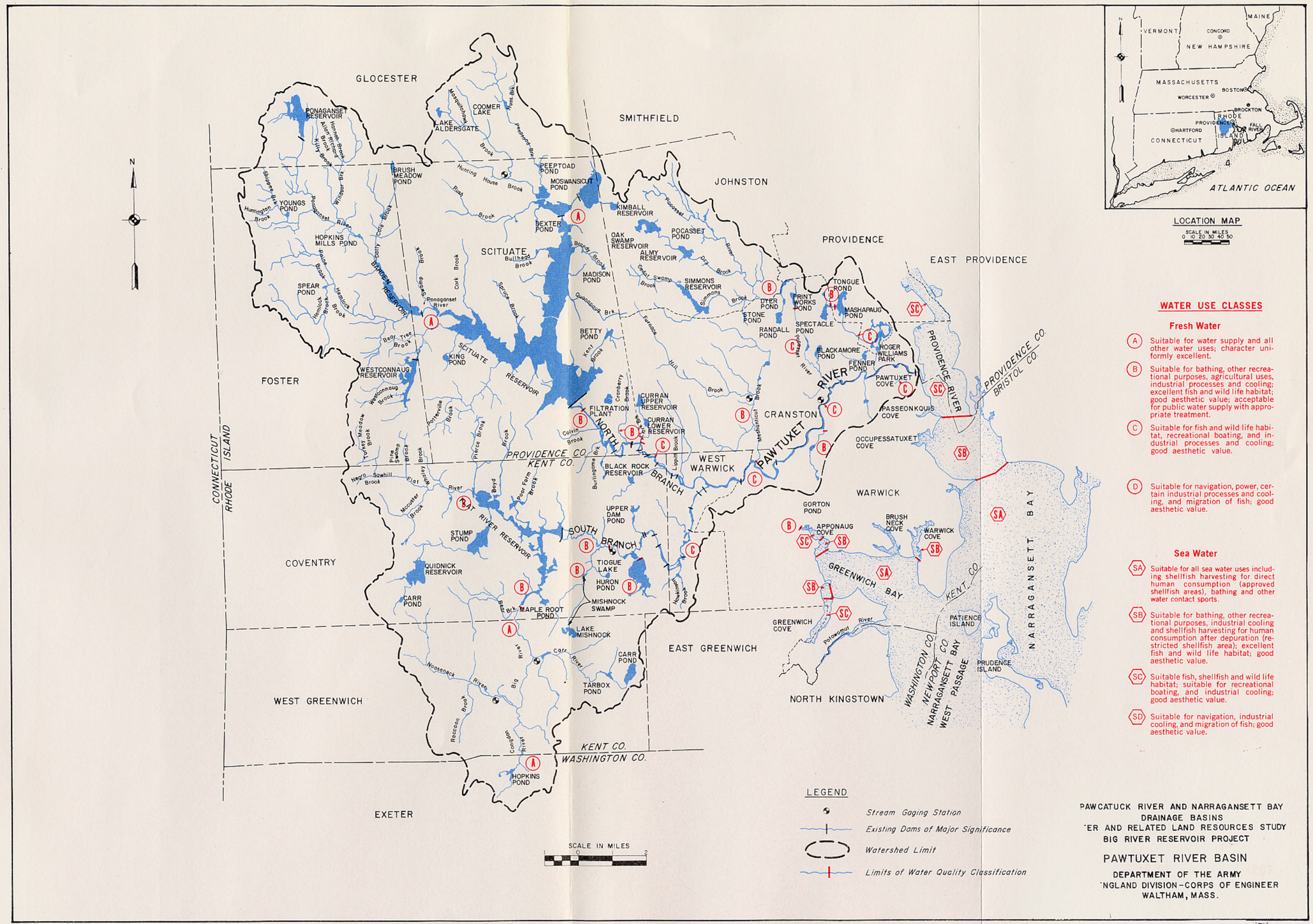
Drainage in the Pawtuxet Basin is generally west to east, and the region has a variable hydrologic character, with hilly topography and numerous small lakes and ponds, plus two larger reservoirs. Drainage is facilitated by many smaller streams and the major stream in the region, the Pawtuxet River. The mainstem flows in a generally northeasterly direction for approximately 11 miles to its mouth at the head of Pawtuxet Cove, with an average slope of about 4.1 feet per mile. The mainstem of the river is formed by the junction of its two principal tributaries, the North and South Branch, in the town of West Warwick. This portion of the river is flat, and highly urbanized along its shores.

The North Branch of the Pawtuxet River has a drainage area of 106 square miles and originates at Scituate Reservoir, the major water supply source for the region with a safe yield of 72 mgd. Below Scituate Reservoir the river flows for 6.8 miles in a generally southeasterly direction, falling fairly steeply (average 21.6 feet per mile) before joining the mainstem.

The South Branch of the Pawtuxet River, with a drainage area of 73 square miles, originates at Flat River Reservoir (Johnson's Pond). This impoundment was constructed downstream of the confluence of the Flat and Big Rivers, and is primarily used for recreational and industrial flow augmentation purposes. The headwaters of the Flat River originate at the head of Turkey Meadow Brook in the town of Foster, while principal tributaries of the Big River are the Nooseneck, Congdon, and Carr Rivers in the towns of West Greenwich and Exeter. Below Flat River Reservoir the South Branch flows generally eastward and then northeasterly for 9.0 miles, falling about 21.9 feet per mile, and joins the North Branch and mainstem in West Warwick.

For more information on the Pawtuxet River Basin see Appendix D, "Hydrologic Analysis," and "Attachment 1."

Water Quality. Existing water quality in the study area ranges from Class A (suitable for domestic water supply) at Scituate Reservoir and the Big River, Class B (suitable for domestic water supply with appropriate treatment and for swimming) at Flat River Reservoir and the upper reaches of the North and South



LOCATION MAP

SCALE IN MILES

WATER USE CLASSES

Fresh Water

(A) Suitable for water supply and all other water uses; character uniformly excellent.

(B) Suitable for bathing, other recreational purposes, agricultural uses, industrial processes and cooling; excellent fish and wild life habitat; good aesthetic value; acceptable for public water supply with appropriate treatment.

(C) Suitable for fish and wild life habitat, recreational boating, and industrial processes and cooling; good aesthetic value.

(D) Suitable for navigation, power, certain industrial processes and cooling, and migration of fish; good aesthetic value.

Sea Water

(SA) Suitable for all sea water uses including shellfish harvesting for direct human consumption (approved shellfish areas), bathing and other water contact sports.

(SB) Suitable for bathing, other recreational purposes, industrial cooling and shellfish harvesting for human consumption after depuration (restricted shellfish area); excellent fish and wild life habitat; good aesthetic value.

(SC) Suitable fish, shellfish and wild life habitat; suitable for recreational boating, and industrial cooling; good aesthetic value.

(SD) Suitable for navigation, industrial cooling, and migration of fish; good aesthetic value.

LEGEND

- Stream Gaging Station
- Existing Dams of Major Significance
- Watershed Limit
- Limits of Water Quality Classification

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PAWTUXET RIVER BASIN

DEPARTMENT OF THE ARMY
'NGLAND DIVISION–CORPS OF ENGINEER
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PLATE 3

Branches, to Class E (nuisance conditions) near the mouth at Pawtuxet Cove. Throughout most of the mainstem, Class C (suitable for fish and wildlife habitat) conditions prevail.

Both point and non-point sources of pollution affect water quality in the Pawtuxet River Basin. Major non-point sources are stormwater runoff from urbanized lower basin areas and leachate from landfill. The major point sources are the municipal wastewater treatment plant discharges and industrial effluents in the lower basin. Water quality for the Pawtuxet River watershed is shown on Plate 3.

Water quality at Scituate Reservoir has generally improved over its lifetime, and now is very good, with low levels of nutrients and metals levels either below detectable levels or EPA recommended limits.

The waters of Big River, Carr River, Nooseneck River and their tributaries, although rated Class A, do not fully meet Class A criteria due to levels of several contaminates in excess of acceptable standards.

The waters of the Wood River are of high quality and fully meet Rhode Island Class A criteria. Bucks Horn Brook and the Moosup River are of generally high quality but do not fully meet the Rhode Island Class A criteria because of high levels of coliform bacteria. Flat River Reservoir has generally good quality water which meets the Class B requirements except for low dissolved oxygen levels.

For more detailed information on water quality in the study area see Appendix E, "Water Quality," and "Attachment 1."

Groundwater. Ten major water supply agencies within the State of Rhode Island rely solely on groundwater resources while another four agencies utilize systems which combine both groundwater and surface water sources of supply. The most significant groundwater supplies in the State as well as in the study area are those of the Kent County Water Authority which serves the communities of East Greenwich and West Greenwich as well as parts of Coventry, Scituate and West Warwick.

In 1975 the estimated withdrawal of groundwater by municipal systems in the State of Rhode Island amounted to about 24.0 million gallons per day (mgd). Another estimated 13.0 mgd was withdrawn for private residential usage and industrial needs. Within the study area, the two municipal water supply systems utilizing groundwater resources - Kent County Water Authority and Bristol County Water Company - supplied about 7.0 mgd from groundwater wells in 1975. Estimates of private residential and industrial usage from groundwater sources amounted to an additional 7.0 mgd in 1975.

Groundwater aquifers with the greatest potential for development of municipal water supply sources have been identified by both the USGS and the State of Rhode Island Water Resources Board in various communities within the study area. However, potential additional groundwater development within the study area is limited by high natural concentrations of iron and manganese in some areas, and pollution due to urbanization in others. Although large areal deposits of outwash

materials exist in Providence, Cranston, Warwick, West Warwick and Coventry, their development as municipal supply sources is hampered by the high degree of urbanization. Wellfield development by Kent County Water Authority in the area of the South Branch Pawtuxet River and in the Hunt River Basin in East Greenwich accounts for the largest existing public supply sources within the study area. Groundwater resources in the Providence-Warwick region supply primarily industrial users due to poor water quality. Other existing groundwater supply sources within the study area are used by publicly operated water systems and to meet the demands of private domestic and industrial users.

Water Supply. Three major water supply agencies are located within the study area. The Providence Water Supply Board serves Providence, Cranston, Johnston, North Providence, East Providence, Smithfield and Warwick directly, and also supplies water to the Kent County Water Authority for distribution to its service area. Scituate Reservoir supplies the Providence system with a safe yield of 77.0 mgd, according to studies undertaken by the Corps as a part of this feasibility report, and a maximum day capacity of 144.0 mgd. In 1975 the average daily demand of the system was 62.4 mgd and the maximum day demand was 106.0 mgd.

The Kent County Water Authority serves Coventry, East Greenwich, West Greenwich, West Warwick, and Scituate. Groundwater supplies for this system have a safe yield and maximum day capacity of 10.9 mgd. Average daily demand for the system was 6.0 mgd in 1975, with a maximum day demand of 12.4 mgd.

The Bristol County Water Company serves Bristol, Barrington and Warren with surface and groundwater supplies. System safe yield is reported at 3.2 mgd with a maximum day capacity of 4.7 mgd. In 1975 demands were reported at 3.4 mgd on the average day and 5.8 mgd for the maximum day.

Commercially Valuable Mineral Resources. Sand and gravel resources within the Big River Reservoir site total over thirty million cubic yards, the largest single mineral deposit within the region. Three private contractors are currently removing one million cubic yards under an agreement with the State, and it is expected that approximately seven million more cubic yards could be removed over the next ten years, reducing the total unmined sand and gravel deposits possibly affected by any reservoir development at Big River to twenty million cubic yards. Other active sand and gravel quarries in the study area are located in Coventry, West Greenwich, West Warwick, Warwick, Johnston, and Cranston. The largest producer of crushed stone in the State is also located in Cranston, and other crushed stone producers in the study area are in Johnston, Warwick and West Warwick.

Social and Economic Resources

Population. Based on 1975 data the population of the Big River Reservoir study area is 575,000 people. With a land area of 469.1 square miles the population density is 1,235 persons per square mile, making the combined 17 towns of the study area among the most densely populated areas in the country. These 17 communities make up only 45 percent of the total land area of the State of Rhode Island but are inhabited by 60.5 percent of the total State population.

The study area's rate of population increase has been less subject to fluctuation than that of the State as a whole. Although the rate of growth has slowed on both levels, the period of time for which the downturn has occurred is too short to establish a definitive long term trend. In addition, the circumstances surrounding the recent downturn are somewhat unusual in that around 26,000 military personnel were transferred away from the State when three military installations were closed during the early 1970's.

Although total population in the study area increased from 1960 to 1975 by about 54,100 people, for the City of Providence a decrease of about 39,400 people was noted. Providence is the most densely populated community in the study area, at about 9,300 persons per square mile, and the decreases in Providence's population may be due to both out-migration to surrounding towns and to the effects of urban renewal programs on the inner city during the 1970's.

Employment. Employment data for the study area, taken from the 1970 U.S. Census, indicates that 34.6 percent of the working population is employed in manufacturing, 24.3 percent in services, and 18.6 percent in wholesale and retail trade. A further breakdown of the employment mix is shown in Table 1.

TABLE 1

PERCENTAGE EMPLOYMENT MIX

Category	Study Area	State
Manufacturing	34.6	36.6
Trade	18.6	16.4
Service	24.3	25.4
Government	6.2	5.9
Finance, Insurance, Real Estate	5.0	4.4
Transporation, Communications, Utilities	5.0	4.7
Construction	5.5	5.3
Mining, Agriculture	0.6	0.8
Others	0.2	0.5

SOURCE: Compiled from 1970 U.S. Census Data

The major products manufactured within the State and the study area, based on the size of the work forces involved in their production, are jewelry and silverware, textiles, electrical and non-electrical machinery, fabricated metals, and rubber and plastics.

The occupational structure of the labor force in the study area is assumed to be very similar to that of the State, due to the large segment of the State's working population which resides in the study area. U.S. Census data for the state indicates operatives, except transport, to be the largest occupational category totaling 20.4 percent of the 372,304 employed persons; followed by clerical and kindred workers, 17.6 percent; craftsmen and foremen, 14.7 percent; professional and technical, 13.8 percent; service workers, 11.4 percent; managers and administrators 7.2 percent; sales workers, 6.6 percent; and all others 8.3 percent.

The average unemployment rate for the study area, taken from the Rhode Island Department of Employment Security, is 6.3 percent, lower than that of the State which averages around 8.8 percent.

The median family income for the study area has increased from $5,702 in 1959 to $10,136 in 1969, or approximately 77.8 percent. The median family income for the State increased from $5,589 in 1959 to $9,736 in 1969, or 74.2 percent, which indicates that the study area enjoys a slightly higher median family income than does the State as a whole.

Land Use. The 469.1 square miles of the Big River Reservoir study area consist primarily of forest and open land. A 1970 study determined forest and open land to be 70.2 percent of the total study area, with residential land being the second largest category, 16.6 percent of the land area. Other land use categories comprise a much smaller percentage of the land area as shown on Table 2.

The higher density residential and major industrial areas are located in the eastern part of the study area, while the large forested areas and open areas are located in the western portion, closer to the Connecticut border. Northern and southern portions of the study area support a diversity of land uses.

During the mid-1960's the State of Rhode Island acquired approximately 8300 acres of land located in Coventry, West Greenwich and Exeter for the site of the planned Big River water supply reservoir. The site is heavily forested, with numerous wetlands, and open land which includes several surface mining areas. It has remained essentially unchanged since being purchased by the State, and is presently managed for recreation by the Rhode Island Department of Environmental Management.

For a detailed presentation of land use within the Pawtuxet River Basin, see "Attachment 1."

TABLE 2

1970 DISTRIBUTION OF LAND USE IN THE BIG RIVER RESERVOIR STUDY AREA

Category	Percentage of Total
Residential	16.6
Commercial	1.9
Industrial	2.2
Government/Institutional	0.9
Airports	0.3
Recreation	1.0
Conservation	6.9
Forest and Open Land	70.2

Sources: Remote Sensing Land Use and Vegetative Cover in Rhode Island, 1974. State Land Use Policies and Plan, 1975.

Transportation. The study area contains a well developed highway system, including Interstate Route 95, a principal connector between New York, Providence, and Boston. Other major highways in the study area are I-195, I-295 and U.S. Route 6.

Interstate bus service is provided from a main terminal in Providence to points in Massachusetts, Connecticut and New York by Greyhound and Bonanza bus lines. Intrastate service is provided by several carriers, including the Rhode Island Public Transit Authority, ABC, Pawtuxet Valley and Bonanza bus lines.

Passenger and freight rail service is provided by Conrail (and its passenger subsidiary, Amtrak) plus a number of small freight carriers including the Providence and Worcester, Moshassuck Valley, Narragansett Pier, Seaview, and Warwick rail companies.

T. F. Greene Airport in Warwick, with proximity to Providence and direct access from I-95, is the major freight and passenger air terminal facility in Rhode Island. There are also five other State airports in Rhode Island that provide private plane and charter facilities.

The Port of Providence, which has a 40-foot deep main channel and 27 public and private docks, serves most of the commercial waterborne traffic in the area. There are also cargo facilities accessible to the study area at recently phased out Navy bases in Portsmouth, Middletown and North Kingstown.

Recreation. Five major recreational areas are in or adjacent to the study area. Beach Pond State Park and Arcadia State Park are adjacent to the study area. Colt State Park and two State management areas, Durfee Hill and Wickaboxet, are contained in the study area, as well as the site of the proposed Big River Reservoir. These State-owned lands, totaling approximately 30,000 acres, support a wide variety of recreational activities, including boating, camping, fishing, golfing, hunting, picnicking, swimming and hiking.

Detailed information on recreation resources within the study area is contained in Appendix H, "Recreation and Natural Resources."

Institutional Arrangements. A number of regional water supply agencies, as well as several local systems for individual towns, provide water to the study area. Various other local, State, and Federal agencies have powers related to water supply management.

Within the study area, the two regional agencies supplying water at present are the Providence Water Supply Board, and the Kent County Water Authority. These agencies have the full capability for development and sale of water on the retail and wholesale level.

Local systems provide water for other parts of the study area. Bristol County Water Company is a private company which provides water for Bristol, Barrington, and Warren. Individual private wells provide water to meet the needs of Foster and Scituate, and also supply much of Glocester's needs.

State and Federal agencies regulate the water suppliers, and provide services and investigations involving related aspects of water resources development and water supply management, such as protection of water quality, land use planning, flood control, and fish and wildlife management. Among these agencies are the Rhode Island Department of Environmental Management, Public Utilities Commission. Federal agencies involved in water resources include the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Soil Conservation Service, Water Resources Council, and several other agencies with peripheral involvement in aspects of water supply or water resources.

For a detailed description of present and alternative future institutional arrangements for the study area, see Appendix K, "Institutional Analysis."

Cultural and Historic Resources. Before the advent of European settlers, the region now known as Rhode Island was inhabited by several different native American groups of Algonquin stock. Archaeological evidence of these early residents still exists today at several locations within the Big River area.

European settlement of the State began in the early 1600's when Roger Williams and his followers fled from neighboring Massachusetts Bay Colony in the wake of religious persecution. The early settlers generally lived on widely scattered farms with the occassional village necessary to provide local services and a few manufactured goods.

During the 1800's numerous small water-powered mills were established along the rivers and streams in the Big River area. Over the years the economy of the area declined, as the mills failed and the farms and villages were abandoned. The ruined remnants of the mill dams and buildings can be found along the now forested banks of the rivers. There are also many abandoned farms and small family graveyards spread across the landscape.

A detailed inventory of the cultural and historic resources of the study area is contained in Appendix I, "Social and Cultural Resources."

WITHOUT CONDITION PROFILE

The without condition profile, which describes conditions which will occur if no Federal action is taken, is based on the projection of the most probable future condition for the study area, which is chosen from among the possible alternative futures studied.

In order to develop plans that would be responsive to immediate, short and long-term needs of the study area, and also to statewide planning goals, the without condition was developed using available planning data and information from Federal, State and local agencies.

Projected population growth is the most important element in developing a most probable future condition, and in this case several alternative scenarios were developed by various agencies. These alternative growth projections were analyzed to determine the most probable and the most compatible with other factors associated with without condition profile including land use and economic projections.

The Rhode Island Statewide Planning Program developed population projections for the State Land Use Policies and Plan, January 1975, which showed estimates of the population that could be accommodated by 1990 land use projections. In April of 1975, updated population projections were published by the Statewide Planning Program developed primarily to assess the impact of the closings of naval installations in Rhode Island during the early 1970's. The projections showed a gradual reduction in statewide growth over the 1970-2040 time period.

In April 1975 population projections were utilized by the Corps of Engineers to project future conditions for the study area during the early stages of this study, and for other water resources investigations then being undertaken for the entire PNB area.

In 1979, revised population projections were developed by the Statewide Planning Program which showed marked differences from the 1975 projections, due mostly to the projected birth rates assumed for the State. The revised projections show reductions from the 1975 forecasts of about 19 percent and 27 percent in the population of study area communities, in the years 2000 and 2030 respectively. State population figures show similar reductions of 14 and 25 percent respectively for the years 2000 and 2030, when compared to 1975 figures. Plate 4 shows the two projections for both the study area and the State.

Because the differences between the 1975 and 1979 Statewide Planning Program projections were so significant, these forecasts were compared with OBERS Series E projections developed by the U.S. Water Resources Council. The OBERS projections are only available for the entire State or the Providence-Warwick-Pawtucket Standard Metropolitan Statistical Area (SMSA), which is somewhat larger than the study area, including all of Providence, Kent and Bristol counties. However, this SMSA was considered similar enough to the study area in economic and land use factors that comparison was considered valid between the different population projections, when adjusted for the size of the area.

Population and economic projections based on OBERS projections are normally used to develop future conditions in planning Federal water resources development programs. However, the State of Rhode Island requested that Statewide Planning figures be used in this study to aid in coordination with existing State plans. Thus, the OBERS projections were used only to help in assessing the Statewide Planning projections. Table 3 shows projected population for the study milestone years according to the three different population projections.

The population projections developed by the Statewide Planning Program show such a large disparity between them that a choice had to be made as to which series, 1975 or 1979, would more accurately reflect future conditions. When compared to the OBERS projections, the 1975 Statewide Planning figures are much closer to the trends projected by OBERS. Likewise the 1975 projections reflect more closely the degree of development anticipated in the State Guide Plan, which provides guidance for future development of the entire state. Thus, the 1975 population projections represent the most probable future condition as the basis for determining water resources development needs of the study area.

TABLE 3

COMPARISON OF POPULATION PROJECTIONS

RHODE ISLAND STATEWIDE PLANNING PROGRAM

	1975		2000		2030	
	1975 [1] Projection	1979 [2] Projection	1975 Projection	1979 Projection	1975 Projection	1979 Projection
Total Study Area	579,500	571,300	726,600	590,700	833,400	605,300
Total State	952,200	936,300	1,173,600	1,005,600	1,377,800	1,040,000

[1] Rhode Island Statewide Planning Program, Technical Paper No. 25, April 1975

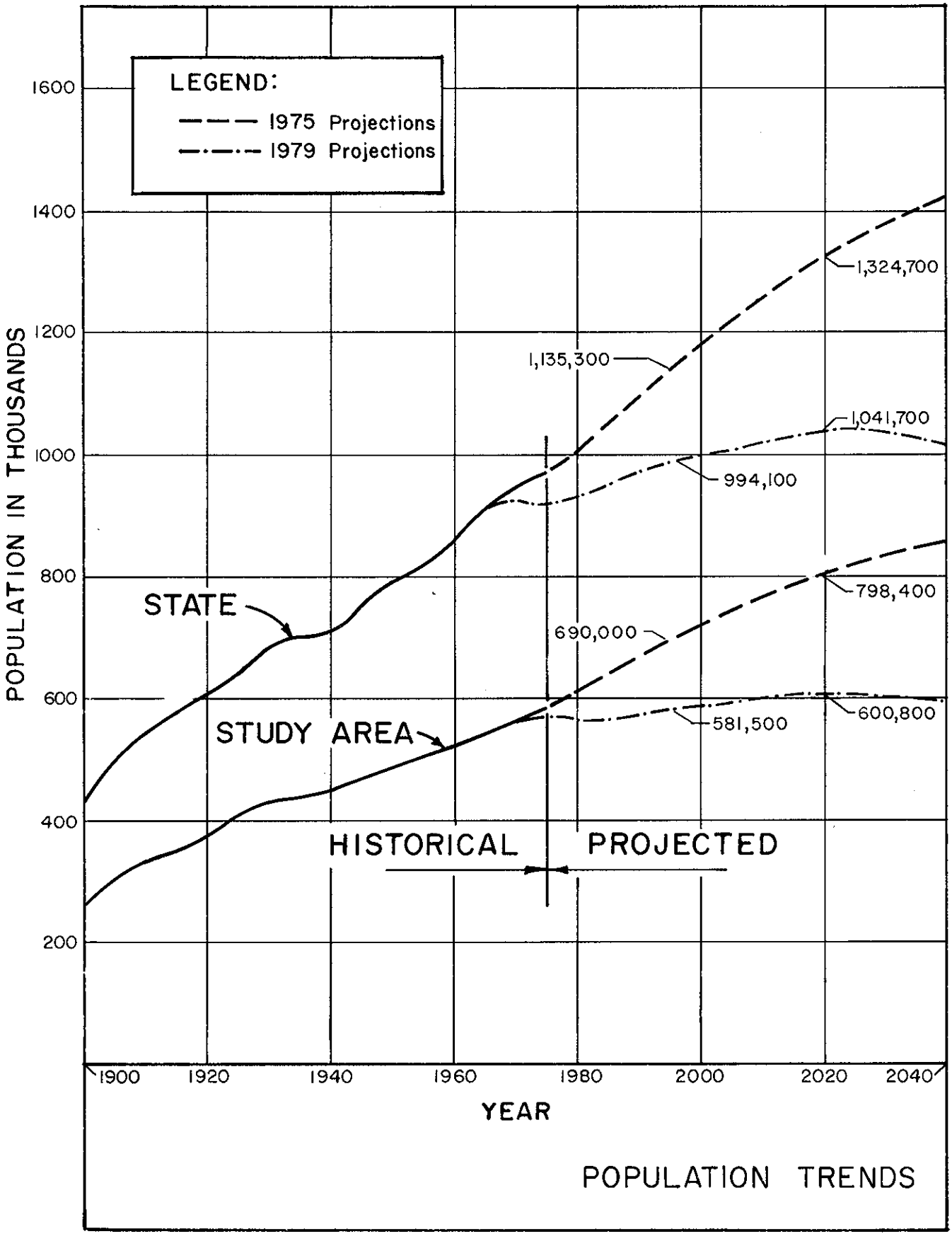
[2] Rhode Island Statewide Planning Program, Technical Paper No. 83, April 1979

OBERS SERIES "E"

	1970	1980	1990	2000	2020
Providence - Warwick - Pawtucket SMSA [3]	770,800	832,300	890,700	945,500	1,046,600
Total State	951,000	1,031,600	1,115,200	1,191,700	1,340,800

Source: 1972 OBERS Series E Projections, U.S. Water Resources Council
Note: OBERS projections not available for 2030.

[3] SMSA is somewhat larger than study area; includes all study area communities and Burrillville, North Smithfield, Woonsocket, Cumberland, Lincoln, Central Falls and Pawtucket.



Source: R.I. STATEWIDE PLANNING PROGRAM

PLATE 4

Land use and economic projections support this scenario. The State Land Use Policies and Plan, which provides a basis for planning development in such areas as transportation, utilities and other public facilities, addresses development through the year 1990. It strives to promote balanced urban development and compact, directed development throughout the State.

Land use projections for 1990 show a significant increase in residential land use, from 16.6 percent in 1970 to 26.1 percent predicted for 1990. Forest and open land show a significant decrease, from 70.2 percent in 1970 to 51.9 percent in 1990. The only other notable land use change is in recreation lands, which increases from 1.0 percent in 1970 to 7.8 percent in 1990. The remaining land use categories show little project change during the 20-year period. Projected development trends are shown on Plate 5.

In Rhode Island, continued economic development is important to allow change and expansion while meeting environmental objectives. Economic projections are based upon an objective analysis of past trends. Over recent years, the economy of the State has changed considerably, with a decline in the manufacturing sector and increase in the service-oriented sector.

Economic projections for Rhode Island show a continuation of the present shift from a manufacturing-based economy to more dependence on the service sector. The Providence metropolitan area is also expected to experience steady growth, with a similar trend, a service oriented economy.

The projections described above form the basis for the overall projection of the without condition profile, which provides the information to enable a comparison between plans and allows evaluation of each plan's impacts. The following discussion profiles conditions in the study area related to water supply, flood damage reduction and recreation.

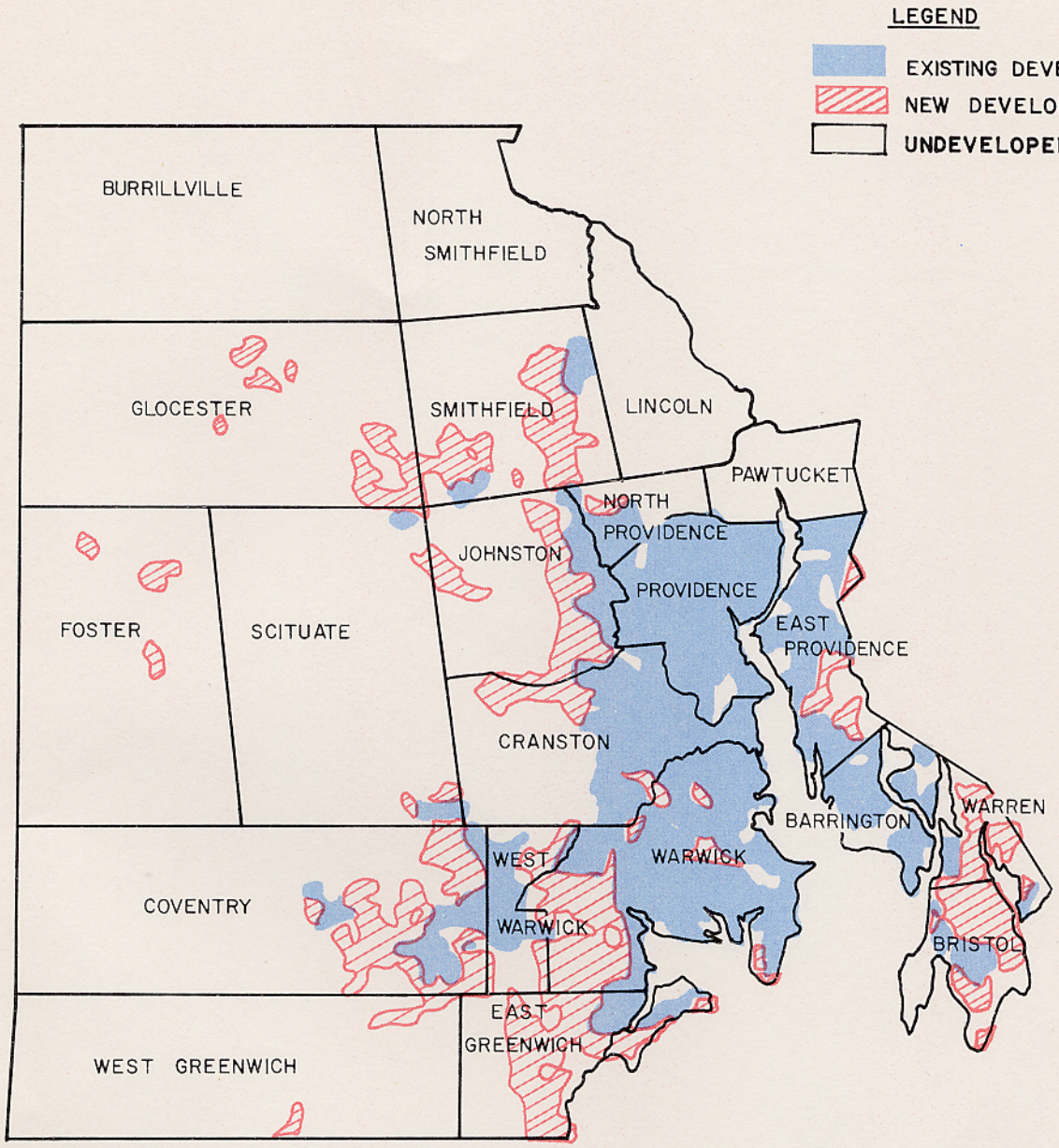
Existing water supply management programs would be expected to continue for the foreseeable future, with the agencies relying on existing sources of supply to meet any future demands. Only the Bristol County Water Company would be expected to augment its present system, as there is an immediate need for additional supplies to meet existing demands on that system. Bristol County has faced shortages over the past several years, and has had to place restrictions on users during high demand periods. To meet its present and projected future needs, the Bristol County Water System would obtain additional supplies through phased development of surface and groundwater resources in Rehoboth, Massachusetts, as well as improvements to existing facilities.

The Providence metropolitan area would continue to be served by the Providence Water Supply Board and Kent County Water Authority systems, utilizing existing surface and groundwater supplies. When water demands exceed the available supplies, shortages would begin to occur throughout the service area for these regional systems. Various social, environmental and economic effects would be faced by municipal and industrial water users due to water shortages or inadequate system capacity.

In less urbanized outlying communities in the study area, private on-lot systems would continue to be utilized until such time as municipal systems become appropriate due to growth of the towns. Privately supplied industrial users could be expected to continue to utilize present sources to satisfy their needs.

Average annual flood losses of about $1,429,000 (September 1978 price levels) would continue to result from flooding in the Pawtuxet River Basin. Both physical and nonphysical losses would be incurred due to damaged goods and property, lost wages and business income, and disruptions in utility service. Development in flood prone areas would continue to be regulated by the requirements of the National Flood Insurance Program.

Recreational demands in Rhode Island would continue to increase during the study time frame. Recreational demands within the study area would continue to be met by existing resources, except in the cases of boating and golfing facilities. However, demands on facilities in communities surrounding the project area would continue to increase.



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS

WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

DEVELOPMENT TRENDS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 5

PROBLEMS, NEEDS AND OPPORTUNITIES

Problems, needs and opportunities for the study area were derived from a combination of publicly expressed concerns and an analysis of the existing conditions and without condition profile. Water and related land resources needs thus compiled were reviewed to determine those appropriate for investigation under this study authority. Water supply, flood control, and recreation problems were included as project purposes. Hydroelectric power generation was investigated, but not included as a project purpose. An ongoing Corps study of small hydropower potential for New England is addressing the regional potential. Preliminary investigations of possible small hydropower installation at the proposed Big River Reservoir recommended that further investigations be deferred until a decision is made on construction of the dam, as hydropower installation has not been shown to be definitely cost-effective, and would only be a small part of the total facilities.

Several other possible water resource development features were ruled out after analysis of their applicability to this study. Wastewater management and low flow augmentation are water resources problems that have been studied in a recently released report by the State, the findings of which have been acknowledged in this study. Investigations in these areas were felt to be duplicative, so they were not included as project purposes, and problems and needs in these areas were not directly addressed.

Water Supply

The existing conditions presented earlier showed that over most of the study area, additional water supply is not needed immediately, as system capacities are not presently being exceeded, with the exception of Bristol County. However, projections of population and economic growth for the study area, making up the without condition profile, show that increasing water supply demands within the study area will exceed the capacities of all supply systems in the near future.

Projections of water demands were based on estimates of population, percentage of the population served, per capita consumption, and industrial water use. These parameters were projected based on historical data and assumptions of future growth trends. Population served was assumed to gradually increase until by 2030 the entire study area would be 100 percent served. Likewise, per capita consumption would increase over the entire study area, with rural area consumption growing by more than that of urbanized areas. Large increases in industrial water use are not expected to occur, as no major new industries are assumed for the study area. A complete description of the water demand projection methodology used is given in Appendix A, "Problem Identification."

The projected water demands for the study area, shown on Table 4, are based on the "most probable future" and the methodology outlined above. The table shows average day demands for the study area increasing from approximately 72 mgd in 1975 to almost 109 mgd in 2000 and to about 142 mgd by the year 2030. Based on the study area's base year safe yield of 91.1 mgd, deficits would thus be about 18 mgd and 53 mgd in the years 2000 and 2030 respectively.

Maximum day demands must also be met for a system to be considered adequate, and these demands will increase from about 124 mgd in 1975 to 190 mgd in 2000 and almost 250 mgd in 2030. With a maximum day capacity of the study area systems of 159.6 mgd in the base year, deficits of about 30 mgd by 2000 and 90 mgd by 2030 would thus occur.

TABLE 4

MUNICIPAL WATER SUPPLY REQUIREMENTS FOR STUDY AREA 1)

WATER SUPPLY AGENCY	COMMUNITIES SERVED	1975 SOURCES OF SUPPLY	1975 SAFE YIELD, MGD.	MAXIMUM DAY CAPACITY, MGD	1975 AVERAGE DAY DEMAND, MGD.	1975 MAXIMUM DAY DEMAND, MGD.	2000 AVERAGE DAY DEMAND, MGD.	2000 MAXIMUM DAY DEMAND, MGD	2030 AVERAGE DAY DEMAND, MGD.	2030 MAXIMUM DAY DEMAND, MGD
Bristol County Water Company	Barrington	G. W.	0.7	0.7	1.0					
	Bristol	S. W.	2.5	4.0	2.4					
	Warren									
			3.2	4.7	3.4	5.8	5.3	9.2	6.9	11.9
Providence Water Supply Board	Cranston									
	Providence									
	Johnston									
	North Providence									
	East Providence									
	Smithfield									
	Warwick									
		S. W.	77.0	144.0	62.4	106.0	91.0	155.4	117.4	200.5
Kent County Water Authority	East Greenwich									
	West Greenwich									
	Coventry									
	Scituate									
	West Warwick									
		G. W.	10.9	10.9	6.0	12.4	12.0	24.4	16.9	34.5
	Foster	none	0	0	0	0	0.2	0.3	0.4	0.9
	Glocester	none	0	0	0	0	0.4	0.7	0.8	1.7
Total Study Area			91.1	159.6	71.8	124.2	108.9	190.0	142.4	249.5

1) Based on 1975 population projections
G.W. - denotes groundwater
S.W. - denotes surface water
MGD - denotes million gallons per day

The deficits described above are significant, and some action must be taken to meet the water supply needs of the study area by increasing supplies and/or reducing demand in the study area. Development of surface water and groundwater resources are among the opportunities available for increasing supplies, and demand reduction could be addressed through water conservation techniques.

Flood Damage Reduction

Flooding in the Pawtuxet River Basin, which occurs primarily from runoff caused by precipitation of high intensity or prolonged duration, has adverse effects on the economy and general well-being of the flood prone areas. Flooding causes physical damage to property, nonphysical losses associated with interruptions of commercial, industrial and public activities, loss of business and personal income, and also threatens the health and safety of residents and workers in flood prone areas.

The possibility of flooding exists year round in the Pawtuxet River Basin. The headwaters of both the Scituate Reservoir, which feeds the North Branch of the Pawtuxet River, and the Flat River Reservoir, which provides flow for the South Branch of the Pawtuxet, are rural in character and support only minimal development in their floodplains. Because of the hilly topography and steep stream profiles the areas upstream of the Scituate and Flat River Reservoirs experience only moderate increases in river stages during periods of heavy rainfall and runoff.

The magnitude and timing of releases of water from Scituate and Flat River Reservoirs as well as rainfall and resulting runoff downstream of both reservoirs impact on flooding problems on the mainstem and the North and South Branches.

Historical data on flooding in the Pawtuxet River Basin dates to the early 1800's. Throughout this period numerous flood-producing storms have been experienced by the region, but the area has not suffered high monetary losses. However, the continuing trend of urbanization in the basin has left the basin vulnerable to severe flood losses.

Increased urbanization in the Pawtuxet basin is projected in the "most probable future" and will result in increased development of non-floodplain areas. This development will cause increased rates of runoff, resulting in higher flood stages than previously experienced. Thus, flood prone areas can expect more frequent and severe flooding than before, and a significant worsening of the flood problem in the basin.

Principal flood damage areas are located along the mainstem Pawtuxet in West Warwick, Warwick and Cranston. The most significant damage areas are at the West Warwick Industrial Park, Ciba-Geigy, Inc. industrial complex, the Norwood-Belmont residential area, Bulova industrial complex and the Warwick and Midland Shopping Malls and surrounding stores and apartment complex.

Moderate damages could be expected at the Wellington Avenue Industrial Park, Jefferson Avenue Industrial Park, and the Pontiac Mills industrial complex. Other location within the basin subject to damages are at the West Warwick, Warwick and Cranston municipal wastewater treatment plants and areas along Meshanticut Brook and the Pocasset River, tributaries influenced by flooding on the mainstem Pawtuxet.

The effects of increased urbanization in the upstream communities will be felt in downstream areas, and increased damages will occur even without new development in the flood prone areas. Flood losses, based on projected 1990 conditions, are estimated at over $3,650,000 for a 20-year frequency flood and over $5,470,000 for a 50-year event, at September 1978 price levels.

Opportunities for flood damage reduction exist by both structural and nonstructural means. Flood control storage at upstream reservoirs and local protection projects are some structural methods available for reducing damages, and floodproofing, relocation and regulatory measures are among the nonstructural techniques which could be utilized.

For further information on flooding in the Pawtuxet River Basin, see "Attachment 1."

Recreation

Recreation demands of the study area were investigated to determine the need for additional facilities which could be incorporated in water resources development plans. Three use areas were examined, including the site of the proposed Big River Reservoir, the local communities surrounding the Big River site and the entire State of Rhode Island.

Estimated demands for recreation, for each of the use areas, is shown on Table 5, along with the existing supply capacity. Projections were developed for the years 1995 and 2020, and show that the most significant needs on a statewide basis are for boating, camping, golfing, hunting, picnicking, and swimming facilities. Recreation demands for the local area and on-site are not nearly as significant and center on the addition of boating, golfing and picnicking facilities.

Rhode Island is a small state, and only a relatively short travel time is required to reach even the most distant parts of the State. Thus, in developing recreational facilities alternatives as part of the overall water resources plans for the study area, satisfaction of statewide needs was considered a prudent approach.

Recreational facilities development opportunities are available in conjunction with other water resources development plans by utilizing the environmental features of lands acquired for the other development.

For a detailed discussion of recreation demands of the study area, and plans for meeting these demands, see Appendix H, "Recreation and Natural Resources."

PLANNING CONSTRAINTS

Planning constraints are those conditions imposed upon the planning process that limit the range of easible alternatives available to the planner. These constraints may be legal, public policy, economic, social or environmental factors of such importance that to violate them would compromise the entire planning effort.

TABLE 5

ESTIMATED RECREATION DEMANDS
(Persons per day)

ACTIVITY	SUPPLY CAPACITY 1)	PRESENT DEMAND	1995 DEMAND	2020 DEMAND
BOATING				
State	46,471	19,426	34,491	77,614
Local	770	657	1,451	3,341
Big River	342	45	90	207
CAMPING				
State	17,104	14,854	20,936	28,607
Local	2,864	128	180	247
Big River	0	0	0	0
FISHING				
State	26,308	5,939	8,358	11,375
Local	6,176	330	464	632
Big River	360	100	128	174
GOLF				
State	11,328	5,951	10,883	22,462
Local	1,008	793	1,450	2,579
Big River	144	175	286	509
HIKING				
State	17,847	4,534	6,333	9,824
Local	6,210	50	70	94
Big River	2,700	10	13	17
HORSEBACK RIDING				
State	11,940	2,543	4,679	8,370
Local	2,050	55	101	181
Big River	1,500	20	33	59
HUNTING				
State	6,000	2,326	4,160	7,687
Local	3,290	115	206	380
Big River	1,600	100	165	304
PICNICKING				
State	32,047	51,951	58,300	59,881
Local	2,655	2,420	2,627	2,698
Big River	0	100	101	104
SWIMMING				
State	53,792	50,501	74,466	107,777
Local	8,089	2,633	3,883	5,619
Big River	9,450	200	277	401

1) "Supply Capacity" refers to the maximum number of persons which ideally can utilize existing recreational facilities each day. The estimated demands given are based on the "design day demand" which refers to the estimated number of persons wishing to participate in a certain recreational activity on a peak day.

One public policy constraint on the planning process results from the State's purchase of lands in the mid 1960's for reservoir development. These State-owned lands include the proposed Big and Wood River reservoir sites. As these lands are already targeted by the State for reservoir development, the selection of other sites would be contrary to existing State planning. In addition, the existing system serving the metropolitan Providence area has been designed for an eventual connection from the Big River Reservoir, and major modifications to the system might be necessary should another alternative be adopted.

PLANNING OBJECTIVES

The final array of planning objectives was derived from an analysis of the water and related land resources problems and needs of the study area in relation to the most probable alternative future and reflects several iterations of the planning process. Thus, the planning objectives provided the basis for formulation of alternative water resources plans. The planning objectives address the water supply, flood damage reduction, and recreation needs of study area communities, including a thorough evaluation of technical, economic, environmental and social concerns. They evolved through interaction with the public and other agencies during the course of the study.

Objectives addressing water supply management were directed at preservation of existing resources, flexibility in the development of additional supply sources, and conservation of both municipal and industrial water usage. Objectives addressing the associated environmental needs of water supply management were direct principally at protection of unique natural areas, conservation of wetlands values and fish and wildlife resources, and enhancement of human use value of the area's natural resources.

Objectives addressing flood control and floodplain management in the study area were aimed at reduction of flood damages resulting from increase development in the Pawtuxet River Basin and provision of both structural and non-structural solutions. Objectives associated with environmental needs were directed at preservation of existing stream conditions since no highly productive habitat exists in the Pawtuxet River Basin as a result of the urbanized nature of the watershed.

Comprehensive recreational resource enhancement was considered in view of the diversity of recreational needs within the study area and the State. Planning objectives were directed at enhancement of the value of human use of natural resources in compatibility with the environment.

Wastewater management and water quality problems in the study area were considered under programs of other Federal, State and local governmental agencies and were not addressed in this study except as they related to development of other water and related land resources.

The specific planning objectives developed for the study area are as follows:

Water Supply

. Contribute to the preservation of existing surface water and groundwater resources to meet short-term (2000) and long-term (2030) needs of the study area.

. Contribute to the modification of water usage within the study area to optimize existing resources and to meet short-term (2000) and long-term (2030) water demands.

. Contribute to the development of additional groundwater and surface water resources to meet the projected short-term (2000) and long-term (2030) municipal and industrial water supply needs of the study area.

. Contribute to the conservation of wetlands values and fish and wildlife resources in the study area through protection and enhancement of other lands during the study time frame (1980-2030) and beyond.

. Contribute to the protection of unique natural areas in the study area during the study time frame(1980-2030) and beyond.

Flood Damage Reduction

. Contribute to reduction of the flood hazard and associated urban flood damages in Coventry (South Branch) and in West Warwick, Warwick and Cranston (Pawtuxet River) during the study time frame(1980-2030) and beyond.

. Contribute to the preservation and maintenance of the resources of existing stream environments within the study area during the study time frame (1980-2030) and beyond.

Recreation

. Contribute to recreational opportunities in the Big River Reservoir area during the study time frame (1980-2030) and beyond.

. Contribute to the preservation of water quality in the Big River Reservoir through discreet siting of recreational resources during the study time frame (1980-2030) and beyond.

. Contribute to the enhancement of the value of human uses of natural resources within the study area during the study time frame (1980-2030) and beyond.

FORMULATION OF PRELIMINARY PLANS

In this section, a broad range of management measures are identified and examined. Plans of other agencies that address our planning objectives are considered. After analyzing the measures with specific technical, environmental, social, and economic criteria, the surviving measures are combined into a range of water resource plans. The preliminary alternatives are compared to each other to ensure a broad mix that addresses the national and planning objectives established for the study. The plan formulation process and evaluation criteria are presented in detail in Appendix B, "Plan Formulation."

PLAN FORMULATION RATIONALE

Before discussing the plans that resulted from the preliminary plan formulation, a brief summary of the formulation process and the evaluation criteria used is presented here to brief the reader on the screening process used to arrive at the best alternative plans.

First, all possible measures for meeting the study objectives were identified. Those measures that were obviously infeasible or unacceptable were removed from further consideration at the outset of the screening. The remaining measures were arranged into various plans to meet the study area's needs. The plans were then compared and evaluated according to the criteria presented below, with the results being the formulation of a set of preliminary single-purpose plans for water supply and flood control.

Recreation plans were developed similarly to those for water supply and flood control, except that they were limited to those plans that could act in conjunction with possible development of Big River Reservoir.

As the preliminary plans were formulated separately the preliminary plan formulation section is arranged into three parts by project purposes. Formulation and evaluation criteria are common to all purposes, and are presented in a single section. This section is followed by three sections, one for each project purpose, which present management measures and preliminary plan formulation for each project purpose. The results of the formulation of preliminary plans are then combined into the detailed plans and presented in the Assessment and Evaluation of Detailed Plans.

Formulation and Evaluation Criteria. Selection of a plan of improvement which represents an acceptable and justifiable solution that best responds to the problems and needs of the area entails the application of technical, economic and social criteria to all possible alternatives, including consideration of all beneficial and detrimental effects on the area's environment.

Basically, the plan must be economically sound with a benefit-to-cost ratio of at least one. It must be technically feasible and complete in itself to fulfill the intended purpose. The environmental and social

impacts of any plan must be fully accounted for and analyzed, and management actions to enhance environmental quality should be identified. The public views about a plan must be positive before it can be selected for implementation.

Evaluation criteria are applied broadly at first and then in more detail as plan formulation proceeds towards the selection of detailed plans. A more complete description of the plan formulation process and the formulation and evaluation criteria can be found in Appendix B, "Plan Formulation."

WATER SUPPLY

Management Measures

In formulating alternatives an array of potential measures was investigated. These included nonstructural and structural measures and a No Action plan. Table 6 lists the measures considered in this initial screening.

TABLE 6

WATER SUPPLY MANAGEMENT MEASURES

No Action Program

Nonstructural Measures

1. Demand Modification
2. Weather Modification
3. Direct Wastewater Reuse

Structural Measures

1. Surface Water Resources
2. Ground Water Resources
3. Importation
4. Dual Water Supply Systems
5. Desalination
6. Iceberg Harvesting

No Action. The No Action alternative assumes that the lack of additional water supplies, if no action is taken by any water supply agency or individual community, would cause socioeconomic impacts on the area, limiting growth to conform to the available supply.

Water Demand Modification. When the demand for water increases, the usual response is to construct new waterworks facilities. However, an alternative approach is to reduce demand in conformance with available supplies. Following are five methods which have been suggested as effective in controlling demands on water supplies:

1. Pricing policies (changing rate structures).
2. Installing water saving devices.
3. Water conservation education programs.
4. Imposing restrictions on water use.
5. Controlling water system losses.

Each of these methods may be used singly or in combination to achieve a reduction in total water use. The reduction may be an absolute one, in which demand is less than before implementation, or it may be a reduction in the rate of increase of water use.

Rate structures may be changed in several ways. Some alternative pricing policies include spatial differentation of prices, seasonal pricing, increasing block rates, and average variable cost pricing.

Water saving devices reduce flows from showers, lavatories and toilets to the minimum necessary to accomplish their purpose. Flow reducing devices can be added to existing fixtures, or replacement fixtures designed to reduce flows can be installed. Some flow reducing devices currently in use include water saving toilets, reduced flush devices, flow limiting shower heads, water conserving dishwashers and clothes washing machines, flow control devices for faucets, and pressure reducing valves to reduce unnecessarily high system pressures.

Modification of water use attitudes and habits can reduce consumption significantly. Education and information campaigns directed toward the consumer can bring about reduced waste in water usage by the voluntary efforts of the educated consumers.

Institutional restrictions are administrative and legislative controls which can be implemented by water suppliers and government agencies to insure public welfare during times of water supply shortages. Some institutional restrictions applicable to the study area are restrictions on domestic water use, water rationing, building and plumbing code restrictions, industrial reclamation and reuse, maintenance water control, inspections, fire hydrant use restrictions, and landscape watering restrictions.

Control of water system losses can be accomplished by a program of leak detection and repair, metering of the entire system, and reduction of illegal uses, such as opening of fire hydrants.

Weather Modification. The primary focus of research in this field is cloud seeding, although long term seasonal precipitation forecasting and fog drip augmentation are also being studied. However, only cloud seeding is applicable to the Rhode Island area.

Rain falls from clouds when water vapor in the clouds condenses around particles and forms rain drops large enough to overcome frictional

resistance to falling. Cloud seeding is based on the introduction of foreign particles, such as dry ice and silver iodide, into clouds to enhance condensation, producing rain.

Several studies have been made on the feasibility of cloud seeding as a means of augmenting water supplies. The results show that weather modification is an inexact science at best, with much refinement needed before it can be considered a reliable method, and with its ultimate feasibility questionable. Thus, weather modification operations do not appear to provide a viable solution to the study area's water supply problems in the near future.

Direct Wastewater Reuse as a Municipal Supply. Direct wastewater reuse involves returning the effluent from sewage treatment facilities to industrial or municipal supplies. Advanced treatment techniques would be used to make the effluent safe for human consumption.

Direct wastewater reuse has been successful in industrial process applications in some parts of the country. However, its use for drinking water supply is still lacking in much basic research, and many questions remain. Until this research is completed and appropriate technology is developed, direct wastewater reuse is not a viable alternative to the study area's water supply needs.

Surface Water. Surface water development may be by drafting or impounding streamflow. Larger rivers and lakes may be drafted continuously, while smaller streams may be drafted during high flows, depending upon the demand and the source's ability to meet it.

Impounding reservoirs, generally on upland streams, may be the most desirable method of supply. Water quality is generally better than from other methods of surface water development, thus treatment is not always necessary, and supply can usually be by gravity flow through aqueducts.

Ground Water. Ground water storage comprises most of the fresh water storage in the United States by far, and is commonly tapped for water supplies by wells. The most commonly used type is the drilled well, particularly for deep wells when other types are not feasible. Water supplied by wells is generally less likely to need treatment than surface water and is considered less expensive to develop in most cases.

Importation. This technique involves the diversion of ground water or surface water supplies from watersheds outside the study area to augment existing supplies. In some cases the diversion would be made from existing sources that are expected to be otherwise underutilized over the long term. In other cases, the diversion could be made from presently undeveloped sources.

Dual Water Supply Systems. These systems establish a hierarchy of water uses, with higher quality supplies furnished for drinking, cooking,

dishwashing, cleaning, bathing and laundering. Other uses would be satisfied by a lesser quality supply.

Dual systems could work by recycling water at the point of usage, with effluent from higher-level uses treated and used for lower level purposes. A second approach would involve using two distribution systems to accommodate the two supplies. Potential health problems are inherent in any system that introduces less than potable water into the home environment. This factor, when combined with the high capital cost of dual water supply systems, precludes the use of such systems in the study area.

Desalination. Desalination, the process by which brackish and saltwater is converted to fresh, is currently being used in some parts of the world as an economically feasible source of fresh water. There are four major processes for desalination: distillation - evaporation, membrane separation, crystallization, and chemical differentation. Distillation and membrane separation are most applicable to large-scale operations, according to the present state of the art.

Desalination is already feasible in certain parts of the world where the natural water supply is either scarce or of poor quality, and the relatively high cost of desalination is justified. However, in the study area desalination process costs are much greater than that of possible surface and ground water developments in the study for the near future. Thus, desalination was ruled out as a solution to the study area's short term water supply problems.

Icebergs. Recent proposals have been made to transport slab icebergs from the polar regions to areas with water shortages. An iceberg would be towed by ocean-going tugboats to the needy area, where it would be melted.

There are many technological problems involved in the use of icebergs as a source of drinking water. These problems must be addressed to bring the high cost of this technology into line with conventional sources, which will not occur until costs from conventional sources increase a good deal. This process does not appear feasible for the near future and was ruled out as a solution to the study area's water supply problems.

Results of Preliminary Screening. The potential measures were evaluated at the outset to rule out those which could not meet even broad criteria for economic feasibility, engineering practicality, social and environmental acceptability, or adequacy as a solution. The preliminary screening showed that demand modification, surface water development, ground water development, and importation warranted further evaluation. The No Action plan was not considered an appropriate response to the study area's water supply problems and was ruled out at this time.

Intermediate Screening. Those measures which passed the initial screening were considered in more detail before being combined into

plans. Surface water and ground water sites for potential development were reviewed individually to determine those which would be most feasible to meet study area needs either separately or as part of an overall plan. Demand modification measures were screened to determine the overall effectiveness of such a program. Importation of surface water or ground water supplies from outside the study area was investigated as a part of an overall surface water and ground water site screening, and no distinction was made between sites inside or outside of the study area in the application of selection criteria.

a. Surface Water. Six surface water sites were considered for development in the northern part of the State, in the Blackstone River Basin, as shown on Plate 6.

The Chepachet River Reservoir site, located in Burrillville and Glocester, would yield 18.1 mgd but was dropped from further consideration when unfavorable foundation conditions were found at the dam site.

Smith-Sayles-Keech Reservoir, on the Chepachet River in Glocester, would be created by raising the spillway level of an existing dam. Further development of this site was ruled out when it was discovered that raising the spillway level would not increase the reservoir's yield due to increased evaporation losses. Moreover, the shallow depth of the existing impoundment and the extent of shoreline development around the reservoir caused this site to be dropped from further consideration due to unfavorable water quality.

Nipmuc River Reservoir and Tarkiln Brook Reservoir, located in Burrillville, were proposed as a system for staged development with a total yield of 15 mgd. The system is still considered technically and economically feasible, but only as a regional supply source for the northern part of the State. Transmission costs to the Providence system would be excessive compared to other alternative sites in the western part of the State, and new supply sources would have to be developed for the northern region, so this system was dropped from consideration.

Wilson Reservoir is an existing impoundment on the Clear River in the Blackstone River Basin. A diversion facility at the existing reservoir or a new dam to increase the yield were both rejected. New construction would have unjustifiable costs, and the proposed diversion to Nipmuc Reservoir would not increase Nipmuc's yield, as all of Nipmuc's storage would be required to develop its own watershed. This site was thus dropped from further consideration.

Oak Valley Reservoir would yield about 6.3 mgd on Tarkiln Brook in the Blackstone River Basin. This reservoir appears to be technically and economically feasible, but would provide only local water supply benefits, so no Federal interest was found in the project and it was ruled out.

In the west central area of Rhode Island, systems involving six sites were examined to determine which alternatives could meet the study area's needs in the most efficient manner. See Plate 6 for the locations of the sites.

Nooseneck River Reservoir would be contained in the Big River watershed, yielding 7.1 mgd, and was considered for part of a system. However, the combined yield of a system with Big River Reservior would be less than 1 mgd greater than Big River Reservoir's yield alone, making the cost of Nooseneck River Reservoir unjustifiable. This reservoir was thus dropped from further consideration.

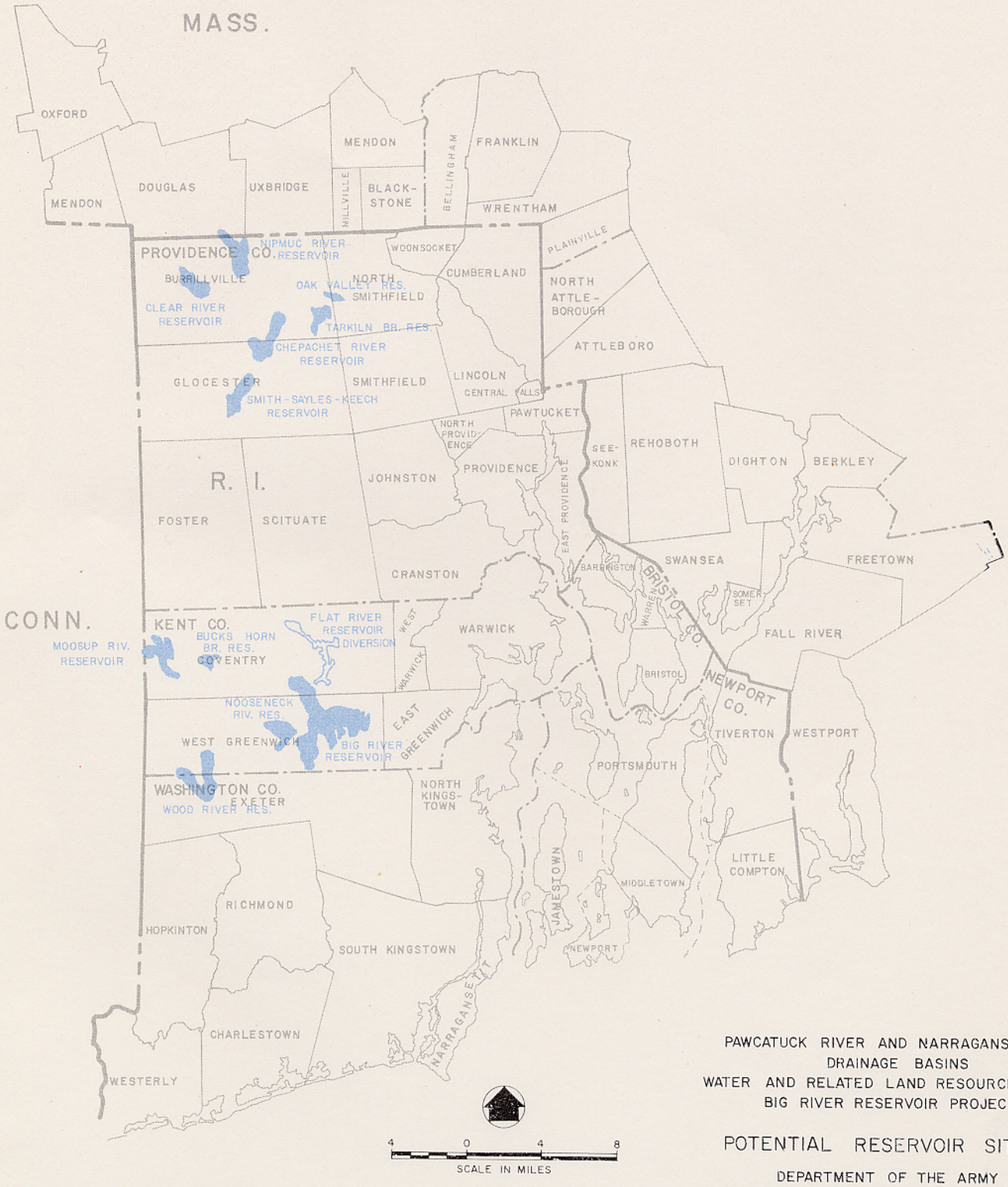
The Wood River watershed is contained in the Pawcatuck River Basin in the western part of the State. Proposed for development of this site was a diversion or reservoir as part of a system. The reservoir was rejected because the higher cost was not justified by the higher yield, and the environmental damage caused by the larger inundated area would be unacceptable due to the area's recreational popularity and fish and wildlife value. The diversion facility, which would yield 18 mgd, was reserved for further study as a part of a system.

Located on the South Branch of the Pawtuxet River, Flat River Reservoir is an existing industrial water supply reservoir. Development as an independent source of municipal water supply was rejected. The yield would not be sufficient to meet the study area's projected needs, requiring additional development elsewhere. Water quality of the reservoir would require extensive treatment, and land acquisition would be a problem if the privately owned reservoir were converted to water supply purposes. The flood skimming operation as a diversion would avoid some of these impacts at considerably less cost, and could provide 13 mgd yield, so it was retained for further study.

Big River flows into the southern end of Flat River. The proposed reservoir would be impounded just above the Flat River Reservoir and would provide 36 mgd safe yield. Big River Reservoir could be built independently to meet the area's short term needs and could also accept diversion flows from other sites. This proposal was carried forward for more detailed investigation.

The Moosup River Basin is in the eastern part of the Thames River watershed, situated largely in Connecticut. A diversion facility would be located just over the State line in Connecticut, with the 17 mgd yield pumped into a storage reservoir nearer to Providence. The plan is considered feasible as a long range source for when other, cheaper alternatives are fully utilized.

Bucks Horn Brook flows westerly into the Moosup River and would be developed as a reservoir to be connected with the Moosup River transmission line. Considered feasible but expensive, this reservoir would not be developed until all other cheaper sources, including Moosup River Diversion, were developed.



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

POTENTIAL RESERVOIR SITES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 6

The Bucks Horn Brook development was not carried forward for further study, although deemed feasible, because it would not be utilized until beyond the study time frame, if at all.

b. Ground Water: Investigations of local ground water showed no significant resources in several of the study area communities, and limited yields coupled with potential poor water quality in some of the others. Most of the remaining ground water resources are already developed. However, the towns of Foster and Glocester could develop sufficient ground water in Glocester and Burrillville to serve local needs. The development of ground water in Rehoboth, Massachusetts to serve Bristol County appears viable, as Rehoboth has projected surplus ground water which could meet the needs of Bristol County. Institutional arrangements between the states and water systems would be the major stumbling block to implementation of such a plan. However, development of ground water to serve Bristol County was retained for further consideration.

Aquifers in Lincoln and Cumberland were estimated at a possible 20 mgd. However, this ground water is of unacceptable quality, due to induced infiltration from the highly industrialized Blackstone River. Thus, this area was ruled out as a source for study area water supply.

In the southern part of Rhode Island, large amounts of ground water appear to exist in the Pawcatuck River Basin. An estimated 45 mgd yield could be obtained from aquifers there. However, this estimate would have to be reduced, possibly substantially, if water is to be exported from the basin, to avoid potential stream drying up. The communities in this region are experiencing strong growth pressures that are expected to continue, so most, if not all, of the area supplies are expected to be utilized locally. In addition, transmission costs to the Providence system and the rest of the study area would be excessive, due to the long distances involved. Development of ground water in southern Rhode Island was thus ruled out as a source of supply for the study area.

c. Water Demand Modification: Results of water demand modification efforts have varied widely among different studies. Realistic estimates of the effectiveness of various methods for the study area were developed and used in the screening process to determine the feasibility of each method.

The price of water in the study area is so low that pricing policy changes would have little, if any, effect on use. This method was dropped from further consideration.

Water conservation education and water saving devices are techniques that are generally pursued simultaneously. They were evaluated jointly, using case study data and information on the efficiency of appliances and

techniques currently in use. It was determined that an estimated five percent reduction in consumption could be achieved by the use of thse two techniques.

Institutional restrictions of the types mentioned earlier could reduce water use by around four percent by 2030. This estimate is based on building code restrictions and does not assume regular use of severe restrictions such as lawn sprinkling bans, since such restrictions would be imposed only during periods of severe shortages.

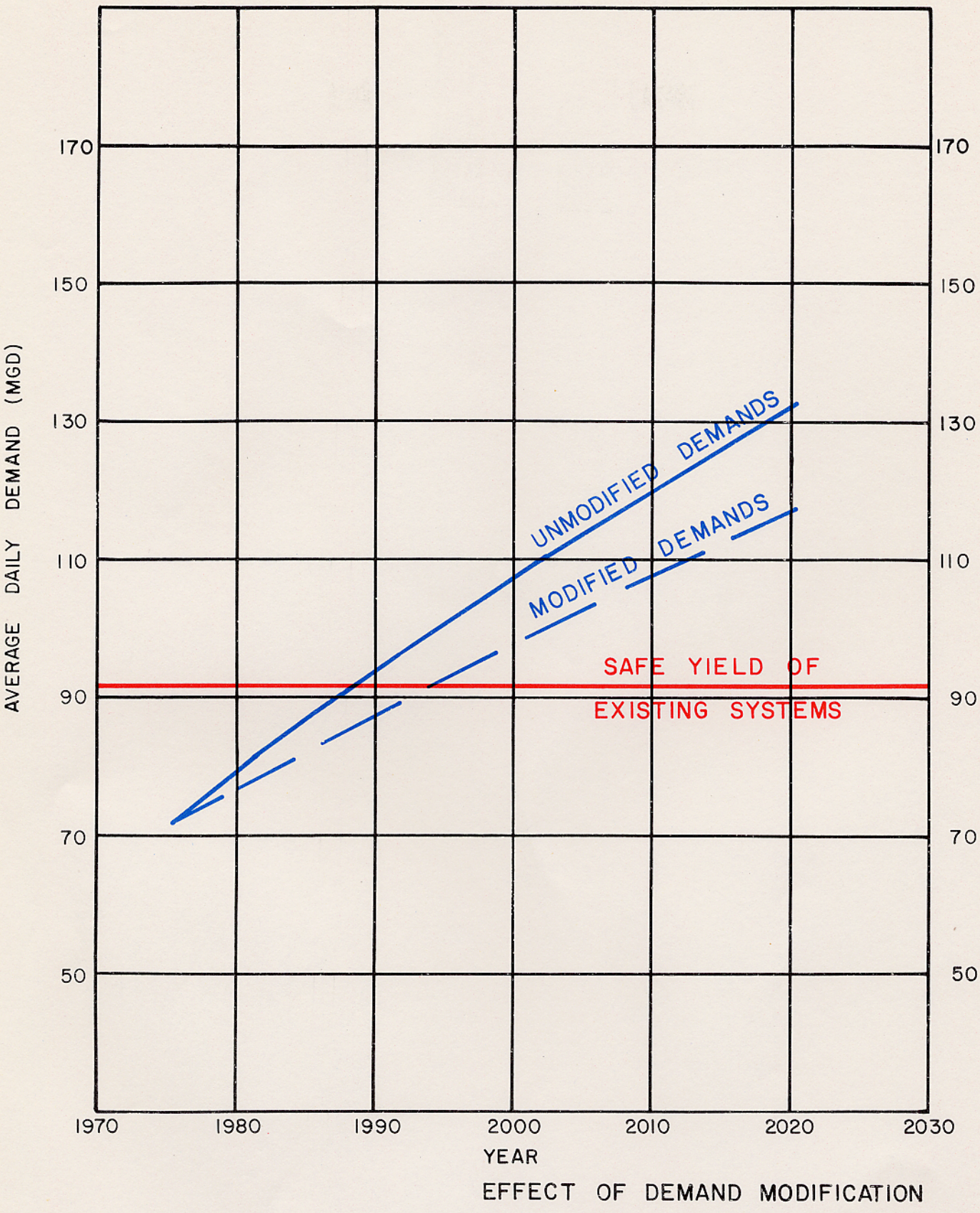
Due to the low amount of unaccounted for water in the Providence water supply system, the potential for reduction in consumption by leak detection and repair is small. A reduction of 2 percent is considered a reasonable estimate for the study area.

Aspects of the four techniques discussed above were deemed feasible for the study area. Additional reductions in demand could be achieved by utilization of other techniques discussed previously, but would only have a small effect on demand compared to a comprehensive program including water conservation education and water saving devices, building code restrictions, and leak detection and repair which is expected to reduce overall demand by approximately nine percent by 2000 and 11 percent by 2030. Plate 7 shows the effect of demand modification on the study area's water supply requirements. Unmodified demands are those projected to occur based on 1975 population projections. Modified demands show the reduction in projected demands resulting from the application of the demand modification techniques described above. The safe yield of existing systems in the study area is based on 1975 data and includes all municipal systems serving the study area.

For more detailed information on water demand modification, see Appendix B, "Plan Formulation."

d. Importation: The feasibility of importing water from other areas of the State to meet the needs of the study area was investigated as part of the surface water and ground water investigations. As noted in preceding paragraphs, several areas showed promise. Ground water development in Burrillville could help serve Glocester, allowing resources in that town to meet the needs of neighboring Foster. Rehoboth, Massachusetts has a surplus of ground water which could help meet existing deficits of Bristol County.

Results of Intermediate Screening. The intermediate screening of management measures showed that various surface water and ground water sites, both inside and outside the study area, could be feasible alternative solutions to the area's water supply problems. The effectiveness of demand modification was estimated for the study area, and this measure was also carried forward. Importation of supplies into the study area was deemed feasible in certain areas, and was studied under the surface water and ground water categories. For more detailed information on the screening of management measures, see Appendix B, "Plan Formulation."



EFFECT OF DEMAND MODIFICATION

PLATE 7

Plans of Others

The Rhode Island Water Resources Board and the Providence Water Supply Board have adopted similar water resource development plans. The construction of Big River Reservoir to augment existing water supplies is a significant feature of both programs.

The State's Comprehensive Water Resources Development Plan, drawn up in 1967 for the Rhode Island Water Resources Coordinating Board, was developed in response to the drought conditions of the early 1960's and the attendant water supply problems experienced throughout the State. The plan outlines a time-phased water supply development program designed to meet projected water demands through 2020.

The principal features of the plan are:

1. The construction of the Big River Reservoir, a water treatment plant, and transmission mains which would connect with the existing Providence water supply system. This expansion would produce an initial 29 mgd of additional water supply. The plan also provides for flood skimming of Flat River Reservoir, Moosup River and Wood River and subsequent transfer to Big River Reservoir in order to augment the reservoir's yield.

2. The development of Tarkiln Reservoir, with a treatment plant and transmission mains to supply Woonsocket and the Blackstone Valley after 1990, followed by the development of a reservoir on the Nipmuc River prior to 2020.

3. The development of wells in the upper Pawcatuck River Basin and construction of transmission mains to Jamestown and Newport as well as development of additional wells in North Kingstown, as needed to meet the 2020 water supply requirements of the southern portion of the State.

4. In the eastern portion of the State the utilization of additional water supplies from Fall River, Massachusetts for North Tiverton and northern Portsmouth as they become available. Service would be provided to the southern part of Tiverton and Little Compton from Watson Reservoir.

5. The plan also discusses the possibility of using water from the upstream reservoirs of the Pawtucket water system to meet the needs of the northern part of the town of Cumberland.

In 1968 the Providence Water Supply Board adopted a water resource development program which set forth a variety of measures developed to augment and enhance the available water supply in the Providence Water Supply Board service area.

Four major points were outlined in the plan:

1. The immediate development of the Big River Reservoir, a water treatment plant, and transmission mains, followed by development of Wood River Reservoir in 1997 and Moosup River Reservoir in 2012. Development of these three reservoirs would ultimately add 64 mgd safe yield to the Providence Water Supply Board system. Flood skimming of Flat River Resevoir and development of Bucks Horn Brook Reservoir is proposed to meet water supply needs beyond 2018.

2. The development of Big River, Wood River, and Moosup River Reservoirs would lead to an estimated 6 mgd reserve capacity in the Providence water supply system in 2015. Therefore, consideration should be given to extending service to fringe areas to the east and south of the existing service area.

3. Water storage capacities at Aqueduct, Neutaconkanut and Longview Reservoirs should be expanded by 91 mgd by the year 2010.

4. The development of approximately 4.4 mgd of additional ground water by 2015 in Smithfield, Coventry and Glocester.

Analysis of Plans Considered in Preliminary Planning

Description of Plans. The measures that resulted from the preliminary and intermediate screening were then assembled into alternative water supply plans. Four basic alternatives were derived, with several measures common to some or all of the alternatives.

A program of demand modification would be undertaken in the study area in the manner described in the intermediate screening of management measures. Such a program would reduce average daily demands of the study area communities from approximately 109 mgd to 99 mgd in the year 2000 and from about 142 mgd to 127 mgd by the year 2030. Maximum day demands would also be reduced, from 190 mgd to around 173 mgd in the year 2000 and from around 250 mgd to about 222 mgd by the year 2030. Although development of additional supplies would still be necessary to meet study area needs, demand modification would have a significant effect on the amount of additional development required.

The towns of Foster and Glocester have small projected demands, and are somewhat isolated from the existing systems in the study area. Local ground water development to serve these two towns was thus investigated, resulting in a plan to serve Foster with ground water from Glocester, which would then be served by an extension of the Pascoag Fire District, utilizing ground water in Burrillville.

Bristol County has an immediate need for additional supplies which cannot be met from sources within the Bristol, Barrington and Warren area. The most feasible method of obtaining the needed supplies for the short term, until any regional development is completed, was determined to be the development of ground water in Rehoboth, Massachusetts to meet Bristol County's needs through the year 1995. At that time, any additional supplies needed could be obtained through additional ground water development or through connection with a regional system.

The measures described in the above paragraphs were included in all of the intermediate alternatives, and are thus included in the costs of the alternatives. The major portions of the plans where differences occur are described below:

a. Alternative 1: Includes construction of Big River Reservoir initially, augmented by a flood skimming diversion at Flat River Reservoir by the year 2020. Big River would be developed to a maximum water supply pool elevation of 292.0 NGVD for a safe yield of 25 mgd. The flood skimming diversion at Flat River Reservoir would add 13 mgd to the system safe yield. Treatment facilities at Big River would be built with a capacity of 55 mgd. An additional 3 mgd of ground water supplies in Rehoboth, Massachusetts, would be developed in phases to meet the needs of Bristol County. Estimated construction cost of this plan, not including real estate or relocation costs, is $83,100,000.

b. Alternative 2: Includes development of Big River Reservoir to elevation 292.0 NGVD maximum water supply pool level. Flood skimming of the Moosup River, developed by 2020, would increase Big River's safe yield of 25 mgd by an additional 17 mgd. Treatment facilities at Big River would have a capacity of 60 mgd. The future needs of Bristol County would be met by construction of a transmission main and pumping station connecting the Providence system to the Bristol County supply system. Estimated construction cost for Alternative 2 is $103,000,000 not including real estate and relocations.

c. Alternative 3: Big River Reservoir would be constructed as in Alternatives 1 and 2, and a flood skimming diversion of the Wood River would provide 18 mgd, giving a total safe yield of 43 mgd. Treatment facilities at Big River and transmission facilities to serve Bristol County would be built as in Alternative 2. Construction cost of this alternative is estimated at $102,500,000, not including real estate or relocation costs.

d. Alternative 4: Big River Reservoir would be constructed with a maximum water supply pool elevation of 300.0 NGVD, providing 36 mgd safe yield. Treatment facilities would have a capacity of 55 mgd, and ground water development in Rehoboth, Massachusetts would serve Bristol County, as in Alternative 1. The estimated construction cost of Alternative 4, not including real estate and relocation costs is $81,700,000.

Comparative Assessment and Evaluation of Plans. The intermediate alternatives were studied to determine impacts of each. The various impacts were assessed to allow comparative evaluation of the alternatives, resulting in a selected alternative to be considered in the detailed multipurpose plan formulation.

All of the alternatives could be expected to create various impacts, both temporary and permanent. Air quality, noise levels and water quality would be adversely affected in construction areas during construction of structural measures. Construction activities would cause wind-blown dust and exhaust emissions from equipment, and dam construction would impact on water quality downstream unless precautionary measures were taken. All of these impacts would be temporary in nature.

Certain long-term impacts would be associated with all of the alternatives. Beneficial impacts include the provision of safe, dependable water supply to the study area, thus minimizing threats to public health and safety, social well-being and regional development, that are associated with water shortages. The demand modification program will reduce future demands allowing structural measures to be less intensively developed and thus less costly.

Adverse impacts of a long-term nature would be felt in the areas slated for reservoir development. Inundation of wetlands, forestland and open land would reduce wildlife habitat and recreational opportunities associated with these areas. However, mitigation measures would be undertaken to minimize these adverse effects. Demand modification would create few adverse social impacts as measures would be voluntary for the most part. However, structural measures for each plan would require the acqusition of real estate at each site and easements for construction of facilities.

Significant impacts associated with each of the four intermediate alternatives are presented below:

a. Alternative 1: Aqueduct construction by cut and cover methods would create both environmental and social impacts. Wetlands ecosystems and stream water quality would be adversely impacted and access to roads along the transmission route would be interrupted. These impacts would be temporary.

The Flat River flood skimming diversion would cause impacts on the area environment due to fluctuating pool levels, reduced downstream flows, and clearing for pumping station construction. Economic impacts would be felt by downstream water-using industries, due to the reduced flows. Another economic effect would be that, since droughts cannot be forecasted, much unnecessary pumping would be undertaken during normal operation of the flood skimming facilities.

Ground water development in Rehoboth, Massachusetts would entail temporary adverse environmental impacts which are not highly significant. Interstate institutional arrangements would be necessary, which could be a major social impact.

b. Alternative 2: Significant impacts of this alternative are similar to those under Alternative 1. Differences occur in the diversion facilities proposed and in the method of serving Bristol County.

The Moosup River diversion reservoir would eliminate some local cold water stream fishery, and reduced downstream flows would adversely effect aquatic resources below the dam. Interstate institutional arrangements would be required for the diversion of flows from an interstate river basin, as the Moosup River flows into Connecticut. Temporary environmental effects from construction include decreased water quality downstream and increased noise and dust in the area of the facilities. Social disruptions would occur in towns that the pipeline passes through.

The pipeline serving Bristol County from the Providence system would cause temporary impacts, during construction, interfering with shipping on the Providence River and affecting organic biota in the areas of all three river crossings. Local streets in the areas of pipeline construction would be detrimentally affected by construction.

c. Alternative 3: Impacts of this alternative are similar to those associated with Alternative 2, with the difference being that the diversion to Big River Reservoir would be from the Wood River watershed. Diversion facilities constructed on the Wood River would cause temporary degradation of water quality due to increased turbidity. Reduction of downstream flows by the diversion would have long term adverse water quality effects and would also affect stream habitat. Wildlife habitat would also be temporarily disrupted in the areas of pipeline construction.

d. Alternative 4: Impacts associated with this alternative are similar to those of Alternative 1. The major difference is that a flood skimming diversion at Flat River Reservoir would not be built, so the adverse impacts associated with the diversion would not be felt. Big River Reservoir would be developed more extensively, but the larger reservoir would only cause minimal increased impacts over those already occurring at the site.

Conclusions

The impacts of the four alternatives, presented above, were analyzed and comparatively evaluated to determine the plan that would best fulfill the planning objectives and be most acceptable to the public. All four alternatives are feasible solutions to the area's water supply problems, but Alternative 4 emerged as the best choice.

Three of the alternatives required diversions in addition to Big River Reservoir to meet future needs. The land takings, construction activities, and institutional arrangements necessitated by the diversion proposed under Alternatives 1, 2 and 3 would create adverse environmental and social impacts not caused by Alternative 4, as well as being more expensive to implement than the provisions of Alternative 4.

Alternatives 2 and 3 were much more expensive than Alternatives 1 and 4, and would create more adverse environmental and social impacts, so Alternatives 2 and 3 were ruled out.

Alternative 1 also creates more widespread impacts than Alternative 4. The present recreational usage of Flat River Reservoir raised questions about the possibility of degrading water quality in Big River Reservoir by diverting lower quality water from Flat River Reservoir. This possibility, along with the other adverse impacts of the diversion, ruled out Alternative 1.

Alternative 4 represented the most efficient plan of the four water supply alternatives studied. It also caused less adverse environmental and social impacts than the other alternatives. It was thus chosen for further evaluation as the water supply alternative to be included in the analysis of detailed multipurpose plans.

For more detailed descriptions and information on the water supply alternatives formulated in preliminary planning, see Appendix B, "Plan Formulation."

FLOOD DAMAGE REDUCTION

Management Measures

Potential measures for flood damage reduction can be divided into regulatory measures and corrective measures. Regulatory measures do not reduce or eliminate the threat of flooding, but rather regulate the use and development of the flood plains, lessening the potential for flood damage and loss of life. Corrective measures are designed to modify the natural flood regime to protect individual structures or entire areas from flooding.

Regulatory measures include the National Flood Insurance Program, which provides flood insurance to property owners in flood prone areas, provided that State and local governments restrict future development in the affected areas. Flood plain regulations, such as zoning controls and building codes, could restrict new floodway area uses to help prevent increases in flood heights. Land use programs can restrict the amount and type of development in the flood plain. Other regulatory measures include urban renewal, which can allow flood prone areas to be rebuilt to withstand flooding; tax incentives to landowners, to encourage the preservation of open space in the flood plain; public open space acquisition,

which can insure that flood plains remain open and available for public use.

Corrective measures include land treatment, an effective tool in controlling streambank erosion in areas where land use patterns are changing from agricultural to residential or other urban types. Reservoirs can store floodwaters temporarily to reduce flood peaks and then release them slowly. Walls and dikes of concrete or earthen construction can be used to confine floodflows to the channel or floodway. Hurricane barriers protect low-lying, heavily developed areas from storm-induced tidal surges. Stream modifications can increase the hydraulic efficiency and flood carrying capacity of waterways by such methods as widening and deepening channels, eliminating abrupt turns and oxbows, removing dams, and diverting floodflows. Floodproofing and relocation protect individual buildings and their contents by modifying or moving the structure.

In addition to regulatory and corrective measures, a No Action program was considered. Such a program would entail no Federal participation, assuming that all communities would control growth in their flood plains to meet the requirements of the National Flood Insurance Program.

A more detailed description of possible flood damage prevention measures is given in "Attachment 1" of this report.

Analysis of Plans Considered in Preliminary Planning

The regulatory and corrective measures discussed above, as well as the No Action plan, were evaluated on their own merits, and those not considered feasible or implementable, or those measures socially or environmentally unacceptable, were eliminated from further consideration.

Initial Screening. Land treatment measures in the area near Big River were retained as a possible adjunct to development of a reservoir there. Throughout the rest of the basin, erosion and sedimentation problems did not warrant land treatment measures.

Reservoirs were investigated throughout the basin, with only the Big River Reservoir project having the potential for substantial benefits. Modification of Scituate Reservoir was rejected as too costly for the additional flood control storage provided. Reservoir management programs, on the other hand, were reserved for further evaluation at Scituate and Flat River reservoirs.

Hurricane barriers to alleviate tidal flooding were considered, and rejected, at the mouth of the Pawtuxet and at the entrance to Pawtuxet Cove. The proposals would be too costly and environmentally harmful.

Several types of stream improvements were considered. Removal of dams was rejected, as all of the proposals were either impractical or environmentally unsound. Channel modifications were dropped, as they

would not solve major problems, and were impractical to deal with minor problems in the basin. Intrabasin diversion schemes were investigated but none were justified. An interbasin diversion seemed viable for the West Warwick/Cranston area of the mainstem, and it was retained for further consideration.

Floodproofing and relocation was found to warrant further evaluation throughout the basin, as were all regulatory measures and the No Action plan.

Advanced Screening. Measures retained after the initial screening were further analyzed to determine their effectiveness. A nonstructural program was analyzed first due to public interest. Structural and future action programs were also analyzed.

The nonstructural plan utilized flood proofing as a major element, and involved the application of evaluation criteria to determine when and where it could be effectively applied. Such criteria as depth of design floodwaters, type of building construction, and esthetics of proposed measures were applied to the analysis. Costs of flood proofing were developed for both 100-year and Standard Project Flood (SPF). Benefits were likewise calculated, with B/C ratios of .10 and .04 for 100-year and SPF conditions, respectively, showing the economic infeasibility of floodproofing alone as a solution to the basin's flood problems. This measure was retained to be used in combination with others.

Structural flood control programs considered at this stage included two wall and dike systems and two possible diversion projects.

The wall and dike protection plans entailed 12 local protection projects in three communities, but were found to be economically unjustified. However, the analysis showed that local projects at Warwick and Elmwood Avenues warranted further study.

Diversions were considered for the Natick Dam and Pontiac Dam on the mainstem. Both proposals were developed for a number of different designs, but only the Natick Diversion, with a rock tunnel, could be economically justified.

Future action programs of three types were found to be viable. Construction of Big River Reservoir, management of Scituate and Big River Reservoirs as a system, and erosion control measures at the Big River site were all plans that could be implemented by local interests.

Nonstructural flood proofing, although economically infeasible as an independent measure, was retained for consideration in conjunction with the Natick Diversion and the Elmwood Avenue and Warwick Avenue local protection projects. Reservoir construction, reservoir management and land treatment measures were retained as future action measures, and No Action and regulatory programs were retained for consideration as supplements to specific corrective measures.

Assessment and Evaluation of Detailed Plans. Ten detailed plans were formulated to address the basin's flood problems with a wide range of possible solutions.

Four plans (Plans A, B, C and G) included the Natick Diversion, at two different tunnel diameters. Three of these plans also included local protection projects at Warwick Avenue and/or Elmwood Avenue. All of the plans developed high annual benefits, but all were dropped due to lack of public acceptance, arising from public concerns over environmental impacts in Greenwich Bay from the diversion.

Plan D involved the Warwick and Elmwood Avenue local protection projects, alone, deleting the Natick Diversion. Cost sharing for this plan was not acceptable to local sponsors, so it was dropped.

Plan E involved provision of flood control storage of the proposed water supply reservoir on the Big River. The reservoir would be built by non-Federal interests under this plan. This plan had limited effectiveness in reducing overall damages, and was dropped due to the large residual losses expected.

Plan F was the No Action program, and did not effectively meet the planning objectives due to the large residual losses expected. It was thus dropped.

Plans H and I included Big River Reservoir, as a Federally constructed multipurpose project, and local protection for downstream areas. Plan I, including Warwick Avenue Local Protection and the Norwood Land Bank, was the more efficient of the two, and was retained.

Plan J was the nonstructural plan, involving flood proofing, relocation and regulatory measures. It proved to be extremely expensive and was economically unjustified.

Recommended Plan. Plans H and I were the only plans to meet planning objectives and be economically, socially and environmentally acceptable. As noted above, Plan I was the more efficient plan, and was therefore the recommended plan. The Warwick Avenue Local Protection project was dropped since local support was lacking. The Norwood Land Bank, a major portion of the plan, would involve relocating residents of the Norwood area of Warwick, and developing the land as a park. This part of the plan has strong local support, and appears to be urgently needed. In light of the need for improvements in the area, the Norwood Land Bank is being studied for implementation under the Flood Control Act of 1948, Section 205, which provides continuing authority for small flood control projects. Implementation of the Norwood Land Bank would be greatly expedited under the 205 authority as compared to authorization in conjunction with the rest of the comprehensive water resources plans developed in this study. The Norwood Land Bank proposal is thus not included in the description, impact assessment or evaluation of the detailed plans, nor are costs associated

with it included under the multi-purpose plans developed under this study. For a complete description of flood control plan formulation, including a detailed description of the Norwood Land Bank, see "Attachment 1" of this report.

RECREATION

Management Measures

Potential recreational sites and activities to meet projected needs were analyzed for a region including that area within an hour's drive, about 40 miles, from the Big River site.

Existing use patterns and expected trends in recreation development, along with associated demographic factors, were analyzed to determine the appropriateness of recreational activities developed at the Big River site and other potential sites.

Projected development trends for the State showed that the Big River area would be likely to remain undeveloped and a desirable recreation area, throughout the study time frame. Its location close to the metropolitan area would increase its desirability. Enhancement of the natural attributes of the site was deemed a logical approach to recreational development of the local area.

Potential activities for development of the Big River site include swimming, camping and picnicking, wildlife and freshwater fisheries, boating and extensive outdoor recreation.

Swimming needs can be met by development of new areas at ponds and lakes as well as improvements to existing areas to enlarge or protect them from erosion and deterioration.

Camping and picnicking facilities, in short supply now, could be protected against encroachment, and new areas could be developed to meet increased demands.

Acquiring wetlands and upland wildlife management areas can enhance wildlife and freshwater fisheries recreation opportunities, including hunting and fishing. Providing access to these lands and to ponds and streambanks can also increase recreational opportunities.

Boating needs can be met by providing new launching ramps and allowing access to environmentally acceptable areas for boating.

Extensive outdoor recreation includes nature study, wilderness camping, informal picnicking and trail uses such as hiking, trail biking, and cross counrty skiing. These activities generally require fairly large amounts of land per person, and could be enhanced by the provision of limited public access to water supply watersheds, multiple use of trails, and scenic rivers legislation.

Plans of Others

The State of Rhode Island has identified major recreation needs of the State in its Plan for Recreation, Conservation and Open Space, June 1978. This plan is also Rhode Island's Statewide Comprehensive Outdoor Recreation Plan (SCORP). The plan makes recommendations to meet statewide recreation goals, and several of its recommendations are pertinent to this discussion:

- Provide fresh water swimming opportunities in the west and east metropolitan areas.

- Meet picnicking deficiencies in all regions.

- Provide accessible facilities for and promote use of multi-season recreational pursuits.

Development of Recreation Options

The recreation activities described above were combined into packages representing several levels of recreational development for the Big River site. Projected demands at the site are only a small portion of overall statewide demands, but have a large impact on local supply and demand. Thus, plans were developed to address primarily local needs.

The Big River site is presently being used informally for many recreational activities, but this condition could not be expected to continue should a reservoir be built, as the character of the site would change reducing the scope of some activities, enhancing others. Demand for recreational activities will increase at the site if a reservoir is built, as improved facilities would generate demand.

Three use level options have been developed for the Big River site, ranging from no admittance to a large scale facility.

Option I would prohibit all access to the site for recreation. Existing and future demands would have to be transferred from the site and absorbed by other recreation facilities in the area.

Option II would satisfy most future recreation needs by providing boating, fishing, hunting, swimming, hiking, horseback riding and picnicking. The Zeke's Bridge area, on Flat River Reservoir would be utilized for boating, fishing, picnicking and swimming. The Big River Reservoir recreation area would be developed for picnicking, shoreline fishing, and access to multipurpose trails. Carr Pond would be developed for picnicking and shoreline fishing. This option attempts to meet the "without condition" recreation needs, while minimizing water quality impacts due to recreation activities.

Option III includes all the activities in Option II and adds some activities and areas to provide a maximum recreation development plan for the reservoir. Additional facilities at Big River Reservoir (boating), Carr Pond (swimming, boating, trails), Phelps Pond (swimming, picnicking), and Hungry and Harkney Hills (camping) allow this plan to meet projected demands including those generated by reservoir development.

Analysis of Recreation Options

Impacts of the three recreation options were assessed with regard to the identified problems and needs. Major impacts would be felt in the local area.

Option I would create shortages for most recreational activities in the local area, creating negative impacts for some activities. Boating and hunting are the activities most negatively affected. As access to the site is prohibited, no on-site demands are met. Some environmental quality factors, such as water quality in the reservoir, and fish and wildlife habitat, would be positively impacted by this option.

Option II is essentially a mitigation plan for recreation, as it provides a level of recreation approximately equal to what would have existed without reservoir development. Thus, other local areas would avoid overcrowding under this option. However, shortages in capacity would be experienced in swimming and boating, due to the demand-generating effect of reservoir construction. Water quality effects are expected to be minimized, as intensive recreation activities are outside the watershed.

Option III can not only meet all projected local demands, including the effects of demand generation, but also provides some excess capacity to absorb statewide demands for some activities. According to past experience, Option III would not have any further water quality impacts than Option II, and would more fully exploit the recreational potential of the site.

Conclusions

The three plans considered for recreation represent three clear-cut management options for development of the Big River site. Option I, by prohibiting development, would not meet recreation needs for the area. Option II provides a level of development which would mitigate lost recreation opportunities due to reservoir development. Option III provides the maximum recreation development plan for the site, and has a positive impact on local recreation opportunities.

Option III, as the most efficient development, has been chosen as the recreation plan to be carried forward in the development of water resources management plans for the study area. More detailed information on the formulation of recreation plans is contained in Appendix H, "Recreation and Natural Resources."

ASSESSMENT AND EVALUATION OF DETAILED PLANS

In this section, detailed multipurpose plans are evaluated economically, socially and environmentally to determine the beneficial and adverse impacts of each. The degree of planning objective fulfillment of each is determined. Trade-off analyses are performed to analyze the comparative contributions of the alternative plans. Mitigation requirements, implementation responsibilities, and public views are also outlined for each plan as a further basis for comparison. The evaluation performed in this section provides the information leading to the designation of the NED, EQ and tentatively selected plans in the next section of the report.

Costs for the detailed multipurpose plans were estimated based on January 1979 price levels, using an ENR index of 2870. For more information on the costs of each plan, including the time phasing of costs, see Appendix J, "Economics."

PLAN A

Plan Description

Water Supply. Study area demands of 127 mgd average day and 222 mgd maximum day in 2030 would be met by the implementation of a demand modification program, development of ground water in Burrillville, Glocester and Rehoboth, Massachusetts and by development of Big River Reservoir.

A comprehensive demand modification program, including water conservation education, distribution of water saving devices, institution of building code restrictions, and leak detection and repair programs, would reduce water supply needs by about 16 mgd on the average day and 28 mgd on the maximum day in 2030.

Ground water development in Burrillville and Glocester would serve Glocester and Foster, respectively. Foster's needs would be met by developing 1.0 mgd in Glocester in two phases, 0.5 mgd in 1990 and 0.5 mgd in 2010. Glocester would be served through the Pascoag Fire District, with 1.0 mgd in 1990 and 1.0 mgd in 2010.

The Bristol County Water Company, serving Barrington, Bristol and Warren, would meet its needs through development of ground water in Rehoboth, Massachusetts. Immediate development of 3.0 mgd would be necessary to meet present demands, with 2.0 mgd developed in 1995 and 2.0 mgd in 2015 to meet future demands through the end of the study time frame.

The primary element of this plan is the development of Big River Reservoir on the Big River in Coventry and West Greenwich. The reservoir would be located just upstream of the Flat River Reservoir and would provide 36 mgd safe yield. The dam site would be located where Harkney Hill Road crosses the Big River, with a maximum height of 70 feet and a

total length of 2,240 feet. When filled to the design maximum water supply pool elevation of 300.0 NGVD, the reservoir would inundate approximately 3,200 acres of forestland and streams. Flood control storage would increase the maximum pool level to 303.0 NGVD with the top of dam at 312.0 NGVD.

Along Route 95 in the Division Street area, construction of an impervious blanket to control seepage from the impoundment would be necessary. The impervious embankment fill would be 8,000 feet long with an 8-foot minimum thickness and would also entail construction of three dike sections for a total length of 2,400 feet, built to elevation 312.0 NGVD in certain areas adjacent to Route 95 where the natural hillside does not reach that elevation.

A chute-type spillway 400 feet in length would be located next to the north abutment of the dam and would discharge directly into Flat River Reservoir. Water treatment facilities with a 55 mgd capacity would be constructed on the northeast side of Hungry Hill, adjacent to Route 3. An 84-inch diameter tunnel would transport the treated water approximately 6.7 miles to a connection with the existing PWSB system in West Warwick.

The approximately 8,300 acres of state-owned lands surrounding the reservoir would be utilized for recreation and mitigation of natural and cultural resources impacts created by the project. Primary roads would be relocated as necessary to maintain continued use of through roads.

Flood Damage Reduction. Flood control storage equivalent to six inches of runoff from the watershed would be added to the water supply pool. Potential flood stage reductions would vary according to the type and location of the storm conditions, but would generally be larger on the South Branch and upper mainstem, and less on the lower mainstem. For a 100-year frequency event, flood control storage at Big River Reservoir wold reduce flood stages by 1.6 feet at the Washington Gage, on the South Branch just below Flat River Reservoir; by 1.8 feet at the Natick Dam in West Warwick on the upper mainstem; by 1.2 feet at the Cranston USGS Gage on the middle mainstem; and by 0.8 feet at Warwick Avenue, on the lower mainstem. Reductions from a Standard Project Flood would be 2.4 feet at the Washington Gage; 2.7 feet at the Natick Dam; 2.3 feet at the Cranston USGS Gage; and 0.7 feet at Warwick Avenue.

Recreation. Future recreational needs of the study area would be met by development at the Big River site of facilities for boating, fishing, hiking, horseback riding, hunting, picnicking and swimming, as described under Option III. The Zeke's Bridge area, outside the watershed on Flat River Reservoir, would be developed for boating, fishing, swimming and picnicking. The Big River Reservoir recreation area would include picnicking, shoreline fishing, boating and access to a multi-use trail system. Carr Pond would be developed for swimming, picnicking, shoreline fishing, boating and trails, with additional swimming and picnicking provided at Phelps Pond. Camping would be provided on Hungry and Harkney Hills and hunting areas would be accessible from the south side of the reservoir. These facilities could meet all projected recreation demands expected for the year 2020.

Facilities proposed for Plan A are shown on Plate 8.

Impact Assessment

Plan A has both beneficial and adverse impacts associated with it. Adverse impacts include inundation of approximately 3,200 acres of stream/forest environment at the Big River Reservoir site, with accompanying losses to fish and wildlife habitat, cultural resources, and wetlands. However, mitigation measures would be taken to minimize these losses.

Downstream flows into Flat River Reservoir would be reduced by about 43 percent on the average. Ground water levels in the vicinity of the Big River Reservoir would increase by a small amount. The actual increase cannot be estimated with a high degree of accuracy, thus monitoring of ground water levels would be required after the reservoir is filled. Corrective action would then be taken if high ground water levels actually caused damage to existing development in the area. Approximately 30 million cubic yards of sand and gravel deposits in the impoundment area will be lost to possible mining development. Construction activities would cause temporary adverse effects on air quality and noise levels in the Big River project area. Relocation of about 440 residents located in the impoundment area would be necesssary.

Subsurface easements would be necessary along the routes of transmission facilities, including the tunnel from Big River Reservoir. Transportation facilities in the vicinity of the proposed reservoir would be permanently affected. Road relocations would be included in any development plan to minimize the adverse impacts of any road closings.

The inclusion of flood control storage at Big River Reservoir will create some additional negative impacts beyond those associated with the water supply impoundment. However, these are basically insignificant in view of the temporary nature of flood control storage, and the fact that additional clearing or road relocations would not be made necessary by it.

The recreational activities allowed under this plan would cause some impacts on the local area natural resources, such as damage to vegetation on trails, but with proper management techniques these impacts are expected to be held to a minimum.

Minor environmental and social impacts would be created by ground water development in Burrillville, Glocester and Rehoboth, Massachusetts. The construction of wells, pumping stations and transmission mains would create temporary noise and air quality impacts in the local areas of these activities. Temporary environmental damage may also occur in the immediate vicinity of ground water development, but this is also expected to be minor.

Beneficial impacts include provision of water supplies to meet projected 2030 water requirements for the study area, which would allow long term population and economic growth to occur as expected without constraints due to lack of water. Flood control storage at Big River Reservoir would provide protection to flood prone areas along the South

Branch and mainstem Pawtuxet River. Recreation facilities at the reservoir site would satisfy most of the 2020 recreational needs for the study area.

Evaluation and Trade-Off Analysis

Plan A meets all of the planning objectives in an efficient manner, providing water supply, flood control and recreation benefits to the study area. It does not have a high level of acceptance, however, in the area of the proposed reservoir. It may become more acceptable with time, as water shortages worsen.

This plan would avoid the ill effects of such shortages by preventing them from occurring. It would enhance regional development, social well-being and the overall environmental quality of the study area. Aesthetic degradation due to water shortages would not occur.

The proposal for Bristol County to utilize ground water development to meet its needs would entail less environmental impacts in the Rehoboth, Massachusetts area than the combination of ground water and surface water development which would occur there under the without condition.

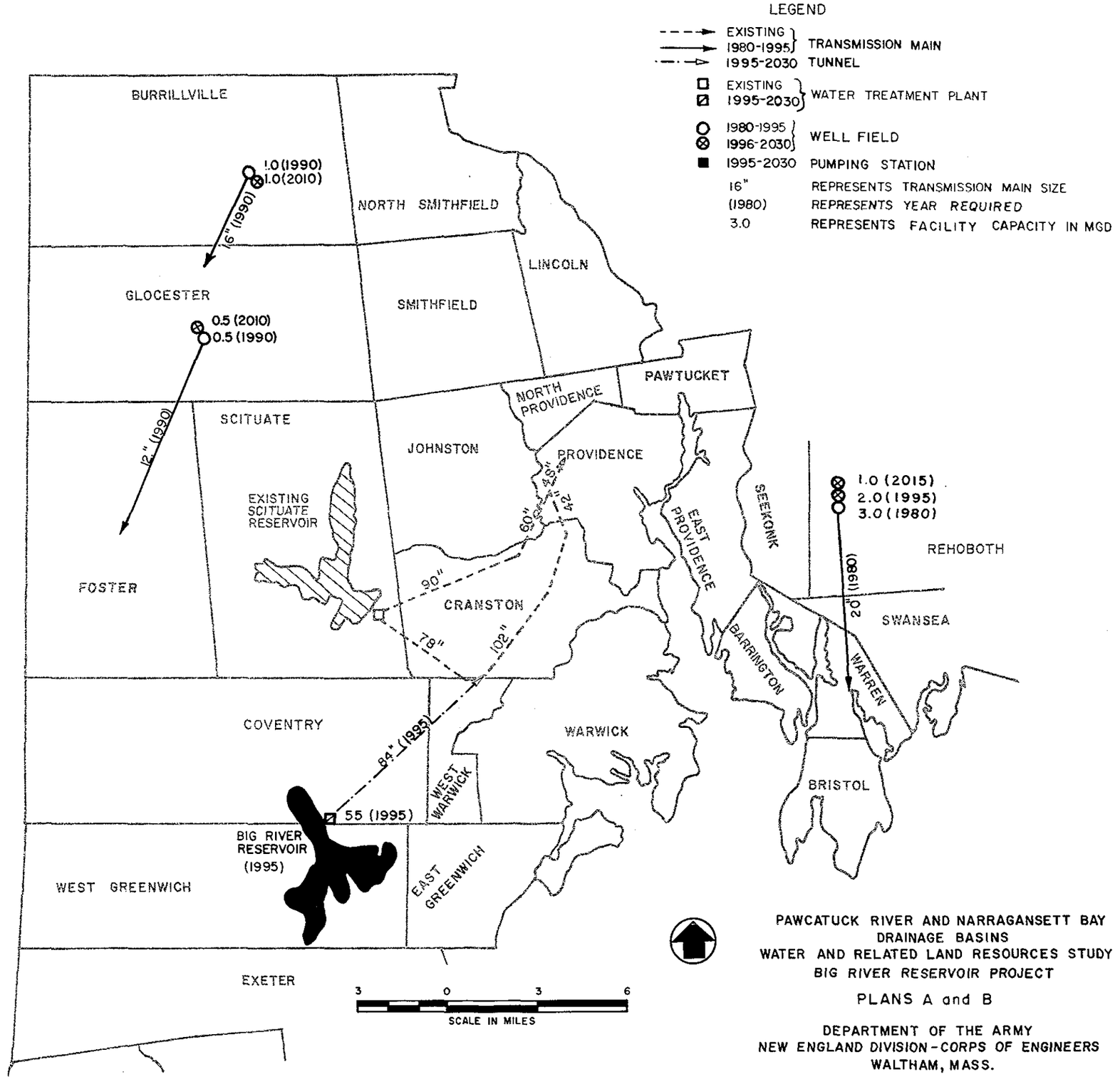
Environmental impacts in the local area of the reservoir development are important. Adverse environmental effects such as loss of wetlands and forestland would be mitigated to some extent. However, the limited mitigation efforts undertaken to meet legal requirements would not take full advantage of the positive features of the impoundment to enhance the local environment in the most productive manner.

Primary road relocations mitigate some social impacts due to the impoundment, but still may leave some negative impacts unmitigated that could be relieved if more extensive relocations were undertaken. These differences would only be felt in the local area.

The capability for implementation of the planned surface water development presently exists within the institutional structure of the study area. Inter-community cooperation would be required to implement the various elements in the plan, especially ground water development for Bristol County, where an interstate agreement would be necessary.

Mitigation Requirements

Mitigation of adverse environmental impacts would be required if the Big River Reservoir Project were Federally implemented. Mitigation measures would be intended to offset or ameliorate effects on fish and wildlife and cultural resources. Among the techniques employed would be preservation and development of ideal wildlife habitat areas and widespread employment of intensive wildlife management techniques to produce special and supplemental wildlife foods and cover. Access control and development would ensure use of wildlife resources for both harvest (hunting) and enjoyment (nature studies) purposes.



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PLANS A and B

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 8

Mitigation of impacts on cultural resources may be required; the extent of impacts would be determined in further studies. Mitigation techniques could include relocation of culturally important buildings, dike protection of archaeological sites, architectural recordings or archaeological recording measures.

Adverse impacts on downstream riparian water users due to reduced streamflows in the South Branch of the Pawtuxet would have to be mitigated. Downstream releases from Big River Reservoir and Flat River Reservoir could be coordinated so as to minimize adverse effects, and compensation would be made for losses suffered by downstream industries.

Fluctuation of Flat River Reservoir pool levels and associated impacts on waterfront property must also be mitigated, as would reduced waste assimilation capacity in the Pawtuxet River. However, all mitigation of downstream impacts such as these are not included in the mitigation costs cited. Advanced engineering studies will determine the costs of such efforts.

Implementation Responsibilities

Cost Allocation. All measures other than Big River Reservoir are single purpose water supply, thus all costs for these measures, including ground water development and demand modification, are allocated to water supply. Costs for the multi-purpose Big River Reservoir development are allocated to water supply, flood control, and recreation. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 1,817,000
Water Supply	46,000,000
Recreation	146,000
TOTAL	$47,963,000

All costs are present worthed values based on January 1979 price levels.

Cost Apportionment. The apportionment of costs between Federal and non-Federal interests reflects Federal water resources policies, which consider water supply storage the primary responsibility of non-Federal entities. However, a Federal interest may be found in projects which include other purposes. Thus, ground water and demand modification measures are the responsibility of non-Federal interests with no Federal cost sharing. Costs of the Big River Reservoir Project, as a multipurpose project, may be apportioned between Federal and non-Federal interests. Two cost sharing policies may be followed:

a. Existing Cost Sharing Legislation: Under existing legislation, construction costs allocated to flood control would be paid by the Federal Government. Lands, easements, rights-of-way, and relocations, and operation and maintenance costs would also be a Federal responsibility. Costs apportioned to water supply would be paid by the Federal Government, and repaid in full by the State of Rhode Island. Lands and damages would be repaid in the same manner as the construction costs. Operation and

maintenance costs would be a non-Federal responsibility. Separable costs of recreation would be split, 50 percent paid by both Federal and non-Federal interests, except operations and maintenance costs associated with recreation, which would be apportioned in the same manner as flood control costs.

b. President's Cost Sharing Policy: Under this policy, the State of Rhode Island would contribute five percent of construction costs allocable to flood control and recreation, and 10 percent of costs for water supply. In addition, the local sponsor (in this case assumed to be the State) would contribute 20 percent of flood control construction costs and 50 percent of separable recreation construction costs. Costs allocated to water supply would be repaid in full by the project sponsor. Lands and damages are shared in the same manner as construction costs for all project purposes. Operation and maintenance costs would be a Federal responsibility for flood control and non-separable recreation, and a non-Federal responsibility for water supply and separable recreation costs.

The Federal and non-Federal share of the construction costs for the two cost sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worthed values.

	Existing Legislation	President's Policy
Federal	$ 1,923,000	$ 1,462,000
Non-Federal	35,447,000	35,908,000
Total Plan First Cost	$37,370,000	$37,370,000

Federal Responsibilities. Federal interests would be responsible for the Big River Reservoir development including the reservoir, recreation facilities and mitigation measures instituted as a result of the Big River development.

The Federal Government would design and prepare detailed plans, construct the project, and share in the cost of the proposed project as set forth above. Construction would be contingent on Congressional authorization and funding and on the receipt of the non-Federal share of the total project cost.

Federal responsibilities would also include any assistance necessary to non-Federal interests for implementation of a demand modification program.

The Federal Government would also provide assistance to localities participating in the National Flood Insurance Program, including technical assistance and establishment of flood plain management measures. These responsibilities are described more fully in "Attachment 1."

Non-Federal Responsibilities. Non-Federal responsibilities under this plan include construction of treatment facilities at Big River Reservoir and construction of the transmission main from the Big River treatment facilities to the connection with the existing PWSB system.

Ground water development in Glocester, Burrillville and Rehoboth, Massachusetts would also be a non-Federal responsibility, as well as operations and maintenance of all facilities.

Public Views

Some elements of the public have voiced concern over the choice of Big River Reservoir to meet the study area's water supply needs, questioning the need for additional surface water development and fearing the potential environmental impacts of any such project. Overall, though, the Big River development appears to have a moderate to high level of acceptance, with State and local water resources agencies favorably disposed towards the project, and growing public awareness of the limits of existing supplies, brought about in part by water shortages during the summer of 1980 in some parts of the study area.

Other elements of this plan are not as controversial as the Big River development, and have not drawn as much public comment. Flood storage at the impoundment is favored should Big River Reservoir be built, and recreational development is generally favored, although some question its compatability with water supply storage. The proposed ground water development and demand modification program have not met with any objections.

PLAN B

Plan Description

Water Supply. This plan entails the same basic water supply development as Plan A, except that the Big River Reservoir would include a higher degree of development to enhance environmental quality as well as to minimize disruption of the social well-being of affected communities.

Demand modification and ground water development would be undertaken in the same manner as described under Plan A.

Development of Big River Reservoir would be the same as in Plan A, except that additional construction would be undertaken to develop environmental habitats in some specific locations as shown on Plate 9. Suitable dikes and control facilities would be constructed to retain water to Elev. 300.0 NGVD for creation of wetlands and waterfowl habitat in those specific areas. Likewise, all roads within the impoundment area would be reconstructed or relocated to permit continued use of both primary and secondary highways in the affected area. Only Division Street would be abandonded under this plan due to the necessity of construction of an impervious blanket to reduce leakage in this area of the reservoir. Vehicular traffic disruption caused by the abandonment of Division Street would be of minor social impact, which the extensive road relocations would help mitigate. Accessibility to recreation areas would be improved by the road relocations as some of the sites are not immediately adjacent to existing roadways.

Environmental enhancement of several existing gravel mining areas, such as replanting of vegetation, would be undertaken to preserve and develop wildlife habitat areas. Stripping and grubbing of selected inundated areas of the reservoir would also be undertaken to improve water quality and enhance aquatic biota habitat.

Flood Control. Under this plan, flood control storage at the Big River Reservoir would be the same as in Plan A.

Recreation. Recreation development would be the same as under Plan A.

Regional facilities proposed for Plan B are shown on Plate 8.

Impact Assessment

Impacts associated with Plan B are similar to those of Plan A. Major differences in impacts of the plans occur to fish and wildlife, transportation facilities, and recreation opportunities.

Plan B includes additional mitigation measures at the Big River site compared to those of Plan A. The various measures proposed under this plan would provide more positive environmental impacts at the Big River site. The quantity and quality of available fish and wildlife habitat would be increased under this plan by the creation of subimpoundments, stripping and grubbing of selected areas and the relocation of strip mining areas.

Transportation facilities in the local area would benefit from the additional road relocations proposed, allowing the maintenance of the existing road network, thus preventing overuse of roads not otherwise affected by reservoir construction. Recreation opportunities would be increased, as the additional road relocations would create improved access to the Big River site.

Other beneficial and adverse impacts of the two plans are virtually the same; for a description of these impacts see Plan A.

Evaluation and Trade-Off Analysis

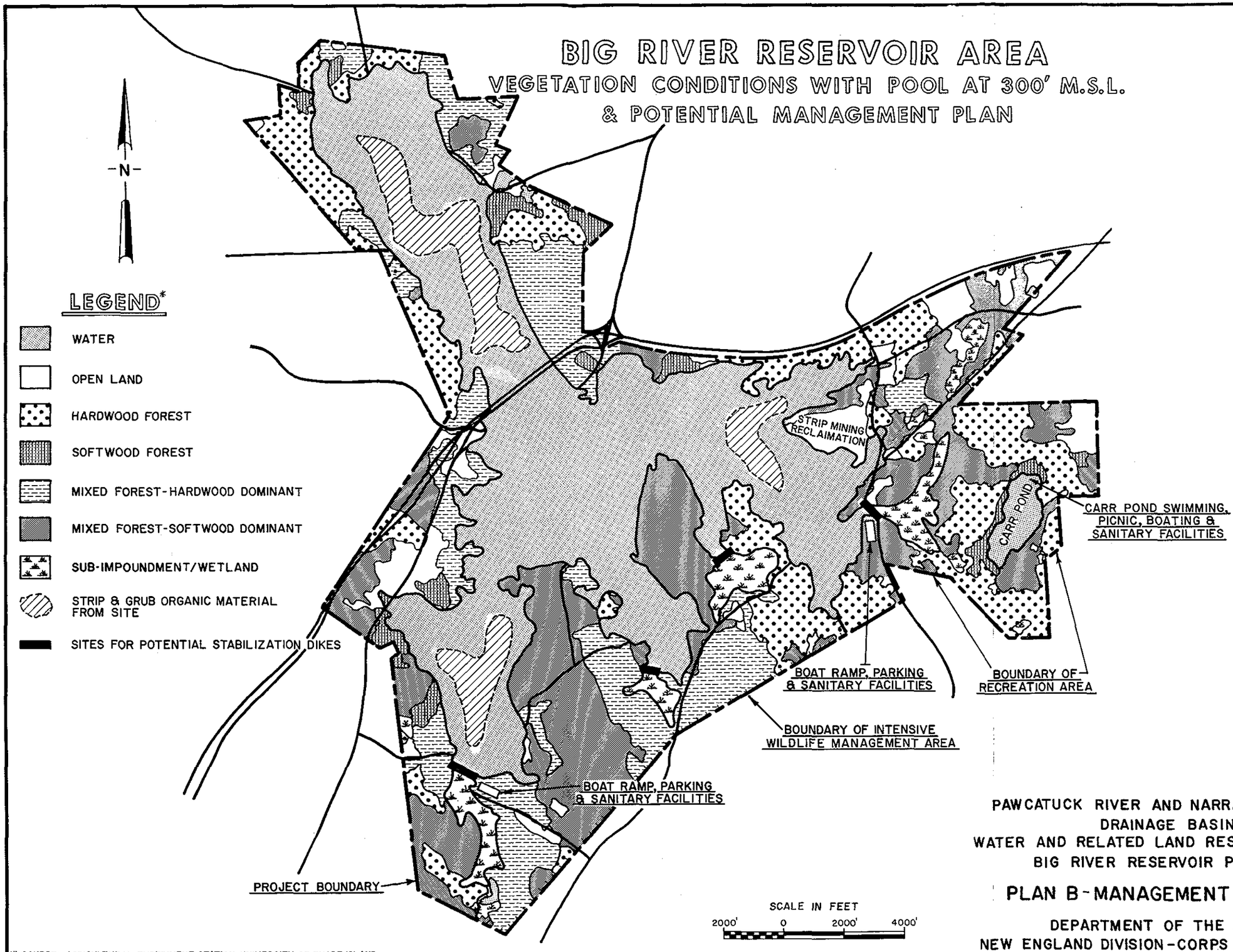
Plan B would meet water supply, flood control, and recreation planning objectives in an efficient manner. This plan is generally similar to Plan A and thus has similar impacts and trade-offs made.

By preventing water shortages, this plan provides positive effects on regional development, social well-being and environmental quality in the study area, as noted in Plan A.

Environmental impacts of ground water development for Bristol County are the same under this plan as under Plan A, and likewise compare favorably to the without condition.

BIG RIVER RESERVOIR AREA

VEGETATION CONDITIONS WITH POOL AT 300' M.S.L.
& POTENTIAL MANAGEMENT PLAN



* SOURCE: AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF RHODE ISLAND
DEPT. OF FORESTRY-KUPA & WHITMAN

PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PLAN B-MANAGEMENT MEASURES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 9

Localized environmental effects of Big River Reservoir would be mitigated to a greater degree under this plan than with the other plans. The additional fish and wildlife mitigation techniques employed at the Big River site would provide for more positive impacts on fish and wildlife, to the extent that negative fish and wildlife impacts would be minimal and would be offset by comparable positive impacts produced by the mitigation measures.

Relocation of both primary and secondary roads will have more positive effects on local transportation facilities and recreation opportunities than under the other plans.

The addition of the above-mentioned mitigation features in the Big River area make the reservoir development under this plan somewhat more costly than the other plans.

Institutional arrangements are incomplete under this plan to the same extent as indicated for Plan A.

Mitigation Requirements

For Plan B, mitigation of impacts will be identical to the requirements of Plan A. The same techniques will be employed to meet mitigation requirements. Additional measures are not required, but some will be employed to enhance local environmental quality. For a full description of the mitigation requirements of this plan, see Plan A.

Implementation Responsibilities

Cost Allocation. As in Plan A, all measures except Big River Reservoir are single purpose water supply, and the reservoir is multi-purpose. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 2,422,000
Water Supply	51,597,000
Recreation	194,000
TOTAL	$54,213,000

All costs are present worthed values based on January 1979 price levels.

Cost Apportionment. Costs are apportioned in the same manner as for Plan A, to reflect the two cost sharing policies described in Plan A. The Federal and non-Federal share of the construction costs for the two cost sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worthed values.

	Existing Legislation	President's Policy
Federal	$ 2,563,000	$ 1,948,000
Non-Federal	41,057,000	41,672,000
Total Plan First Cost	$43,620,000	$43,620,000

Federal Responsibilities. Federal responsibilities under this plan would be the same as under Plan A. Cost apportionment would be as described above.

Non-Federal Responsibilities. Responsibilities of State and local agencies and interests wold be similar to those required under Plan A. Cost sharing would be as described above.

Public Views

Public opinion regarding this plan is essentially the same as that towards Plan A, as the differences between the two plans are not in the overall scope of the facilities developed. The relocation of additional roads, and the environmental enhancement measures included in this plan would be likely to draw favorable local public opinion.

PLAN C

Plan Description

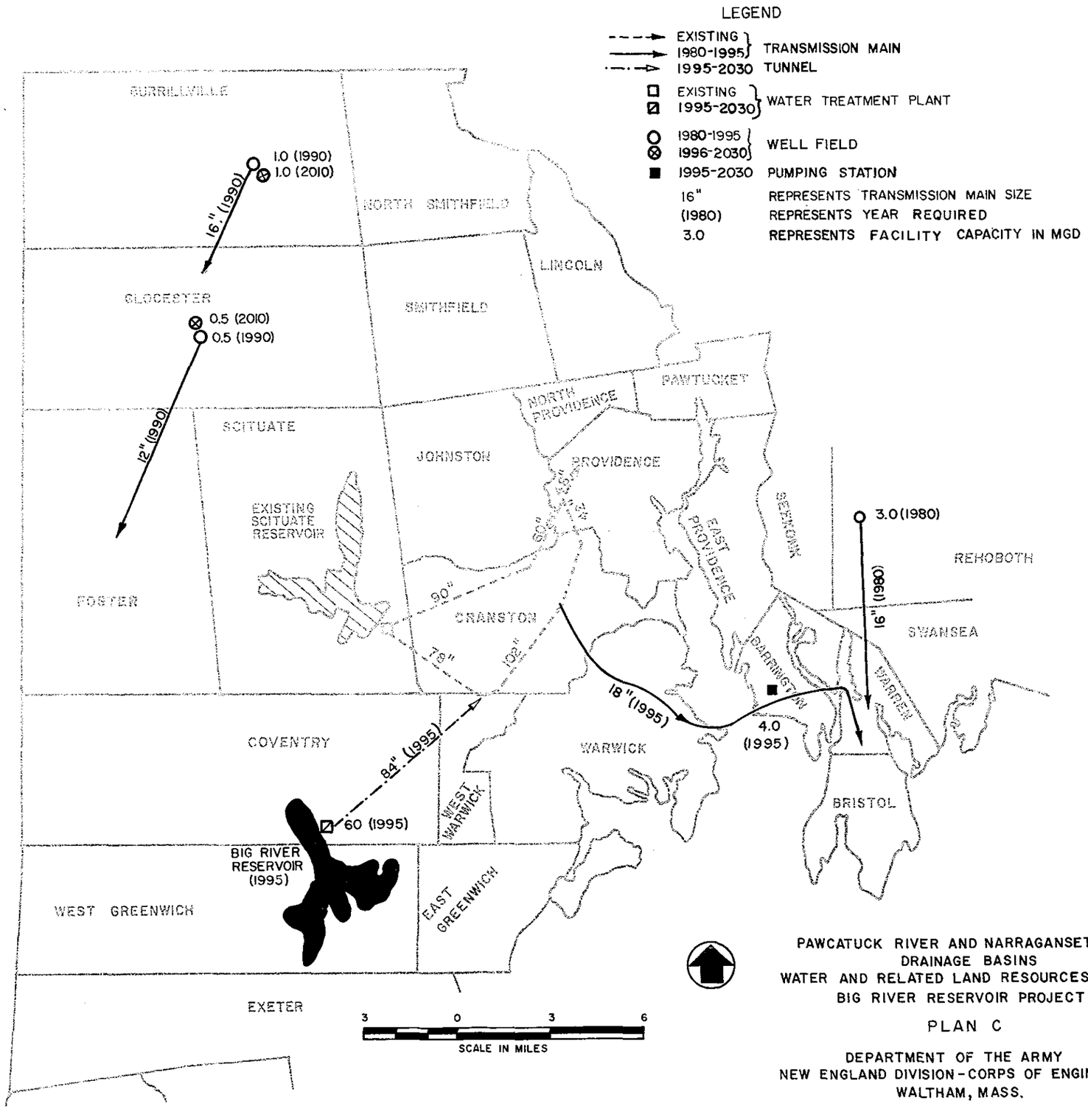
Water Supply. This plan is similar to Plan A, except that it provides a more regional system for the study area. Ground water development to serve Bristol County would not be as intensive as in Plan A. Facilities to deliver water from the Providence water system would be required to meet future demands of the Bristol County Water Company system. Facilities developed under this plan are shown on Plate 10.

Development of ground water to serve Foster and Glocester would be the same as under Plan A, as would the demand modification efforts undertaken for this plan.

Ground water development would be undertaken in Rehoboth, Massachusetts to meet present needs of Bristol County until the time when water from the Big River Reservoir system becomes available. An immediate development of 3.0 mgd would be required to supplement existing supplies to meet average and maximum day demands through 1995.

Development of Big River Reservoir would be similar to that proposed in Plan A, except that treatment facilities of 60 mgd capacity would be built. All other aspects of the Big River development, including mitigation and relocation efforts, would be the same as under Plan A.

The Bristol County Water Company system would receive water from the Providence water system through a pipeline originating in Cranston. The



PAWCATUCK RIVER AND NARRAGANSETT BAY
DRAINAGE BASINS
WATER AND RELATED LAND RESOURCES STUDY
BIG RIVER RESERVOIR PROJECT

PLAN C

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION - CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 10

transmission main would be approximately 12.4 miles in length, crossing the Providence River and Warren River before terminating at the existing distribution system in Warren. A booster pumping station of 4.0 mgd capacity would be built in Barrington at the site of the existing Nyatt Road water treatment facilities. The pipeline and pumping station would be built in 1995 along with the Big River Reservoir development.

Flood Control. Flood control storage under this plan would be the same as in Plan A.

Recreation. Recreation facilities development would be the same as under Plan A.

Impact Assessment

Impacts occurring under Plan C are similar in many ways to those associated with Plan A. Development of a reservoir at the Big River site would have the same effects under this plan as in Plan A. Ground water development for Foster and Glocester would impact these areas to the same extent as in Plan A.

Differences in impacts would occur in the Bristol County development, to noise, air quality, and natural resources. Less intensive ground water development in Rehoboth, Massachusetts would cause less construction related noise and air quality degradation than caused by the staged development in Plans A and B.

Construction of the Providence-Bristol County connector pipeline would cause some impacts on noise and air quality along the pipeline route. These impacts would not occur under Plans A and B. However, both noise and air quality impacts are temporary, and would cease when construction activities end.

The Providence-Bristol County connector would also create major impacts on natural resources, particularly disruptions to marine biota in upper Narragansett Bay due to the excavation required to place the pipeline just beneath the surface of the bay floor. These disruptions would occur in the area between Conomicut Point in Warwick and Nyatt Point in Barrington.

The impacts described here, which represent differences between this plan and the other two plans, relate generally to temporary effects, so the differences are not major. The most important difference is in the disruption of marine life due to the pipeline construction, since the effect on the ocean floor would be more long lasting than other construction-related impacts. However, the marine impacts would also be temporary, and would cease to be a factor sometime after construction, when regrowth has occurred in the pipeline area.

Other beneficial and adverse impacts of Plan C are the same as for Plan A; for a description of these impacts see Plan A.

Evaluation and Trade-Off Analysis

Plan C would meet all study objectives in an efficient manner. This plan incorporates elements similar to Plan A, except in the Bristol County area. Regional development, social well-being, and environmental quality of the study area would be enhanced by the plan in the same ways as the other plans. However, greater adverse environmental impacts are created by the regional water supply elements of this plan than under the other plans. These impacts are fairly localized in the area of the connector between Providence and Bristol County.

Impacts associated with ground water development for Bristol County are less severe under this plan than under Plans A or B or the without condition, all of which entail greater development in the Rehoboth area than this plan.

This plan is more costly than Plan A, but less costly than Plan B. Additional ground water development in Rehoboth appears less expensive than the Providence connector proposed under this plan. However, institutional arrangements are much more complete for the Providence connector. Existing agreements between Providence and Bristol County authorized construction of the pipeline, whereas no arrangements have been made for transmission of any amount of ground water from Rehoboth to Bristol County. Provision of ground water would require passage of legislation in Massachusetts, which could be largely dependent upon the expressed wishes of Rehoboth and nearby communities regarding their own use of the available resources. The likelihood of such authorization is greater if the amount of ground water requested is kept to a minimum, as proposed in this plan.

Mitigation Requirements

Mitigation requirements under this plan would be the same as under Plan A.

Implementation Responsibilities

Cost Allocation. As in Plans A and B, all measures except Big River Reservoir are single purpose water supply, and the reservoir is multi-purpose. Estimated construction costs of this plan are allocated as follows:

Flood Control	$ 1,863,000
Water Supply	49,289,000
Recreation	149,000
TOTAL	$51,301,000

All costs are present worthed values based on January 1979 price levels.

Cost Apportionment. Costs are apportioned in the same manner as for Plan A, to reflect the two cost sharing policies described in Plan A. The

Federal and non-Federal share of the construction costs for the two cost sharing policies follow. Cost of land for the Big River development is not included, as the land is already in State ownership. All costs are present worthed values.

	Existing Legislation	President's Policy
Federal	$ 1,971,000	$ 1,498,000
Non-Federal	38,737,000	39,210,000
Total Plan First Cost	$40,708,000	$40,708,000

Federal Responsibilities. Federal responsibilities under this plan would be the same as under Plan A. Cost apportionment would be as described above.

Non-Federal Responsibilities. Responsibilities of State and local agencies and interests would be similar to those required under Plan A, and also include construction of the Bristol County connector and the associated pumping station in Barrington. Cost apportionment would be as described above.

Public Views

Public views on this plan are much the same as those regarding Plan A. The only differences between the plans are in elements that are relatively uncontroversial, on which public views are not known.

COMPARISON OF DETAILED PLANS

In this section, the plans evaluated in the previous section are compared, and the NED and EQ plans are chosen. The tentatively selected plan is also determined based on the best mix of elements of the detailed plans.

COMPARISON OF DETAILED PLANS

The three plans describe in detail possible ways of meeting the area's pressing water resource needs. All three plans do contain several common elements within the framework of the combination of the single purpose water supply, flood control and recreation alternatives.

A demand modification program was included in all plans, as it was shown to be both environmentally beneficial and economically sound as a water supply management measure. Ground water development for Foster and Glocester was likewise included in all plans as the most feasible alternative to meet those towns' needs. All plans contained surface water development at Big River Reservoir as the most practical way to provide the necessary water supply for the overall study area.

Differences between the plans are significant in several areas, especially between the proposal for Plan C and the other two plans. Impacts of the plans are similar in many ways, but also illustrate the different mixes of the elements in the plans.

Environmental impacts on the Big River site are major, as the local environment will be drastically altered, from small streams and ponds to a large open water lake. The impacts of such a change are not entirely negative, however, and mitigation measures undertaken under Plans A and C would be sufficient to offset most adverse effects on local fish and wildlife. Plan B includes more extensive measures to enhance environmental productivity, thus would produce more benefits to the local environment, particularly on fish and wildlife habitat.

Plan C would cause disruptions to marine life in a part of Narragansett Bay, a major environmental impact not seen in the other plans. However, Plans A and B would provide for more ground water development in Rehoboth, Massachusetts, creating more impacts there than would be caused by Plan C. The significance of impacts of additional ground water withdrawal under Plans A and B is not known, but some additional lowering of ground water levels would probably occur, which could have significant effects on surface water flows in the area.

All three plans have moderate acceptability, with State agency support for the Big River development. All of the plans can meet the planning objectives efficiently and effectively, and are relatively adaptable to alternative futures. Plan C is the most implementable plan, as necessary actions are more complete, and interstate agreements may be more likely under that plan's proposals. However, only a small part of

the necessary actions and investments have been completed for any of the plans. Plan C is less reversible than Plans A or B, but none of the plans has a high degree of reversibility, due to the structural measures involved in all of the plans.

RATIONALE FOR DESIGNATION OF THE NED PLAN

An NED plan addresses the planning objectives in the way which maximizes net economic benefits. National Economic Development is optimized by the plan that is most economicallly efficient, as shown by the benefit to cost ratio, and which has the optimum scale of development. The NED Plan includes all measures with net positive economic benefits.

Plan A has been selected as the NED plan based on a B/C ratio of 1.24, as compared to the B/C ratios of Plans B and C of 1.12 and 1.16, respectively. Plan A includes the most efficient development of water resources to meet the study needs, as shown by the measures included in this plan. Demand modification to reduce demands is much more economical than development of new sources of supply. Ground water development for Foster and Glocester is cheaper than extending the Providence system to meet their needs. Likewise, ground water development for Bristol County is the most economical alternative to meet that area's needs. The Big River Reservoir development has been scaled to achieve maximum economic benefit, and only essential mitigation measures have been included. In addition to being economically efficient, this plan is also responsive to other evaluation criteria, such as acceptability, effectiveness and stability.

RATIONALE FOR DESIGNATION OF THE EQ PLAN

An EQ plan addresses the planning objectives in a way which emphasizes aesthetic, ecological and cultural contributions. Beneficial environmental quality contributions are made by preserving, maintaining, restoring or enhancing the significant cultural and natural environmental attributes of the study area.

Plan B has been selected as the EQ plan for the study area. This plan contains those elements that are EQ maximizing, while still meeting all the study planning objectives.

Plan B incorporates demand modification as a measure to reduce future water supply development needs. Beneficial environmental effects also occur from reduced wastewater flows to be treated. Individual subsurface disposal systems would also benefit from decreased consumption. Less environmental damage would be likely to result from malfunctions and overloading of these systems if demands were reduced.

Ground water development for Foster, Glocester and Bristol County is the most environmentally sound method of supplying these areas, as construction of long pipelines would not be necessary.

At the Big River Reservoir development, mitigation measures in addition to those required would be undertaken to enhance the area's fish and wildlife habitat value. Additional roads relocated under this plan would allow better access to the management area, and would minimize social disruptions in the local area.

RATIONALE FOR TENTATIVELY SELECTED PLAN

The tentatively selected plan is designed to be the best possible mix of measures to meet the planning objectives and respond to the goals of NED and EQ. Trade-offs are made in cases where NED and EQ measures are not compatible, and thus the tentatively selected plan is developed to respond to the needs of the study area, while reflecting public desires and legal, institutional, environmental, social and economic constraints applicable to any proposals.

Plan C is the tentatively selected plan for the study area. This plan is not the most efficient economically, nor is it the best plan environmentally, but existing institutional arrangements and constraints have been taken into account in this plan, resulting in the most implementable alternative among the detailed plans.

Several measures included in this plan are common to both the NED and EQ plans, as they were considered best from both points of view. Any such measures were included if also considered the most implementable alternative.

Ground water development for Foster and Glocester was included in both the NED and EQ plans and is also a part of the tentatively selected plan. Water demand modification provides both environmental benefits and positive economic factors by deferring the need for additional supplies, treatment capacity and wastewater treatment facilities until later.

The tentatively selected plan includes Big River Reservoir with the required mitigation and road relocations, as indicated in the NED Plan (Plan A). The mitigation measures implemented offset any negative impacts of the reservoir, and the expense of additional mitigation and relocation actions was not felt to be justified for the additional benefits gained.

The major difference between the tentatively selected plan and the other two plans is in the proposal for a pipeline connecting Bristol County with the Providence system, which also includes reduced ground water development in Rehoboth, Massachusetts. This proposal is more costly than the more extensive ground water development in the other two plans, but the pipeline across Narragansett Bay does not require any interstate cooperative agreements. Implementation authority already exists for pipeline connecting the Providence Water Supply Board system with that of the Bristol County Water Company. The lesser amount of ground water developed under this plan is more likely to obtain approval from Massachusetts, as a surplus would remain to accommodate any possible future needs of Rehoboth and nearby communities.

In addition to being more readily implementable, the pipeline proposal may actually entail less adverse impacts overall than full-scale ground water development in Rehoboth. Environmental impacts caused by the pipeline would be temporary, whereas the possibility exists that full-scale development of ground water may create adverse effects on local surface water resources in the Rehoboth area, due to drawdown of the water table. However, further detailed studies will be required to determine the impacts of ground water development in Rehoboth.

PROPOSED PROJECT FOR FEDERAL IMPLEMENTATION

Implementation of the Tentatively Selected Plan would require the combined efforts of Federal, State and local interests to develop various components of the plan. Development of ground water required to meet the immediate needs of Bristol County and long term needs of Foster and Glocester would be undertaken by local water supply agencies. Implemenetation of demand modification measures would be undertaken at the State or local level, using public or private organizations and voluntary efforts by residential users.

The multipurpose Big River Reservoir would be eligible for Federal implementation under present law. However, Federal involvement would be limited to construction of the reservoir and dam, outlet works, spillway, raw water conduit to the treatment plant, dike sections, recreational facilities, and cultural and natural resources mitigation. Other elements of this project, including treatment and transmission facilities, would be built by non-Federal interests. Complete detailed descriptions of the components of the proposed project for Federal implementation are presented in Appendix G, "Design and Cost Estimates" and Appendix H, "Recreation and Natural Resources." Project first costs and annual costs are summarized in Table 7.

Each of the project purposes - flood control, water supply, and recreation - have been evaluated to determine the economic justification of the proposed project. Project costs are allocated between the purposes to assure equal sharing in the savings from multiple-purpose development. Costs were allocated using the Separable Costs - Remaining Benefits (SCRB) method, as detailed in Appendix G, "Design and Cost Estimates."

All of the approximately 8,300 acres considered for implementation of the proposed Federal project are publicly owned by the State of Rhode Island through its Water Resources Board. These lands were originally purchased for the purpose of developing the Big River for water supply storage, including lands for watershed management and water quality control.

TABLE 7

SUMMARY OF FIRST COSTS AND ANNUAL COSTS

PROPOSED PROJECT FOR FEDERAL IMPLEMENTATION

PROJECT FIRST COSTS
(January 1979 Price Levels)

BIG RIVER RESERVOIR	$17,024,000
RECREATION	550,000
MITIGATION	940,000
CONTINGENCIES	3,703,000
ENGINEERING AND DESIGN	2,666,000
SUPERVISION AND ADMINISTRATION	1,777,000
REAL ESTATE COSTS	30,800,000
TOTAL PROJECT FIRST COST	$57,460,000
INTEREST DURING CONSTRUCTION	[illegible]
TOTAL INVESTMENT	$65,935,000

ANNUAL COSTS

INTEREST AND AMORTIZATION	$4,867,000
OPERATION AND MAINTENANCE	370,000
MAJOR REPLACEMENTS	1,000
TOTAL ANNUAL COSTS	$5,238,000

The proposed multipurpose Big River Reservoir would inundate an area of 3,240 acres at the maximum water supply pool elevation of 300.0 NGVD. The approximately 5,000 acres remaining would be utilized to provide 1) development of flood control storage, 2) development of recreation facilities, 3) measures for mitigation of cultural and natural resources impacts, 4) watershed management and water quality control, and 5) development of water treatment and related facilities.

Details of real estate requirements and costs are presented in Appendix G, "Design and Cost Estimates." Details of proposed recreation facilities and measures for natural resources mitigation are presented in Appendix H, "Recreation and Natural Resources."

Alternative Projections - Sensitivity Analysis

As noted in the Without Condition Profile, significant differences exist between the 1975 and 1979 Statewide Planning Program population projections for the study area. Projected water supply demands based on the population projections likewise show significant variations between the two projections. Average day demand in 2030 based on the 1979 projections would be about 109 mgd, or a 23 percent reduction from the 142 mgd figure based on the 1975 projections. Maximum day demands would be similarly affected, with 2030 maximum day demands reduced by 24 percent, from 250 mgd to 191 mgd, when based on the 1979 population projections as opposed to the 1975 projections. If the demand modification techniques included in the Tentatively Selected Plan are implemented to the degree of effectiveness assumed under that plan, the need for additional water supply development at Big River Reservoir would be pushed back from 1995 to approximately 2025.

The reduced growth indicated by the 1979 projections when compared to the 1975 projections would probably have some effect on flood plain growth thus affecting growth in future flood losses. However, flood damage reduction needs already exist in the Pawtuxet Basin, so any change in population projections would not delay the need for any proposed flood damage reduction measures.

Recreation needs would probably be reduced to some extent should the reduced population projections hold, but the effect on time-phasing of the proposed facilities is difficult to estimate, due to these facilities' small impact on statewide recreation needs. The initial development will probably still be needed in 1995, but additional recreation development may be altered to delay the timing and reduce the scope of such development.

Economics of the Proposed Project

The tangible economic justification of the proposed project for Federal implementation was determined by comparing the equivalent average annual costs (interest, amortization, operation and maintenance and major replacement costs) with the estimated equivalent average annual benefits

expected to accrue over the economic life of the project. An interest rate of 7-3/8 percent was used to obtain comparable equivalent average annual costs and benefits which were estimated at January 1979 price levels. A complete discussion of the economic evaluation of all alternative water resources plans is presented in Appendix J, "Economics."

Estimated Project Costs. The total project first cost is estimated to be $57,460,000 and includes the cost of construction, lands and relocations, recreational facilities, and mitigation requirements for cultural and natural resources. The cost breakdown of the proposed multiple-purpose project and for alternative single- and dual-purpose projects is shown in Table 1 in Appendix G, "Design and Cost Estimates." Cost allocation for the proposed multipurpose project is summarized in Table 8.

Operation and maintenance costs of $370,000 per year were estimated on the basis of experience with other projects. Interest during construction was estimated for a four-year construction period by applying an interest rate of 7-3/8 percent for 2 years. Annual costs were computed on the basis of a 100-year project life with major replacement of equipment based on a useful life of 30 years.

Estimated Annual Benefits. Benefits derived from the proposed project for Federal implementation include average annual damages prevented by flood control storage at Big River Reservoir, water supply benefits and recreation benefits. Average annual benefits resulting from flood control storage are estimated at $782,000 in reduced flood damages to the communities of Coventry, West Warwick, Cranston, and Warwick. Water supply benefits were estimated on the basis of a single-purpose water supply project at the Big River site and amount to $5,104,000 annually. Recreation benefits were determined based on a comparison of annual attendance for recreational activities at the site with and without the Big River project. The average annual benefits resulting from the project's recreational facilities are estimated to be $66,000, and are presented in detail in Appendix H, "Recreation and Natural Resources."

Benefits for water supply and flood control are described in detail in Appendix J, "Economics."

Economic Justification. The comparison of average annual benefits and average annual costs results in a benefit to cost ratio of 1.14 for the entire multiple-purpose project as shown in the summary presented in Table 8. Benefit to cost ratios for each of the project purposes are 1.46, 1.10, and 1.20 for the flood control, water supply and recreation components respectively. Details of the cost allocations and economic justification are more fully presented in Appendix G, "Design and Cost Estimates."

TABLE 8

SUMMARY OF ALLOCATION OF COSTS
(In $1,000 at January 1979 Price Levels)

MULTIPLE PURPOSE PROJECT

	FLOOD CONTROL	WATER SUPPLY	RECREATION	TOTAL
Project Cost	5,424	51,601	435	57,460
Interest During Construction	800	7,611	64	8,475
Investment	6,224	59,212	499	65,935
Annual Charges:				
Interest & Amortization	459	4,371	37	4,867
Operation & Maintenance	75	277	18	370
Major Replacement	0	1	0	1
Total	534	4,649	55	5,238
Annual Benefits:				5
Flood Control	782			782
Water Supply		5,104		5,104
Recreation			66	66
Total	782	5,104	66	5,952
B/C Ratio	1.46	1.20	1.10	1.14

Division of Responsibilities

Legislative and administrative policies have established the basis for Federal and non-Federal sharing of responsibilities in the construction, operation and maintenance of Federal water resources projects. Cost apportionment under both existing cost sharing legislation and the President's cost sharing policy are explained for the Big River Reservoir development under the Implementation Responsibilities section in the Assessment and Evaluation of Detailed Plans. Other Federal and non-Federal responsibilities are also detailed in that section, for the detailed plans. Other responsibilities relating specifically to the proposed project for Federal implementation are given below.

Federal Responsibilities. The Federal Government, in addition to its responsibilities regarding design, construction and cost sharing in the project, would direct the operation of the flood control element of the project. The Corps of Engineers would set procedures by which local authorities would operate the project's flood control element, under Corps of Engineers direction. Radio communications equipment wold be installed to facilitate Corps direction of flood control activities. Monitoring and

data collection equipment would be installed throughout the watershed to aid in regulating flows. Operation and maintenance of flood control elements are normally a Federal responsibility, so reimbursement would be made to the operating non-Federal agency, by the Federal Government.

It is anticipated that agreements would be made to provide coordination of regulation activities at Scituate Reservoir and Flat River Reservoir in an effort to minimize flood damages in the Pawtuxet River Basin.

Non-Federal Responsibilities. Cost sharing, construction of treatment and transmission facilities, and operations and maintenance of the water supply and recreation portions of the project would be undertaken by non-Federal interests as described in the detailed plans. In addition, flood control operations and maintenance would be undertaken as described above, with Federal reimbursement of those costs.

Cost apportionment between Federal and non-Federal interests for the proposed project for Federal implementation is shown in Table 9.

TABLE 9

COST APPORTIONMENT
(In $1,000 at January 1979 Price Levels)

PROJECT FIRST COSTS

Existing Cost Sharing Legislation

	Federal	Non-Federal	*	Total
Flood Control	5,424	-	-	5,424
Water Supply	-	20,291	30,680	51,601
Recreation	315	-	120	435
Total Project First Cost	5,739	20,291	30,800	57,460

President's Cost Sharing Policy

	Federal	State	Non-Federal	*	Total
Flood Control	4,068	271	-	1085	5,424
Water Supply	-	5,160	16,846	29,595	51,601
Recreation	293	22	-	120	435
Total Project First Cost	4,361	5,453	16,846	30,800	57,460

*Allocated fair market value of State-owned lands.

TABLE 9 (cont'd)

ANNUAL CHARGES
(Same for both policies)

	Interest & Amortization	Operation & Maintenance	Major Replacements	Total
Federal				
Flood Control	459	25	-	484
Water Supply	-	-	-	-
Recreation	26	3	-	29
Total Federal	485	28	0	513
Non-Federal				
Flood Control	-	50 *	-	50
Water Supply	4,371	277	1	4,649
Recreation	11	15	-	26
	4,382	342	1	4,725

*Estimated Operations and Maintenance cost for on-site flood control activities; would be reimbursed by the Federal Government.

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1980

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Feasibility Study of Big River Reservoir
West Greenwich, Rhode Island

The responsible lead agency is the U.S. Army Corps of Engineers, New England Division.
The responsible cooperating agency is the U.S. Fish and Wildlife Service.

Abstract: The proposed Big River Reservoir area is located in Coventry and West Greenwich, Rhode Island within the state-owned Big River Management Area. The proposed Big River dam would be located at the confluence of Big River and the Flat River Reservoir in Coventry, Rhode Island. It would inundate approximately 3240 acres in the 29.7 square mile Big River watershed. The Corps' study focused on the identification of water supply, flood damage, and recreation problems in the Big River study area, and the formulation of a recommended water resources development and management plan by analyzing the area's needs, concerns, and alternative solutions. Out of seven methods studied to satisfy the water supply needs in the study area, groundwater, demand modification (water conservation), and surface water development were determined as the most feasible alternatives. Through analysis of the intermediate study results, three basic plans were developed utilizing portions of these alternatives to provide for the projected water supply needs of the study area to the year 2030. Plan A consists of implementation of a demand modification program throughout the study area, development of groundwater sources in Foster, Glocester, and Rehoboth, MA to serve Bristol County, development of a multipurpose Big River Reservoir, flood damage reduction measures and recreational development. Plan B is similar to Plan A; however, under this plan Big River Reservoir would include additional construction to develop environmental habitats in some specific locations. Plan C is also similar to Plan A except that it provides a more regional system for the study area, groundwater development for the Bristol County area would not be as intensive, and facilities would be required to deliver water from the Providence water system to meet future demands of the Bristol County Water Company system. Flood control and recreation potential were evaluated equally in the three plans. Plan C has been tentatively selected based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

SEND YOUR COMMENTS TO THE
DIVISION ENGINEER BY 1 APR 1981

If you would like further information on this statement, please contact:

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Waltham, Massachusetts 02254
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NOTE: Information, displays, maps etc. discussed in the Big River Main Report are incorporated by reference in the EIS.

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1.0 SUMMARY

1.01 MAJOR CONCLUSIONS AND FINDINGS

The objective of this feasibility study is to arrive at a recommended water resources development and management plan for those communities within the Pawtuxet River basin, one of five major sub-basins comprising the entire Pawcatuck River and Narragansett Bay Study region, and also for those within the legislated service area of the Providence Water Supply Board. Review and analyses of the needs, alternative solutions and concerns of these areas have been the major efforts of the Corps towards the study objective.

Big River was considered early in the study as the most significant study element (Figure 1). It is potentially the structural measure which would most adequately meet the projected needs. Construction of Big River Reservoir would incur significant environmental impacts and thus requires the application of the National Environmental Policy Act (NEPA) in the study. This draft EIS, the Main Report and associated Appendices present the results of the Corps' efforts towards the study objective.

Average water supply needs within the study area are estimated to increase from approximately 72 million gallons per day (mgd) in 1975 to almost 109 mgd in the year 2000 and about 142 mgd by the year 2030. Water deficits resulting from these demand projections would amount to approximately 18 mgd and 51 mgd by the year 2000 and 2030 respectively.

Maximum demands are estimated to increase from approximately 124 mgd in 1975 to 190 mgd in the year 2000 and almost 250 mgd by the year 2030. These demands reflect deficits of approximately 30 mgd and 90 mgd in existing systems projected for the years 2000 and 2030 respectively.

Broad categories of water resource technologies were investigated for the economic and technical potential to meet this need: seawater desalination, weather modification, iceberg transport, wastewater reuse, groundwater, water demand modification, and surface water development. A "No Action" program was reviewed, along with the projected scenario of the "without condition." Groundwater, water demand modification, and surface water were determined to be the most feasible of these technologies.

An evaluation of these potential technologies led to the development of intermediate alternatives for water supply and flood damage reduction measures (Plans A,B, and C). Applicable demand modification available groundwater resources, and potential surface water development including Big River, Flat River, Wood River and Moosup River were studied in detail. Demand modification is predicted to relieve about 11 percent of the estimated 2030 municipal demand. Available groundwater reserves were estimated as able to provide about 9 mgd of additional water supplies. Adequate surface water potential exists to satisfy the total predicted increase. Big River Reservoir would provide about

36 mgd and was chosen as more desirable than the other reservoir sites because of greater potential and environmental and institutional opposition to other sites. Through analysis of the intermediate study results, three basic plans were developed utilizing contributions of these measures to satisfy the projected water supply needs of the study area to the year 2030:

(A) Implementation of a demand modification program throughout the study area, development at groundwater sources in Foster, Glocester, and Rehoboth, MA to serve Bristol County, development at a multi-purpose Big River Reservoir, flood damage reduction measures and recreational development.

(B) Development of Big River Reservoir, demand modification and groundwater development, along with additional construction to develop environmental habitats in specific locations, flood damage reduction measures and recreational development.

(C) Big River Reservoir, demand modification, less intensive development of groundwater for the Bristol County area, and facilities to deliver water from the Providence water system to meet future demands of the Bristol County Water Company system, flood damage reduction measures and recreational development.

In accordance with the Water Resources Council's Principles and Standards and Corps Regulation (ER 1105-2-200), these measures and plans accounted for contributions to National Economic Development (NED), Environmental Quality (EQ), Social Well Being (SWB) and Regional Development (RD) (Appendix B). Through analyses of this "System of Accounts", Plan C has been tentatively selected based on its performance in addressing the identified public concerns and its net positive contributions to the goals of National Economic Development and Environmental Quality.

Basic mitigation recommendations (Appendix H, Vol. IV) have been presented which would offset impacts to terrestrial and aquatic resources. Generally, these plans suggest conceptual measures such as establishing sub-impoundments to regulate water levels and to create wetlands and waterfowl habitat; preserve and develop ideal wildlife habitat areas; employ various intensive wildlife management techniques in some areas to produce special and supplemental wildlife foods and cover to maximize productivity of game species; and implement access control and development to ensure wise human use of wildlife resources for both harvest (hunting and fishing), enjoyment (nature studies) and reservoir water quality protection. A detailed fish and wildlife management plan would be pursued through several avenues: U.S. Fish and Wildlife Service recommendations; State Fish and Wildlife agency recommendations, concerns and needs; and other public (especially State and local agencies) opinions, concerns, needs, and acceptability. It is desirable that the public become involved with the Corps' planning efforts in developing a mitigation management plan. Should the project be authorized for further study, detailed recommendations will be presented in the Final EIS with a refined fish and wildlife management plan.

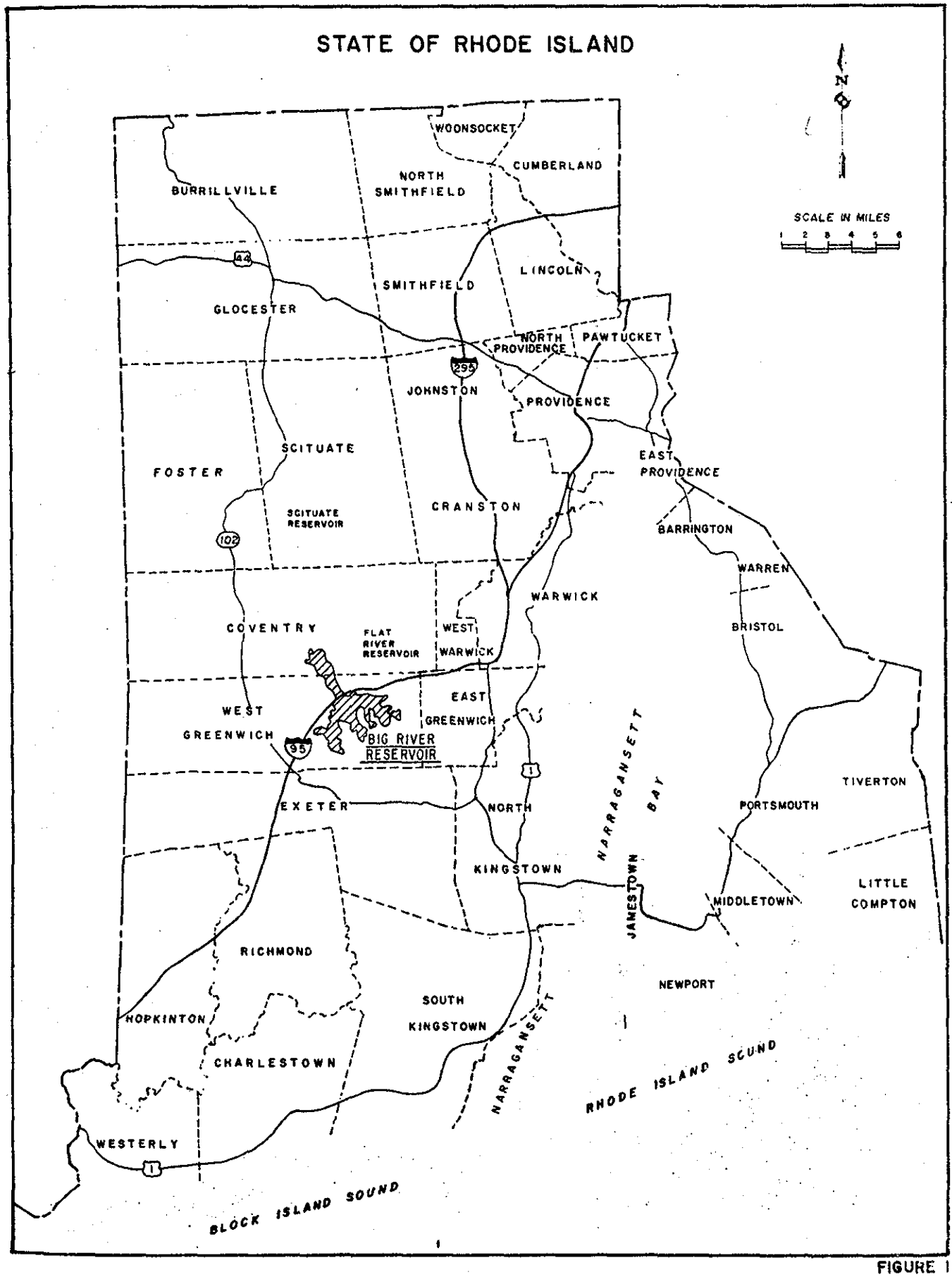

STATE OF RHODE ISLAND
N
SCALE IN MILES
1 2 3 4 5 6
WOONSOCKET
CUMBERLAND
NORTH SMITHFIELD
BURRILLVILLE
44
SMITHFIELD
LINCOLN
GLOCESTER
NORTH PROVIDENCE
PAWTUCKET
295
JOHNSTON
PROVIDENCE
SCITUATE
FOSTER
EAST PROVIDENCE
SCITUATE RESERVOIR
CRANSTON
BARRINGTON
102
WARREN
WARWICK
COVENTRY
FLAT RIVER RESERVOIR
WEST WARWICK
BRISTOL
EAST GREENWICH
WEST GREENWICH
BIG RIVER RESERVOIR
95
1
TIVERTON
EXETER
NORTH KINGSTOWN
NARRAGANSETT BAY
PORTSMOUTH
LITTLE COMPTON
MIDDLETOWN
JAMESTOWN
RICHMOND
NEWPORT
SOUTH KINGSTOWN
HOPKINTON
CHARLESTOWN
NARRAGANSETT
RHODE ISLAND SOUND
WESTERLY
1
BLOCK ISLAND SOUND

FIGURE 1

1.02 AREAS OF CONTROVERSY

Review of the sources and types of concerns within the area revealed areas of disagreement among several of the concerned agencies and interests. These issues of controversy, shown in Table 1 and detailed in Appendix C, were given priority consideration during the Corps' study. It appears that the most significant controversies are related to the multiuse concept, needs for more water supplies, and fiscal and management issues.

1.03 RESOLUTION OF SIGNIFICANT AND CONTROVERSIAL ISSUES

Although some issues are beyond the authority of the Corps to resolve, various studies were conducted to develop recommendations and answers for the more significant questions raised, particularly where controversy was apparent. Such studies and analyses included:

(1) an up-to-date analysis of the water supply needs of Rhode Island. The results of this study are presented in Appendix A;

(2) special studies evaluating the potential of demand modification and groundwater resources available to the study area (Appendices A and B);

(3) examination of multiuse potential of the proposed Big River Management Area and Reservoir. This is presented in Appendix H, "Recreation and Natural Resources;"

(4) special ecological studies to describe the natural resources and social values associated with the Big River Site. Appendix H, "Recreation and Natural Resources," and Appendix I, "Social and Cultural Resources," present the results of these studies. They provide substantive estimates of natural and cultural values which would be lost due to implementation of the Big River Reservoir construction and in some manner, relate these impacts to various alternatives and Statewide resources; and,

(5) the Corps has conducted engineering studies to determine the technical and economic feasibility of the proposed Big River Project. Appendices D (Hydrologic Analysis), E (Water Quality), F (Geotechnical Investigations), and G (Design and Cost Estimates), describe the results of these studies.

Through analyses of these various studies, resource management alternatives which best address the problems of water supply, flood damage reduction, and recreation in the study area were derived. The selected plans were based on the following conclusions:

(1) the eventual need for additional water supplies is evident;

TABLE 1
PUBLIC INTEREST ISSUES - ANALYSIS OF CONTROVERSY

PUBLIC INTEREST CATEGORIES	TYPES OF ISSUES/CONTROVERSY: NEED FOR RESERVOIR ALTERNATIVE ASSESSMENT	FISCAL AND MANAGEMENT	ACCESS AND MULTI-USE OF RESERVOIR	ENVIRONMENTAL CONSIDERATIONS	ECONOMIC/TECHNICAL FEASIBILITY
FEDERAL AGENCIES U.S. Fish & Wildlife Service	*High concern - calls for additional studies*	*No expressed concern* NEC[1]	*High concern - esp. favors access for hunting and fishing*	*Major concern - esp. fish & wildlife impacts & minimization & mitigation of impacts*	NEC
STATE AGENCIES Office of State Planning	Some concern	High concern-esp.over lack of comprehensive State policy on water resources mgmt.-desire State ownership & mgmt.	Concern - question single-use concept	NEC	NEC
RI Water Resources Board	High concern - feel need is already evident,stress avoidance of further delays	Some concern - favor State ownership	Some concern-advocate multi-use w/emphasis on prevelant constraints	NEC	NEC
Dept. Environmental Mgmt.	NEC	NEC	Div.Fish & Wildlife disfavor single-use, desire use for hunting & fishing	Div.Fish & Wildlife, impacts to F&W & minimization & mitigation	NEC
LOCAL GOVERNMENT Providence Water Supply Board	Consider need is evident for Big River & possibly additional sources	Desire that they construct and operate Big River	High concern-disfavor multi-use of reservoir. Feel it would compromise water quality	NEC	NEC
Providence Planning and Urban Development	Consider need is evident	High concern, agree w/PWSB but wish to expand authority & service area in Metropolitan Board	High concern-disfavor multi-use. Agree with PWSB	NEC	NEC
Communities at Big River Site	Concern	High concern-disfavor any future land acquisition.Concern over fiscal/mgmt. as related to town revenues	Some concern-disfavor single-use concept. Locals would be most impacted thereby	High concern-desire knowledge of extent of impacts to local community	Some concern - desire more evidence
INTEREST GROUPS *Environmental*	High concern - calls for additional studies	High concern-esp. desire studies of secondary costs & comprehensive water resource mgmt. policy	High concern-disfavor single-use concept.	Major concern-desire significant env. studies-esp. fauna & flora	Some concern-esp. of water quality and secondary economic impacts
Recreational	Some concern - desire evidence of need	Concern-as related to access & multi-use	Major concern-strongly disfavor single-use concept	High concern-esp. recreational opportunity losses	Some concern - desire more evidence
UNAFFILIATED CITIZENS	Concern-mostly desire better evidence	Concern - mostly who and how	Concern-mostly desire multi-use	Concern - varied, but desire more knowledge	Concern

[1]No Expressed Concern.

(2) demand modification and greater groundwater development are practicable and desirable to help meet these needs. Big River Reservoir alone would not be sufficient to meet the projected needs without effective demand modification or adequate groundwater development or additional surface water supply development;

(3) Big River Reservoir is economically and technically feasible and preferable over development of other surface water sites;

(4) the Corps favors and supports multiuse of the reservoir and adjacent public lands. The recreation analysis (Appendix H) indicates that studies conducted country-wide support recreational use of water supply reservoirs;

(5) analysis of the natural, cultural and economic resources of the proposed Big River project area has identified significant potential impacts which can be minimized and mitigated by appropriate watershed management and the multiuse concept (hunting and fishing); and

(6) the need for reduction of flood damages in the developed areas of the Pawtuxet River Basin.

1.04 ENVIRONMENTAL REQUIREMENTS

Table 2 presents the relationship of the proposed project and study to relevant environmental requirements.

TABLE 2
RELATIONSHIP OF PROPOSED BIG RIVER RESERVOIR STUDY
TO RELEVANT ENVIRONMENTAL REQUIREMENTS

REQUIREMENT TITLE	OBJECTIVE OF REQUIREMENT	NATURE OF STUDY COMPLIANCE	REFERENCE
Fish and Wildlife Coordination Act	Requires coordination with U.S. FWS and State F & W agencies to obtain views and concerns on F & W in relation to potential project - authorized F & W mitigation	Coordination was developed - U.S F & WS planning aid letter considered. State concerns received informally. Mitigation plan being developed	Appendix H, Vol. 4
National Environmental Policy Act	Requires that environmental concerns receive equal consideration to other study elements, especially in alternative review and selection	Preparation of EIS to show how NEPA was utilized in study planning	This document (EIS)
National Historic Preservation Act	Requires investigation and consideration of archaeological and historical resources in project planning	Studies conducted to determine extent of resources and predict impact	Appendix I
Clean Water Act Section 404	Requires evaluation of effects of discharge on aquatic resources, especially wetlands, recreation, and water supply	Evaluation conducted and condition recommended to minimize relevent effects	404 Evaluation
Endangered Species Act	Established and requires consideration of endangered species list.	Potential effect on endangered species or critical habitat thereof evaluated	Appendix H, Vols. 2 & 3
Executive Order (11990) Protection of Wetlands	Emphasizes protection of wetlands in any proposed development	Wetland values studied in proposed project mitigation proposed	Appendix H, Vols. 3 & 4
Water Resources Planning Act	Established Water Resource Council (WRC) and requires compliance with recommendation	Utilized WRC principles and standards during plan formulation	Appendix B
Rhode Island Law (46-14-1) Pollution or Misuse of Drinking Water Source Prohibited	Prohibits discharge of wastes or pollution in Rhode Island drinking water sources; specifically prohibits bathing and swimming	Recreation planning conforms to law	Appendix H, Volume 1

2.0 NEED FOR AND OBJECTIVES OF STUDY

2.01 STUDY AUTHORITY

On 29 March 1968, the Committee on Public Works of the United States Senate adopted a resolution requesting the Board of Engineers for Rivers and Harbors to study the advisability of improvements for flood control, navigation, water supply, water quality control, recreation, low-flow augmentation and other allied water uses within the Pawcatuck River and Narragansett Bay drainage basins (Appendix A, pages 1-2). The study area includes all of Rhode Island (except the south coastal section) a portion of southeastern Massachusetts, and the Pawcatuck River area in Connecticut.

This resolution promulgated the Pawcatuck-Narragansett Bay (PNB) study by the Corps of Engineers, New England Division in 1969, and, in 1978, Governor Garrahy of Rhode Island requested the Corps of Engineers to focus their ongoing PNB study toward a timely evaluation of the feasibility of Big River Reservoir.

Big River Reservoir has been proposed by the Rhode Island Water Resources Board as a primary measure to augment existing water supplies in view of predictions of water supply needs in Rhode Island.

Authorization for this study, along with those studies that indicate the advisability of the Big River site, are discussed further in the Main Report.

2.02 PLANNING OBJECTIVES

The primary objective of this study is to determine the feasibility of the proposed Big River Reservoir to serve as an element in an overall water resources development and management plan for the State of Rhode Island, and to arrive at a recommended plan consisting of acceptable measures which best satisfy the needs of the study area including flood control and recreation potential. The Main Report discusses further the planning objectives and formulation process.

2.03 PUBLIC CONCERNS

The most significant concerns elicited from the public participation program include the following:

(1) a comprehensive, realistic analysis of the need for Big River Reservoir and other potential sources in light of more up-to-date population and water demand predictions;

(2) appropriate consideration be given to alternatives, especially demand modification and groundwater development;

(3) development of a comprehensive water resources management plan that proposes a wise and conservative use of natural resources;

(4) due consideration and study of the potential of a reservoir such as Big River for multiple uses, i.e., recreation rather than the "single-use" (water supply only) policy that prevails now at most New England water supply systems, including that of the Providence Water Supply Board;

(5) analysis, consideration, and presentation of the environmental impacts associated with Big River Reservoir, i.e., destruction of wildlife, effects on groundwater and migrating aquatic life; and,

(6) a thorough study of the technical and economic feasibility of the Big River site for a large reservoir, i.e., adequacy of watershed to fill and operate the reservoir, water quality in the reservoir, necessity for diversions, adequate foundation (potential leak problem).

3.0 ALTERNATIVES

3.01 ALTERNATIVES CONSIDERED DURING THE PLANNING PROCESS

3.01.1 General

Alternative technologies reviewed by the Corps of Engineers' study for meeting the needs of water supply in the Providence metropolitan study area include: icebergs, wastewater reuse, weather modification, desalination, groundwater, water demand modification, and surface water. Each of these alternatives is discussed in more detail in Appendix B. In the preliminary investigations (Appendix B) each of these technologies was analyzed independently for generic potential to satisfy the objectives of the study.

Detailed investigations for flood damage reduction measures were carried out for the Pawtuxet River Basin, and have been presented in the interim report to the PNB study "Pawtuxet River Watershed - Flood Control Report." Flood control alternatives have been subsequently proposed and evaluated, and are presented in Appendix B - Plan Formulation.

Three use level options for development of recreation facilities in the Big River Reservoir area are discussed in Appendix H - Recreation and Natural Resources.

3.01.2 Iceberg Harvesting

Recent proposals have indicated that removal and transport of large icebergs from polar regions to areas of water needs is somewhat feasible. The technique, however, involves transportation and storage problems as yet unresolved and the feasibility has not yet been successfully demonstrated. Therefore, this alternative was not considered for further study.

3.01.3 Wastewater Reuse

Water treatment technology has recently made wastewater reuse a viable source of water for many uses; the level and cost of treatment is related to the intended use. Several industrial firms have found it to be economical for quenching, cooling and fire protection. Other applied uses include irrigation, underground water barrier and municipal water supplies. However, municipal water supplies require high quality water for use in the home; the level of treatment necessary to provide this quality of water has to date made wastewater reuse noncompetitive with other available methods of water supply in areas of adequate rainfall. An advantage to wastewater reuse is that poorly treated wastewater discharges and associated pollution would be eliminated. This method is the most environmentally acceptable method known, but is not considered economically acceptable within this study's criteria.

3.01.4 Weather Modification

Rhode Island has adequate rainfall to provide water for all its predicted needs. The problem is storage for safe yields in periods of low rainfall. Rain making techniques such as cloud seeding have shown promise in many areas of the country. However, dry periods would also be the

most likely periods where cloud seeding would be ineffectual. During dry periods, no clouds would be present to seed. This method, although of limited application in the western states for irrigation, shows little promise in New England. The potential environmental impacts of artificially releasing water in one area, and not in others are not fully understood.

3.01.5 Desalination

Methods of desalination include distillation, crystallization, reverse osmosis, and ultrafiltration. A discussion of each is found in Appendix B. Partically all plants in operation today use the distillation process; a few use the membrane and crystallization processes. Desalination shows the most promise as a future source of water supply in arid regions near oceans, especially where operation can be in conjunction with a large power plant whose waste heat can be used as part of the heat source necessary for the distillation process. Major environmental problems associated with desalination are the disposal of wastes (brine) which are high in salts, organic and mineral contaminants, and the high energy requirements of the process.

3.01.6 Groundwater

Groundwater is often the most economical and, if used prudently, one of the least environmentally damaging methods of water supply for residential, agricultural and industrial use. It is usually the least likely to require treatment and least expensive to develop on a small scale.

Groundwater development has historically been most preferable in areas of low rainfall and ample groundwater reserves. Arizona, New Mexico, Oklahoma, Arkansas, Kansas, Nebraska and South Dakota each obtain at least 50 percent of their total water supply from groundwater reserves. In many instances the supplies are being severely overdrawn and are predicted to be unuseable in the near future. In contrast, New Hampshire, Massachusetts, and Rhode Island obtain only about 8 percent each of their total water supply from groundwater, Maine 5 percent and Connecticut only 4 percent. Vermont has higher groundwater usage at about 38 percent, owing to its highly rural population.

Groundwater is regarded as a desirable and reasonable source of water supply in Rhode Island. Unfortunately, available groundwater reserves are not sufficient to significantly offset predicted needs in the study area. Many of the existing aquifers in the study area (and throughout the populated Northeast) have been polluted by improper waste disposal. Estimates indicate that about 13 mgd of good quality groundwater could presently be obtained in the study area (Appendix B).

3.01.7 Water Demand Modification

There are five basic ways to control water demands in contemporary municipal water supply systems: pricing policies, water saving devices, conservation education, restrictive use, and control of system losses. These methods can be used singly or collectively to reduce water use in a municipal system, or, more likely, to curb the ever increasing water use. The Corps study of the potential of demand modification in the Providence area (Appendix B) indicates that implementation of a comprehensive program of water conservation utilizing education, water saving devices, building code restrictions, and leak repair comprise the most feasible plan for implementation in the study area. This type of plan could reduce municipal water use as much as 11 percent by the year 2030.

3.01.8 Surface Water

Surface water use is the oldest and most widespread source of water for public and private uses in the world. Major cities are located along waterways and near lakes not only because of transportation opportunity but also for an adequate water supply. Another major waterway use -- as a repository for industrial and municipal wastes -- has in most urban areas degraded water quality enough that substantial chemical treatment is now necessary to render the water safe for human consumption.

In Rhode Island all of the rivers large enough to serve as a dependable water supply are somewhat polluted and utilized for a variety of industrial purposes. The Blackstone River, largest in Rhode Island, is reported as being utilized more heavily for industrial purposes than any other river in the world (Encyclopedia Americana, 1976). The smaller tributaries generally provide good quality water but small and undependable safe yields, unless storage is provided.

In areas with topographic conditions that permit effective impounding structures, surface water storage has traditionally been the most desirable method of water supply. Given appropriate conditions and management, a reservoir is relatively dependable, pure and can supply water by gravity at a low cost to the consumer. The Providence Water Supply Board presently receives all water supplies from Scituate Reservoir. The 3,400-acre Scituate Reservoir is surrounded by about 12,000 acres of land owned and managed by the Providence Water Supply Board for water quality control. The water leaving Scituate Reservoir is considered by many to be among the best quality in the country. Given existing technology and the Rhode Island setting, it is believed that additional surface water storage would offer the best potential and economic feasibility to meet projected demands for the Providence metropolitan area. As such, various potential reservoir sites in Rhode Island have been evaluated in the Corps studies (Appendix B).

Environmental considerations for surface water storage are primarily related to the displacement of existing land use at the site, associated natural, cultural and social values and modification of the quality and quantity of downstream water resources.

3.01.9 Conclusion

The foregoing analysis indicates that surface water development is the only method to satisfactorily meet the predicted water supply needs of the study area. Groundwater development and demand modification, although limited in potential, were seen as desirable methods to be included in a comprehensive water resource management plan because of their high economic and technical feasibility, public desirability, and relatively low adverse environmental impact. Consequently, these three methods were studied in more detail toward development of intermediate resource management plans.

3.02 Without Condition (No Federal Action)

The "without condition" alternative used in this report means no Federal participation in the development of solutions to the study area water supply needs -- the recommended plan would not be implemented through Federal involvement. This does not, however, restrict local development on much smaller scales to assist in localized water supply problems. The extent of possible local solutions has been described in the Main Report.

The types and magnitude of social, economic and environmental impacts of the "without condition" would differ greatly among communities based on the character of the community and the degree of deficiency. Adverse impacts would be more severe in those communities with the greater water supply deficiencies (Appendix A). Communities with more adequate water supplies would experience an increased population growth rate as less growth would occur in nearby areas with deficient water supplies. This would increase predicted demands for their public utilities and lands.

The area considered for the development of Big River Reservoir was purchased by the State by eminent domain in the mid-1960's. Should the reservoir not be built, the land would most likely continue as a largely undeveloped area, managed primarily for recreational activities.

Water supply programs for public management would continue as at present, relying on presently developed sources to meet future demands. The Bristol County Water Company would be expected to develop new supplies because of the immediate need for additional capacity in that system. These additional supplies would be obtained through the phased development of groundwater and surface water resources in Rehoboth, MA in addition to implementation of modifications to improve the existing water supply system. Existing surface water and groundwater supplies would supply the needs of the Providence Water Supply Board and Kent County Water Authority service areas until demands exceed the available supplies. The less urbanized communities would continue to utilize private on-lot water systems or construct municipal supply systems through the development of groundwater resources.

The average annual flood losses of $1,986,310 (Sept. 1980 price levels) would continue to result from flooding in the Pawtuxet River Basin. Physical and non-physical damages to homes and local businesses due to flooding would continue.

Although recreation resources needs within the State of Rhode Island would continue to increase during the study time frame, demands except for boating and golfing activities would continue to be met with existing resources. Also, demands on facilities in communities surrounding the Big River site would increase.

Tables 3 and 4 describe in a comparative form the significant social, economic, and natural resources impacts of the major components of Plans A,B,C, and the "without condition".

3.03 Detailed Project Planning

The recommended comprehensive water resources development and management plan for the Providence metropolitan area as defined in the Main Report includes: (1) immediate implementation of a demand modification program for the study area; (2) immediate development of groundwater supplies for Bristol County and the towns of Foster and Glocester; and (3) construction of Big River Reservoir. Flood damage reduction measures and floodplain management objectives in the study area were directed at reducing flood hazards and associated urban flood damages in Coventry (South Branch) West Warwick, Warwick and Cranston (Pawtuxet River).

Recreational resource enhancement was studied taking into consideration the diversity of recreational needs within the study area and the State of Rhode Island.

This plan optimizes both the NED and EQ contributions of all measures considered in the intermediate planning phase to satisfy the planning objectives (Section 2.02).

In accordance with Principles and Standards, alternative features and provisions of Big River Reservoir were evaluated for their NED/EQ contributions prior to selection. Those found to satisfy both NED and EQ objectives were selected as preferred features. Such selections included those listed below.

(1) Aqueduct -- cut and cover versus tunnel (Appendix G). The tunnel method was chosen over a cut and cover option because of the environmental and social degradation due to disturbance associated with creating the channel involved with cut and cover. Also, the tunnel was found to be slightly less expensive.

(2) Pipeline construction -- construction of a pipeline from the Providence system to Bristol County to supplement initial groundwater development in Rehoboth was selected over additional local development. The existence of institutional arrangements will make the pipeline system easier to implement as a result of less extensive interstate agreements. The development of additional groundwater supplies in Rehoboth could result in additional environmental impacts related to

TABLE 3

ENVIRONMENTAL IMPACT SUMMARY
SOCIAL ECONOMIC RESOURCES

PROJECT EFFECTS	(1) WITHOUT CONDITION	(2) DEMAND MODIFICATION	(3) GROUNDWATER DEVELOPMENT	(4) BIG RIVER RESERVOIR
DEMOGRAPHY:				
Study Area	Limit growth	Reduce (1)[1] growth limitations	Reduce (1) growth limitations	Permit most of projected growth
Displacement	Incentive to move to water-richer areas	None	None	Relocation of approximately 440 residents
AESTHETIC VALUE:				
Resource Altered	Might cause neglect of property	Might limit care of gardens & lawns	Alleviate (1) & (2)	Change is highly visible to I-95
Resource Created	None	None	No significant effect	Same as above
CULTURAL RESOURCES	No significant effect	No significant effect	No significant effect	No significant effect
TRANSPORTATION:	No significant effect	No significant effect		Relocate & abandon several facilities
RECREATION:				
Resource Altered	Could limit some water related recreation	No significant effect; alleviate (1)	No significant effect; alleviate (1)	Significant effect to stream fishing and hunting
Resource Created	None	None	Preservation of groundwater recharge area could alter	Same as above
ECONOMIC EFFECTS:				
Direct	Save development costs	Development costs	Development costs; water supply value; some employment opportunity	Significant lose existing land uses
Secondary	Limit growth	Ameliorate growth	Ameliorate growth & preclude potential land use/development	Significant ameliorate growth and preclude potential land use/development

1 - When a number appears in parentheses, i.e. (1), refer to effect on alternative numbered in same row.

TABLE 4

ENVIRONMENTAL IMPACT SUMMARY
NATURAL RESOURCES

PROJECT EFFECTS	(1) WITHOUT CONDITION	(2) DEMAND MODIFICATION	(3) GROUNDWATER DEVELOPMENT	(4) BIG RIVER RESERVOIR
HYDROLOGY:				
Water Quantity	Eventual periodic significant reduction in water supply res. levels	Improve (1)[1]; potential decrease in wastewater	Improve (1) potential reduction in stream low-flow	Potential decrease in wastewater more significant at high flows; downstream effects incurred may create resources.
Water Quality	Severe drawdown-existing reservoir would experience reduced WQ	Same as above	Reduce dilution & assimilate capacity for wastes	Significant in RI; WQ would improve at site
Groundwater	Possible depression due to overpumping	Improve (1)	Expand extent of use; improve (1)	More significant potential impact on Mishnock area
AQUATIC BIOTA	Hydrologic effects would stress biota	Improve (1)	Improve (1)	Significant replacement of existing habitat w/new resource
TERRESTRIAL RESOURCES:				
Vegetation (General)	No inundation	No significant effect	No significant effect; perhaps preserve new areas for aquifer recharge protection; minor negative impact at well site.	3154 acres would be affected.
Wetlands	No inundation	Same as above	Same as above	17% of area would be displaced
Wildlife	No inundation	Same as above	Same as above	Significant effect due to acreage of habitat to be displaced.

1 - When a number appears in parentheses (1), refer to effect on alternative numbered in same row.

the drawdown of the groundwater table, which would not occur should the pipeline be constructed. Further studies would determine the significance of these impacts.

The future needs of the Bristol County Water Company would be served from the Providence water supply system by construction of transmission facilities in various public ways and permanent easements, with underwater crossings of the Pawtuxet River, Providence River, and the Warren River. (Refer to Main Report for a detailed description of the pipeline facilities).

(3) Reservoir size -- water supply pool size, flood control and conservation storage.

a) Alternative water supply pool sizes studied range from 32,200 to 73,600 acre-feet of storage, providing 25 to 36 mgd safe yield of water supply respectively. Since this difference in yield is arrived at through the expense of only about 800 additional acres of impoundment (this additional acreage is mostly "upland", forested hillside habitat as opposed to the more valuable "bottomland" with extensive wetland and openland habitat which would be inundated regardless of the size of the reservoir) and the extra yield would preclude further development to meet future demands, the larger size is considered as more environmentally efficient. It is also more economically efficient.

b) Flood control at Big River Reservoir would consist of adding 3 feet of elevation to the reservoir, or 9,500 acre-feet of storage, equivalent to about 6 inches of runoff from the watershed. The environmental impacts of this addition would be minor as flood control inundation would be short-term in duration and intermittent. However, economic benefits in the towns of Warwick, West Warwick and Cranston, Rhode Island would be significant (Refer to Main Report).

c) Conservation storage is provided below water supply pool to allow for sedimentation and enhance water quality, particularly during reduced water levels. 12,300 acre-feet of conservation storage would be provided, increasing the maximum depth of the reservoir by about 7 feet. By not providing conservation storage, the reservoir would be shallower and warmer, water quality and fish habitat would be poorer, and less upland would be inundated. The aquatic benefits are believed to outweigh the additional terrestrial impacts. Conservation storage was also found to be economically desirable because it would provide water supply during emergency conditions.

(4) Recreation -- this was an object of controversy during project planning (Section 1.02). Through analysis of the needs, opportunities, benefits, and potential impacts (particularly to reservoir water quality) of recreation in association with Big River Reservoir, it was determined by the Corps that sufficient need and opportunity existed and that, at the Big River site, a recreation plan be recommended as a project purpose. Detailed discussion of the recreation demands of the study area and optional plans for meeting these demands is contained in Appendix H, "Recreation and Natural Resources." Further input, analysis and planning would develop a final plan which would be designed to optimize use of the available natural resources without significant degradation of environmental quality, particularly the reservoir water quality.

A detailed Master Plan for development of the recreation resources of the project would be prepared, at such time as advanced engineering and design is undertaken. A Master Plan would be prepared in conjunction with development of the Phase I General Design Memorandum, if so authorized.

(5) Mitigation -- development of Big River Reservoir would result in losses to fish and wildlife resources. In compliance with the National Environmental Policy Act (NEPA) and the Fish and Wildlife Coordination Act, structural and nonstructural measures are planned to mitigate to the extent feasible and practical impacts due to project implementation.

The following basic mitigation recommendations are conceptual measures for fish and wildlife management at the proposed Big River Reservoir area. Many are structural and administrative measures that could be incorporated into construction and post construction activities. Plans would be studied in further detail to define the viability of the conceptual measures should Advanced Engineering and Design studies be authorized. It would be at this time that further public input would be sought to assist in final mitigation planning.

In order to implement a fisheries management program, multilevel intakes should be incorporated to provide discharge temperatures similar to existing temperatures downstream in Flat River Reservoir, and to establish a stable hypolimnion in Big River Reservoir.

Selective removal of vegetation and organic material from the pool would be carried out. Cover and spawning sites for cold and warm water fish could be created in various places in the reservoir by utilizing slash from vegetation removal operations, in addition to boulders and stones from construction areas.

The U.S. Fish and Wildlife Service has recommended measures for stripping the organic material from low pool elevations which would decrease the dissolved oxygen losses in the hypolimnion as a result of decomposition reactions. Water quality would be improved, and the pool could be made suitable for a cold-water fishery soon after filling. Refer to Appendix H, "Recreation and Natural Resources," for further discussions of structural and operational modifications recommended for fisheries management.

Recommended species to be stocked include: rainbow and brown trout, smallmouth bass, and crappie. Largemouth bass, pickerel and some forage species are already present in the watershed, and would be able to establish themselves in the reservoir pool.

Wildlife management would include the following:

(1) implementation of a detailed forestry management plan;

(2) reclamation and management of surface mining sites; and

(3) construction and management of subimpoundments to create wetland habitats.

A comprehensive forest management plan would include promotion of natural regeneration through manipulation of the existing cover types. Sites would be identified for improving existing stands for wildlife and timber by thinning, pruning and controlled burns. Service roads, gates, fire breaks and clearing would be specified in the plan. Several large clearings or isolated peninsulas would create Canada goose habitat.

Site characteristics, habitat requirements and area management guidelines would regulate the planting of trees and shrubs.

The carrying capacity of the existing habitats would be increased by a program of prescribed burns in certain portions of the reservoir area.

Terrestrial habitat management plans would be prepared cooperatively by Rhode Island resource management agencies and the Corps prior to construction. It is recommended that the Rhode Island Department of Fish and Game be the managing agency for the fish and wildlife resources on project lands after the project is completed.

Reclamation of the active mining operation in the project area would enhance the management potential of the mitigation land. This would be accomplished by restoring the landscape to its natural contours and replanting with drought-tolerant native vegetation.

Shoreline management for the reservoir would be carried out by the creation of islands, leaving some timber in shallow areas, and planting food crops.

The creation of subimpoundments would mitigate the loss of wetlands. Emergent wetland vegetation would be established and maintained by dikes, water control structures, and limited plantings of desirable plant species. A detailed analysis of proposed sites for viability and specific modifications would be included in advance studies should the project be authorized.

4.0 AFFECTED ENVIRONMENT

Descriptions of the study region are found in appropriate appendices, i.e., Hydrology, Social, Cultural, Recreation and Natural Resources. Appendix H, Volume 1, pages 12-20, provides a comprehensive summary of these aspects. The Main Report has also summarized relevant factors describing the study area. This chapter focuses on the Big River Management Area, with emphasis on that area proposed for inundation and the more significant resources that would be affected should the project be implemented.

4.01 General Environmental Setting at Big River

Between 1963 and 1966 the State of Rhode Island obtained by eminent domain the 8,300 acre[1] Big River Management Area (Figure 2) to protect the proposed Big River Reservoir area from development. About 7,600 acres are within West Greenwich, Rhode Island (about one fourth of the town's total area). Rivers flowing through the area include the Big, Nooseneck, Congdon, and Carr Rivers. Big River flows into Flat River Reservoir in Coventry, Rhode Island below which begins the south branch of the Pawtuxet River. The proposed Big River dam would be located at the confluence of Big River and Flat River Reservoir and would inundate about 3,240 acres in the 29.7 square mile Big River watershed.

Interchanges where Interstate Highway 95 crosses the proposed site provide easy access by automobile to Providence, Rhode Island, approximately 15 miles northeast from the Big River Management Area.

Approximately 440 tenants have remained in the management area and are renting their residences from the State with the knowledge that relocation would be necessary if the planned development occurs. Many of the buildings in the area have been neglected; some are in ruin, some have been burned. Litter and junk are plentiful along many of the small roads that traverse the site. The old Hopkins Mill, which was entered into the National Register of Historic Places in 1964 was destroyed in September 1978. The area has remained undeveloped, a "backwoods" in the heart of the State. Two old unpaved roads, the New London Turnpike and Sweet Sawmill Road, and the old Nooseneck Factory sites have been recommended for inclusion into the National Register of Historic Places.

Since purchased by the State, the increasingly undeveloped nature of the Big River area has prompted its usage for outdoor recreational purposes. However, because of a lack of commitment to recreational management, resources are only informally used by local residents who are familiar with

[1]The numbers reported in this report are generally "rounded off" to give a general impression of the size of various components for comparative discussion--many numbers have been obtained from the State of Rhode Island. Numbers given in various other reports may not be entirely consistent due to use of different mapping scales and delineation errors which are compounded when computed into areal figures.

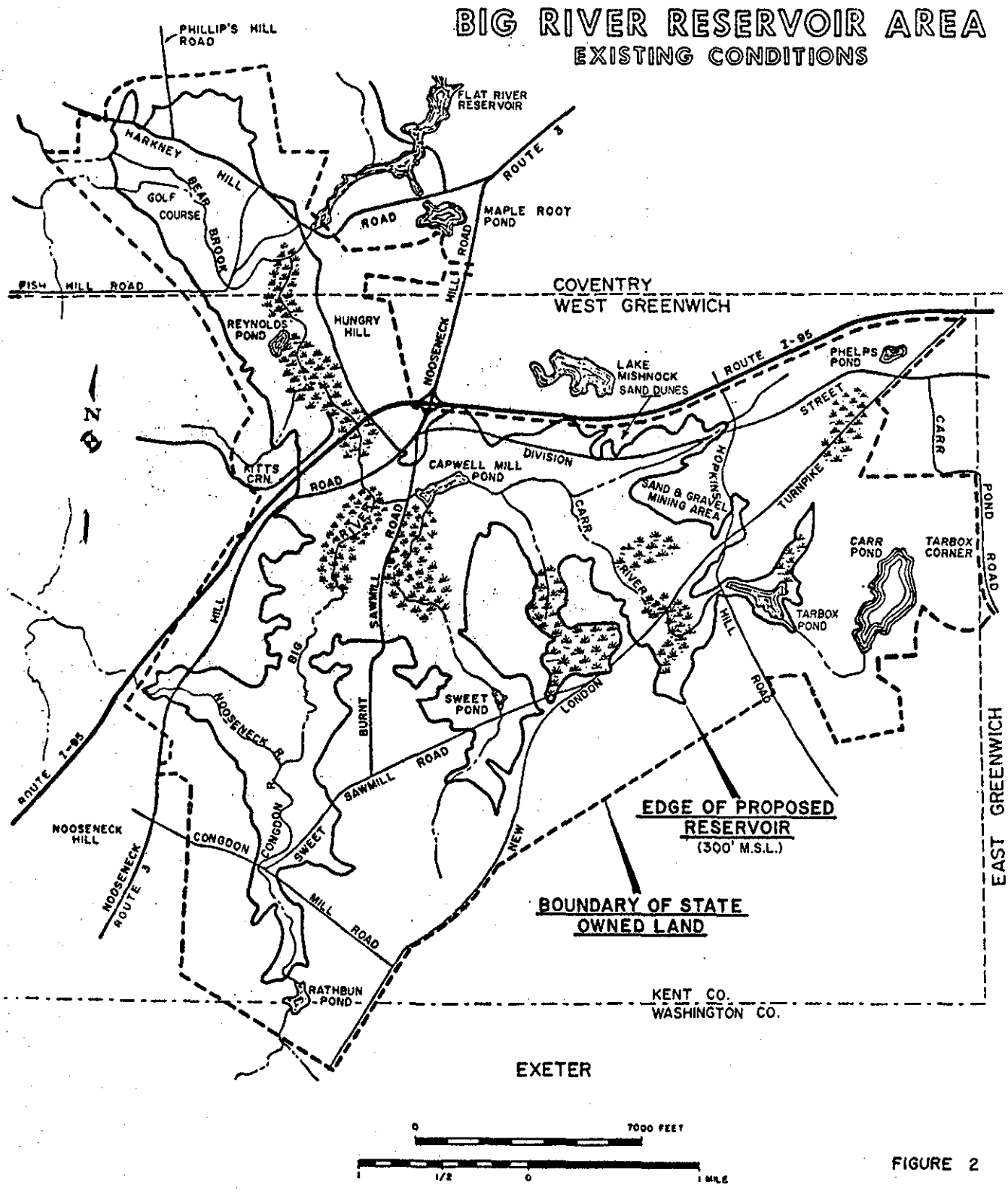

BIG RIVER RESERVOIR AREA
EXISTING CONDITIONS
PHILLIP'S HILL ROAD
FLAT RIVER RESERVOIR
HARKNEY HILL
GOLF COURSE
BEAR BROOK
ROUTE 3
ROAD
MAPLE ROOT POND
FISH HILL ROAD
COVENTRY
WEST GREENWICH
REYNOLDS POND
HUNGRY HILL
NOOSENECK HILL ROAD
LAKE MISHNOCK SAND DUNES
ROUTE I-95
PHELPS POND
STREET
CARR
POND
ROAD
N
W
E
S
RITTS CRN.
ROAD
CAPWELL MILL POND
DIVISION
HOPKINS HILL
SAND & GRAVEL MINING AREA
TURNPIKE
CARR
RIVER
ROAD
CARR POND
TARBOX CORNER
TARBOX POND
HILL
ROAD
BIG
SAWMILL
BURNT
SWEET POND
LONDON
ROUTE I-95
NOOSENECK R.
SAWMILL ROAD
NOOSENECK HILL
CONGDON
CONGDON R.
SWEET
NEW
MILL ROAD
ROUTE 3
EDGE OF PROPOSED RESERVOIR
(300' M.S.L.)
BOUNDARY OF STATE OWNED LAND
RATHBUN POND
KENT CO.
WASHINGTON CO.
EAST GREENWICH
EXETER
0
7000 FEET
1
1/2
0
1 MILE

FIGURE 2

the area. The rivers, streams and ponds are used for boating, fishing and swimming; the wetlands and adjacent woods (which together cover 90 percent of the proposed inundation area) are used for hunting; and the sand dunes, fields and trails are popular with motorcyclists, snowmobiles and horseback enthusiasts.

The study area is part of the White Pine-Hemlock-Hardwood Forest Region and is located near the southern boundary of the New England Section of this region. The uplands are dominated by oak forests, white pine stands and mixtures of upland hardwood, pine, and wetland species. Open areas such as farmland, old fields, and sand or gravel areas contain plant communities in various stages of development from grassland to shrubland.

Most commonly observed mammals in the study area include red squirrels, gray squirrels, and chipmunks. The Rhode Island Department of Environmental Management lists whitetail deer, snowshoe hare and cottontail rabbit as occurring in the study area.

The Big River study area is within the range of the Indiana bat, eastern cougar, bald eagle and peregrine falcon. All are listed as endangered species by the Department of the Interior under the Endangered Species Act of 1973. There are no known sitings of these species within the area. Bald eagles and peregrine falcons may occur during migration and utilize the area as resting and feeding habitat.

One fish species, the Swamp Darter, was found in the area; but although never before reported from Rhode Island, it is not considered endangered by any Federal or State criteria.

Minor commercial activities within the proposed reservoir area include a golf course, the operation of a drinking establishment, and timber, sand and gravel removal under agreement with the State. The lumber resources within the area proposed for inundation are estimated to have a value of around one-half to one million dollars if cut and sold prior to reservoir construction.

4.02 Significant Resources at Big River

One major nonrenewable resource within the Big River Management Area of local and state-wide significance is the extensive sand and gravel deposits. It is estimated that 30 million cubic yards of sand and gravel exist within the management area. The total commercial value of these sand and gravel resources, based on information supplied by local contractors, is approximately $30-45 million at current dollar values. Three private contractors are currently removing one million cubic yards each under agreement with the State, a task that should be accomplished during 1983.

At this time, the State of Rhode Island is preparing guidelines for a study to determine if it would be feasible to remove more or all of the sand and gravel prior to construction of a reservoir and to store it at another site. Because the State owns the land on which the sand is located, and the

fact that the value of sand and gravel for construction purposes increases due to its scarcity in the study area, the findings of the upcoming study are expected to result in a resource management plan designed to mitigate the potential loss of the resource.

Studies were conducted by the Corps in 1978 to determine the extent of the recreation value and natural resources of the area (Appendix H - "Recreation & Natural Resources"). Existing recreational demand and potential of the site were evaluated.

The natural resources of the Big River site (wildlife, woodlands, wetlands, streams and ponds) require significant attention for many reasons; a reservoir the size of Big River would become the second largest reservoir in Rhode Island and would inundate about 1 percent of the remaining undeveloped land in the State. The relatively undeveloped natural amenities at the Big River site have been estimated to offer about five percent of the horseback riding capacity, 10 percent of the hunting capacity, and about 10 percent of the hiking capacity of the State of Rhode Island (Appendix H).

Vegetation surveys and wildlife habitat evaluations were conducted within the proposed Big River Reservoir Site. Bird populations were censused along six transects encompassing the major habitat types (hardwood forest, softwood forest, mixed forest, wetland and open land) (Appendix H). Aquatic surveys were conducted to ascertain the physical and biological characteristics of the streams and ponds of the Big River Management Area (Appendix H). Information obtained from literature review and interviews with the State Fish and Game Department supplemented this study.

The vegetation, wildlife and aquatic resources of the Big River area and the possible alternative reservoir sites are summarized in Table 5.

TABLE 5

NATURAL RESOURCES

ECOSYSTEMS	VEGETATION/HABITAT CATEGORIES	PREDOMINANT VEGETATION	PREDOMINANT WILDLIFE*	SIGNIFICANT FACTORS** AT STUDY SITES: BIG RIVER 3280 a(acres)33 mgd	WOOD RIVER 900 a-26 mgd	MOOSUP 510 a-12 mgd	BUCKS HORN 510 a-5 mgd
TERRESTRIAL (1) Open Land	Dry/sandy areas Abandoned fields Pasture Disturbed areas	Hawkweed Quack grass *Timothy* Yarrow Small trees	Cottontail rabbit,bobwhite quail, ringnecked pheasant (3), *meadow voles*, some song birds, red fox(2,3) weasel(3)	325 a 10% of area	*26 a* 3% of area	47 a 9% of area	*6 a* 1% of area
TERRESTRIAL (2) Woodlands		(1)=Overstory (2)Understory					
	Softwood forest	(1) White pine & pitch pine (2) Young pine & oak,huckleberry & low bush blueberry	Red squirrel,snowshoe hare	872 a			
	Hardwood forest	(1) Red & white oak (2) High bush & low bush blueberry, huckleberry princess pine	White-tailed deer(1,3,4) gray squirrel white footed mice	832 a	691 a 78% of area	333 a 62% of area	294 a 62% of area
	Mixed forest	(1) Oaks & pines (2) Young oaks & pines, low bush blueberry, sheep laurel; sheep berry	Raccoons (3,4) Ruffed grouse American woodcock, most diverse for songbirds,owl(1,3)	601 a			
				2306 a 73% of area			
AQUATIC (3) Wetlands	Swamps	Red maple, white pine, pepper bush, button bush, high bush blueberry, pickerel weed	Wood duck Songbirds	524 a 17% of area	166 a 19% of area	159 a 29% of area	178 a 37% of area
	Marshes	Sedges, rush, burreed, pondweed, pond lily	Black duck, kingfisher, herons, otter, songbirds				
AQUATIC (4) Water	Lentic (Still water)	Green algae, Desmids, Blue green algae } algae Also,fringe marsh(see above) Vegetation present in many areas.	Wildlife as indicated above and aquatic organisms: Fish include bridle shiner, golden shiner, pumpkinseed, banded sunfish,creek chubsucker,white sucker,fallfish,*brown* bullhead,yellow perch,swampdarter,brook trout,pickerel, largemouth bass	Combination of streams & several ponds. 19.7 stream miles inundated. 5.4 miles considered "fishable".[1] Class B. Fishing marginal.	Almost entirely lotic. Streams rated Class A. Regarded as best trout stream in RI. 6 stream miles inundated.	One large pond. Less lotic.Provides cold water fishing. Rated Class A. 5.3 stream miles inundated.	Mostly small streams & swamps.Considered Class A.Considered good brook trout spawning area. 2.3 stream miles inundated.
	Lotic (Running water)	Same as above but diatoms are dominant algae species					

* When a species is followed by numbers in parenthesis, that species requires or is significantly enhanced by the presence of the habitat number as indicated on the left margin; i.e., water = (4), wetland = (3), woodland = (2); the name appears in the habitat of most importance, when name appears in more than one, they are @ of equal importance. Scientific names of all species listed here are found in App.H, Vol. 2 & 3.

** Numbers (acreage, percent) are estimates - other estimates may not be the same; a = acres, mgd = million gallons per day safe yield.

[1]Personal communication, Richard Guthrie, RI Dept. Fish & Game.

5.0 ENVIRONMENTAL EFFECTS

The scope of this chapter focuses on analysis of the predicted effects of Big River Reservoir. A level of detail has been presented to offer decision makers and the general public a comprehensive understanding of the significant trade-offs and alterations that would be incurred should the Big River Reservoir be developed. Those with greater interest in a particular topic are referred to more detailed information available in the various technical appendices.

5.01 Socio-Economic Effects

5.01.1 General

Significant social and economic effects of various types would occur should the proposed Big River Reservoir be constructed. Following is a listing of the more significant impact areas:

(1) effects on the size, density, and distribution of human population (demographic);

(2) the cost of the project and fiscal arrangements (direct economic) and modification of existing public services, i.e., waste treatment, water delivery, employment and development opportunity (indirect economic);

(3) road relocation and/or modification (transportation);

(4) change in the visual or other sensory perception of the environment (aesthetics);

(5) displacement or destruction of historical or archaeological resources (cultural resources); and

(6) effects on the existing and future potential and existing value of the area for recreational endeavors (recreation).

5.02.2 Demography

Development of Big River Reservoir would fulfill the intended State land use plans for the Big River Management Area. The plan would allow inundation of the 3,240-acre impoundment site; it would also provide watershed protection and water treatment facilities on the additional 5,320-acre State-owned lands surrounding the reservoir site. Approximately 440 people are now residing on these lands; 306 are scattered throughout the area in houses rented from the State and 134 are living in a trailer court at the water treatment plant site. They have been allowed to reside on the State-owned lands with the knowledge (and under conditions) that relocation would be necessary should the planning Big River Reservoir development occur.

The fulfillment of study area water supply needs would have even greater significance by allowing predicted population distribution and growth and concomitant economic development to occur throughout the study area.

Present zoning requirements have almost eliminated development within the 100-year floodplain. However, new growth is allowed at or above this level even though it could be damaged by a major flood. Big River Reservoir will provide additional safeguards to new residences, commercial and industrial firms.

5.01.3 Economic Effects

The major commercial activity within the area that would be precluded by reservoir construction is the sand and gravel extraction operation (Figure 2). Value of the reservoir and the effects of eliminating the mining of sand and gravel on the areas economy acquire increased significance. when weighed against the predicted scarcity of sand and gravel for construction purposes in southeastern New England, and in particular, Rhode Island. Those contractors currently involved in excavation operations at the Big River site claim that this source provides the highest quality sand and gravel for the lowest cost possible in Rhode Island. Although none of the three contractors employ any workers solely to complete their contractual agreement with the state, several of their employees are involved in that operation at various times. While two of the three contractors regard their excavations in the Big River area as a small portion of their overall operation, one claimed that his business was largely dependent on the contract to remain profitable. Alternative sources of sand and gravel exist, but involve much greater transport distances at greater expense. Transportation costs have been estimated at $30 per hour per truckload of approximately 20 cubic yards. It is also estimated that one hour is required to complete a round trip delivery for each additional seven to eight mile distance from the source to the user. These additional transportation costs are reflected in the price of sand and gravel in the local market, and are therefore passed on to the construction industry.

It is apparent that curtailment of sand and gravel removal at the Big River site would have some impact on the regional economy. The severity of that impact would depend on how the State of Rhode Island decides to manage the resources.

Other less significant commercial activities within the proposed reservoir area, including a golf course, a bar, and timber harvesting, are described elsewhere in this report. The economic impact on the region due to the loss of these activities would be minimal.

Temporary economic benefits would be expected in the local area during the active construction phase. A project of this magnitude would require a fairly large construction work force and may result in some permanent and temporary job opportunities to the surrounding area.

The most significant economic consideration in the construction of Big River Reservoir is the actual cost of implementation. Cost estimates for the reservoir to be constructed in the year 1995, range from $123,238,000 to $141,409,000 (1979 dollars) depending on the plan selected. In present worthed dollars, adjusted for the time which would elapse between 1980 and 1995 construction, these same estimates would range from $42,383,000 to

$48,632,000. It should be noted that the overall plans being considered involve several features such as treatment facilities, transmission facilities, groundwater development, and a demand modification program which are not included in the Reservoir cost estimates because they are not a Federal responsibility.

The overall economy of the area would be improved as a result of flood control storage. The additional length of construction time and the use of more equipment would increase the utilization of the local construction industry. Secondary benefits would be evident with local merchants and flood-prone industrial and commercial firms.

5.01.4 Transportation

Interstate 95, the main transportation route crossing the Big River Site, was constructed above the proposed reservoir pool level and thus would not present any adverse social and economic impacts (Figure 2). The embankment along I-95 in the Big River watershed would nevertheless require the following modifications should the reservoir be constructed:

(1) Route 3 (Nooseneck Hill Road) would be relocated along the I-95 embankment where it crosses Big River;

(2) runoff control and stilling basin facilities would be desirable along the highway to prevent uncontrolled contamination of the reservoir from deicing salts, road grit and associated contaminants and the possibility of a hazardous waste spill into the reservoir; and

(3) the embankment would require stabilization work to prevent excessive reservoir induced erosion that might affect highway stability.

The only other road relocation currently anticipated would be Harkney Hill Road. This could be accomplished by constructing a bridge to replace Zeke's Bridge and a new road along the edge of the reservoir or by utilizing Hill-Farm Road and its bridge over Flat River Reservoir and connecting it across Rock Hill to Harkney Hill Road outside the reservoir lands. Further studies would determine the most desirable alternative.

Other roads within the area would probably not require extensive relocation. Sub-impoundment dikes on the Carr and Congdon Rivers could allow contiguous access along Hopkins Hill and Congdon Mill roads, respectively (Figure 2). If dikes are not constructed at these locations, it is doubtful that relocation of these two roads would be cost effective -- environmentally or economically.

The effect of flood control storage on downstream transportation systems would be beneficial as the likelihood of inundation would be decreased.

5.01.4 Aesthetics

Clearing the reservoir site of woody vegetation would produce a bare ground/shrub/sapling landscape prior to reservoir filling. This would encourage erosion and subsequent turbidity and nutrient loading of Big River and a portion of Flat River Reservoir. Erosion control techniques would be recommended to minimize this impact. Contractors would be required to landscape construction scars in areas above the pool and maintain acceptable water quality through runoff control techniques (404 Evaluation, Section 230. 4-2). Construction of the dam and associated facilities would also produce similar effects. The noise associated with both clearing and construction activities would also be heard by nearby residents and travelers.

Construction-related impacts would be short in duration, lasting over a 4-year period. Subsequent inundation would have the most profound aesthetic impact: total alteration of the valley floor into a large body of water. The acceptability of this effect is highly subjective. A resident, hunter, or fisherman of the Big River site might regard the change as an obtrusive reminder of the irreversible loss of aesthetic value. A traveler on I-95 might however find the reservoir a pleasant element of diversity and beauty in the forest-covered hills and valleys that dominate the Rhode Island landscape.

Preservation of aesthetic value on project lands would be a key element in the final detailed design. Access roads would be constructed to achieve scenic enhancement through proper location, alignment and minimum cut and fill. Conservation practices such as fertilizing, reseeding and mulching eroded sites, stabilizing reservoir banks, and reclaiming mining areas would prevent aesthetic (as well as water quality) degradation.

5.01.5 Cultural Resources

Cultural resources are defined as any building, site, district, structure, object, data (submerged or terrestrial) or other material significant in history, architecture, science, archaeology, or culture. Historical and archaeological sites are physical remains of past cultures. Analysis *in situ* allows reconstruction of the culture of historic and prehistoric societies.

The Big River Cultural Resource Reconnaissance (Appendix I) conducted in 1978 by the Corps includes a preliminary predictive study of archaeological sensitivity within the reservoir land-taking and an inventory of historic resources within those bounds. This study located 12 possibly significant historic features (including the New London Turnpike, Sweet Sawmill Road, and the Nooseneck Factory sites already recommended for the National Register of Historic Places) within the impoundment area. If these or others are found to be of national significance, impacts of construction or inundation would be mitigated through intact removal and/or architectural recording. Fourteen small cemeteries within the inundation area have been found to possess historic or scientific value. Relocation would be recommended in a manner consistent with this cultural value. In addition, about

16 recorded sites of potential archaeological significance are within the inundation area. Mitigation of impacts on such sites could be achieved through modification of construction activities and/or archaeological salvage. Five prehistoric and 30 historic sites are also known to exist within the Management Area, but above pool elevation. Planning of recreational or management facilities in this zone would consider these sites.

The effects on cultural resources due to flood control storage at Big River Reservoir would not be significant.

At the next stage of project planning, Advanced Engineering and Design (AE&D), a cultural resource survey would be performed. Goals of this survey would be to locate a statistically valid sample of archaeological resource locations within the project area, assessment of the eligibility of historic and archaeological resources for inclusion in the National Register of Historic Places, and recommendation of specific mitigation strategies for adverse project impacts upon resources determined to be National Register eligible.

One advantage for cultural mitigation in the case of constructing Big River Reservoir would be the potential for utilizing a portion of the adjoining State-owned lands to relocate (when deemed applicable) and preserve significant resources now in the inundation area. Historical cemeteries, buildings, or artifacts could be arranged into a "Historical Park" -- one that would represent the history of the Big River Management Area. One seemingly ideal location would be along the existing Nooseneck Hill Road, between Big River and Nooseneck River (Figure 2).

5.01.6 Recreation

Since taking the Big River Management Area lands out of private ownership in the mid 1960's, the State has allowed the area to be used for a variety of recreational purposes described in the preceding chapter. Its full recreational potential has not been utilized for a lack of commitment to recreational management. Nevertheless, the expansiveness and undeveloped nature of the area provide excellent opportunities (mostly utilized by local residents) of varying value for hunting, fishing, horseback riding, swimming, boating, motorcycling, hiking, and general enjoyment of the outdoors. Development of the reservoir would significantly modify the recreational potential of the area.

Through analysis of existing recreational opportunity and needs of the area (Appendix H), consideration of public concerns (Section 2.03), and in accordance with Federal policy (Section 1.04), the Corps has determined it in the best public interest to include recreation as a project purpose. Although some recreational uses of the area would be limited or precluded by project implementation, others would be enhanced considerably.

The most obvious change in recreation opportunity would be the conversion of 3,240-acres of bottomland into a reservoir, based recreation opportunity. However, the overriding interest in protecting water quality in the reservoir for water supply purposes would limit the kinds and magnitude of recreation that would be recommended.

Generally, the tentatively selected plan would provide limited boating and fishing at Big River Reservoir, hunting in specified areas, swimming and picnicking at three use areas, and multiuse trails, field and parking facilities. In accordance with State Law (Appendix H, Vol I, page 5) swimming would not be allowed in Big River Reservoir. Boating would be restricted to small fishing boats, "dry" sailboats, and canoes and would only be permitted in the portion of the reservoir southeast of I-95. Access to the reservoir and adjoining lands northeast of I-95 would not be allowed in order to provide the greatest protection for the water quality near the water supply intake of the dam.

5.02 Natural Resources

5.02.1 General

Construction of Big River Reservoir would change the existing stream-wetland-forest ecosystem to a 3,240 acre reservoir. Other areas that would be impacted include a golf course, small yards and fields, and one area of sand dunes. The reservoir would be interspersed with ten to twenty small islands. These resources have been summarized in Table 5.

5.02.2 Fish and Wildlife Management Plans

Any mitigation techniques adopted would be incorporated into an overall Natural Resources Management Program. The land around the reservoir has been generally classified according to the type of management to be applied, such as natural areas, wildlife areas, recreation lands and forest lands. Conceptual measures have been presented which would maintain and enhance wildlife habitat through such methods as installing nesting boxes, planting wildlife food plots, trees, hedgerow, cover and selective forestry and water level management.

The U.S. Fish and Wildlife Service has provided the Corps with Planning Aid Reports which introduce for consideration in the Corps planning process several recommendations. Many of these are generally part of the Corps basic mitigation recommendations:

(1) the public lands around the reservoir be managed to mitigate wildlife losses due to the project;

(2) multiple level outlet structures and selected organic material removal be implemented to enhance fishery habitat in the proposed reservoir;

(3) sub-impoundments created to enhance waterfowl and wetland habitats; and,

(4) the Rhode Island Division of Fish and Wildlife manage resources at the project site.

Refined specifications for implementation of the plans would be developed should the project be authorized for further study.

The Fish and Wildlife Service report has made several recommendations which the Corps does not support, and have not been incorporated into the basic plans:

(1) the project not be constructed;

(2) an additional 5,800 acres of land be acquired to be managed exclusively for wildlife;

(3) the minimum downstream release from Big River Reservoir be increased from 6 cfs to 18 cfs; and

(4) additional studies be conducted to more precisely define probable impacts to fish populations both within and downstream of Big River Reservoir.

The Corps rationale in rejecting such proposals is based on a lack of justification:

(1) neither the Fish and Wildlife reports, nor the Corps studies (Appendix H) have demonstrated that fish and wildlife impacts are so significant as to outweigh economic and social justification for the project;

(2) the wildlife benefits of acquiring and managing 5,800 acres of additional lands have not been shown to outweigh the social and economic impacts of such an acquisition. The 5,800 acre figure was justified by USFWS through analysis of losses by HEP (Habitat Evaluation Procedures) which is not an established nor verified procedure, and not as yet accepted by the Corps upon the premise that 100 percent compensation of wildlife impacts is necessary. The Corps takes a more conservative view toward the trade-offs necessary through construction of a reservoir. Mitigation is recommended only as shown to be prudently feasible and commensurate with the overall project costs and benefits to society;

(3) increasing the downstream release from Big River Reservoir would decrease the yield of the reservoir for water supply, and the benefits for the increased releases have not been justified in the Fish and Wildlife Service Report; and

(4) the fishery studies that have been conducted (Appendix H) are considered by the Corps as adequate to explain the effects of the impoundment on the fishery resources of the area. The effect of the reservoir should be of net benefit to the fishery resources of Rhode Island.

Although mitigation is to offset, or compensate for, impacts incurred by project implementation, there are nevertheless impacts associated with implementing mitigation and management programs. Should the project be authorized for further study, additional analysis will be carried out to

determine the extent of impact associated with mitigation proposals for Big River.

Recommendations have been presented in Appendix H for stripping organic material from low pool elevations for the establishment of a cold-water fishery, and for improved water quality. This would result in a decrease in the dissolved oxygen losses in the hypolimnion due to decomposition reactions, and make the pool suitable for cold-water species soon after filling. The extent of impact on the area would be directly related to the acreage that is to be cleared. Any removal of vegetation and organic material from the pool would be selective.

Incorporation of multi-level outlets would be associated with pool stripping. These would control the quality and temperature of the released water and of water in the pool which would increase the cold-water habitat zone. Dissolved oxygen levels, turbidity and dissolved solids could also be controlled by these structures.

Clearing operations carried out for mitigation would have similar impacts as those associated with construction of the reservoir.

Impacts due to forest management activities would be those associated with land acquisition, the improvement of existing stands for wildlife and timber through thinning, pruning and prescribed burns, and construction of service roads, gates, firebreaks, and clearings. Any road development and maintenance associated with the general management plan could increase human access to the wildlife habitat which would adversely impact wildlife species in the area which are less tolerant of human interference.

A forestry management plan would be implemented to increase the wildlife habitat productivity by enhancing the availability of food and other habitat requirements for most species of wildlife.

Reclamation of any surface mining areas would greatly enhance major habitat requirements for many species. Proper management of these areas would create a diverse habitat of vegetation. There would be minimal impact to these areas by machinery as they have been worked on in the past.

Creation of subimpoundments at the edge of the reservoir pool would mitigate wetland losses within the study area. These areas would be cleared of trees, brush, etc. during construction activities, but most woody vegetation would be kept intact. In the deeper portions of the reservoir (4-8 feet) trees and shrubs would die shortly after filling. Minimal impacts would occur to vegetation along the edges of the reservoir as it would not be subject to continual inundation; however, some vegetation may not be able to survive periodic fluctuations in pool level. By effectively managing these areas, they would become a mixture of various types of vegetation - scrub/shrub wetland, forested wetland, and open water, which, if not managed, would otherwise be open reservoir. Wildlife species would benefit from creating this mixture of habitat.

Construction of dikes for wetland management in the upper parts of the reservoir would stabilize water levels behind these dikes whereby aquatic plants could become established.

The Corps has recommended that extensive land purchases not be acquired for mitigation purposes. Instead, it has proposed multiple use of all lands that are purchased with more intensive management and enhancement on these lands to mitigate losses. Fish and wildlife management would be carried out should the project be constructed, whereas there are no plans in the future for these activities to be carried out by the State of Rhode Island in the Big River area.

5.02.3 Aquatic Resources

The various aspects of aquatic resources that would be affected by Big River Reservoir development, and prediction of the magnitude of any potential impacts are presented in detail in the supporting Appendices, and are summarized below.

(1) "Hydrologic Analysis", (Appendix D) describes the physical characteristics of potentially affected water resources and predicts impacts of Big River Reservoir on these resources with emphasis on potential impacts at Scituate Reservoir, Flat River Reservoir, Big River and the Pawtuxet River. Significantly beneficial hydrologic effects include increased water supply yields to the existing water supply system, relieving potentially excessive future demands on Scituate Reservoir and providing flood control along the Pawtuxet River in Warwick, West Warwick and Cranston, Rhode Island. Detrimental impacts include decreased hydrologic potential at Flat River Reservoir (drawdowns would be of greater extreme and duration -- a predictive simulation of the potential magnitude of the effect is graphed on Plate 15, Appendix D) and a decrease in average downstream flows in the Pawtuxet River with potential effect on the river's waste assimilation capacity.

Changes in groundwater levels due to the addition of flood control storage are negligible, as there is less than a three foot difference between the water supply and flood control levels, and waters would only be temporarily stored;

(2) "Water Quality", (Appendix E) predicts that the proposed Big River Reservoir should present no water quality problems. The lake should be a relatively deep (maximum depth about 60 feet, average about 25 feet), oligotrophic impoundment characterized by a relatively shallow thermocline, low nutrient level, and comparatively high dissolved oxygen levels throughout the year. Big River Reservoir should be very similar to Scituate Reservoir and provide excellent water for water supply to the study area, as well as desirable fish habitat.

Water quality in the lower Pawtuxet River can be expected to improve during periods of high flows as the reduced flood stages would cause less inundation at the three community sewage treatment plants and lowlying homes.

(3) "Aquatic Ecosystem Assessment", (Appendix H) reports on information collected from field surveys. It describes aquatic biota including phytoplankton, periphyton, zooplankton, benthic macroinvertebrate, herptile and fish communities and related water quality and physical features existing within the proposed reservoir site. Those aquatic resources which could be affected by the development of Big River Reservoir are summarized in Table 5. Species composition of the existing aquatic communities would be altered and a new equilibrium established. Species that could not favorably adapt to the new environment would be displaced by the introduction or proliferation of forms inherently adaptive to the new condition. No rare or endangered aquatic species were found or believed to be at the Big River site.

Assuming the reservoir would be available for public use and that the Rhode Island Division of Fish and Wildlife does manage the fish and game resources, it could be managed to provide a fishery of greater dimension then the existing fishery. Species such as trout, salmon, walleye and smallmouth bass would be introduced and managed. Many existing species such as sunfish, pickerel and perch would also experience expanded habitat and offer greater fishery potential. Pre-impoundment stripping and grubbing of organic material from selected areas in the pool, and leaving trees, brush, and boulders in other areas are recommended to significantly enhance the fishery potential of the reservoir.

No significant effects on downstream (Flat River Reservoir or Pawtuxet River) aquatic biota are expected. Flat River Reservoir is a warm water, relatively eutrophic lake providing largemouth bass and northern pike habitat. The average decrease in inflows to this lake should not have a significant detrimental effect on these populations. The Pawtuxet River is heavily industrialized and has poor quality water and very limited biota with practically no fishery value (R.I. "208" Water Quality Management Plan). Additional discussions of acquatic resources are found in the Big River Reservoir, 404 Evaluation.

Dam and reservoir construction operations and transmission facility construction would all produce localized short term impacts on the aquatic resources. The proposed alignment of the aqueduct to connect water supply for Big River to the existing system would be primarily through urban areas.

Crossings of the Pawtuxet, Providence and Warren Rivers (Figure 3) would result in short-term impacts on the aquatic ecosystem. Increases in turbidity, displacement and destruction of benthic organisms, disturbance of local fisheries, and increases in nutrient loading due to runoff from shoreline disturbances would occur during construction operations. The severity of

these impacts would depend on the length of pipeline that would be installed. The crossing of the Providence River by an approximately 6,000 foot long pipeline between Conimicut Point in Warwick and Nayatt Point in Barrington would result in impacts of greater adversity than those that would be associated with the shorter crossings of the Pawtuxet and Warren Rivers.

As flood flows would be regulated only during the peak flow periods several times per year, effects on downstream fish and wildlife resources would be negligible.

5.02.4 Terrestrial Resources

The terrestrial ecosystem studies provide descriptions of vegetation, including inventory, mapping and value for wildlife; animals, including some inventories, habitat evaluations, relationship to vegetation, carrying capacity estimates for the Big River area; and management possibilities to offset or mitigate terrestrial damages due to project implementation (Appendix H). Through analysis of this information, in conjunction with review of relevant environmental policies (Section 1.04) and public concerns (Section 2.03), it is apparent that the most significant terrestrial impacts would fall into three main categories:

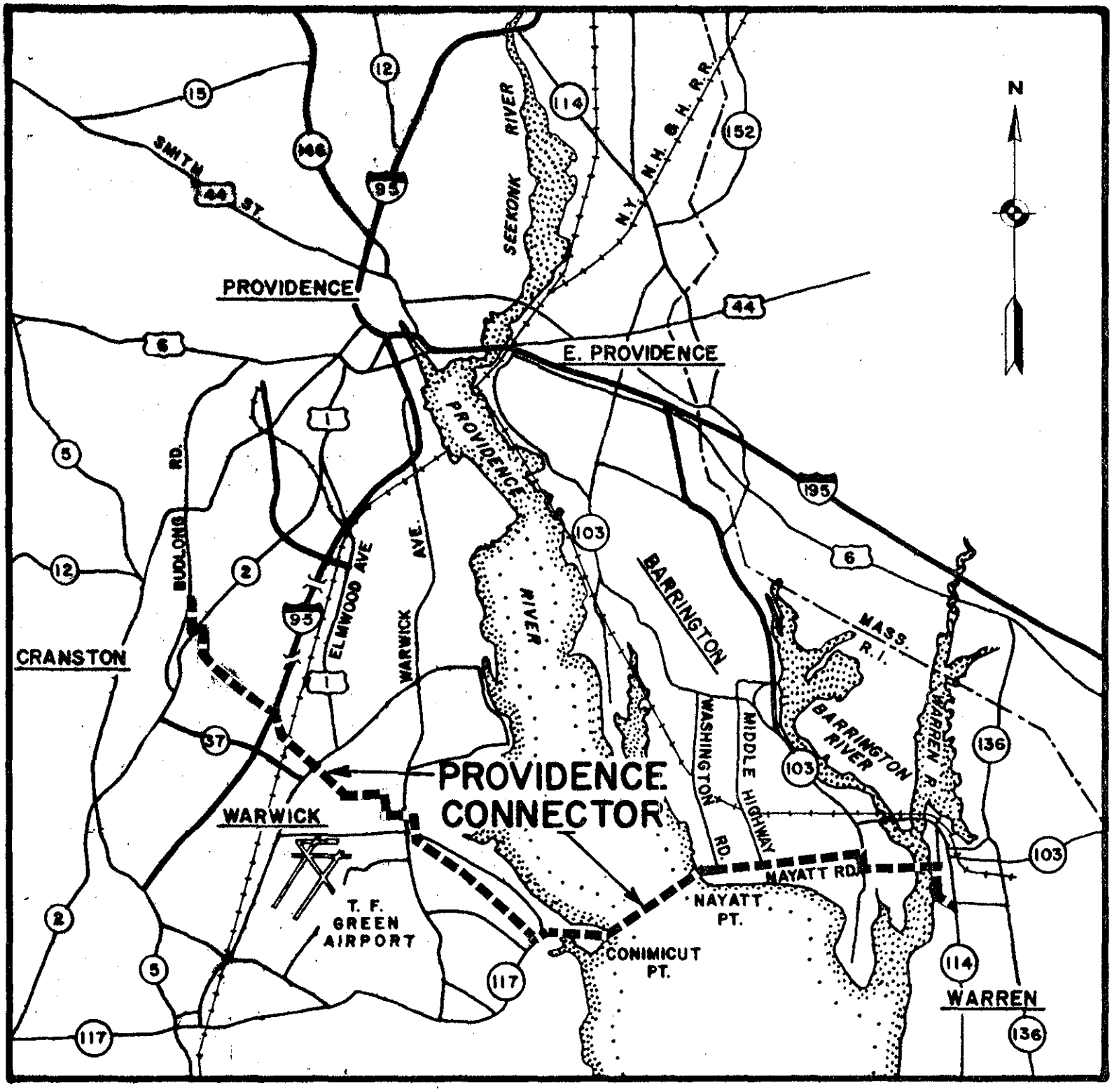
(a) wetlands -- not only for their intrinsic biological value (404 Evaluation, Section 230, 41-A) but also for their contribution to (b) and (c) below;

(b) game resources -- deer, waterfowl, pheasant, grouse and small mammals; and

(c) nature study and enjoyment -- diverse wildlife habitat, educational and recreational values such as songbirds, unique or significant natural sites, and related aesthetic values.

Creation of the Big River Reservoir would remove 3,240 acres of wildlife habitat which would result in a decrease in wildlife populations in the area. (This has been described in Appendix H, "Terrestrial Ecosystem Assessment Report", and impacts have been summarized in Table 5). Displaced wildlife would attempt to relocate to areas outside the proposed reservoir. However, those species that move to new areas would survive only if the carrying capacity for that species has not been reached in this area. If the habitat is already at its carrying capacity for that species, the excess would continue searching for available habitat or die.

Clearing and construction activities would directly affect small mammals which occupy burrows, such as mice, voles, and shrews. Gray squirrels, flying squirrels, porcupines and other mammals which occupy trees may be killed during tree felling operations. Noise would cause some animals to leave the area on a temporary basis. Clearing operations prior to inundation would result in nutrients being released into the surface waters which could cause eutrophication problems in the reservoir.



LOCUS PLAN

0 1 2 3 4Mi.

FIGURE 3

Impacts on avifauna would be minimal except during the spring and early summer when there could be a high mortality of eggs and young, along with destruction of nesting habitat.

Big River Reservoir would provide suitable habitat for waterfowl species such as scaup, common goldeneyes, buffleheads, and other diving ducks. The edge of the reservoir would be utilized by puddle ducks, wading birds and aquatic furbearers.

The open reservoir would result in a greater environmental diversity by the creation of different types of habitat in the region which would support a higher diversity of species.

Clearing or additional cutting of vegetation for flood control storage should not be necessary, and there would be no loss of wetlands due to the additional flood control increment.

As only 3 feet would be added to the height of the dam for flood control, effects on fish and wildlife resources in the reservoir area would be minor when compared to those associated with the creation of the reservoir itself.

Further discussion of impacts associated with the implementation of flood damage reduction measures can be found in Appendix B - Plan Formulation.

Construction noise associated with installation of pipelines in the Providence, Pawtuxet and Warren Rivers would distrub resident wildlife in those areas for only the duration of the construction activities. Vegetation in access areas may have to be cut and removed to allow equipment access to the pipeline sites. Any existing waterfowl nesting areas could be disturbed depending on the time of year the transmission lines are installed.

6.0 LIST OF PRIMARY PREPARERS

The following persons were responsible for principal contributions to this Environment Impact Statement or significant background reports (as indicated):

Name	Professional Discipline	Education	Experience
Robert Brustlin (Consultant, AppH-I)	Environmental Planning	MLA (Masters Landscape Architecture) BS Civil Engineering BA Engineering Economics	Project manager for various engineering/environmental studies; including planning and design of various recreation facilities, 4 years.
Douglas Cleveland	Recreational Planning	BS Civil Engineering	12 years environmental and recreational resource planning with Corps of Engineers, NED
David Coon (Consultant, AppH-III)	Fisheries Biology	MS Fisheries Biology/Limnology BS Biological Sciences	7 years environmental studies; esp. impact studies for power plants, reservoirs, and industrial effluents on aquatic biota.
John Craig (Study Manager)	Water Resources Planning	BS Civil Engineering	12 years sanitary engineering consulting; 5 years water resources planning, Corps of Eng., NED.
Michael Grubb (Consultant, AppH-II)	Wildlife Biology	MS Wildlife Management BS Biological Sciences	4 years environmental consulting addressing impacts of highway, airport, and reservoir construction on wildlife populations.
Dennis Magee (Consultant, AppH-II)	Plant Ecology	MS Forest Ecology BS Wildlife Biology	7 years consulting addressing impacts of highways, airport, pipelines, and building construction on plants, wildlife, and especially wetlands.
Phillip Rieger (EIS Coordinator)	Applied Ecology	MS Zoology BS Biology/Chemistry/Geography	2 1/2 years Fisheries Research; 2 1/2 years Environmental studies with Corps of Engineers, NED.
John Wilson	Archaeology/Anthropology	MS Anthropology BA Anthropology	3 years Archaeological consulting; 3 years (combined) Cultural Resources Manager for the State of Massachusetts and the Corps of Engineers, NED.
Susan E. Brown (EIS Preparation)	Biology	BS Biology	4 years General Biology and Environmental Studies with Corps of Engineers, NED.

7.0 PUBLIC INVOLVEMENT

Four initial public meetings were held in May 1969 for the Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Study. These meetings were held in Taunton and Uxbridge, Massachusetts and Providence and Kingston, Rhode Island. The purpose of these meetings was to afford local interests the opportunity to express their needs and desires, to exchange information concerning the study, and to comment on some of the possible plans that could be considered. Subsequent to those meetings, numerous informal meetings were held with State and municipal interests and concerned citizens.

Two plan formulation public meetings were held on 6 and 8 May 1975 in Warwick and Cranston, Rhode Island, respectively. The purpose of these meetings was to present all of the alternative plans developed during the investigation and to incorporate public desires in plan formulation and choice of the most desirable alternative. Subsequent to these meetings nearly 100 field contacts were made, several informal meetings were held with citizens groups, approximately 20 informal contacts were made with State and municipal interests and nearly 50 informal contacts were made with Federal agencies.

The requested work items evolving from the public participation program were completed. A subsequent public meeting was held in Warwick on 14 October 1976 presenting the results of the study findings. Copies of the draft report and the Draft Environmental Impact Statement (EIS) prepared for the Pawtuxet River flood control study were distributed to the public prior to the meeting. Subsequent meetings held between October 1976 and May 1977 to determine the future course of action resulted in additional plans being offered for consideration. They were presented at another late stage public meeting held on 19 May 1977. Local flood management measures and study findings were discussed with Warwick and State officials on 3 March 1979, Warwick residents on 8 March 1979, and Cranston officials on 4 May 1979. A revised Selected Plan was subsequently developed.

Principal participants contacted during the progress of the Pawtuxet River Basin Study included the following:

Federal Agencies

U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
New England River Basins Commission

State Agencies

Rhode Island Water Resources Board
Statewide Planning Program
Department of Public Health
Department of Environmental Management
Historical Preservation Commission

Local Agencies/Organizations

City of Warwick
City of Cranston
Town of West Warwick

Although a Draft EIS was prepared for the Pawtuxet Study, further action on these documents was not carried out. The Report and Draft EIS have been combined in the Big River Reservoir study report.

A significant portion of the Corps' efforts in determining the scope of the feasibility and environmental studies pertaining to the Big River proposal also entailed solicitation of public concerns regarding the issues surrounding the proposed Big River Reservoir and related water resource needs and solutions in Rhode Island. The primary avenue of this effort was through public workshops. An initial four were held in September 1978, with another three in June 1979. These workshops were intended to acquaint public officials, interest groups, governmental bodies and other segments of the public with the Corps study -- general scope, methods of analysis, restrictions and tentative results -- and to obtain input to ensure that the scope of the study would, as comprehensively as justified, reflect the true public concerns surrounding any proposed measures.

In addition to the workshops, interviews with key State agencies and interest groups were conducted to highlight and bring additional insight into potential issues and concerns. These interviews were conducted with the following:

Organization	Contact
Audubon Society of Rhode Island	Alfred Hawkes
Ecology Action of Rhode Island	Bonnie Cimino/ Barry Schiller
Environmental Consultant	Dr. John Kupa
Kent County Water Authority	Norman St. Serveire
Natural Resources Group	Dr. Arthur Jeffrey
Office of the Governor	Anne Stubbs
Providence Dept. of Planning & Urban Development	John R. Kellam
Providence Water Supply Board	Peter J. Granieri
RI Dept. of Environmental Management	Calvin Dunwoody
RI Dept. of Health	John Hagopian
RI Federation of Riding Clubs	Joan Burgeault
RI Trail Advisory Group	Jack Deary/ Joan Burgeault
RI Water Resources Board	Peter Calise
RI Statewide Planning Program	J.Deary/V. Parmentier/ George Johnson
Town of Coventry	James Clarke
Town of East Greenwich	J. Burke/S. Deutch
Town of West Greenwich	Robert Maguire

Also, during the first workshop meetings, position papers and issue statements on Big River Reservoir issues were presented by representatives of the Providence Water Supply Board, the Rhode Island Office of State Planning, the Audubon Society of Rhode Island, the Town of West Greenwich, the Rhode Island Water Resource Board, the Federated Sportsman Club of Rhode Island, the Providence Department of Urban Development and the Office of the Governor. *Refer to Appendix C for a summarization of these papers and statements.*

TABLE 6

INDEX, REFERENCES AND APPENDIXES
BIG RIVER RESERVOIR

Subjects	STUDY DOCUMENTATION: Environmental Impact Statement	Main Report (References Incorporated)	Report Appendixes (References Incorporated)
Affected Environment	pp. EIS 20-22 para. 4.0	pp. 7-16	App. A, pp. A-12-A-33
Alternatives	pp. EIS 9-19 para. 3.0	pp. 49-59	App. B, pp. B-62-B-75
Areas of Controversy	pp. EIS 3-5 para. 1.02-1.03	pp. 3, 17	App. C, pp. C-35-C-44
Comparative Impacts of Alternatives	pp. EIS 14-15 para. 3.03	pp. 60-61	App. B. pp. B-74-B-80
Cover Sheet	pp. EIS i-ii	---	---
Environmental Conditions	pp. EIS 20-22 para. 4.0	pp. 7-16	App. H, Sections 2 & 3
Environmental Effects	pp. EIS 24-35 para. 5.0	pp. 51,54, 56	App. B, pp. 3-73-B-75
List of Preparers	pp. EIS 36 para. 6.0	---	---
Major Conclusions and Findings	pp. EIS 1-2 para. 1.02	---	---
Need for and Objectives of Action	pp. EIS 7-8 para. 2.0	pp. 7, 21-24	App. A, pp. A-44-A-55
Planning Objectives	pp. EIS 7 para. 2.02	pp. 26-27	App, A, pp. A-60-A-61
Plans Considered in Detail	pp. EIS 13-19 para. 3.03	pp. 49-59	App. B, pp. B-62-B-75, App. H, Sec. 1
Plan Eliminated from Further Study	pp. EIS 9-12 para. 3.01	pp. 38-48	App. B, pp. B-38-B-47, B-51-B-54
Public Concerns	pp. EIS 7-8 para. 2.03	pp. 2-3, 21-24	App. C, pp. C-35-C-44
Public Involvement	pp. EIS 37-39 para. 7.0	pp. 2-3	App. C.
Public Involvement Program	pp. EIS 37-39 para. 7.0	pp. 2-3	---
Public Views and Responses		---	---
Relationship to Environmental Requirements	pp. EIS 5-6 para. 1.04	pp. 7, 26-27	App. H, Sec. 1,2,& 3, App. I Sec. 2
Required Coordination	pp. EIS 5-6 para. 1.04	---	---
RESOURCES:			
Aesthetics	pp. EIS 27 para. 5.01.5	pp. 8-9, 14,16	---
Aquatic Resources	pp. EIS 32-34 para. 5.02.3	pp. 8-12	App. H, Section 2
Cultural Resources	pp. EIS 27-28 para. 5.01.6	p. 16	App. I, Section 2
Demography	pp. EIS 24-25 para. 5.01.2	pp. 12-14	App. A, p. A-25, A-35-A-38
Economics	pp. EIS 25-26 para. 5.01.3	pp. 12-14	App. A, pp. A-25-A-31
Mitigation	pp. EIS 17-18, 29-32 para. 3.03, 5.02.2	pp. 52,55	App. H, Section 4
Recreation	pp. EIS 28-29 para. 5.01.7	p. 15	App. H, Section 1
Terrestrial Resources	pp. EIS 34-35 para. 5.02.4	p. 9, 12	App. H, Section 3
Transportation	pp. EIS 26 para. 5.01.4	p. 15	App. A, pp. A-31-A-32
Significant Resources	pp. EIS 21-22 para. 4.02	pp. 8-16	App. A, pp. A-16-A-33
Statement Recipients	---	---	---
Study Authority	pp. EIS 7 para. 2.01	p. 1	App. A, pp. A-1-A-2
Summary	pp. EIS 1-6 para. 1.0	---	---
Table of Contents	pp. EIS iii	p. i	
Unresolved Issues	pp. EIS 3-4 para. 1.02	---	---
Without Conditions (No Action)	pp. EIS 12-13 para. 3.02	pp. 16-20	App. A, pp. A-58-A-59

Pawcatuck River and Narragansett Bay Drainage Basins

Water and Related Land Resources Study

BIG RIVER RESERVOIR PROJECT

DRAFT

THE CLEAN WATER ACT

SECTION 404 EVALUATION

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1980

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

This report is intended to provide an evaluation of the Big River Reservoir Project, a proposed water supply/flood control impoundment in central Rhode Island. This evaluation is in conformance Section 404 of the Federal Water Pollution Control Act of 1972, amended as the Clean Water Act, December 27, 1977.

Application and administration of the 404 requirements are assigned to the administrator of the Environmental Protection Agency (EPA) and the Secretary of the Army. Guidelines for the evaluation were published by the EPA in the Federal Register, September 5, 1975 (40 CFR 230, hereinafter refer to as the guidelines). Pursuant to a recent Corps of Engineers regulation (ER 1105-2-90, dated October 10, 1978), the guidelines are to be applied in evalutation of all Corps of Engineers activities involving discharge of dredged or fill material in navigable waters.* Any impacts to the specific items addressed by the guidelines that would presumably result from construction of the dam are therefore addressed in this report.

The purpose of the Act is to provide a means of protecting vital water resources from despoilation through irresponsible and irreversible decisions and actions. This evaluation should therefore provide or reference information sufficient to determine whether unacceptable or unnecessary degradation of such values would result from project implementation.

The guidelines are particularly applicable in relation to wetlands, water supply, fishery resources, wildlife, and recreational values. The intent of the guidelines is to require an ecological evaluation of such aspects (Section 230.4) and pertinent consideration and conditioning of the discharge (Section 230.5) to minimize or prevent unneccessary degradation of aquatic resources. Corps of Engineers ER 1105-2-90 specifies that evaluation analysis and findings shall be presented so that reviewers may clearly find each of the points listed in Section 230.4(1); Chapter IV is intended to fulfill this requisite.

Because of the structured technical nature of this evaluation, Chapters IV, V and VI can best be comprehended by familiarity with the guidelines. Chapter III however summarizes, in a less specific and

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*See glossary for definitions per EPA guidelines.

technical nature, the more significant relevant impacts. Related information is also available in the Big River Reservoir Environmental Impact Statement (EIS), the Feasibility Report, and associated appendices, particularly in Appendix D (Hydrologic Analysis), E (Water Quality) and H (Recreation and Natural Resources). Reference to these publications may be desirable to fully understand certain conclusions regarding impacts only superficially discussed in this evaluation.

CHAPTER II

DESCRIPTION OF PROPOSED PROJECT AND ITS SETTING

The proposed 3400 acre multi-purpose (combined water supply, recreation, and flood control) reservoir would be located in the Big River Basin, a tributary to the south branch of the Pawtuxet River, Rhode Island (figure 1, EIS). The installation would consist of a 70 foot high dam to elevation 312 feet above NGVD located at the confluence of the Big River with Flat River Reservoir (figure 1). The 2315 acres of forests within the reservoir site would be cleared prior to impoundment to elevation 303 feet NGVD (maximum water supply pool). This includes an additional 3 feet for 9,500 acre feet of flood control storage; an equivalent to 6 inches of runoff from the 29.7 square mile watershed.

Approximately 7 miles of underground aqueduct would transfer the reservoir water to the existing City of Providence water supply system.

The watershed upstream of the proposed Big River Dam is of relatively mild topographic relief, with broad poorly drained swampy valleys. This area is within one of the largest relatively uninhabited areas in the State of Rhode Island. The existing character of the region has resulted from State ownership since 1965 of about 8,300 acres of land, known as the Big River Management Area. The area was purchased by imminent domain to protect the reservoir site from development incompatible with the proposed project purpose. Existing use of the area consists of primarily of informal recreational activities such as hunting, fishing, motorcycling, and horseback riding. Although the presence of a water supply reservoir would preclude the area being considered for all recreation uses with the project, it has the potential for providing compatible recreation under proper management. A more detailed description of the project, its setting, impacts, and various alternatives to the project and alternatives within the project is provided in the Main Report and EIS.

CHAPTER III

EVALUATION SUMMARY

The most obvious and direct impact of the proposed Big River Reservoir on the environment would be the irreversible transformation of an existing 3240 acre stream-forest ecosystem to one of standing water. Some 19.7 miles of stream habitat (54.5% of the 36.2 miles in the Big River Basin) and at least 10 small ponds totalling about 45 acres would be inundated; 3154 acres of terrestrial habitat including 2305 acres of forest, and 524 acres of wetlands and 325 acres of open land would be lost.

These components of the existing ecosystem would be replaced by the 3240 acre Big River Reservoir. As a consequence, various wildlife, fishery, aesthetic, recreation, and botanical values would be *affected -- some displaced, some created.* *Appendix H contains* substantial information regarding these values. The conversion of terrestrial habitat into aquatic habitat would displace all wildlife species existing within the proposed area for inundation as well as impact those which utilize the area during part of their lives. Wildlife in adjacent regions would be affected through crowding by increased immigation of those animals utilizing the habitat that would be impounded. Proper management of these adjacent regions would significantly ameliorate this impact (see Fish and Wildlife Mitigation Plan, EIS).

In addition to upland resources lost by inundation, many acres of wetland and riparian habitats would be lost. Representing about 17% of the area that would be inundated, wetland losses should be considered as a significant impact due in part to the relative scarcity in the State (1.5% of the total land area), and to their important contribution to the overall biological productivity and diversity of a region. Because of the significance of wetlands, Section 230.4-1 is devoted primarily to consideration of wetlands;* and the Corps' Fish and Wildlife mitigation plan (Appendix H, Vol. 4) emphasizes mitigation of wetland losses. This plan proposes dikes to be strategically placed in selected shallow coves to stabilize water levels and allow aquatic plants to establish. If properly constructed and managed, these areas would become very attractive wildlife habitats, important to many of the species presently inhabitating or utilizing the proposed area to be inundated.

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*See Glossary for definition.

The existing stream fishery setting would be replaced by a lake fishery. A total of 15 fish species, including sports fish such as brook trout, largemouth bass, and pickerel, are known to inhabitat the area to be inundated. As explained in Appendix H, Vol. 2 , the streams and ponds of the project area have been found to be of low productivity and unable to sustain a significant fishery -- the reservoir would provide much greater fishery potential. Generally the species now found in the area are capable of maintaining viable populations in the proposed impoundment. Some will adapt more favorably than others. Also, some new species (trout and smallmouth bass) may be introduced to the reservoir thus generating a more diverse and more productive sports fishery than now exists. A fishery management plan will be proposed by the Corps as part of the Fish and Wildlife Mitigation Plan for appropriate consideration.

Project implementation would provide a significant change in recreational use of the region. In addition to alteration of fishing and hunting opportunities, areas of horseback riding, motorcycling, hiking, and other activities would be displaced by the reservoir. New recreational opportunities based on the lake environment would replace those types of recreation in many areas (see Appendix H, Vol. 1 "Recreation").

In comparison to those values displaced (which are noticeably irreversible, short-term construction and operational off-site effects are less significant. Downstream sedimentation during construction, a modified downstream flow regime and various biological stresses subsequently created, are unpreventable, but efforts would be made to minimize undesirable degradation where possible.

CHAPTER IV

SECTION 230.4-1

ECOLOGICAL EVALUATION

230.4-1(A) PHYSICAL EFFECTS

Physical effects on the aquatic environment include destruction of wetlands, impairment of the water column, and covering of benthic* communities. Evaluation of the significance of such effects is based primarily on the extent of the discharge area and related environmental values displaced or affected by the proposed discharge. Following is a short explanation of how such physical effects relate to the Big River Reservoir Project per the guidelines.

230.4-1(A-1) Effects on Wetlands: From a national perspective, according to the guidelines the Clean Water Act regards the degradation or destruction of wetlands as the most qualitatively significant type of environmental impact: "Destruction of wetlands [is] an irreversible loss of invaluable aquatic resource."

The implied categorical significance of wetland destruction is primarily related to the value of wetland as a function toward the ecological integrity of a region. Briefly, wetland functions as specified in the guidelines (hereinafter inquotes) would apply to Big River Reservoir project as follows.

> (i) "Wetlands that serve important natural biological functions, including food chain production, general habitat and nesting, spawning, rearing and resting sites for aquatic or land species . . ."

Many such wetlands exists within the proposed area. Appendix H, Vol. 3 expounds upon such values. The mitigation utilizes the value of these wetlands for certain wildlife species as a guide to provide (through appropriate project modification, i.e., stabilization structures in shallow coves) the types of wetland habitat (within site limitations) of most value to the ecosystem with the project.

> (ii) "Wetlands set aside for the study of the aquatic environment or as sanctuaries or refuges . . ."

No such areas are found within the project area.

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*See Glossary.

(iii) "Wetlands contiguous to areas listed in (A)(i) and (ii) this section, the destruction of which would effect detrimentally the natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics of the above area . . ."

The (A)(i) areas would no longer exist, and (A)(ii) are not found in the watershed or downstream of the project.

(iv) "Wetlands that are significant in shielding other areas from wave action, erosion or storm damage. Such wetlands often include beaches, islands, reefs, and bars . . ."

The magnitude of hydrologic effects of the reservoir itself should be considered as replacement for any loss of this nature. The reservoir would displace the wetlands but provide much greater shielding against erosion, flooding, etc.

(v) "Wetlands that serve as valuable storage areas for storm and flood waters . . ."

The flood storage capability of the reservoir would more than compensate any loss of this function.

(vi) "Wetlands that are prime natural recharge areas . . . where surface and ground water are directly interconnected. . ."

Again, the recharge potential of the reservoir would more than compensate for such losses.

In summary, the ecological significance of wetland losses due to project implementation would primarily relate to biological (A-1)(i) functions. It is the objective of management strategies and modification structures to mitigate primarily for such lost biological functions.

230.4-1(A-2) Effects on the Water Column: Inundated water resources would change from stream/pond to a lake environment. About 10 small ponds and 19.7 miles of intermittent and continuous streams would be inundated. The two largest ponds, Tarbox pond (17.5 acres) and Capwell Mill Pond (11.7 acres) with an average depth of about 3.5 feet provide a limited warm water fishery, and with the fringe marsh wetlands, provide habitat for various waterfowl and wetland wildlife. Specific physical changes include: a dampened temperature regime; a

sink affect on incoming suspended sediments; a shift in planktonic* populations from lotic to lentic species; and aesthetically, the aquatic landscape would change from flowing water (with a few scattered ponds) setting to a large body of open water. Also, the downstream water column (a portion of Flat River Reservoir) would be affected by increased suspended sediment and nutrient loads during the construction period.

230.4-1(A-3) Effects on Benthos: Existing stream species within the impoundment area would be replaced by lake species. Also, construction-related and operational stresses on the downstream benthic communities are expected.

230.4-1(B)

CHEMICAL-BIOLOGICAL INTERACTIVE EFFECTS

Ecological perturbation caused by the chemical-biological interactive effects would result from release of contaminants from the inundated soils, particularly soils disturbed during clearing activities and dam construction. The principal 404 concern is the potential effect benthic and fish communities. Clearing activities would in the long term be beneficial to the ecosystem by allowing the reservoir to become more oligotrophic* -- a condition of minimal aquatic biological and chemical interaction --through removal of much of the organic material within the site (See App. H, Mitigation Plan). This not only allows better quality drinking water, but would provide a habitat more suitable for desirable fish species such as trout and smallmouth bass; species that have all but disappeared from Rhode Island waters due to cultural eutrophication.*

230.4-1(B-1) Evaluation of the Potential of Chemical-Biological Interactive Effects: Potentially detrimental chemical constituents that may be present in existing soils in sufficient quantities to leach into and affect lake or downstream waters primarily include nutrients and organic material. The potential of such contamination is discussed in the following subsections.

230.4-1(B-2) Water Column Effects: The procedures proposed by the EPA in the guidelines to predict water column effects although suitable for the effects of dredged material disposal, are not appropriate in reservoir analysis. However, qualitative inferences as to water quality affects can be made based on past studies, samples in the project area, and appropriate analytical techniques.

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*See Glossary.

Analysis of water quality data collected throughout the Big River watershed (Appendix E) indicate that such potential pollutants as organic material, nutrients, coliform bacteria, turbidity, pesticides, chlorides, and heavy metals including iron and manganese will not be present in the reservoir in concentrations harmful to aquatic life. Iron and manganese however are estimated to possibly exceed national drinking water regulations (300 and 50 micrograms per liter, respectively) during the initial stabilization of the reservoir (10-20 years); appropriate water treatment would be provided at the treatment plant as necessary. Generally, the water quality of Big River Reservoir is predicted to be as good as or better than Scituate Reservoir, the existing water supply reservoir for the providence water supply. Although no data on aquatic life in Scituate Reservior is available, this water is regarded by many as among the finest natural quality in the country.

Other water quality parameters such as color, pH, dissolved oxygen, and temperature are predicted to be variable with seasonal conditions, but generally favorable for aquatic life. It is predicted that the chemical and physical aspects of Big River Reservoir would support salmonoid fish species -- a factor that is generally indicative of a "high quality" aquatic resource. The reservoir would limnologically* be classified as oligotrophic.**

During the clearing-construction-filling period, low flows and higher temperatures combined with higher quantities of nutrients may create algal blooms in downstream areas, particularly one area of Flat River Reservoir; however, this reservoir is already relatively eutrophic** due in large part to the highly residential watershed and resulting nutrient loading. The increase of organic material from either algal blooms, or directly introduced with erosion may however increase the biological oxygen demand (BOD)* enough to create greater oxygen deficient conditions in a small portion of Flat River Reservoir. The extent of such potential effects is as yet unpredictable. Although it could have no noticeable effect, the probability for a detrimental effect in a small area is high. Precautionary control conditions would be established and coordinated with the State to lessen the possibility of the latter situation. Superimposing the assumed Big River Reservoir Operation (Appendix D) into the Upper Pawtuxet Basin obviously would have a marked effect on the hydrology

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*See Glossary.

**A characterization of oligotrophic and eutrophic lakes is provided on page 23 following the glossary.

of Flat River Reservoir and the South Branch of the Pawtuxet River. By reducing the natural average flow into Flat River Reservoir by about 43%, the average minimum downstream yield of Flat River Reservoir as augmentation to the Pawtuxet River would be reduced from about 40 to 33 cfs with existing operational policy of Flat River Reservoir continuing (See Appendix D, page 31). However, if modification to the existing Flat River operation were implemented in light of the impact and the augmentation potential of Big River Reservoir, this average minimum release could be maintained at about 37 cfs. Plate 15, Appendix D simulates this effect.

Under these conditions, the water levels in Flat River Reservoir would also be impacted and drawdowns would be more frequent and of greater duration and magnitude. A plot comparing pool levels of Flat River Reservoir with and without Big River Reservoir is also shown on plate 15, Appendix D.

230.4-1(B-3) Effects on Benthos: Concentrations of contaminants are not expected to be sufficient to impair benthic productivity.

230.4-1(C) Comparison of Sites

Not applicable to this evaluation; it applies to disposal of dredged material.*

*See glossary.

CHAPTER V

SECTION 230.4-2

WATER QUALITY CONSIDERATIONS

Creation of the Big River impoundment would preclude existing water quality standards for streams within the impounded areas; such standards would be inappropriate for a reservoir. The predicted water quality of the reservoirs is explained in more detail in the EIS, and in Section 4-1(B-2) of this evaluation. The results of water quality predictions (Appendix E) indicate that the reservoir should present no water quality problems. The lake is predicted to be a relatively deep, oligotrophic impoundment characterized by relatively shallow thermocline, low nutrient levels, and comparatively high dissolved oxygen levels throughout the year. The lake water quality should be better than existing conditions both empirically and as habitat for aquatic organisms. The State of Rhode Island will presumeably establish reservoir water quality standards and monitoring provisions with the intent of providing quality drinking water to the Providence Metropolitan Area water supply system.

Downstream water quality considerations are however necessary. The "mixing zone" as described in the guidelines, Section 230.5(E), (forthcoming) as applicable to such considerations would include part of Flat River Reservoir downstream to Narragansett Bay via the south branch of the Pawtuxet River (See Figure 1, EIS). The altered flow regime from the impoundment may effect the assimilation of pollutants in the Pawtuxet River. As recommended in the Rhode Island 208 Water Quality Management Plan, a 10 year 7 day low flow of about 17 cfs (10 mgd) would be required in the South Branch of the Pawtuxet below Flat River Reservoir to ensure predicted assimilation of the various pollutant loadings along the River. The calculated safe yield of Big River Reservoir takes into account a release of 6 cfs toward this goal (Appendix D, page 28). Presumably, the augmentation potential of Big River Reservoir could be utilized to maintain this low flow if the benefits thereof outweigh the need for water supply in a given circumstance.

As presented in Section 230.4-1(B-1), chemical constituents that would influence long term water quality within the reservoir, and thus possibly downstream, are predicted to be very low. Short term water quality impacts will however relate physically to the turbidity and sedimentation caused by erosion from dam construction and site preparation activities. During construction, increased releases of

chemical contaminants would accompany erosion to the river, however it is expected that the physical effects of turbidity would be of most concern. Because of the potential of erosion related impacts, extensive erosion and siltation control methods would be proposed. These methods should employ clearing, excavation, and grading practices; diversions, disposal and land stabilization structures; and, mulching and vegetal control measures. In spite of utilization of such methods undesirable siltation to some degree would unavoidably occur during periods of heavy rainfall, the extent of which can not be predicted. The goals of control measures are however to lessen such effects with the intent of not degrading downstream water quality conditions at magnitudes unacceptably greater than natural conditions.

CHAPTER VI

SECTION 230.5

SELECTION OF DISPOSAL SITE AND THE CONDITIONING OF DISCHARGE OF DREDGE OR FILL MATERIAL

230.5(A) GENERAL CONSIDERATIONS AND OBJECTIVES

The following impact summary (as outlined in conformance with the guidelines, Section 230.5(A)) would result from implementation of the proposed Big River Reservoir project. Many are unavoidably objectionable and have been considered in the determination of recommendations regarding the proposed project under the authority of these guidelines:

(1) Significant disruption of the chemical, physical and biological integrity of the aquatic ecosystem of which aquatic biota, the substrate and the normal fluctuations of water level are integral components would occur;

(2) Significant disruption of the food chain, including alteration or decrease in diversity of terrestrial plant and animal species within the impoundment area would occur;

(3) Inhibition of movement of fauna, including movement into and out of feeding, spawning, breeding, and nursery areas, would occur;

(4) The wetlands of the area do not have significant functions in maintaince of water quality;

(5) The impoundment would inundate areas presently serving to retain natural high or flood waters, but the reservoir itself would provide even more flood control than presently exists;

(6) Adverse turbidity levels would result from construction activities;

(7) Existing aesthetic, recreational and economic values would be displaced; and

(8) As was indicated in Section 230.4, water quality degradation during construction and filling, would result. In the long run however, the quality of water leaving the watershed would be better than existing conditions.

According to the guidelines: "In evaluating whether to permit a proposed discharge of dredge or fill material into navigable waters, consideration shall be given to the need for the proposed activity, the availability of alternative sites and methods of disposal that are less damaging to the environment, and such water quality standards as are appropriate and applicable by law."

In planning the Big River Reservoir facility, many water supply and flood control alternatives were considered. Alternatives such as other surface reservoir sites, existing reservoirs, ground water, demand modification, sea water desalinization, and structural and non-structural site flood control alternatives are addressed in the Big River EIS and Feasibility Report and Attachment 1.
Studies thus far indicate Big River Reservoir, for various reasons (environmental, need resolution, State policy, and practicality) as the most desirable alternative. The EIS, Chapter 1 expounds upon the decision factors as summarized here:

(1) Other surface water storage sites include impoundments in the Flat River, Wood River, Moosup River, and Buck's Horn Brook. All of these would involve intra-basin water transfer. All would impact better, and more heavily utilized stream habitats (fish, recreation, water quality). None offer the desirable flood damage prevention to the towns of West Warwick, Warwick, and Cranston along the mainstem of the Pawtuxet River. None provide as much water supply yield possible with the Big River site.

(2) Various existing reservoir sites could be tapped in a combination of new transmission and treatment facilities (Appendix B). However, all of these reservoirs already have purposes deemed incompatible to water supply: recreation, industry, residential, etc. State law* precludes such activities as bathing and dumping refuse into a public water supply. Recreation would be halted, residents nearby would have to be relocated, and several industrial uses would be precluded, or, the State law would have to be changed and more expensive water treatment would be required for the lower quality water available in such existing sites. Again, no flood control to the Pawtuxet River would be offered.

(3) The potential safe yield of yet untapped groundwater reserves available for use in the demand area has been estimated at about 7.0 mgd. This resource can and should utilized to supplement the water supply system, but it doesn't satisfy the predicted need.

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*See Appendix H, Vol. 1

(4) Weather modification, although a potential water supply measure, is not technically reliable and the environmental impacts are unknown.

(5) Demand modification would, if implemented, curtail up to about 11 percent of the predicted need.

(6) Sea water desalinization is an almost unlimited supply source, however, the non renewable energy costs involved with all methods of this process when weighed against the low cost of a natural storage site have made this alternative economically impractical in an area with adequate rainfall.

230.5(B) Considerations Relating to Degradation of Water Uses at Proposed Disposal Site

Some existing water uses would be affected through implementation of the Big River Reservoir project. Consideration of such values is summarized in accordance with the guidelines covering this section as follows:

(1) Municipal Water Supply Intakes - No known public water supplies would be adversely effected by Big River Reservoir; the Providence water supply be augmented by the reservoir.

(2) Shellfish - No areas of important shellfish populations would be affected.

(3) Fisheries - The Big River project would completely change the existing fishery habitat. This change is discussed in more detail in the EIS and Appendix H, Vol. 2 and 4. The change is not regarded as unacceptable because the lake fishery afforded by the project is predicted to be better than the existing fishery resource.

(4) Wildlife - The habitat, food chain and community structure of existing wildlife within and nearby the proposed impoundment would be affected. The EIS, Appendix H, Vol. 3 and 4 discuss this aspect in detail.

(5) Recreation Activities - Appendix H, Vol. I discusses recreational impacts in detail. In relation to this evaluation, concerned factors apply as follows:

(i) Reasonable methods to minimize adverse turbidity would be employed (See Section 230.4-2);

(ii) The release of nutrients during construction is not expected to unacceptably increase downstream eutrophication, and thusly degrade aesthetic values. It may however impair recreation uses of a very small portion of Flat River Reservoir (See Section 230.4(B-2);

(iii) No material that would result in unacceptable levels of pathogenic organisms would be discharged in areas to be used for recreation;

(iv) No material would be discharged which would result in release of oil or grease in harmful quantities.

(6) Threatened and Endangered Species - The various studies as discussed in the Appendix H have not indicated that any endangered species or habitats thereof would be adversely affected by the proposed action.

(7) Benthic Life - Existing benthic communities within the impounded areas would be displaced and a new benthic habitat would result and allow new community structures to establish. Also, benthic life directly below the impoundment would be stressed during construction related sedimentation and diversity would be reduced. More details are available in the EIS and Appendix H.

(8) Wetlands - The effects of Big River Reservoir on wetlands were discussed in Section 230.4-1 and in the EIS. Any reservior project of a magnitude similar to Big River Reservoir in the northeastern United States would undoubtedly have such effects -- alternative sites only affect wetlands at other sites. As was stated in Section 230.4(C-1) the primary detrimental impact of this project on wetlands is related to biological systems. Wetland impacts, according to the guidelines, may be permitted if:

"(a) the activity associated with the fill must have direct access or proximity to, or be located in, the water resource in order to fulfill its basic purpose, or that other site or construction alternatives are not practicable; and (b) that the proposed fill and the activity associated with it will not cause a permanent unacceptable disruption to the beneficial water quality uses of the affected ecosystem, or that the discharge is part of an approved Federal program which will protect or enhance the value of the wetlands to the ecosystem."

An examination of these factors as related to the proposed Big River Reservoir allows determination that the project is permitted through these requirements:

(1) Dam construction ("the activity associated with the fill") must be located in the water resource in order to create an impoundment for the basic purpose of water storage;

(2) Other sites to provide the same purpose has been consider and determined as not practicable (Appendix B).

(3) Construction alternatives to provide mitigation of unpreventable wetland losses have been proposed (see mitigation plan); and

(4) The major beneficial water quality use of the affected ecosystem include primarily a limited fishery. The reservoir would create a more beneficial water quality use -- water supply to a large Rhode Island metropolitan area and a better fishery.

9. Submerged Vegetation - Many wetlands contain submerged vegetation. Such areas within the project area and the significance of biological productivity thereof can be derived from Appendix H, Vol. 3.

10. Size of Disposal Site - In consideration of alternative reservoirs sizes and sites, it was found that water resource impacts would be qualitatively similar or less at the Big River site. The selected level and site for the Big River Dam was based on optimization of economic and water supply potential of the environment. Reduction of the size of the reservoir to a degree sufficient to realize meanful environmental advantages would also defer feasibility of the site. Such a reduction would mostly create the need for other alternative water supply sources as were discussed in Section 230.5(A).

230.5(C) Applicable Considerations In Determining the Site and Disposal Conditions To Minimize the Possibility of Harmful Effects

1. Appropriate scientific literature has been consulted for all aspects of the project to find, investigate, describe, and propose mitigation measures for impacts to fisheries, wildlife, wetlands, downstream water quality and reservoir management (see mitigation plan, EIS, and Appendix H, Vol.4);

2. Alternatives to the method of inundation do not exist;

3. Not Applicable - Refers to disposal of wastewater;

4. Not Applicable - Refers to open disposal of waste material;

5. Not Applicable - Refers to covering contaminated waste material;

6. Conditions to minimize the effect of runoff from construction areas have been considered (EIS); and

7. Conditions would be established as necessary to control and minimize water quality degradation (see section 230.4-2).

230.5(D) Contaminated Fill Material Restrictions

The material that would be discharged is not expected to contain unacceptable quantities, concentrations or forms of the constituents deemed potentially critical by the analysis presented in Section 230.4.

230.5(E) Mixing Zone Determination

Methods specified in the guidelines to be used in determining the mixing zone are only vaguely appropriate to show dispersion of the constituents for discharged material in this project. The area of inundation was, of course arrived at by other analytical methods. The downstream mixing zone of constituents identified in Section 230.4-2, is related to factors outlined in the guidelines as follows:

(1) Surface area, shape and volume of the discharge site;

(2) Current velocity, direction and consistency at the discharge site;

(3) Degree of turbulence;

(4) Stratification attributable to causes which include, but are not limited to, salinity, obstructions and specific gravity;

(5) Any on-site studies or mathetical models which have been developed with respect to mixing patterns at the discharged site; and

(6) Other factors prevailing at the discharge site that affect rates and patterns of mixing.

Consideration of all such factors indicate that the construction of the Big River Reservoir would affect water resources a considerable distance downstream (i.e., to Narragansett Bay) in some manner. Item (6) above is however the most appropriate consideration in this instance. Although some effects of the reservoir would occur in the Pawtuxet River (flood control and flow augmentation) the contiguous

area of Flat River Reservoir would be the downstream area where ecological effects would be most noticeable. This area and the potential impacts thereto are discussed in more detail in the EIS.

CHAPTER VII

CONCLUSION

It is my opinion, through review of this evaluation, that the water resource concerns outlined by the EPA 404 Guidelines (40 CFR 230) have been clearly identified and presented to allow the determination required by Section 230.3(a) of the Clean Water Act. In accordance with this requirement, I have made the following conclusions:

1. Every attempt has been made to provide for, with pertinent consideration of physical laws and known ecological phenomenon, reasonable minimization and/or mitigation for adverse environmental impacts.

2. Consideration has been given to the need for the project, the availability of alternative sites and methods of disposal that are less damaging to the environment, and such water quality standards as are appropriate and applicable by law.

3. The activity associated with the fill (Dam Construction) must be located in the water resource to provide its basic purpose (impounding water).

4. No unacceptable disruptions to existing beneficial water quality uses would result for the proposed project.

I therefore conclude that the Big River Reservoir Project can be specified through application of the Clean Water Act of 1977.

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Date

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WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting Division Engineer

GLOSSARY

The following terms are defined in the perspective of this evaluation.

Benthic. Of, relating to, or occurring at the bottom of a body of water.

Biological Oxygen Demand. The oxygen used in meeting the needs of aerobic microorganisms is water rich in organic matter.

Constituents*. Chemical substances, solids, and organisms associated with dredged or fill material.

Contaminant. Something that, when introduced into an environment, creates undesirable reactions.

Cultural Eutrophication.

Discharge of Fill Materal*. The addition of fill material into navigable waters for the purposes of creating...(among other things) impoundments of water. The term generally includes...dams and dikes.

Dredged Material*. Material that is excavated or dredged from navigable waters.

Eutrophic**. Rich in nutritive matter.

Fill Material*. Any pollutant used to create fill in the traditional sense of replacing an aquatic area with dry land or of changing the bottom elevation of a body of water for any purpose.

Limnology. The study of fresh water.

Mitigate. To cause to become less harsh or hostile; to make less severe or painful; alleviate.

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*Definitions from 40 CFR 230 (EPA Guidelines App. A).

**Since these terms were used to categorize (and compare in some respects) Big River Reservoir and Flat River Reservoir. A summary of some of the more important characterization according to Welch, 1952 of each category is provided on page 23.

Navigable Waters*. Generally, up to the high water mark of any U.S. waters greater than 5 cfs average flow, and any water resources contiguous to such waters including, but not restricted to lake, ponds, wetlands, and intermittent streams.

Oligotrophic**. *Poor in nutritive matter.*

Plankton. The passively floating or weakly swimming, usually minute animal and plant life of a body of water.

Riparian. Related to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Wetlands*. Those areas that are periodically inundated and that are normally characterized by the prevalence of vegetation that requires saturated soil conditions for growth and reproduction.

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*Definitions from 40 CFR 230 (EPA Guidelines App. A).

**Since these terms were used to categorize (and compare in some respects) Big River Reservoir and Flat River Reservoir. A summary of some of the more important characterization according to Welch, 1952 of each category is provided on the next page.

Characterization Summary (Welch, 1952)* of Oligotrophic and Eutrophic Lakes

1. Oligotrophic lakes:

   a. Very deep; thermocline high; volume of hypolimnion large; water of hypolimnion cold.
   b. Organic materials on bottom and in suspension very low.
   c. Electrolytes low, or variable; calcium, phosphorus, and nitrogen relatively poor; humic materials very low or absent.
   d. Dissolved oxygen content high at all depths and throughout year.
   e. Larger aquatic plants scanty.
   f. Plankton quantitatively restricted; species many; water blooms rare; Chlorophyceae dominant.
   g. Profundal fauna relatively rich in species and quantity; Tanytarsus type; Corethra usually absent.
   h. Deep-dwelling, cold-water fishes (salmon, cisco, trout) common to abundant.
   i. Succession into eutrophic type.

2. Eutrophic lakes:

   a. Relatively shallow; deep, cold water minimal or absent.
   b. Organic materials on bottom and in suspension abundant.
   c. Electrolytes variable, often high; calcium, phosphorus, and nitrogen abundant; humic materials slight.
   d. Dissolved oxygen, in deeper stratified lakes of this type, minimal or absent in hypolimnion.
   e. Larger aquatic plants abundant.
   f. Plankton quantitatively abundant; quality variable; water blooms common; Myxophyceae and diatoms predominant.
   g. Profundal fauna, in deeper stratified lakes of this type, poor in species and quantity in hypolimnion; Chironomus type; Corethra present.
   h. Deep-dwelling cold-water fishes usually absent; suitable for perch, pike, bass, and other warm-water fishes.
   i. Succession into pond, swamp, or marsh.

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*Welch, Paul S., 1952. Limnology. 2nd Edition. McGraw-Hill Corp., 538 pp.