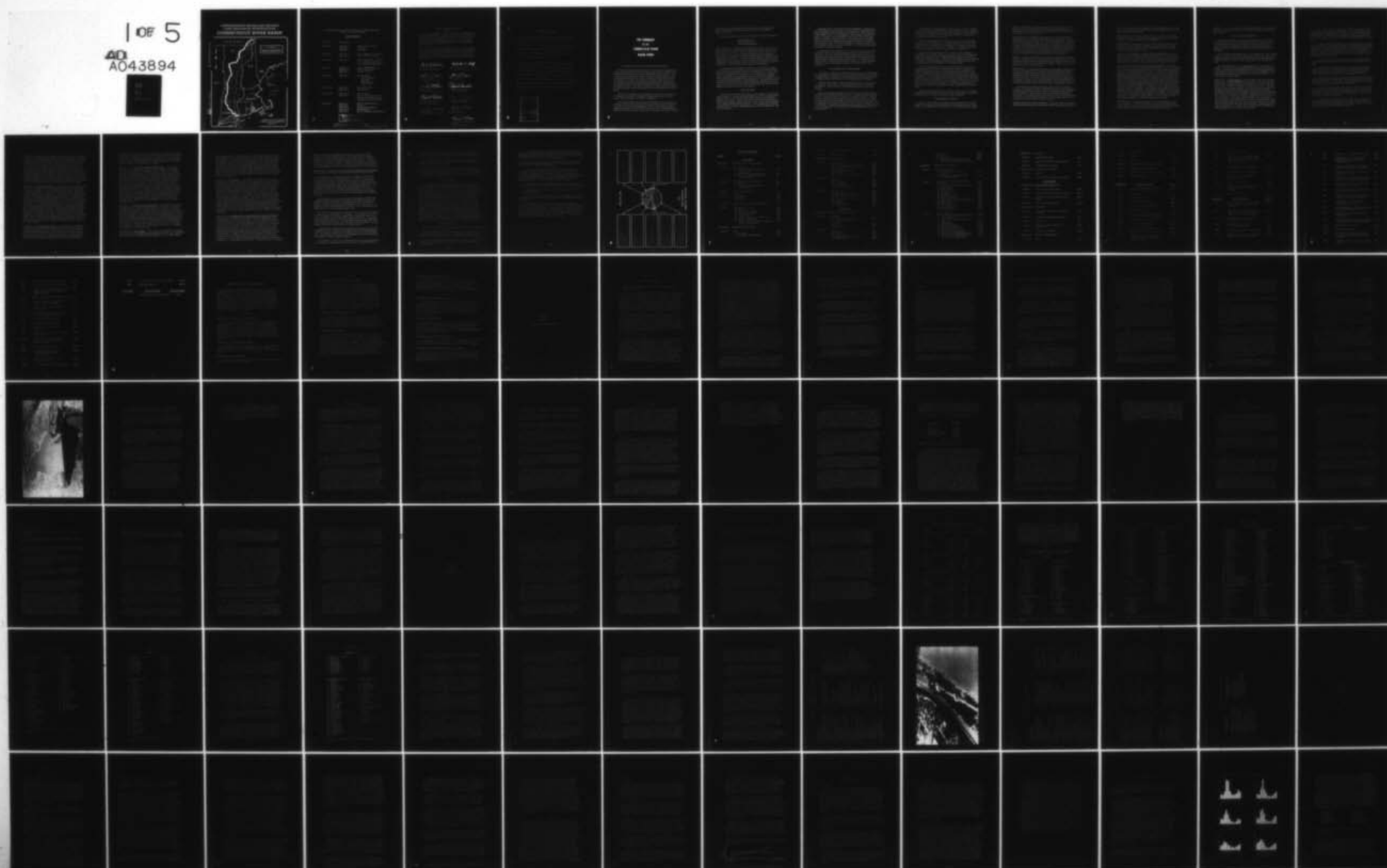
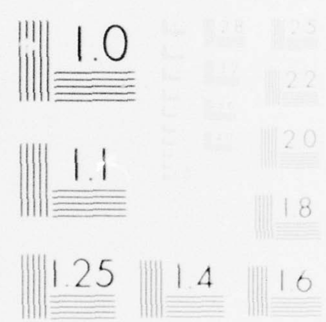
AD-A043 894 ARMY ENGINEER DIV NEW ENGLAND WALTHAM MASS F/G 8/6
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION. C--ETC(U)
JUN 70

UNCLASSIFIED NL

1 OF 5
AD
A043894




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2

COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION

CONNECTICUT RIVER BASIN

• VOLUME I •

MAIN REPORT

CONNECTICUT RIVER BASIN
COORDINATING COMMITTEE
JUNE 1970

COMPREHENSIVE WATER AND RELATED LAND RESOURCES
CONNECTICUT RIVER BASIN . Investigation. Volume I. Main Report.

Jun 70

VOLUME INDEX

394p.

Volume I	Main Report	
Volume II	Appendix A	History of Investigation
	Appendix B	Economics
	Appendix C	Hydrology
Volume III	Appendix D	Water Supply & Water Quality
	Appendix E	Ground Water Resources
Volume IV	Appendix F	Water and Related Land Resources Management, Use and Development Opportunities
Volume V	Appendix G	Fish & Wildlife Resources
	Appendix H	Outdoor Recreation
	Appendix I	Electric Power
Volume VI	Appendix J	State Reports New Hampshire Vermont Massachusetts Connecticut
Volume VII	Appendix K	Plan Formulation
	Appendix L	Navigation
Volume VIII	Appendix M	Flood Control
	Appendix N	Mineral Industry Water Requirements and Mineral Investigations at Selected Sites
Volume IX	Appendix O	History and Environment
	Appendix P	Estuary
	Appendix Q	Subcommittee Reports
	Appendix R	Health Aspects
	Appendix S	Mineral Industry and Resources

391 659

CONNECTICUT RIVER BASIN STUDY
JUNE 1970

This report presents the results of a comprehensive, coordinated study of the Connecticut River Basin. The study has been directed and reviewed by the Connecticut River Basin Coordinating Committee composed of representatives of the Departments of Agriculture; Army; Commerce; Health, Education and Welfare, and the Interior; the Federal Power Commission; and the States of New Hampshire; Vermont; Massachusetts; Connecticut, and the New England River Basins Commission. The New England Division, Corps of Engineers acted as chair agency.

The Connecticut River Basin Coordinating Committee report was prepared at field level and presents a proposed plan for the preservation, development, and management of the water and related land resources of the Connecticut River Basin. The report is subject to review by the interested Federal agencies at departmental level, by the Governors of the affected States, the New England River Basins Commission and by the Water Resources Council prior to its transmittal to the Congress for its consideration in authorizing those Federal items in the plan.

Donald G. Burbank
DONALD G. BURBANK
U.S. Department of Agriculture

Malcolm E. Graf
MALCOLM E. GRAF
New England River Basins Commission

Ralph F. Kresge
RALPH F. KRESGE
U.S. Department of Commerce

John J. Curry
JOHN J. CURRY
State of Connecticut

Paul H. Shore
PAUL H. SHORE
Federal Power Commission

Arthur W. Brownell
ARTHUR W. BROWNELL
State of Massachusetts

Floyd B. Taylor
FLOYD TAYLOR
U.S. Department of Health, Education, and Welfare

Mary Louise Hancock
MARY LOUISE HANCOCK
State of New Hampshire

Mark Abelson
MARK ABELSON
U.S. Department of the Interior

Forrest E. Orr
FORREST E. ORR
State of Vermont

Frank P Bane
FRANK P. BANE, COLONEL, CE
CHAIRMAN
U.S. Department of the Army

ACKNOWLEDGEMENT

The six-year study effort has markedly improved coordination and has established planning techniques which will be of significant importance in future detailed studies required toward implementing the comprehensive basin plan. It will help guide the orderly development and stewardship of natural resources over the next fifty-year period.

The Chairman of the Connecticut River Basin Coordinating Committee wishes to express his appreciation to those agencies who have participated in this challenging undertaking and have made available the services of many of their people. The cooperation of interested citizens and water resources groups is also gratefully acknowledged. Special thanks are in order for those detailed to the task of supplying information, writing, and checking draft materials.

THE SUMMARY
OF THE
CONNECTICUT RIVER
BASIN STUDY

INTRODUCTION TO A PLAN FOR DEVELOPMENT

This summary sets forth the results of a six-year comprehensive study of the 11,250 square mile Connecticut River Basin together with a Plan of Development of the water and related land resources. Foreseeable short and long-term resource needs are identified and a plan for the best uses of the resources to meet the needs is spelled out in the report. The study is the product of Federal, State and regional representatives working cooperatively under the broad supervision of the Connecticut River Basin Coordinating Committee. Guidance was provided by criteria of the Water Resources Council which will forward the report, together with its comments, to the President and the Congress.

Projects and programs recommended for initiation in the next 10 to 15 years are included. Potential measures designed to meet the basin needs through the year 2020 are identified.

This planning effort was brought about because of the necessity to solve the many complex water resources problems that are being produced by an ever-increasing population; by an ever-enlarging mass urbanization pattern of development; and by an ever-increasing and sophisticated technical change. Meeting this challenge effectively requires careful planning so that judgments and decisions can be made upon fact and not personal preferences, and it is to this end that this report is directed.

The following three objectives form the basis of plan formulation:

National Efficiency
Regional Efficiency
Environmental Quality

National Efficiency is getting the greatest return and economic benefits by investing in water resource restoration and development from the viewpoint of the whole country. Regional Efficiency is producing the greatest return in economic and social benefits by investing in water resource restoration and development from the viewpoint of the Connecticut River Basin. The Environmental Quality objective is the improvement of the quality of the environment through water resource investment. This objective includes not only preservation but positive measures to restore and enhance the present environment.

The Basin Plan, conceptual in nature, is not a final blue-print. It is a series of proposals or various courses of action which Federal agencies and the basin States may take individually or as a group and which can withstand future compromise. There has been unanimity in the concept but not necessarily on specifics that have resulted. The Coordinating Committee truly hopes the work accomplished is carried into some future phases of implementation. The information developed and the methods and techniques provided should have a major influence on future decisions which can be made on the basis of knowledge now available by reason of this study.

ORGANIZATION

The Connecticut River Basin Report is the product of a Coordinating Committee: a Board of Representatives of the U. S. Departments of Agriculture; Army; Commerce; Health, Education and Welfare; Interior; the Federal Power Commission; and the New England River Basins Commission, together with the States of Vermont, New Hampshire, Massachusetts and Connecticut. In accordance with Congressional directive, the New England Division, Corps of Engineers, was the chair agency.

In quest of every factor which would contribute to a valid evaluation of problems in and solutions for the Basin, the Committee gave careful consideration to meeting present and future requirements for water supply, flood control, navigation, water quality, hydroelectric power, recreation, fish and wildlife, land use and other allied purposes, all related to water resources. Guidelines for the planning effort provide for consideration of multiple objectives and multiple water resource uses. This criteria applies to regional areas as well as to specific projects such as a reservoir, or a non-structural measure such as a scenic riverway.

The plan presents a framework into which can be fitted in proper relation all other projects and programs as they are developed. It spells out a series of objectives and discusses programs and priorities within the framework and provides guidance for programs sponsored by State, Federal and regional planners. The Plan being conceptual invites coordination and separate efforts, in orderly fashion, leading to a balanced program of water and related land resource allocations.

THE CONNECTICUT RIVER BASIN

"To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining, in the days of our children, the very prosperity which we ought by right to hand down to them, amplified and developed."

Theodore Roosevelt, in 1907, sent that message on conservation to Congress. The warning can be applied to the Connecticut River Basin and to similar areas now heavily taxed by human usage and demands.

The Coordinating Committee was struck with the natural wealth generated by the beautiful 400-mile river. Rising beyond the Canadian border, it flows through four states into Long Island Sound. Vermont has the largest basin land mass of the four states, 35 percent. Massachusetts has 24, New Hampshire 28 and Connecticut 13 percent. At its widest span, the basin is 60 miles. Elevations reach from sea level to 6,000 feet. Located within the Appalachian highlands of North America, the Berkshires, Green Mountains and White Mountains are important ranges.

Rain and snow average about 43 inches of water annually. Records of river discharges at Hartford show an average flow of about 18,000 cubic feet per second. This contrasts with a maximum flow of 289,000 cfs experienced in March 1936. *During the drought of the sixties*, a minimum flow of 1,100 cfs occurred.

There are approximately 170,000 acres of water and 7,000,000 acres of land in the study area. The distribution is as follows: 79% in forests; 9% in croplands; 4% in pastures; 4% in urban and built-up areas; and 4% carried in the "other" category. Presently, over 85% of the land is privately owned by individuals or corporations.

The best 1970 estimates indicate a current Basin population of 1,900,000. The majority of this current population, nearly 84%, live south of the northern border of Massachusetts residing in approximately 4% of the basin area. Population is expected to reach 3,100,000 in 50 years. The percentage concentrated in the Massachusetts and Connecticut portions of the Basin will increase to 89%.

The Connecticut River Basin is characterized in its entirety by a stable, prosperous economy. Employment is found in agriculture, manufacturing, trade, finance and insurance, forest products, services, recreation and tourism, and higher education. The personal income in the Basin is higher than the national average and is expected to remain so. The Connecticut River Basin economy remains more dependent on manufacturing than does the economy of the nation, with more than 40% of the area's total labor force engaged in manufacturing industries. It is interesting to note that in 1967 the total expenditures of tourism and recreation amounted to over $115,000,000 for the entire basin.

There have been substantial investments made in water resources developments which relate to land treatment, conservation, watershed protection, flood control, hydro-power, and navigation.

PROBLEMS AND NEEDS

What are the problems and needs of the Connecticut River Basin? What will be required in the immediate and long-range future in water supply, for example, and in flood control, in the improvement in water quality, in additional recreation facilities, even in the preservation and restoration of the natural beauty of the Basin if the Basin's opportunity for development is to be met and if the needs of the increasing population are to be satisfied?

WATER QUALITY - Existing water quality is seriously degraded in significant portions of the basin precluding the use of water for many desirable and legitimate uses. The most immediate and pressing need is for the construction of adequate waste water treatment facilities at all municipal and industrial waste sources. Problems of nutrient enrichment and pollution from uncontrolled sources such as produced by runoff from urban and rural watersheds are mounting. Requirements for low-flow augmentation after appropriate levels of treatment are likely if established water quality standards are to be upheld.

POWER - Development within the Basin will require ever-increasing amounts of electric energy. Although present or planned supplies will just meet demands (5,000 megawatts) through 1980, projections through 2020 indicate that 33% of the then demand (42,000 MW) will have to be met from sources outside the basin.

RECREATION - An expanding population enjoying higher standards of living, more affluency, more leisure time, and improved methods of transportation will spend more time on outdoor recreation. Overcrowding of the Basin's public and private recreational facilities is already occurring. Less than 4 percent of the area is currently publicly-owned recreation land. Improvements in the way of stream bank acquisition, access, scenic and recreational rivers and open space corridors are needed if the public is to share in the natural resources.

The demand for fishing and hunting opportunities is rapidly increasing. The needs for fishing opportunities show a major deficiency in the middle and lower basins. There is a strong desire to realize the full potential of the anadromous fishery resources of the basin. This desire is concerned chiefly with restoration of the historical runs of American shad and Atlantic salmon, to provide high quality fishing opportunities and long-term needs for sea food.

PRESERVATION OF PRICELESS SITES - There is a need for conserving archeological, historical and natural sites in the Connecticut River

Basin, and establishment of a program to identify additional sites. Unless a concerted effort is made to protect these outstanding and valuable sites, they will be lost forever.

WATER SUPPLY - There are sufficient water resources to meet the foreseeable in-basin demands for domestic and industrial water supply. Further out-of-basin diversion is a consideration.

NAVIGATION - Increased boat use of all kinds requires channel modifications for commercial and recreation craft as well as increased flows for canoeing, additional access ramps at power pools, and improved facilities at Windsor Locks.

LAND USE - TREATMENT - MANAGEMENT MEASURES - There is a need for improved use, treatment, and management of land to reduce runoff, erosion, and sediment, thereby preserving the land base and improving water quality. Such measures will strengthen the economy and improve the quality environment and natural beauty of the Basin.

FLOOD CONTROL AND FLOOD PLAIN MANAGEMENT - Much has been done to alleviate flood damages but additional measures are needed. More upstream watershed projects are required to protect agricultural and rural areas and smaller urban centers. Additional local protection projects are needed at specific tributary areas where concentration of damages makes this type of protection practical and economical. More major multiple-purpose reservoirs are needed for conservation storage, for recreation, fish and wildlife and water quality, where flood control is the primary project purpose. These latter units are required to reduce flood stages along the main stem of the Connecticut River and to provide major reductions on tributaries where these reservoirs would be located. The dams, if constructed, would control 25% of the drainage area above Hartford. This goal was established 17 years ago by the Connecticut River Valley Flood Control Compact. Without these units, there is possibility of overtopping of six existing local protection projects protecting major urban centers vital to the basin economy. Flood plain regulation is imperative throughout the basin.

EDUCATION - The foregoing needs are physical and subject to technical resolution. Of equal importance is the need for educating the public in water resources needs and solutions because there is competition between the needs of the different segments of the public.

Education is vital if communication and understanding is to be achieved, for this, in the final analysis, will be the basis for decision-making on plan elements.

A PLAN FOR DEVELOPMENT

In formulating a plan to meet the needs and desires of the people in the Connecticut River Basin, the Coordinating Committee strove to insure that all elements be compatible and that programs and projects be flexible and adaptable to unforeseen demands and changing patterns of needs. Alternatives were given due and responsible consideration.

The Committee developed a plan to accommodate two time frames, namely, an "early action" plan covering the next 10 years; and a "long range" framework type plan embracing requirements and opportunities to the year 2020. A resume of the "early action" plan is presented here.

The 1980 Basin Plan, as recommended by the Coordinating Committee, is estimated to cost $1,800,000,000 (based upon 1969 price levels). The plan is described briefly in the following paragraphs and in more detail in the report and in specific resource appendices. The proposals are presented in 10 broad element categories that in turn cover some 53 specific parts.

Element No. 1, Water Quality. This element concerns five separate parts, four of which represent the basin States. New and improved waste water treatment facilities, at least to the secondary treatment level, are an essential first step in all parts of the basin. The estimated cost of secondary treatment for known sources of pollution in the basin is $240,000,000 allocated as follows: Massachusetts $96,000,000, Connecticut $70,000,000, New Hampshire $43,000,000, and Vermont $31,000,000. Additional expenditures are also required for construction of interceptor sewers, pumping stations and collection systems. Flow augmentation storage is recommended in certain new reservoirs to serve areas where more than secondary treatment is required and where the cost of flow augmentation is less than the cost of equivalent advanced waste treatment. The fifth and final part of Element No. 1 concerns other considerations for further and future detailed studies. These are as follows:

a. The role of low-flow augmentation after implementation of the above early action four parts of Element 1. These studie s would be undertaken after implementation of planned secondary treatment facilities so that these might be analyzed for their performance and evaluation could be made of new waste treatment technologies which are underway.

b. Further study of the methods of controlling effects of combined sewer discharges. Although the separation of sanitary and storm water systems or the temporary holding of these waters have in the past been considered as possible solutions, continuing research indicates combination of these and other methods, such as micro-screening, air floatation, and biological treatment may provide an adequate and more economical means of solution.

c. Further study of pollutants from rural watersheds and urban watersheds which contribute natural and man-created background pollution.

d. Further study of sewage diversions to alternate treatment plant locations and/or alternate points of discharge to larger water bodies. This would involve inter-basin or intra-basin diversion of waste water with treatment prior to or subsequent to diversion.

e. Water quality studies are needed at existing reservoirs where long-term discharge of wastes have created sludge deposits which have long-term effect upon water quality. This is particularly the case behind certain main stem power dams in the basin.

f. Further study is needed in the control of bank erosion and the undesirable effects produced by sedimentation which deprive fishery resources of valuable food areas and spawning zones. Such sediment also causes turbidity which affects the desirability of waters for recreational use or other purposes.

g. Further study is needed to evaluate the impact of multiple thermal discharges on receiving waters. Heat in combination with other natural and man-made factors, may impair aquatic life and reduce the stream's waste assimilative capacity.

Element No. 2, Power. This element involves five sources of energy, as follows: conventional hydropower; fossil fuel generation; pump storage hydro; nuclear generation; and energy to be imported from outside of the basin areas. By 1980, the supply of power in the Connecticut River Basin will more than double. A major portion of this increase will be due to the installation of pumped-storage peaking plants and expansion of base-load power capability by means of nuclear generation plants. Two new pump storage plants will provide 1,600 megawatts of peak power, while additional nuclear plant construction would add 1,800 megawatts to the system. During this period, there will be a slight increase in conventional hydro capacity but a decline in the role of conventional hydroelectric plants in supplying peaking power. Fossil fuel thermal plants, which now supply base-load generation are expected to decline in both kilowatts of capacity and percent of total supply.

Element No. 3, Outdoor Recreation. This element is presented in seven parts, four of which concern the requirements for water surface area in the four basin States. To meet the growing needs, the Committee recommends firstly the expansion of facilities and improved access at existing water bodies, and secondly, construction of new water bodies. There is need for 15,000 additional acres of water in New Hampshire; 13,000 acres of additional water needed in Vermont; 25,000 acres of additional water needed in Massachusetts; and an additional 22,000 acres of recreation water needed in the State of Connecticut. The fifth part of Element No. 3 concerns the implementation of the Bureau of Outdoor Recreation's National Recreation Area Plan, a coordinated Federal-State-community framework plan for recreation development along the main stem of the Connecticut River. Part number 6 of this element concerns the establishment of wild, scenic, and recreational stream categories. Part number 7 provides for the utilization of existing water supply reservoirs to meet recreation needs. These 7 parts to the recreation element will not only meet the outstanding needs to a great degree, but will provide for many multiple-purposes available in the control of these lands.

Element No. 4, Preservation of Sites. This element is presented in four parts and provides for the preservation of those sites of unique or unusual nature which should not be disturbed if possible by future developments within the basin. Some 850 sites of archeological, historical, or natural resource areas were identified. Historic and natural areas to be preserved in the State of Connecticut consist of 49 sites, in the Commonwealth of Massachusetts a total of 114 sites, in the State of New Hampshire a total of 57 sites, and in the State of Vermont a total of 35 sites. The concerted local, State and Federal effort, as well as a commitment on the part of the people of the valley to protect the basin's remaining heritage is one safeguard for coming urbanization and future industrialization which have already been cruelly destructive of the physical remains of the past.

Element No. 5, Anadromous Fisheries Restoration. This element is presented in five parts, and consists of the following: fish passage facilities; fish hatcheries; streambank access; interstate regulation; and low-flow augmentation and reregulation of flows. Initial action programs consists of the erection of fish ladders at the remaining four power dams, and the installation of fish hatchery facilities to provide 1,000,000 smolt (2-year old salmon) annually. The fish ladder program will greatly enhance the existing shad runs, as well as provide access for the restored salmon runs. Closely allied to these actions is a program of streambank acquisition for fishing. It would be coordinated with acquisition needs for other water uses such as outlined above in Element No. 3. In addition, interstate coordination would be maintained to insure the best operation of the hatcheries and also that each of the four basin States shares equitably in the fish harvest. Finally, adequate river flows are necessary to maintain the fisheries and the plan recommends that these be provided by releases from existing dams, together with flow augmentation from new multiple-purpose reservoirs.

Element No. 6, Resident Fish and Wildlife. This element is presented in six parts, four of which provide for those new reservoir areas and tributary requirements of the basin States. Part number 5 provides for streambank acquisition and part number 6 provides for water-oriented wildlife programs. The plan has analyzed resident fisheries, that is, with the exception of salmon and shad, in six categories namely, cold, warm and combination streams, and cold, warm and combination ponds. The plan presents over 90 small upstream reservoir sites and seven major reservoirs which together will help balance needs related to fish and wildlife, in addition to providing for other water resource needs. Land acquisition necessary for streambank access is to be coordinated with acquisition for other purposes.

Element No. 7, Water Supply. This element is presented in five parts, four of which concern water supply requirements for the four basin States and part number 5 in regard to out of basin diversion of water supply.

Water supply needs are presented for each of the basin States in detail. The study finds that the natural abundance of available surface and ground-water supplies, if properly developed, can meet all projected municipal and industrial needs of the basin. Out of basin needs for the 1980 time period can be met by flood-skimming operations such as that proposed in conjunction with the Northfield Mountain pump storage power project. Similar operations can be introduced at the existing Corps of Engineers' Tully Reservoir located in the Millers River watershed. "Flood-skimming" is a procedure for diverting surplus high river flows from a stream which are considered excess to the needs or uses within that stream at the time of occurrence.

Element No. 8, Navigation. This element is presented in four parts; the first part provides for commercial navigation from Long Island Sound to Hartford; navigation improvements from Hartford to Holyoke; recreational navigation improvements at main stem power pools; and main stem and tributary improvements for canoeing. The plan in summary provides for deepening and widening the navigation channel from the mouth of the Connecticut River to Hartford for a distance of about 52 miles. This portion of the river is used now for commercial and small boat activities. In addition, a 32-mile recreational navigation project is included from Hartford to Holyoke. Boat ramps will be constructed at various points along the river and trailer service will be established at four existing power dams to permit by-passing of these dams during the boating season, as well as improved access to these attractive water bodies. Although no reservoir storage has been specifically justified to augment flows for canoeing, some benefits will be obtained through the implementation of other multiple uses at the reservoirs that are included in the plan.

Element No. 9, Upstream Water and Related Land Resource Potential. This element is presented in five parts: Structural Measures - (1) multiple-purpose upstream watershed projects; (2) other upstream impoundments not part of watershed projects; and (3) structural programs in national forests; Non-Structural Measures - (1) land use, treatment, and management programs; and (2) resource planning with local and state units of government. The early-action program includes eight multiple-purpose watershed projects currently being planned under Public Law 566, and nine additional potential watershed projects found to be feasible. In addition to the 78 multiple-purpose floodwater retarding structures contained in these 17 watershed projects, another 118 reservoir sites on small upstream drainage areas have been recommended to meet 1980 water resource needs. The plan further recommends three recreational impoundments and facilities and acquisition of 69,300 acres within national forests; and 1,200,000 acres of land treatment to agricultural and private forest land; as well as technical assistance in resource planning to some 180 communities. Soil surveys are recommended on about 1,500,000 acres of private land. Watershed analysis and soil surveys on 306,600 acres and fish and wildlife surveys and analysis on 30,500 acres in national forests are recommended.

Element No. 10, Flood Control and Large Multiple-Purpose Reservoirs. This element is presented in seven parts consisting of the following:

Part number 1 is in the non-structural category and includes an effective flood plain management program providing for flood plain zoning, flood proofing, encroachment lines, flood insurance and the establishment of regional drainage codes to make existing drainage systems function properly with the rapid urbanization of watersheds. This flood plain management program to be closely allied with scenic, recreational and open space programs which will improve access for other resource activities, insure retention of existing valley storage areas and, at the same time, provide for a high degree of environmental quality.

Part number 2, also in the non-structural category, includes the enlargement and improvement of existing flood warning systems with expanded communication and coordination between the United States Weather Bureau, the United States Geological Survey, the Corps of Engineers, other Federal agencies, the States, local communities and those individuals located in flood-prone areas.

Part number 3 provides for construction of seven major reservoirs for flood control and multiple-use; namely, Victory Dam on the Moose River, and Gaysville Dam on the White River, both in the State of Vermont; Bethlehem Junction Dam on the Ammonoosuc River; Claremont Dam on the Sugar River; Beaver Brook Dam and Honey Hill Dams both in the Ashuelot River Basin; all in the State of New Hampshire, and the Meadow Dam on the Deerfield River in Massachusetts.

Part number 4 provides for the modification of four existing Corps of Engineers dams; namely Union Village Dam on the Ompompanoosuc River in Vermont, Tully Dam in the Millers River Basin, Barre Falls Dam in the Chicopee River Basin, and Knightville Dam in the Westfield River Basin, all three in Massachusetts.

Part number 5 provides for construction of five local protection projects; namely, at Lancaster on the Israel River in New Hampshire, at

St. Johnsbury on the Passumpsic and Sleepers Rivers, and at Hartford on the White River, both in Vermont, at Westfield on the Westfield River in Massachusetts, and on the Park River in Connecticut.

Part number 6 provides for upstream flood control projects consisting of eight Public Law 566 watershed plans now under planning and nine potential watershed projects.

Part number 7 includes incidental but additional flood control as provided at three major multiple-purpose reservoirs; namely, Gardner Dam in the Millers River Basin in Massachusetts, and Cold Brook on Roaring Brook and Blackledge Dam in the Salmon River watershed, both in the State of Connecticut.

CONCLUSIONS

The Committee believes that the basin needs that have been identified and analyzed reflect current population desires as expressed by public participation. Social and behavioral patterns will change over the 50-year projection period. Thus, proposals suggested for meeting 1980 requirements are more apt to reflect the nature of the needs to which the Basin Plan addresses itself. The Connecticut River Basin has, since its initial settlement, been dependent upon its natural resources. Its people developed these resources, not always in the wisest manner. The Coordinating Committee concludes that a more careful allocation of natural resources will be necessary if the basin is to continue to grow and still maintain a high quality in its environment. There are sufficient water and related land resources in the valley to meet the large and broad scale needs projected for the 1980 and 2020 time frames, provided that enhancement, preservation, restoration, conservation, and orderly development of resources in the public and private sectors are assured. There are adequate resources to permit the preservation of areas of unusual quality and to maintain open space to balance new growth areas. The Committee finds opportunities and requirements for Federal, State, local and private action.

RECOMMENDATIONS

The Connecticut River Basin Coordinating Committee recommends:

(1) The Basin Plan, as presented and discussed in this report, be accepted and used as a guide for the development and beneficial use of the water and related land resources of the Connecticut River Basin;

(2) The projects and programs in the 10 to 15 year category, referenced as the 1980 Plan for Development, be implemented through appropriate agencies;

(3) This report be used as a supporting document for the individual agency reports which would be the basis for authorization of the various parts of the plan with particular reference to those areas where Federal cost sharing requires authorization by the Congress;

(4) Each of the affected and concerned Federal and State agencies review periodically those segments of The Plan for which, under law, it is, or may be, assigned responsibility;

(5) Within the New England River Basins Commission there be established a Connecticut River Basin Program assigned the task of coordination of planning in the interest of a balanced management of water and related land resources. This joint Federal-State comprehensive planning organization would provide the leadership required to bring the many projects outlined in this report to fruition;

(6) Those areas of the development plan which are applicable to on-going Federal programs and State programs proceed as soon as possible;

(7) Those additional studies discussed in this report be made as soon as practicable; and

(8) There be initiated a broad base education program to assist in making the public more effective participants in the planning and decision making process.

A chart showing the over-all cost breakdown for the 1980 Early Action Plan is found on page XV in this summary Those items for which specific estimates of cost were not possible, such as separation of combined storm and sanitary sewers, or preservation of cultural sites, are listed, without expressed value, to indicate the comprehensive nature of the study and the recommended plan. A basin map displaying the individual elements of the plan is appended to this report.

TOTAL COST $1.8B

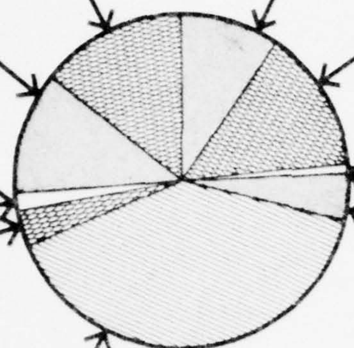
WATER QUALITY
1. Secondary Level Treatment for 1980 .... $ 240M
2. Advanced Waste Treatment for 1980 19
3. Others (Costs not available)
   Low Flow Augmentation
   Combined Sewer Separation
   Uncontrolled Runoff
   Diversion of Wastewaters
   Bottom Deposits
   Cost $259M

WATER SUPPLY
1. Northfield Mt. Diversion .... $ 60M
2. Expansion of Municipal and Industrial Supplies 125
3. Corps' Reservoirs 19
   Beaver Brook
   Tully
   Honey Hill
4. Upstream Reservoirs 3
   Cost $207M

ANADROMOUS RESTORATION
1. Fish Ladders at Five Existing Power Dams .... $ 13M
2. Construction of New Fish Hatchery Facilities 7
3. Streambank Acquisition 5
4. Provision of Reservoir Flow Releases 4
   Cost .... $ 29M

RESIDENT FISH AND WILDLIFE
1. Improved Access at Existing Water Bodies (approx) .... $ 3M
2. Provision of New Water Bodies 37
   Corps' Reservoirs 12   P.L. 566 Reservoirs 2
   Other Upstream Reservoirs 23
3. Expansion of Hatchery Facilities 5
4. Extensive Streambank Acquisition Program 20
   Cost .... $ 65M

POWER
   Installed Capacity 1,660 megawatts
1. Conventional Hydro .... $ 50M
2. Pumped Storage Hydro 210
3. Int. Combustion/Gas Turbine 40
4. Nuclear-fueled Steam 400
   Cost (private sector) .... $ 700M



FLOOD CONTROL
1. Corps' Dams .... $ 86M
   Victory $ 2   Honey Hill $ 3
   Bethlehem Junction 5   Meadow 41
   Gaysville 23   Beaver Brook 1
   Claremont 10   Knightville 1
2. Seventeen Upstream Watershed Projects 25
3. Other Upstream Dams 11
4. Five Local Protection Projects 51
5. Flood Plain Regulation (estimate not possible)
   Cost $173M

OUTDOOR RECREATION
1. Expansion of Existing Water Bodies .... $ 10M
2. Construction of New Water Bodies 41
   Corps' Reservoirs $13   P.L. 566 Reservoirs $10
   Other Upstream Reservoirs 28
3. National Recreation Area Plan 180
4. Wild and Scenic Rivers 25
5. Modification of three existing Corps' Reservoirs 3
   Cost $259M

NAVIGATION
1. Long Island Sound to Hartford
   Commercial project .... $ 4M
2. Hartford to Holyoke
   Recreation project 7
3. Improvements in Main Stem Power Pools, etc. 1
   Cost .... $ 12M

UPSTREAM WATER AND RELATED LAND RESOURCE MANAGEMENT
1. Land Resource Planning .... $ 3M
2. Land Treatment 33
   Private Lands $31   National Forests $2
3. Resource Conservation and Development Projects 24
4. National Forest Structural Improvements 15
5. Land Acquisition for National Forests 9
   Cost .... $ 84M

PRESERVATION OF SITES
1. Archeological
2. Historical
3. Natural Resource
   Cost .... *
   * Estimate not possible

1980

EARLY ACTION PLAN

CONNECTICUT RIVER BASIN

TABLE OF CONTENTS

PART TWO

TABLE NO.	LIST OF TABLES	PAGE

ORGANIZATION OF THE MAIN REPORT

The Main Report is drawn from 19 separate appendices and is divided into a summary and 11 chapters. In order to facilitate use of the report, the 11 chapters are grouped in three parts separating specific areas of interest. Part One includes chapters entitled Authority and Background, Description of the Basin, and Physiography. Part Two, comprised of 4 chapters, presents the analysis of the problems and needs engendered by the basin's population and economy and describes solutions and alternatives. Part Three introduces and discusses the Coordinated Basin Plan, presents the views of the participating States and agencies and finally outlines the Coordinating Committee's recommendations to Congress.

PART ONE

CHAPTER I - AUTHORITY AND BACKGROUND

Provides authority as presented in legislation by Congress and the criteria as established by the Water Resources Planning Act, the Water Resources Council, and the Title II River Basins Commission which report to the Council. Reference to the earlier studies of the basin, as well as a reporting of the various planning efforts under way in the valley and coordination of the Connecticut Study are presented. The maturity of the Connecticut River is highlighted includings its intense water resource development history, concluding with a summary of water law and policy.

CHAPTER II - DESCRIPTION OF BASIN

This chapter describes the basin area, location, extent and study subdivisions, beginning with natural and historical accounts, and including some insight into the social, economic, and cultural characteristics.

CHAPTER III - PHYSIOGRAPHY

This chapter presents the basin's land form; its geology, hydrology, biota, land use, and aesthetic qualities.

PART TWO

CHAPTER IV - POPULATION AND ECONOMY

This chapter presents the basin's population, viewed from the numbers of people both now and in the future, their demographic character, and social patterns. The complex human social wants are discussed. Projections used note the degree of population control envisioned in the future and demonstrate the contrast with the earlier population projection curves. The economy segment of this chapter contrasts the manufacturing and service type industries' economy of the lower reaches with the more limited manufacturing, agricultural and recreation type economy of the upper basin. The dependence of the upper reaches upon the financial resources of its southern neighbors is noted. Since upstream States draw a significant part of their income from a transient population, this aspect of the economic character and political consequences is explained.

CHAPTER V - NEEDS AND PROBLEMS

A discussion of what are needs and what are problems and why they are different is presented. As for specific details of how needs figures were developed individually for the various resource categories, this is cross-referenced to their respective appendices. Needs in different units and for different areas of the basin, together with their flexibility of movement, as well as where they overlap, are noted.

CHAPTER VI - SOLUTIONS

This chapter brings out the various devices or options available to meet needs, with their magnitude set as goals. The advantages and disadvantages of single-purpose, multi-purpose, and complementary purpose structural solutions are demonstrated. This chapter draws heavily from Plan Formulation, Appendix K. The means by which devices and allocation of natural resources can be combined to solve the flood control problem, or provide for units of needs, are given. Non-structural solutions are discussed, such as zoning, encroachment lines, early warning and flood plain management as well as other land use practices. The differences between the solutions and alternatives producing the same units of measurement are discussed.

CHAPTER VII - ALTERNATIVE PLANS

This chapter concerns alternative plans and draws heavily from supporting appendices with cross-reference where necessary for individual details. Alternatives are rated not solely on a dollar cost basis as there are many areas where measurement tools are not available. The benefit to cost relationship is presented and deviations from this measurement criteria noted where considered appropriate.

PART THREE

CHAPTER VIII - COORDINATED BASIN PLAN

This chapter presents the Basin Plan on the premise that all participants were required to plan and act as one, although decision at times was by consensus. It recognizes that participants, by reason of their positions in State or Federal organizations, may not necessarily support all proposals presented; however, it was necessary to present a coordinated joint Federal-State plan from which modification could later occur upon review.

CHAPTER IX - DISCUSSION

This chapter discusses the economic impact of the Basin Plan and the priorities which must be met to keep open the options allowing for wise growth and maintenance of environmental quality. Methods of scheduling and implementing the plan are described along with a discussion of those measures of public education and communication which will be needed in support of the plan.

CHAPTER X - VIEW OF PARTICIPANTS

This chapter presents participant views and particularly those items with which they disagree and reasons why. As the report proceeds to higher review levels, this chapter should assist in further coordination.

CHAPTER XI - RECOMMENDATIONS FOR CONGRESS

This chapter presents a format whereby the different Federal and State agencies can select and promote those program elements which fall under their statutory area of interest. Recommendations are substantial enough so that the individuals participating can facilitate their future reporting to higher levels of authority.

PART ONE

CHAPTER I

AUTHORITY AND BACKGROUND

CHAPTER I

Section 1 - Study Authority

A. United States Senate Resolution Committee on Public Works, Adopted 11 May 1962

"That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved 12 June 1902 be, and is hereby, requested to review the reports on the Connecticut River, Massachusetts, New Hampshire, Vermont, and Connecticut, published as House Document 455, 75th Congress, Second Session, and other reports, with a view to determining the advisability of modifying the existing project at the present time, with particular reference to developing a comprehensive plan of improvement for the basin in the interests of flood control, navigation, hydroelectric power development, water supply, and other purposes, coordinated with related land resources."

The above Senate resolution provided the principal authority and direction to the chair agency to proceed with a comprehensive study on the Connecticut River Basin. Approximately 3 years later, 22 July 1965, Congress approved the Water Resources Planning Act which provides for the optimum development of the nation's natural resources through the coordinated planning of water and related land resources through the establishment of a Water Resources Council and River Basins Commission, as well as providing financial assistance to the States in order to increase State participation in such planning.

B. Water Resource Planning Act

The Connecticut comprehensive study is one of a series of water resource planning studies being performed for the entire nation under the over-all guidance and direction of the Water Resources Council. This Cabinet level organization, headquartered in Washington, D. C., is charged by Congress to maintain a continuing study, prepare an assessment biennially, or at such less frequent intervals as the Council may determine, outlining the adequacy of supply of water necessary to meet the water requirements in each water resource region in the United States and the national interest therein. In addition, they are to maintain a continuing study of the relation of regional or river basin plans and programs to the requirements of larger regions of the nation. It is also charged to review the adequacy of administrative and statutory means for the coordination of water and related land resource policy and programs of the several Federal agencies. It will appraise the adequacy of existing and proposed policy and programs to meet such requirements and it shall make recommendations to the President with respect to Federal policy and programs. Water Resource Planning Act delineates the duties of the Council and also provides authority for the creation of River Basins Commissions, of which there is one currently in existence in New England, being established in September of 1967. The Federal departments are meeting the challenge of planning for a comprehensive program of water studies through an intense budget and program coordination effort which was actually initiated in 1962, some 3 years before the creation of the Water Resources Council. A program of regional framework Type 1 study to cover the country and more detailed river basin Type 2 study of specific problem areas, such as the Connecticut River Basin, has been developed and is currently under way. Planning for the Type 2 individual river basin programs entailed the identification of existing water resource development needs, those expected to be encountered in future years, and measures for their solution. Definition and evaluation of projects in sufficient detail to provide a basis for authorization however, will be limited to those projects for which starts are required in the ensuing 10 to 15 year period. These are those programs as outlined in the 1980 basin plan wherein there is Federal interest.

The Water Resources Council is composed of the Secretaries of Agriculture; the Army; Health, Education and Welfare; the Interior; and Transportation; and the Chairman of the Federal Power Commission. President Nixon has designated Secretary Hickel of Interior as Chairman. The Secretary of Commerce and the Secretary of Housing and Urban Development are currently associate members of the Council but have been recommended for full membership by other Council members. In summary, the Water Resources Council has responsibility for the coordination of the Federal effort on the comprehensive river basin studies with respect to budgets, technical, and policy guidelines, and review and submission of the reports to the President and Congress.

C. Recent Legislation Broadening Federal Interests

In a not so distant past, Federal agencies and others were principally concerned with single purpose, separate planning for an array of different projections and in the areas of their statutory responsibilities. Many of the laws restricted consideration of broader aspects of the uses of water and the associated problems. However, water is not a divisible resource. Further as we expand in population, urbanization and technical change, and make greater demands upon what is a fixed natural resource, it is of necessity that legislation be broadened so that other uses be incorporated in the planning. The following array of resource legislation that arrived since 1962, and particularly with the advent of Senate Document S-97 attest to the fact that this has been done by the Congress of the United States.

The Land and Water Conservation Fund Act of 1965 provided financing for the development of State recreation plans and continuing funding for cost sharing of implementation programs for water-oriented public recreation.

The Appalachian Regional Development Act of 1965, and the Public Works and Economic Development Act of 1965 have given strong emphasis towards regional development and such opportunities which may be available by water resource projects to create new employment or alleviate sufferings in areas of chronic unemployment.

The Water Quality Act of 1965 helped establish standards and goals as initial steps to restore and maintain water quality in the nation's rivers. The Clean Water Restoration Act of 1966 presented further assistance for developing comprehensive water quality control programs as well as abatement plants for various river basins.

The introduction of the Department of Transportation Act; the establishment of national flood insurance program; Presidential Executive Order 11296 as relates to Federal development in flood-prone areas, places much emphasis on proper land use through regulation, and administrative policy as a means of reducing future damages. The Estuary Act of 1968 hopes to keep a balance between the conservation of wetlands and natural resources of importance to aquatic life as well as maintain the natural beauty of the nation's estuarine areas. The Wild and Scenic Rivers Act, and the Federal Water Project Recreation Act of 1965 are means to preserve and at the same time use and share resources for the public sector.

Congress has broadened the national objectives to be considered in planning of water and related land resource developments and these have been reflected by the Connecticut Coordinating Committee in its concepts and philosophies as presented in the 1980 basin plan.

CHAPTER I

Section 2 - Prior Reports and Authorities

A. General

Numerous reports have been submitted on the Connecticut River Basin and for many areas of resource interest both in the public and private sectors which cover broad areas of State and local interests. Regarding Federal interests in the Connecticut River Basin, these are principally in the program areas of flood control, navigation, power, (i. e., principally in the regulatory aspects), upstream watershed management, fisheries, and wildlife. For example, in the area of flood control alone, there have been completed, under the Corps of Engineers' program, beginning in calendar year 1926, and through 1968, a total of 25 reports in response to separate Congressional directives. In the area of navigation, and beginning with the year 1911 through 1969, the Corps has submitted 18 separate reports. In the area of flood plain information, 6 summary reports and appendices have been submitted as guides to local municipalities within the basin. For further details concerning the great many reports accomplished, attention is directed to the individual resource appendices.

Because of their significance to this comprehensive study, particular recognition is given to the following Federal reports:

(1) "The Resources of New England-New York Region", as authorized in Section 205 of the Flood Control Act of 1950(P. L. 516-81st Congress, Second Session) together with a Presidential Directive of 9 October 1950, establishing a six member Federal interagency committee. This report recommended that the river basin and regional plans set forth in the report serve as a guide for the development, conservation, and utilization of land, water, and related resources of the New England-New York Region. The report is commonly referred to as NENYIAC,(and sometimes as "the gold books").

(2) Senate Document No. 14, 85th Congress, First Session, 1957, is a summary report which recommends that the river basin and regional plans as set forth in the NENYIAC report serve as a

future guide for the development, conservation and utilization of the land, water, and related resources of the New England-New York Region.

(3) Committee Report on Senate Resolution No. 48, 86th Congress, First Session, 1959. This report, commonly known as the report of the Senate Select Committee was primarily concerned with the ability of the Nation's water resources to sustain continued economic growth which is necessary if the country is to remain strong and to enjoy an ever increasing standard of living. This concerned a series of 32 separate reports.

(4) Senate Document No. 97, 87th Congress, Second Session, 1962, "Policies, Standards, and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water Related Land Resources". This report not only provides the basic criteria, uniform policy, and philosophies of comprehensive river basin planning, but also spawned the Cabinet level Water Resources Council.

(5) Senate Document No. 21, 89th Congress, First Session, 1965 "Water Resources Planning Act" provides for formal creation of the Water Resources Council, its functions and mission, as well as the River Basins Commission, made possible under its Title II, and the grant program to assist planning at the State level, made possible under Title III.

(6) "A Unified Natural Program for Managing Flood Losses", House Document No. 465, 89th Congress, Second Session, as prepared by the Task Force on Federal Flood Control Policy, provides for 15 separate recommendations regarding non-structural programs to reduce flood damages and flood hazards.

B. Earlier Reports Establishing Federal Interest

(1) Prior to the 1920's little attention was given to flood protection on the Connecticut River mainly because no major floods had occurred since 1869 and apparently a certain amount of complacency had set in concerning flooding. Major floods were, however, occurring at about this time in other areas of the country, particularly in the Ohio and Mississippi Basins, that led to the passage of House Document No. 308, 69th Congress, First Session, approved 21 January 1927. It directed the Corps of Engineers to study and make recommendations to alleviate flood problems on several major river systems in the United States. The Connecticut was one of

the rivers included. Oddly enough, just some 10 months later a major flood occurred in November, causing 21 deaths and a property loss of $30,000,000 in the Connecticut River Basin. Following an extensive period of office and field surveys, a report, which took the name "308 Report", dated 11 February 1936 was submitted to Congress with recommendations which included the construction of 10 flood control reservoirs on the tributaries of the Connecticut River in the States of Vermont and New Hampshire. The recommendations of the "308 Report" became the basis of the 1936 Flood Control Act and established the Federal interest in flood control which, up to this point of time, had largely been centered in areas of navigation, power, major drainage, and reclamation. Some 49 hydroelectric sites were also presented as having merit when increased power demand justified their construction.

(2) A month following submission to Congress of the "308 Report" in March 1936, another flood of disastrous proportions occurred in the Connecticut River Basin. Eleven lives were lost and property damage amounted to over $66,000,000. The flood far surpassed any previous occurrences, and until today, is known as the "flood of record" on the Connecticut River. The 1936 flood made it apparent that the measures of the 1936 Flood Control Act as spawned by the earlier 1927 flood were inadequate. The 1937 Flood Control Act followed and amended the 1936 Act by including consideration of areas in the southern portion of the Connecticut River Basin.

(3) This was followed by the 1938 Flood Control Act which was passed 28 June 1938, and provided for the first general comprehensive plan for flood control for the basin, presenting 20 reservoirs, 10 alternative reservoirs and, most important, seven local protection works at Hartford, East Hartford, Springfield, West Springfield, Chicopee, Holyoke, and Northampton. These latter centers of commerce, business, and manufacturing activity were vital to the entire valley economy then as they are today. Shortly thereafter the memorable September 1938 hurricane struck New England with heavy flood damages to the southern States of Massachusetts, Connecticut, and Rhode Island.

(4) The Flood Control Act of 15 October 1940 made minor modifications to the Act of 28 June 1938 by providing additional funds to complete protection at East Hartford, Connecticut. The Flood Control Act of 18 August 1941, modified further the comprehensive plan of 20

reservoirs initially approved in the 1938 Flood Control Act. It expanded the scope of local protection projects in the Holyoke and Springfield area by adding Springdale and Riverdale on the main stem of the Connecticut River, and the Mill River in Springfield, as well as Winsted, Connecticut on the Mad River tributary. It also provided authority to include hydroelectric facilities, as well as extra storage capabilities in those projects under design at that time and for future use.

(5) The Flood Control Act of 26 October 1943, further modified the plan by including construction of Gully Brook conduit at Hartford, Connecticut.

(6) The Flood Control Act of 1944 authorized expenditure of $30,000,000 in addition to previous authorization for comprehensive plan approved in 1938 and modified the plan by directing specific consideration of alternative plan of Vermont State Water Conservation Board. Eight reservoirs in the West River tributary basin in Vermont were substituted for the previously authorized Williamsville Reservoir; authorization was rescinded for construction at the Sugar Hill site in New Hampshire; and authority was established for appropriate consultation with affected States, to include written State views and recommendations.

(7) The Flood Control Act of 1950 modified the project for flood control at Hartford, Connecticut, as authorized by the Flood Control Act of 1938. It amended it to include Folly Brook dike and conduit.

(8) The Connecticut River Flood Control Compact was established by passage of Public Law 52, 83rd Congress, First Session, 6 June 1953. In so doing, Congress granted its consent and approval to an interstate compact covering the Connecticut River Valley that had been previously ratified by the States of New Hampshire, Vermont, Massachusetts and Connecticut. With this compact, the downstream States benefiting from flood protection have agreed to pay to the affected upstream States an equitable portion of the tax and economic loss resulting from the loss of lands due to construction of reservoirs. The four States also agreed to the construction of reservoirs at certain specified locations.

(9) Public Law 566, 83rd Congress, Second Session, 4 August 1954, as amended, authorizes the Department of Agriculture to carry out plans for multiple-purpose small watershed projects for rural and urban communities to deal with land use and water

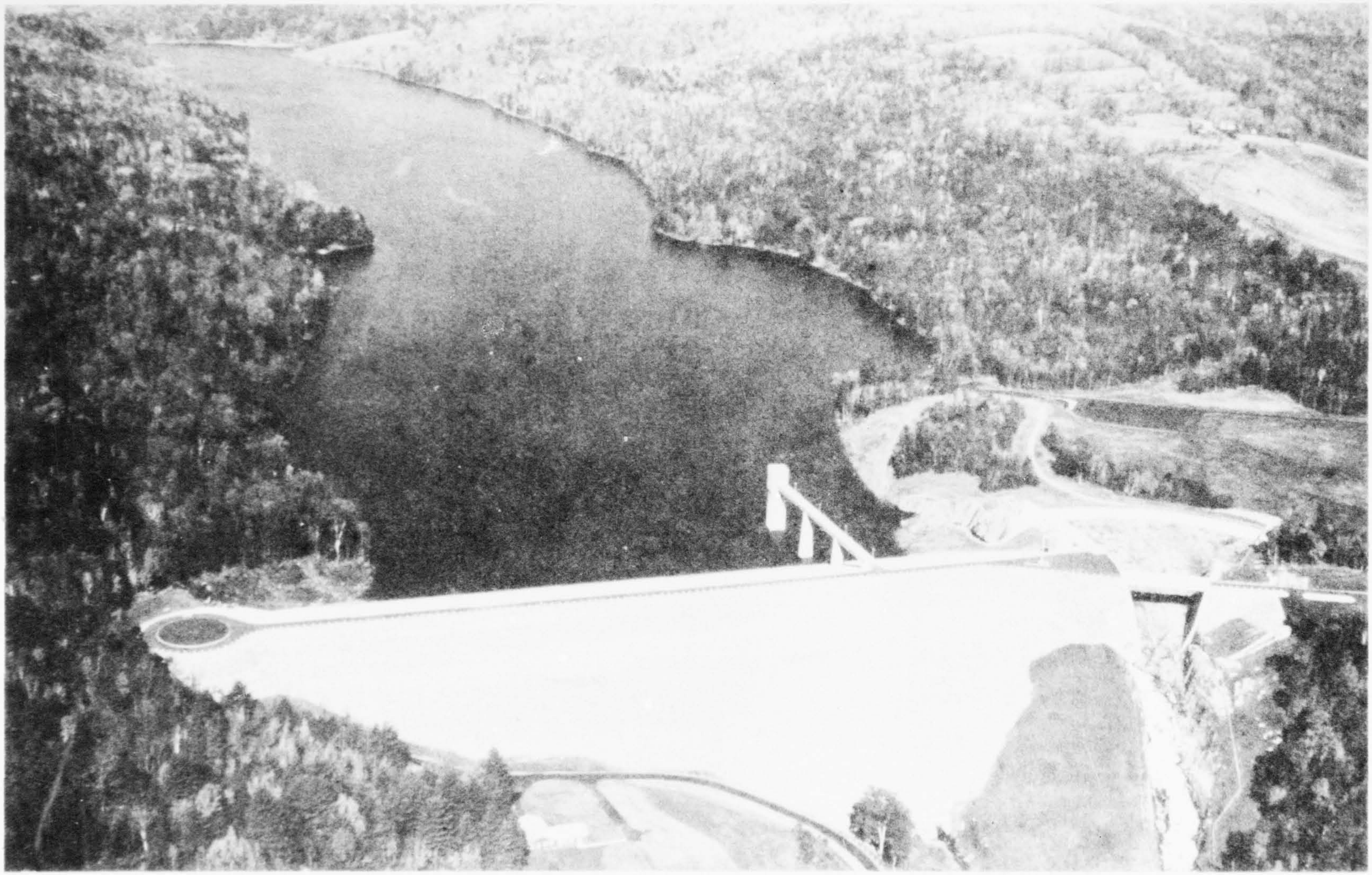
problems. The Soil Conservation Service carries out the Department of Agriculture's program to halt unchecked soil erosion and excessive water run-off on rural land, stop destructive floods, improve drainage conditions on land in agricultural production, and other multiple-purpose uses covering watersheds up to 250,000 acres in size through a project-type undertaking. A project is planned and carried out jointly by local, State, and Federal agencies. There are currently eleven such projects in the Connecticut River Basin that are operating or under construction.

(10) The Flood Control Act of 1954 (9/3/54) modified the plan for flood control in the Connecticut River Basin to provide for new construction of a reservoir on Otter Brook at South Keene, New Hampshire, in lieu of any reservoir or reservoirs heretofore authorized. This Act further modified the plan for West River Basin of the Connecticut River in Vermont to consist of three reservoirs at Ball Mountain, the Island and Townshend sites, in lieu of the plan of eight reservoirs authorized in the Flood Control Act of 1944.

(11) The Flood Control Act of 1958, (7/3/58) modified the plan for flood control in the Connecticut River Basin to include construction of Littleville Reservoir on the Middle Branch of the Westfield River in Massachusetts, and Mad River Reservoir on Mad River above Winsted, Connecticut.

(12) The Flood Control Act of 1960 (7/14/60) included authorization in the Connecticut River Basin of the plan for flood protection on the Chicopee River, Massachusetts, substantially in accordance with House Document No. 434, 86th Congress, Second Session 24 June 1960, plan for flood protection on the Westfield River in Massachusetts , substantially in accordance with Senate Document 109, 86th Congress; and plan for flood control and related purposes on the Farmington River in Connecticut, substantially in accordance with House Document 443, 86th Congress, Second Session, 30 June 1960. This act also authorizes inclusion of water supply in Littleville Dam and Colebrook Dam.

(13) The Flood Control Act of 1968 included authorization in the Connecticut River Basin of a plan for construction of Beaver Brook in Keene, New Hampshire, substantially in accordance with Senate Document 68, 90th Congress, and a plan for flood protection in Park River, Connecticut, substantially in accordance with Senate Document 43, 90th Congress.



MULTIPLE-PURPOSE RESERVOIR - LITTLEVILLE DAM ON THE MIDDLE BRANCH OF THE WESTFIELD RIVER, CHESTER AND HUNTINGTON, MASSACHUSETTS

Corps of Engineers Photo

In addition to the above reports and because of their importance to the flood control needs of the Connecticut River Basin, there are listed the following 4 major items of legislation:

(1) Under the authority contained in Section 205 of the Flood Control Act of 1948, as amended, the Corps of Engineers maintains a continuing Small Projects program limited to $1,000,000 of Federal assistance. Many separate areas in the basin have, or are currently being considered under this continuing small flood control program.

(2) The Flood Control Act, approved 14 July 1960, Public Law 86-645, in its Section 206, as amended, authorizes the Secretary of the Army, through the Chief of Engineers, to compile and disseminate information on floods, flood damage potential, as well as establish general criteria for guidance of Federal and non-Federal interests and agencies in the wise use of flood plain areas. It is under this authorization that the Corps of Engineers carries out its flood plain management service program.

(3) The Housing and Urban Development Act of 1968, Public Law 90-448, Section 13, of the 90th Congress, authorized the establishment of a program for flood insurance, the purpose being to determine what Federal financial assistance could be provided to those suffering losses in floods and in areas where flood protection is not feasible. This program is administered under the direction of the U. S. Department of Housing and Urban Development.

(4) In accordance with Section 209, Public Law 90-483 approved on 13 August 1968, the Secretary of the Army, upon the request of the Governor of the State may assist in securing land or interest therein, as a site for the resettlement of families, individuals, and business concerns displaced by a water resource flood control project as duly authorized by Congress. No acquisition shall be undertaken under the authority of Section 209 unless the Secretary of the Army has determined after appropriate consultation with Federal, State, and local governmental agencies that the development of the new site is necessary in order to alleviate hardships to the displaced persons by reason of the project and who could otherwise find it difficult to acquire land if it were their desire to stay in the general vicinity of their earlier homes, lost

because of the project. The implementation of this assistance requires that the State initially make a request of the Federal Government, and further, that they would initially provide money to buy the land sites, that is, that land required over and beyond those needs of the flood control project. The State would, in turn, be reimbursed once the people who are to be relocated have been fully recompensed through fair market procedures for their property lost because of the project.

CHAPTER I

Section 3 - Scope of Investigations

Scope of investigations has been guided by existing procedures as required by law or established practices of the various Federal agencies in submitting their reports for Congressional authorization for ultimate construction. In addition, the Water Resources Council provided guidelines for Type 2 investigations so as to obtain a reasonable degree of uniformity and consistency in the management and procedures followed in the regional type studies.

Comprehensive planning begins firstly with a series of economic projections of future economic development. These projections are translated into demand for water and related land resource uses. Hydrologic projections of water availability both as to quantity and quality, and projections of related land resource availability were accomplished so as to outline the characteristics of the projected water and related land resources problems, and the general approaches that appear appropriate for their solution. The conceptual studies as presented in Type 2 frameworks provide general guides to future water resource development. These indicate areas where detailed planning efforts are required. In addition, those regions in the basin where there are no problems or none that appeared to be looming, would also be revealed and thereby provide a substantial contribution of fact and analysis to any subsequent detailed planning formulation.

Type 2 studies provide general appraisal of the probable nature, extent, and timing of measures for their solution. Studies concerned principally with intra-regional water and related land resources and their uses. The studies have considered all geographic areas within the Connecticut Basin and all purposes served by conservation, development, and use of water and related land resources.

Early in the study a plan of survey was set out which provided procedures to be followed by all participants. It was used as a management tool to assist in orientation, direction, and coordination. It also helped delineate the interrelationships and missions between the participants within the study. It was updated as required. Essentially, the Connecticut Study proceeded along 5 phases of activity, all of which were parallel efforts. The initial phase "A" concerned an inventory and projective economic study of various activities. The current status of all water and related land resources development in the basin was also accomplished. Utilizing the information presented at the initial 4 public hearings, an array of what was thought to be water needs and problems was prepared. These also reflected the preferences of the public at the time of the initial hearings. A list of improvements desired was disseminated amongst the participants. Each of the agencies accomplished specific assignments in the inventory and economic study phase, and this material provided a basis for needs, which were arrived at by a determination of the supply of the resource and the demand placed upon it. This produced either a negative or positive requirement, which was referred to as net demands or needs. Initially, this provided an existing needs picture. In order to obtain the future needs picture, it was necessary to establish future demands with the aid of projections and future capability on the basis that either new units for resource use would be introduced or more use would be made of existing units. This procedure essentially composed the phase "B" efforts of the study.

A parallel effort to the needs phase was that of evaluating potentials for it was through these potentials that future needs and existing needs could be reconciled. Potentials were arrayed on the basis of their ability to produce or satisfy certain water requirements or use requirements. Potentials in many areas of the resource spectrum were arrayed on the basis of cost and benefits realized.

These potentials then became the building blocks for the plan formulation exercise, carried as phase "D" of the study. Plan formulation was by far the most difficult of the different procedures utilized, principally because of the large array of alternative solutions that were drawn from the array of potentials that were developed in the earlier phase "C".

In order to facilitate and assist in the plan formulation exercises as well as to provide the material in the earlier phases, seven special subcommittees were organized, made up principally of the field staff personnel to give greater attention to specific areas of interest. The following subcommittees were created by the parent Coordinating Committee:

(1) Data Processing Subcommittee- Mission to investigate and establish the use of data bank for data accumulation, storage and quick retrieval.

(2) Subcommittee on Stream Regulation - Mission to determine to what extent existing storages might be used for flow augmentation purposes and to determine desirable levels of flow releases, and to provide guidance in the re-regulation of flows in the tributary and main stem areas of the Connecticut, including those requirements for storage to produce desirable flows to complement a water quality management program.

(3) Subcommittee on Water Quality - Mission to actively sponsor the implementation of an immediate water quality management program.

(4) Subcommittee on Recreation - Mission to review, coordinate, and otherwise assist the participants involved in the development of a recreation plan for the basin.

(5) Subcommittee on Institutional Arrangements - Mission to study and report upon the institutional arrangements necessary to implement the basin plan upon the expiration of the parent Coordinating Committee.

(6) Subcommittee on Non-structural Measures - Mission to identify those non-structural measures which could be employed to meet water resource needs of the basin. To make recommendations as to those new steps necessary to make available additional non-structural measures, such items as tax relief, incentive payments, or other tax adjustments which could expand current State programs.

(7) Subcommittee on Public Information - Mission to produce methodology and procedures for effective communication with basin citizens. It was the Subcommittee's task to organize all public information forums and to assist in the public hearings.

The above special committees, together with additional Ad Hoc task forces functioned in areas of major activity that greatly assisted and expanded the capabilities of the Coordinating Committee. Material developed by these work groups was then presented to the Committee for review, modification, and approval. Details on these activities may be found in Appendix Q.

Studies consisted principally of office analysis utilizing material on file, of field reconnaissance performed by inspection teams made up of engineers, geologists, and environmental planners. Where necessary, survey data was accomplished either in the form of topography or geological explorations. Sampling techniques were utilized in such areas to determine the impact of recreation tourism. Questionnaire forms and interviews of the different citizens were utilized to determine existing demands. Extensive use was made of all available material and data in State agencies as part of their on-going programs. Engineering estimates were prepared and benefits determined on the basis of existing procedures.

CHAPTER I

Section 4 - Coordination

The study effort provided for direct participation and coordination with all interests who proceeded in their respective areas of capability and responsibility. To accomplish this a series of 24 Executive Sessions were held, together with round-table meetings, and "think tank" work sessions principally for field staff. To properly inform the public and to obtain participation from them, several public sessions were held as well as separate meetings with watershed groups and other interests. A total of 10 public sessions held at intervals of every 6 months, as well as 10 regional informational forums held from May 1969 through September 1969; and 8 public hearings, of which transcript records are available, provide the extent of our public communications.

A. Executive

Twenty-four separate Executive Sessions of the Coordinating Committee were held periodically at frequencies of about every three months during the course of the 6-year study effort. These sessions were conducted by the Chairman and allowed for full discussion and exchange of ideas and exploration of differences. Resolution of problems was accomplished generally by arrival at a consensus of opinion, with a member or alternate requesting a vote or stating a position for the record when desired. Executive meetings were open to staff and/or consultants of the members and alternates with participation by staff or consultants at the request of the members or alternates of the Coordinating Committee. Minutes of all these meetings are on file and agendas together with abstracts of meetings are included in Appendix A.

Important field staff meetings revolved about so-called 9 round-table sessions which provided for specific discussions of needs and possible solutions. Minutes are available on all the 9 round-table meetings. In addition "think tank" sessions were held and lasted for approximately a two-week period.

B. Public

Ten formal public meetings were held by the Coordinating Committee to give the public an idea of the study progress and its accomplishments. Formal minutes were distributed to those that attended these public meetings. A series of 10 regional informational meetings were also held to provide the public an opportunity to view the plan and to present its views on elements within the plan. A series of 8 public hearings were held, 4 at the beginning of the study and 4 recently completed during the month of February 1970. A court stenographer was employed to provide permanent records of the hearings. An abstract of the results of these hearings is carried in Appendix A. In addition to these formal type communications, many informal meetings were held at Division Headquarters, generally sponsored by individual watershed groups. For example, the Connecticut River Watershed Council, one of the larger conservation groups in the valley, co-sponsored with the Corps, a series of 8 separate meetings. The League of Women Voters held interleague seminars and also visited the agencies directly to present the views of its 28-member Leagues from the valley. These meetings and extensive letter communications provided the principal means of contact with the public.

CHAPTER I

Section 5 - Water Resources Development History

The Connecticut River is one of the nation's most historic, beautiful, highly developed, and hardest working rivers. Water resources development projects date back more than 180 years. As early as 1785 a dam was constructed to operate a saw mill at what is now the site of Wilder Power Dam. The first lock and canal in the nation was constructed in 1792 at Bellows Falls , Vermont. The nation's second and third canal were also constructed in the Connecticut River Basin at Turners Falls and in South Hadley, Massachusetts. Today Windsor Locks Canal, which was built in 1829 is the only functioning canal remaining on the river.

The early phases of water resources development were oriented toward navigation as the river provided the principal point of access and egress and was the colonialists' principal artery of commerce. This activity was aided by technical developments such as the nation's first steam propelled boat, built at Windsor, Connecticut in 1787. As early as 1836 Congress appropriated funds for Federal maintenance of a navigation channel through the sand bars at the mouth of the river . Authority was expanded in subsequent years so that by 1937 there was a Federal navigation project that provided for a 15-foot depth at mean low water, and generally 150 feet wide to Hartford, 52 miles from Long Island Sound.

At about the beginning of the 18th century industrialization of the river basin began and centering around the many locations where water power could be developed and where adequate process water was available. Many mills were founded with permanent water use privileges which still prevail, an example being the Holyoke canal system and the several industrial manufacturers that abut the canal.

Electric power development started very early in the Connecticut River and today 47% of the total conventional hydro potential of the basin has been developed, as compared to a 26% average for major streams in the nation. Most of the hydroelectric developments in the basin have been in existence for some time. Of a total of 75 units some 40 generally under 1,000 kilowatts in size were installed prior to 1920, several as long ago as 1905. Of the 75 hydroelectric dams 47 are operated by utilities and 28 by industrial firms. More than 40 of the utility dams have licenses and come under the regulatory power of the Federal Power Commission.

There are more than 180 dams in the river basin which each control a minimum of 50 square miles of drainage area and are considered not run of the river type units. Storages are utilized for power, water supply, recreation, flood control, and other industrial purposes. The Table below lists existing storages, together with assigned purposes:

Total basin storage as provided by existing developments is as follows:

Reservoirs	Storage in Acre Feet
Power	523,000
Flood Control	533,000
Quabbin Water Supply	1,280,000*
Other Water Supply	174,000
Other Purposes	77,000
Total	2,587,000

*Quabbin 1 year run-off in storage = 210,000 A. F.

It should be noted that the largest storages exist at Quabbin Reservoir where the water supply system draining 185 square miles drainage basin represents 6 years of average annual run-off in storage. This storage for all practical purposes is lost to the basin as it is diverted into the Metropolitan Boston area, although some does find its way into the Chicopee system and eventually enters into the Connecticut River Basin. If we delete the storages available in Quabbin and the storages available in Corps of Engineer flood control dams (that is capacity available during flood periods) we find there is 774,000 acre foot of storage now in being. This represents about 1.3 inches of run-off over the entire river basin drainage or about 6% of the run-off that might be expected in any given year using annual run-off figures over available years of record. This storage is extremely important to the over-all environmental quality of the flows in the Connecticut River. For example, for five days of the week power operations are beneficial in aerating and moving other waste products of the valley. However, since power operations cease on Friday afternoon and do not commence until early on Monday morning, the regulatory effect of the main stem power dams produce negative side affects over week-end periods when water use is at its highest . Analysis of hydrologic records in the Connecticut Valley indicate that during low flow periods flows may produce, on an average .15 csm as compared to an annual average of 1.6csm, roughly one million gallons a day per square mile of drainage area. Summer low flows in the Connecticut River represent about 1/10 the yearly average flows. It is apparent therefore that proper flow regulation and flow augmentation are important ingredients to the over-all quality of the river. For, together with adequate treatment they present opportunities for increased water management so that many collateral water uses can be achieved. Concerning the storages present in the development as we now have them in the valley low flows would have to rely most exclusively on groundwater yields and since so much of the run-off in the valley is produced in the three months of the spring freshet season (more than 60%) it is only through the capturing of this spring run-off that storages can be made available for either power generation or other uses. Power reservoirs are operated principally for peaking purposes and in conjunction with hydroelectric stations so as to obtain the maximum possible utilization of the stations' capability for capacity and energy. Coordination between plants is achieved with the help of pondage at each plant generally sufficient to enable start-up as required by the system load and continued operation until receipt of releases from the plant next upstream. On this basis, the existing power system is operated most efficiently. With the completion of the S. C. Moore Dam and power station in 1956, all of the favorable hydroelectric sites in the basin are considered as utilized. There are, however, many attractive pump storage hydro opportunities still existing and these units will play a very important part in meeting future power needs which are likely to be thermal oriented.

The Forest Reserve Law of 1891 made possible the establishment of forest reserves, commonly referred to after 1907 as National Forests. Initially, these forest reserves were lands in the public domain and were for the greater part located west of the Mississippi River in areas of the Great Plains. In the early days, legislation did not exist whereby forest reservations could be established for the public domain, although the need was apparent. Following several unsuccessful presentations to Congress, many New England and eastern organizations joined forces and took a prominent part in obtaining an act introduced by Congressman John W. Weeks of Massachusetts. It was passed by Congress on 1 March 1911, and the Weeks Law, as it is now known, empowered the Federal Government, by means of enabling legislation passed by individual States, to purchase land for National Forests. Of prime concern in the legislation was "the protection of flow of water on navigable streams".

One of the first purchases under the Weeks Law was the White Mountain National Forest, with the first areas acquired in 1914. The establishment of the Green Mountain National Forest followed in 1932. About 306,000 acres of National Forest land now lie within the Connecticut River Basin. In addition to the Federal ownership and as early as 1904, other public forest areas were established so that today about 410,000 acres of forest land are currently owned by State, County and municipal governments, all of which is protected and managed for public use. The awakening to the importance of forests as a manageable resource marked the beginning of a new era and has contributed significantly to water resource both in quantity and quality for the Connecticut River Basin.

CHAPTER I

Section 6 - Water Law and Policy

A. General

The study of water law as relates to both surface and ground water resources is extremely complex and would entail a significant comprehensive study in itself. The following remarks are presented to explain in an abbreviated fashion the status of water law and policy as relates to the New England States and in the Connecticut River Basin. Provided within Appendix J of this report, and as performed by the individual participating States, is a discussion on water law and policy. The reader is urged to direct his attention to these appropriate sections for a more detailed analysis of this matter and particularly as relates to various water resources functions and uses.

Several sources of information have been used in summarizing this subject,most appropriate of which was provided by the New England Interstate Water Pollution Control Commission as part of its continuing program of research in connection with the control of water pollution in the New England Compact area. The legal aspects of water rights and the operation of dams and other flow regulation structures is an important adjunct to the attainment of a sound water resources management program.

B. Private Water Rights

All New England States find the basis of their water law under the riparian doctrine. The comprehensive study is particularly concerned with the application of the riparian doctrine as referenced to natural surface water courses. Except for the right of the public to use water in a flowing stream for the purpose of navigation or commerce, and to have rivers kept open for the passage of migratory fish an individual may have "water rights" only if he is a riparian owner which means that the water course must touch his land.

All other owners upon the same stream have the same common right. However, the right of no one is absolute but qualified by the right of the others to have the stream substantially preserved in its natural size, flow, and purity, and to protection against diversion or pollution. The riparian doctrine has had little statutory development whereas the doctrine of prior appropriation which led to the rapid development of western States has been extensively codified by statutes.

The essence of prior appropriation doctrine is priority of "beneficial use", but it does not mean that the most beneficial use is given top priority. Rather, priority of use is determined chronologically and for a prior use to be protected it must be beneficial. The doctrine arose through court decisions modifying the existing common law, in order to meet local needs.

The riparian doctrine is still enforced through the judicial process by courts and juries hearing the facts and arguments of competing users. The modification of the riparian doctrine now provides for the concept of "reasonable use", although earlier it was said that each riparian owner was entitled to the natural flow of a stream's undiminished quantity or quality. Many difficulties are encountered in the determination of what is "reasonable use", which is generally a question of fact. As already noted, it is unlawful for an upstream riparian to divert flows which may deprive downstream riparians of its uses but there have been cases as relates to municipal water supplies where diversions have been permitted by way of State legislative action. Such diversions were granted on the basis that amounts to be diverted were of such quantities so as not to impair the "reasonable use" concept of the downstream riparian.

As competition for water resources becomes keener, it may well be necessary in future years to establish an administrative agency to apportion the available water among competing municipalities rather than leaving this important determination to the political strength which one entity is able to assemble against another.

A riparian owner may make use of water flowing past or through his lands in several ways, such as generation of power through construction of control structures. This can be done as a run of the river type dam or one having considerable storage capabilities. How far a riparian may go in obstructing or detaining stream flow will depend upon a variety of factors.

A serious problem arising in water use cases involves the acquisition of prescriptive rights by riparian owners. Each jurisdiction has a statute of limitations which is usually designed to prevent litigation of an issue long after the events have taken place and when it would be unjust to upset a use of property which has continued for a long time. Therefore, if an individual suffers injuries to a property right, he must commence his action against the defendant within the time prescribed by statutes.

C. Public Water Rights

Public water rights may be considered in five broad categories and as follows:

(1) Property rights which the State itself owns, whether acquired by direct purchase or otherwise. These are similar in extent to those rights of a private owner.

(2) The State may hold title to property in the nature of a trust for the benefit of the public. These rights, however, may be conveyed only by an act of the legislature, and such property may include waters and lands to which the public has a right of use.

(3) There are rights held by the State for the benefit of the public but less than the entire title as distinguished from (2) above. For example the rights of navigation, commerce and fishery in non-tidal rivers, to which the riparian owners have title to the soil, subject to an easement or right for the public.

(4) The fourth category is the power of eminent domain held by the State. By this, the States may take private property for public purposes upon payment of just compensation to the private owner. Once acquired such lands would probably come within category (1) above.

(5) A fifth category is the police power of the State which provides for the regulation of certain activities undertaken in the public interest. In this manner, some citizens are denied the complete freedom of use of the property, but since the property is not taken there is no right to compensation. In this category fall zoning, prohibition and other regulations which limit land use and private activities.

The "navigation easement" or "servitude" is encountered most frequently today in matters of Federal action. For purposes of Federal law, it was held, at an early date, that Congress may regulate navigation, and four decades later, that Congress may control the use of navigable waters under the commerce clause of the Constitution. A navigable stream was defined as one which may, in fact, be used for navigation. Until Congress exercises its power over "navigable waters", the States are free to exercise control over waters within their boundaries in the interests of their citizens. To this end, State regulations may be established to deal with local streams or waters of the United States so long as they are not inconsistent with

Federal regulations of interstate and foreign commerce. If neither Congress nor the State has exercised powers in derogation of private rights, each riparian, whether on a navigable or non-navigable stream is entitled to water use within the doctrine applied in his jurisdiction.

D. The Mill Acts

State action regarding private riparian rights has generally been limited to certain well defined areas. For example, under the Mill Acts, any riparian owner may avail himself of the fall of a river by constructing a mill and dam upon his land. The riparian owner will not be subject to injunction for flooding that occurs to an upstream owner but will only be liable for damages for the reduction in value of the land so flooded. Although the flooding of land upstream appears to be taking of private property for private purposes, the Mill Acts have been upheld in the Supreme Court. The Mill Acts were obviously a necessity of the times in which they were enacted in order to facilitate economic development that accompanied the industrial revolution.

E. Statutory Regulation of Water Uses

Initially these acts, stemming from 1741, provide for the appropriate passage of anadromous fish and state that the riparian owner will alter his dam at his own expense for the proper passage of fish, and further, he will maintain this facility at his own expense. There have been many special acts of the legislature which have enabled municipalities and water districts to take water out of streams with necessary payment of compensation to riparian owners who suffer a reduction in stream flow as a consequence. Most of these actions were taken under the power of eminent domain and should be distinguished from the exercise of proprietary interest in public waters such as those involving navigation, or commerce, or access to "great ponds".

Under the motivation of the Water Quality Act of 1965, the basin States have adopted water quality standards for interstate and coastal waters. The Secretary of the Interior has approved the standards for interstate waters, with certain exceptions to be resolved, thus making them joint State-Federal standards.

The standards represent a general public recognition of the inherent value of good quality water and of the need to preserve it for the future. The water quality standards, arrived at through the political process, are a manifestation of this emphasis which in effect states that certain water quality goals are a national objective justified on the basis of tangible and intangible considerations. The standards provide for public health, public enjoyment, water supply needs, propagation of fish and wildlife and economic and social development. Such statutory regulation of water uses falls under the police power of the State and are considered valid regulations in the public interest.

F. Federal Jurisdiction

Federal jurisdiction or control over rivers and other inland waters finds its genesis in the commerce clause contained in Article I, Section 8 of the Constitution. The dominant servitude of the Federal Government does not involve a taking of property without a consequent compensation for the damages inflicted. Instead, it is the right of the Government to regulate the flow of the river in order to aid navigation, with possible adverse economic results to riparian owners upon the river because the owners use is limited by the right of the public to use the stream in the interests of navigation. It is through the navigation servitude that the Federal Government becomes involved in flood control, water quality control, power projects, construction and control of navigation, and the licensing of works for the development of power through utilization of stream flow, all without payment of compensation to riparian owners who suffer adverse economic results. However, the servitude cannot be utilized to justify every taking of waters of a navigable stream. The licensing of a power company does not possess the same rights that may be the result of the "navigation servitude" already noted. The licensee is in the same position as the riparian owner, who, utilizing the Mill Acts, may undertake a particular water use upon payment of compensation to those damaged.

Under Federal law, any applicant for a Federal license is required to provide the licensing agency with a certification from the State that there is reasonable assurance that such activity will be conducted in a manner which will not violate applicable water quality standards.

G. Rights as Relates to Stream Regulation or Flow Augmentation

At certain times of the year the need for adequate flow of water becomes a serious problem, particularly in those streams which receive industrial and municipal wastes. During the dry season many streams have insufficient water to accommodate the needs of all riparian owners as well as to assimilate and transport treated waste effluents without violating the water quality standards. The oxygen demand of the effluent discharges are primary reasons for the need for adequate stream flow for the attainment of water quality standards. Proper treatment of waste prior to discharge into the river will reduce the oxygen demand of the effluent and keep the water within prescribed water quality standards. The oxygen demand of waste discharge into a river is meaningful only in relation to the quantity of water, and particularly the stream flow rate. The quantity of water in the stream is of less significance than the rate at which it flows for it is through motion that a regeneration of oxygen is attained.

Under riparian doctrine it can be argued that an upstream riparian is not obligated to release flows for a downstream effluent in that the downstream effluent should be entered into the stream when the upstream riparian releases his stored water, be it for the generation of power or other uses. However, under the States power of eminent domain, it may be asserted that augmentation of flow downstream is a public purpose to benefit health and welfare and not to serve any private interest. Although the upper riparian could be required to release stream flow under this theory he would be entitled to just compensation from the State. Another basis for required releases would be the public rights and waters of the stream for navigation and the passage of migratory fish. On this basis the owner of the dam would have no right of compensation unless the legislature provided for it. The State legislature has the power to establish such controls over the operation of flow regulation structures within the State so long as that action does not run counter to Federal controls.

A desirable solution to the problem of stream flow augmentation lies in the construction of multiple-purpose storage facilities. This condition is provided for in Section 3b of the Water Quality Act of 1965 except that such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of control of waste at the source. A means to minimize the infringement of private riparian rights would be the capture of flood waters or high seasonal run-off for storage and release at times of low stream flow. These would be excess waters which few riparians would have use for and would otherwise be wasted. However, the operation of such flow releases must be consistent with other at site project purposes so as to equitably permit project functions and at the same time assist in sound water management programs. There are at present sufficient existing State agencies and additional statutes could be enacted that would permit stream flow regulation and augmentation without any great modification of the riparian doctrine.

PART ONE

CHAPTER II

DESCRIPTION OF BASIN

CHAPTER II

Section 1 - Area

A. Location

The Connecticut River Basin encompasses an area of about 11,250 square miles, of which 114 square miles are located in the Province of Quebec, Canada. The main stem of the river traverses a length of more than 400 miles from the Canadian border to the tidal waters of Long Island Sound. The basin has a maximum width of 60 miles and includes land in 4 States. Land area in these States is distributed as follows: in New Hampshire 3,047 square miles, or about 28%, in the State of Vermont approximately 3,928 square miles, or about 35% of the drainage area, in the State of Massachusetts about 2,726 square miles, or approximately 24% of the basin area, and in the State of Connecticut 1,436 square miles, or about 13% of the study area.

The source of the Connecticut River begins in the mountainous, semi-wilderness area of Northern New Hampshire. The main stem of the river begins at a small boggy lake referred to as the Fourth Connecticut Lake and located in the northwest corner of New Hampshire near the Canadian border. In a short distance it enters the Third Connecticut Lake, a deep typical north-country lake surrounded by a northern spruce-fir forest. Flowing in a southerly course, it meets a small dam at Moose Falls. The first of 17 dams located along its main stem as it makes its way to the Long Island Sound.

The river then flows over a 15-foot dam which forms the Second Connecticut Lake and thence over a 50-foot dam which forms the First Connecticut Lake and thence over a 100 foot dam which forms Lake Francis in the town of Pittsburg. At this point the river has accomplished more than half of its 2,650-foot drop, having only traversed about 30 miles from its origin. Six miles further downstream, the Connecticut River reaches the northeast corner of Vermont where its low water mark on the west bank becomes the State boundary between Vermont and New Hampshire.

The uppermost portion of the river, approximately 360 square miles of area of Pittsburg, was originally developed as "The United Inhabitants of the Indian Stream Territory" which initially declared its independence of both the United States and Great Britain. It was not incorporated into the State of New Hampshire until 1842.

Near Colebrook, New Hampshire the river flows peacefully along a pastureland valley floor dominated by massive grandeur of Mount Monadnock in Lemington, Vermont. This area, referenced as the Upper Coos, extends to the head of Fifteen-mile Falls is an area of highly fertile soil and outstanding scenery. From this point near Gilman, Vermont, the river flows 19 miles to the base of Moore Dam and thence to Comerford Dam. Continuing southward, the river flows through a flat bottomed rather narrow valley and enters what is the longest lake in New England and known as Wilder Reservoir. From Newbury, Vermont, the headwaters of the reservoir, the river flows for 46 miles to the Wilder Dam, which now submerges what was initially known as White River Falls.

The next serious set of rapids occurs at Hartland Falls, after which it quickly passes over three power dams known as Bellows Falls, Vernon, and Turners Falls. The river continues its flow through predominantly scenic country and passes by Northfield, Massachusetts and the spectacular French King Gorgè, picking up several important tributary rivers along its route. The 15 largest tributaries, with watersheds larger than about 200 square miles provide an aggregate area equal to 6,517 square miles, or about 58% of the total basin area. Before flowing through the gap between Mount Tom and Mt. Holyoke, in Massachusetts, it passes through the Great Oxbow. It then moves through an increasingly urbanized area and encounters the Holyoke Dam. (See Profile)

Leaving the Holyoke-Springfield area it passes through a semi-rural and populated area to the Enfield Dam. From this point the river parallels, for about five miles, the historic Windsor Locks Canal. It passes the urban complex of Hartford and East Hartford and thence to Middletown which forms the terminus of its broadest valley area. From this point the river passes through Bodkin Rock, the last natural gorge, as it begins to experience greater influence from the tides.

The estuary is bounded by the mouth of the river at Saybrook. Here the river ends as it enters Long Island Sound. Throughout its entire length, the Connecticut River displays a rather unique profile, augmented along the way by many tributary streams. More than 200 dams controlling 50 square miles of drainage area are harbored within the basin. Most of these dams are used for production of electric energy or for other manufacturing purposes. Several are used as municipal water supply reservoirs. Included are 16 flood control reservoirs constructed by the Corps, representing approximately 60% of a yet to be completed comprehensive flood control system. Many native lakes and ponds are available. For example, within New Hampshire alone, there are 199 of these ponds of over 10 acres, the largest of which is Lake Sunapee with 4,085 acres, followed by the First Connecticut Lake with 2,087 acres.

B. Extent - Parts - Subdivisions

To facilitate planning analysis, the study divided the basin into 6 subareas as shown on Plate No. 1. CRB I represents 15% of the basin area and encompasses all of northern New Hampshire, including the main stem of the Connecticut River and all land lying north of Hanover and Canaan, draining to it with extensive areas of steep slopes; streams possessing high minimum flow; large high yield groundwater conditions; the concentration of some large surface water bodies in a few towns and a paucity of these in remaining towns; there is generally high quality of surface water throughout much of this reach except for severe pollution at some specific locations in the vicinity of Groveton, New Hampshire.

CRB II references the northwestern most subdivision of the Connecticut Basin and represents about 16 percent of the total basin area, all of which is located in Vermont. It includes areas north of the Windsor-Orange County line with drainage to the Connecticut River, and about all of Orange, Caledonia and Essex Counties, as well as small segments of Addison, Washington, and Orleans Counties are in this area. Elevation-space relationships reveal that most of this CRB II lies between 1,000 and 2,000 feet above mean sea level. There are fairly strong slopes to be found in a few widely separated mountain groups as contrasted to CRB I. There are substantial minimum flows of the area streams; high yield groundwater conditions, a significant number of large water bodies; and generally high quality of surface water throughout much of the area.

CRB III concerns that portion of the basin which drains the middle or southern part of New Hampshire. The higher elevations begin to recede. The flood plains broaden and some of the main tributaries provide a generous extent of flood plain so that here one begins to find the several towns of 10,000 population and many more from 5,000 to 10,000. The small but fairly well diversified manufacturing base is also located as are more extensive use of smaller lakes and ponds most significant of which is Lake Sunapee. With the added population there is in this area a greater usage on the existing water bodies, particularly since interstate highways place this reach within one hour of Concord, New Hampshire and two and one-half hours of Boston. The drainage area amounts to 15% of the basin.

CRB Area IV provides for that reach of southern Vermont extending to the Massachusetts border. It is much like its neighboring New Hampshire Area III in that the flood plains of the main stem and the major tributaries have produced sites for relatively good-sized towns. There too, there is a fairly diverse manufacturing base and its close proximity to urban centers of Boston, as well as neighboring southern Massachusetts provides for rather intense use of recreational areas. The drainage area in this Area IV amounts to about 18% of the basin land.

CRB Area V - this reach includes all of the basin located in Massachusetts, representing about 24% of the total basin area. In it are all of Franklin and Hampshire Counties, almost all of Hampden and parts of Berkshire and Worcester Counties. The river enters into its first major significant valley area created by the natural obstructions at Mt. Tom located about mid-point in the reach. Here the valley begins to make a drastic change in its economic activity. Major centers of education and significant manufacturing centers such as Chicopee, Holyoke, and Springfield greatly alter the valley both in character and in activity. More than one-third of the basin's population is located in this CRB Area V. The largest single water body, man-made, referred to as Quabbin Reservoir having a surface area of 38.6 square miles, provides for water supply to the Metropolitan Boston area via a major aqueduct traversing some 83 miles eastward to Boston and surrounding municipalities.

CRB Area VI includes all of the basin located in Connecticut. It is the southern part of the lower basin and represents nearly 13% of the basin area. In it are most of Hartford and Middlesex Counties and parts of Litchfield, Tolland, New London and New Haven Counties. This portion of the basin is rather wedge shaped and houses the greatest number of the basin's population nearly 47% in 1960. Total per capita income is highest in this reach, where industrial and institutional activity provides the major sources of employment. The population of CRB VI is projected to more than double by the year 2020 because of the economic vitality located in this reach.

TABLE II-1 - Land and Water Area in Acres within Connecticut River Basin by State and County

State and Counties	Land	Water	Percent of County within Basin
CONNECTICUT - CRB Area VI			
Hartford	436,868	13,176	94
Litchfield	105,249	4,603	18
Middlesex	187,928	8,125	79
New Haven	3,729	30	1
New London	65,029	6,870	16
Tolland	85,513	1,920	32
Connecticut	884,316	34,724	
MASSACHUSETTS - CRB Area V			
Berkshire	143,146	2,796	24
Franklin	451,238	16,602	100
Hamden	358,364	11,843	91
Hampshire	335,420	13,380	100
Worcester	388,358	23,493	41
Massachusetts	1,676,526	68,114	
NEW HAMPSHIRE - CRB Area I and III			
Cheshire	385,342	9,902	84
Coos	632,856	12,347	55
Grafton	547,339	9,160	51
Hillsborough	9,140	35	2
Merrimac	14,055	2,903	3
Sullivan	319,675	6,686	93
New Hampshire	1,908,407	41,033	
VERMONT - CRB Area II and IV			
Addison	55,613	250	11
Bennington	103,529	346	24
Caledonia	339,157	4,952	87
Essex	361,960	4,970	85
Orange	402,043	2,600	91
Orleans	4,662	12	1
Rutland	81,425	275	14
Washington	23,236	570	5
Windham	502,634	6,806	100
Windsor	614,056	4,824	100
Vermont	2,488,315	25,605	
BASIN TOTAL	6,957,564	69,476	

Within 27 counties a total of 372 minor civil divisions are located all or partially in the Connecticut River Basin. Of the 372, 15 are cities, 337 are towns and 17 are of lesser status. The latter category includes townships, purchases, grants, unorganized areas, one gore and one location. By State, the basin includes: 110 towns and seven lesser types in 10 counties in Vermont; four cities, 79 towns and 11 lesser types in six counties of New Hampshire; six cities and 95 towns in five Massachusetts counties; and five cities and 56 towns in six counties in Connecticut. A table of the minor civil division indicating their general status is shown below by State and county.

TABLE II-2

Cities, Towns and Other Minor Civil Divisions Located All or Partly Within the Connecticut River Basin

VERMONT

ESSEX COUNTY
1. Canaan
2. Averill*
3. Averys Gore*
4. Lewis*
5. Lemington
6. Brighton
7. Bloomfield
8. Ferdinand*
9. Brunswich
10. East Haven
11. Maidstone
12. Granby
13. Victory
14. Guildhall
15. Lunenburg
16. Concord

BENNINGTON COUNTY
1. Peru
2. Landgrove
3. Winhall
4. Sunderland
5. Glastenbury*
6. Woodford
7. Searsburg
8. Readsboro

ORLEANS COUNTY
1. Westmore

CALEDONIA COUNTY
1. Newark
2. Sheffield
3. Sutton
4. Burke
5. Wheelock
6. Lyndon
7. Kirby
8. Stannard
9. Walden
10. Danville
11. St. Johnsbury
12. Waterford
13. Peacham
14. Barnet
15. Groton
16. Ryegate

ORANGE COUNTY
1. Orange
2. Topsham
3. Newbury
4. Williamstown
5. Washington

*Minor civil divisions which are neither towns nor cities
**City

TABLE II-2 (cont'd)

WINDSOR COUNTY
1. Rochester
2. Bethel
3. Royalton
4. Sharon
5. Norwich
6. Stockbridge
7. Barnard
8. Pomfret
9. Hartford
10. Bridgewater
11. Woodstock
12. Hartland
13. Plymouth
14. Reading
15. West Windsor
16. Windsor
17. Ludlow
18. Cavendish
19. Baltimore
20. Weathersfield
21. Weston
22. Andover
23. Chester
24. Springfield

WASHINGTON COUNTY
1. Cabot
2. Roxbury

ADDISON COUNTY
1. Granville
2. Hancock

RUTLAND COUNTY
1. Chittenden
2. Pittsfield
3. Sherburne
4. Mendon
5. Shrewsbury
6. Mt. Holly
7. Mt. Tabor

ORANGE COUNTY (cont'd)
6. Corinth
7. Bradford
8. Brookfield
9. Chelsea
10. Vershire
11. West Fairlee
12. Fairlee
13. Braintree
14. Randolph
15. Tunbridge
16. Strafford
17. Thetford

WINDHAM COUNTY
1. Londonderry
2. Windham
3. Grafton
4. Rockingham
5. Jamaica
6. Townshend
7. Athens
8. Westminster
9. Stratton
10. Wardsboro
11. Brookline
12. Putney
13. Somerset*
14. Dover
15. Newfane
16. Dummerston
17. Wilmington
18. Marlboro
19. Brattleboro
20. Whittingham
21. Halifax
22. Guilford
23. Vernon

*Minor civil divisions which are neither towns nor cities
**City

TABLE II-2 (cont'd)

NEW HAMPSHIRE

COOS COUNTY

1. Pittsburg
2. Clarksville
3. Stewartstown
4. Colebrook
5. Dixville *
6. Erving's Location*
7. Columbia
8. Stratford
9. Odell *
10. Millsfield*
11. Dummer
12. Northumberland
13. Stark
14. Milan
15. Lancaster
16. Kilkenny *
17. Berlin **
18. Dalton
19. Whitefield
20. Jefferson
21. Carroll
22. Randolph
23. Low & Burbanks Grant*
24. Crawford's Purchase*
25. Thompson & Meserve's P'ch*
26. Sargent's Purchase*
27. Chandler's Purchase*
28. Bean's Grant*

MERRIMACK COUNTY

1. New London
2. Newbury

CHESHIRE COUNTY

1. Walpole
2. Alstead
3. Marlow
4. Westmoreland
5. Surry
6. Gilsum
7. Sullivan
8. Stoddard

GRAFTON COUNTY

1. Monroe
2. Littleton
3. Bethlehem
4. Lyman
5. Lisbon
6. Bath
7. Landaff
8. Franconia
9. Easton
10. Lincoln
11. Haverhill
12. Benton
13. Woodstock
14. Piermont
15. Warren
16. Orford
17. Wentworth
18. Lyme
19. Dorchester
20. Hanover
21. Canaan
22. Lebanon **
23. Enfield
24. Orange
25. Grafton

SULLIVAN COUNTY

1. Plainfield
2. Grantham
3. Springfield
4. Cornish
5. Croydon
6. Claremont**
7. Newport
8. Sunapee
9. Charlestown
10. Unity
11. Goshen
12. Langdon
13. Acworth
14. Lempster
15. Washington

*Minor Civil Division which is neither a town nor city.
**City

TABLE II-2 (cont'd)

CHESHIRE COUNTY (cont'd)
9. Nelson
10. Keene**
11. Roxbury
12. Harrisville
13. Chesterfield
14. Swanzey
15. Troy
16. Marlborough
17. Dublin
18. Jaffrey
19. Hinsdale
20. Winchester
21. Richmond
22. Fitzwilliam
23. Rindge

HILLSBORO COUNTY
1. New Ipswich

MASSACHUSETTS

BERKSHIRE COUNTY
1. Florida
2. Savoy
3. Windsor
4. Peru
5. Washington
6. Becket
7. Otis
8. Sandisfield

HAMPSHIRE COUNTY
1. Plainfield
2. Cummington
3. Goshen
4. Worthington
5. Middlefield
6. Chesterfield
7. Williamsburg
8. Hatfield
9. Huntington
10. Westhampton
11. Northampton**
12. Southampton
13. Easthampton

FRANKLIN COUNTY
1. Monroe
2. Rowe
3. Heath
4. Colrain
5. Leyden
6. Bernardston
7. Northfield
8. Charlemont
9. Hawley
10. Buckland
11. Shelburne
12. Greenfield
13. Gill
14. Ashfield
15. Conway
16. Deerfield
17. Whately
18. Sunderland
19. Leverett
20. Shutesbury
21. New Salem
22. Orange
23. Wendell

*Minor Civil Division which is neither a town nor city
**City

TABLE II-2 (cont'd)

HAMPSHIRE COUNTY (cont'd)
14. South Hadley
15. Hadley
16. Amherst
17. Pelham
18. Granby
19. Belchertown
20. Ware

WORCESTER COUNTY
1. Royalston
2. Winchendon
3. Ashburnham
4. Athol
5. Phillipston
6. Templeton
7. Gardner **
8. Petersham
9. Hubbardston
10. Westminister
11. Princeton
12. Barre
13. Hardwick
14. New Braintree
15. Oakham
16. Rutland
17. Warren
18. West Brookfield
19. North Brookfield
20. Spencer
21. Paxton
22. Brookfield
23. East Brookfield
24. Leicester
25. Sturbridge

FRANKLIN COUNTY (cont'd)
24. Montague
25. Erving
26. Warwick

HAMPDEN COUNTY
1. Chester
2. Blandford
3. Montgomery
4. Russell
5. Westfield **
6. Tolland
7. Granville
8. Southwick
9. Holyoke **
10. Chicopee **
11. Ludlow
12. Palmer
13. West Springfield
14. Springfield **
15. Wilbraham
16. Monson
17. Brimfield
18. Wales
19. Hampden
20. East Long Meadow
21. Long Meadow
22. Agawam

*Minor Civil Division which is neither town nor city.
**City

TABLE II-2 (cont'd)

CONNECTICUT

LITCHFIELD COUNTY
1. Norfolk
2. Colebrook
3. Winchester
4. Barkhamsted
5. Torrington
6. New Hartford
7. Harwinton
8. Plymouth

HARTFORD COUNTY
1. Hartland
2. Granby
3. Suffield
4. East Granby
5. Windsor Locks
6. Canton
7. Simsbury
8. Bloomfield
9. Windsor
10. Burlington
11. Avon
12. West Hartford
13. Hartford**
14. Bristol**
15. Plainville
16. Farmington
17. New Britain**
18. Newington
19. Wethersfield
20. Rocky Hill
21. Berlin
22. Glastonbury
23. Marlborough
24. Manchester
25. East Hartford
26. South Windsor
27. East Windsor
28. Enfield

TOLLAND COUNTY
1. Somers
2. Stafford
3. Ellington
4. Tolland
5. Vernon
6. Bolton
7. Hebron

MIDDLESEX COUNTY
1. Cromwell
2. Portland
3. East Hampton
4. Middletown**
5. Middlefield
6. Durham
7. Haddam
8. East Haddam
9. Chester
10. Deep River
11. Essex
12. Old Saybrook

NEW LONDON COUNTY
1. Colchester
2. Salem
3. Lyme
4. Old Lyme

NEW HAVEN COUNTY
1. Meriden*
2. Guilford

*Minor Civil Division which is neither town nor city
**City

CHAPTER II

Section 2 - Social and Economic History

The Connecticut River, referred to in its early history as the "Long Tidal River", or the "Long River", and sometimes the "Great River" owes its name to the River Tribes of Indians. White explorers and settlers in trying to transcribe into English syllables the Indian name had, at one time, some forty-one different spellings. Historical accounts indicate that Governor Winthrop in his document entitled "History of New England" established the correct spelling of the river as we know it today.

The first European exploration of the river, accomplished in 1614, is accredited to a Dutchman named Adrian Block, after whom Block Island is named. It took some 20 years after his initial exploration that the Dutch undertook their first settlement at the site of present day Hartford. However, by that time the English had chosen the river as a site for further expansion of the Plymouth and Bay Colony settlements, establishing its first settlement at Windsor, Connecticut at the mouth of the Tunxis (Farmington) River. During the ten-year period of 1630 to 1640, the English Settlement was capable of engulfing and expelling the Dutch, and incurred its first clash with the Indian tribes. By 1650 there were six settlements established in the Connecticut River Basin of which five, namely Windsor, Wethersfield, Hartford, Fort Saybrook, and Farmington were in what is now the State of Connecticut, and the sixth settlement was in Springfield, Massachusetts.

Chronologically, the settlement of the Connecticut River Basin proceeded up the river from south to north. By 1700, there had still been no significant penetration of either Vermont or New Hampshire. But in the 18th century (1724) the Massachusetts General Court ordered the building of Fort Drummer in what later became Brattleboro, Vermont.

The settlements were named after English towns and names transposed from Indian oral names. There was much repetition between the towns of the upstream states having been spawned by the earlier downstream settlements. Some were named simply by adding north, south, east, or west prefix. This was not necessarily the lack of originality, but rather the fact that as the towns were settled, there was a tendency for farms to settle some distance from the center of the village. Consequently, when these east, west type settlements

TABLE II-2 (cont'd)

CONNECTICUT

LITCHFIELD COUNTY
1. Norfolk
2. Colebrook
3. Winchester
4. Barkhamsted
5. Torrington
6. New Hartford
7. Harwinton
8. Plymouth

TOLLAND COUNTY
1. Somers
2. Stafford
3. Ellington
4. Tolland
5. Vernon
6. Bolton
7. Hebron

HARTFORD COUNTY
1. Hartland
2. Granby
3. Suffield
4. East Granby
5. Windsor Locks
6. Canton
7. Simsbury
8. Bloomfield
9. Windsor
10. Burlington
11. Avon
12. West Hartford
13. Hartford**
14. Bristol**
15. Plainville
16. Farmington
17. New Britain**
18. Newington
19. Wethersfield
20. Rocky Hill
21. Berlin
22. Glastonbury
23. Marlborough
24. Manchester
25. East Hartford
26. South Windsor
27. East Windsor
28. Enfield

MIDDLESEX COUNTY
1. Cromwell
2. Portland
3. East Hampton
4. Middletown **
5. Middlefield
6. Durham
7. Haddam
8. East Haddam
9. Chester
10. Deep River
11. Essex
12. Old Saybrook

NEW LONDON COUNTY
1. Colchester
2. Salem
3. Lyme
4. Old Lyme

NEW HAVEN COUNTY
1. Meriden*
2. Guilford

*Minor Civil Division which is neither town nor city
**City

To give some hint of the abundance of the wildlife resource, it is hard to realize that fur trade was centered in Massachusetts in the Springfield area during these early days. But as the ranks of the Indians depleted, so did the fur trade.

Economic diversification in the valley began very early and Yankee ingenuity created many different means for increasing income, many of which were in the handicraft stage of development. For nearly a hundred years shipbuilding was a major industry along estuary portions of the Connecticut River. Some of these ships participated in the Revolutionary War and in the War of 1812.

In the 19th century, New England became the tool center of the world and much of this capability was drawn from industrial centers located in the Connecticut River Valley. Economic diversity which centered initially around the lower portion of the valley moved upstream. By 1850 almost one-third of all employees in manufacturing in the United States were found in New England, and since another forty-four percent were in the adjoining middle Atlantic, the northeast was well on its way to becoming the industrial center of the nation.

The reason for this comparatively rapid industrial growth as relates to the Connecticut Valley was the fact that the soil did not permit much market type agricultural pursuit. It thus paved the way for other commercial activities in the way of shipping and fishing. Further, because of the distinct advantage presented by natural high quality streams and the abundance of this water power manufacturing was able to take hold. Attention is drawn to the discussion of water law in this report where reference to the "Mill Acts" is given as these were institutional means to assist the evolution into economy.

Early settlements in the Connecticut River Basin were located adjacent to the river, not only to take advantage of the more fertile agriculture lands, and workable terrain, but to provide major avenues of transportation. From the colony period up to the advent of the railroads in the 1840's, all sorts of commerce was carried by river vessels of all sizes and shapes. Initially, commerce in the river was confined between the mouth of the river and Enfield Rapids. Later as canals were built, navigation was extended as far north as Barnet, Vermont, or a distance of nearly 250 miles from Long Island Sound. The major rapids which were bypassed with locks and canals included Enfield in Connecticut, Hadley Falls and Turners Falls in Massachusetts, Bellows and Sumner Falls and Hartland and White River in New Hampshire and Vermont.

By 1829 all major falls or rapids had been by-passed and the river's navigation system was ready to flower, ironically, just on the eve of the railroad boom. A lively trade sprang up along the river. Up the river went a wide variety of merchandise - salt, molasses, household goods, and rum. Down the river came potash, shingles, and lumber and other native products from the northern valley.

The two major innovations in land transportation which occurred with the advent of the railroad in the 1830's and the automobile in the early 20th century tended to shift transportation activity away from the river. Prior to these important modes of transportation, land travel was accomplished by walking, horseback, and horse drawn vehicles. Thanks to trails established by the Indians through the forests, the Colonists were able to utilize these into paths as a basis for highways which, in many cases, became post roads or turnpikes. The first colonial highway in the valley extended from Hartford to Windsor and was ordered by the General Court in 1638. Many years later, in 1670, a similar road was laid on the eastern side of the Connecticut River about in the area of current U.S. Routes 5 and 5A.

About this time, through the efforts of the Governor of New York, a post road was constructed between New York and Boston by way of Hartford. By the time of the American Revolution, another post road between Hartford and Springfield was added. Shortly thereafter, as part of revolutionary activities which brought the capture of British cannon from Fort Ticonderoga to Boston the "Knox Trail" was cut, which later became part of Massachusetts Route 23.

Other important road networks were also constructed, for example, from the Charlestown, New Hampshire area extending northwesterly in Vermont and towards Lake Champlain. Early roads were meandering in nature following the banks of rivers and the flat valley region adjacent to the Connecticut River, and soon it became necessary to cross over the river itself. Initially this was done by ferry and then by bridge with the first one occurring in 1785 crossing between the river towns of Walpole, New Hampshire and Bellows Falls, Vermont.

The "turnpike era" extending from 1790 to 1850 followed with principal attention being given to the lower part of the basin. This was the era of the stagecoach and the familiar two-wheeled vehicle commonly referred to as a chaise. As the roads improved so did the carriage industry. Many of these early roads were made in the form of wood, initially in the form of corduroy construction, and later plank roads were used with sand placed as a surface.

CHAPTER II
Section 3 - Cultural Resources

The Connecticut River Basin, prominent in the history of the nation, continues to serve through its abundant natural resources, its inhabitants, industries, and visitors, with timber, agricultural products, power, water for industrial process uses, and an outstandingly attractive environment for living, working, studying, and recreating. In the field of higher education the region has been called an "Educated Valley" with 40 colleges located within its boundaries.

Through the compilation of material contained in secondary references as well as the solicitation of information from appropriate agencies and qualified individuals sites have been identified within the basin which are regarded as possessing features or characteristics of such outstanding natural history that they merit special attention and efforts to preserve their integrity. Conscious of its heritage, the valley features many museums and other cultural sites and institutions with some of the more important ones listed in Table II-3.

Prominent Early Personages

Thomas Hooker's thesis of government stated "that the foundation of authority is laid firstly in the free consent of the people" and therefore, that "the choice of the public magistrates belongs unto the people by God's own allowance". Since the magistrates are appointed by the people, the people have the power to set the bounds and limitations of their activities. Mr. Hooker's philosophy held an important place in the evolution of the American Constitution. With these fundamental concepts there ensued an array of new municipalities granted initially by charter which were achieved by the personal diplomacy of John Winthrop, Jr., in his trips to England where he was able to get the King's approval. Small municipalities moved northward but were initially restrained by marauding Indians.

Two important landmarks in the history of American Democracy were founded along the shores of the Connecticut River. At Hartford, in 1639, the "Fundamental Orders of the Connecticut" were framed. A hundred years later, at Windsor, Vermont, a new State Constitution was drafted which was the first to grant universal manhood sufferage and to abolish all human slavery. The early wars with the Indians fostered the need for Government so that valley towns could act in concert. In the early days, the Government was ruled by Puritans with severe restrictions on suffrage and little opportunity for democratic expression. The basic unit of Government in the valley in the early days, and still outstanding today, is that of the Town Meeting. In the earlier centuries these were held on a monthly basis but are now reduced to an annual basis. Town affairs are handled by Townsmen, now referenced as the Board of Selectmen.

Listed in Appendix O of this report are an array of 28 of the more prominent early personages which guided the religious, political, cultural, and economic destinies of the basin. These people, together with their beliefs, creative ability, and inventions, made the Connecticut River Valley initially the "frontier line" of New England and of the country.

The Connecticut Valley bore the brunt of the Indian attacks of the 17th and 18th centuries, and it sent a relatively large proportion of its sons into the battle for independence. On several occasions the American and French armies crossed and recrossed the valley in their military expeditions against the British in the American Revolution.

The Connecticut Valley was in the forefront of movement for a new constitution. For example, the Shay's Rebellion, along with similar unrest in other States was an important factor in the movement for a new constitution. This action contributed to calling of the great Philadelphia Convention of 1787. Once the drafting of a new constitution was completed in January and February of 1788, the States of Connecticut and Massachusetts were among the earliest of the nine States required to ratify the new constitution and New Hampshire was the ninth. Vermont's ratification in 1791 made it the fourteenth State, the first new State beyond the original thirteen.

The Connecticut Valley played an important role in the numerous reform movements that arose in the first half of the 19th century. It has been a leader in education. It has seen various waves of migration so that in the 20th century we find it to be a mixture of the very old and very new, and this characteristic is particularly evident in the lower valley portion of the basin.

Urbanization and industrialization have brought great economic progress to the valley, but it has also been destructive of the physical remains of the historic past. It is the desire of the Coordinating Committee that through concerted governmental effort the remains of this heritage be preserved. The historic sites listed as candidates for preservation in Appendix O can afford a basis for such a plan.

TABLE II-3

HISTORIC & CULTURAL SITES AND COLLEGES

CONNECTICUT

A. HISTORIC SITES

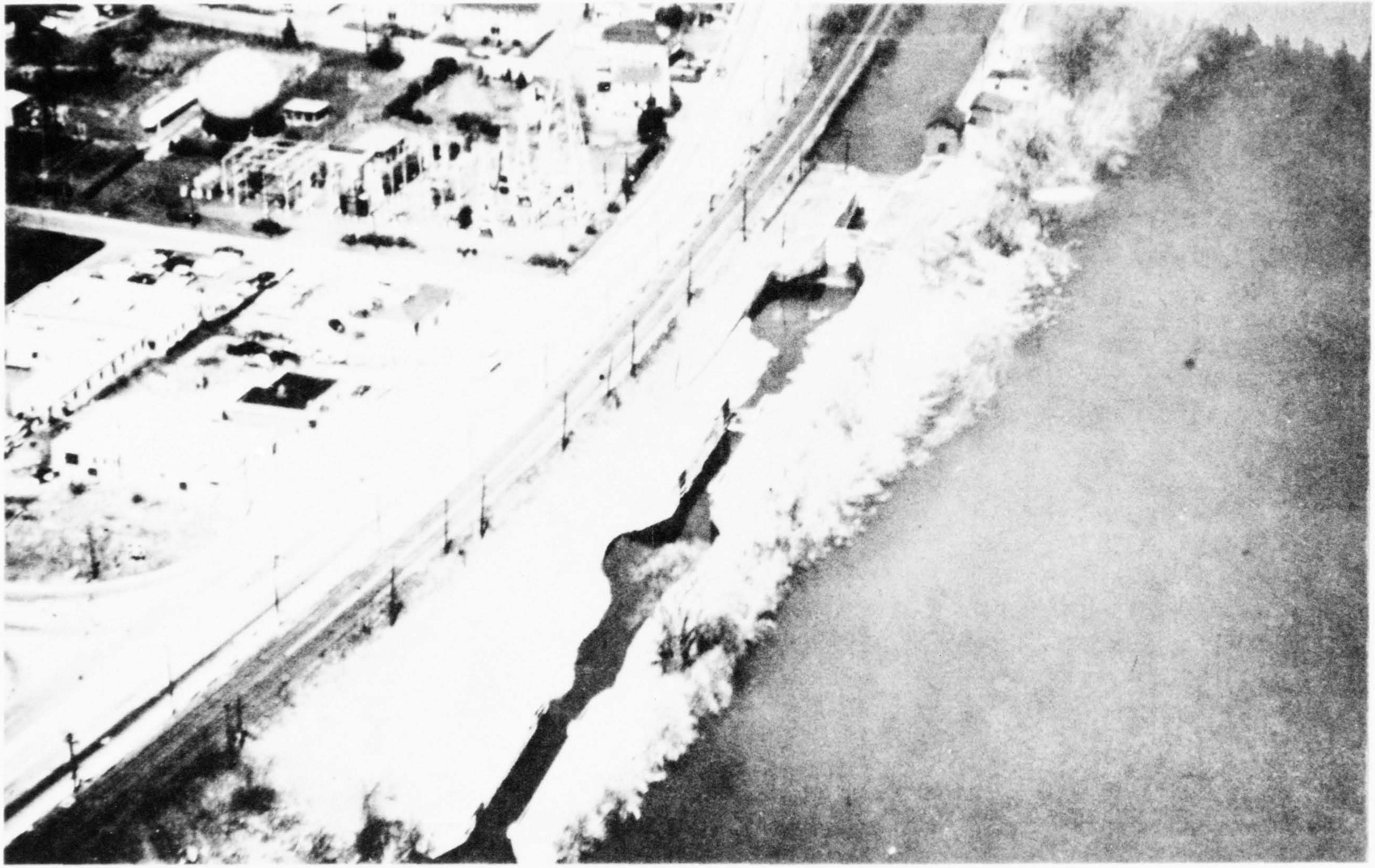
1. Old Fort Saybrook, Saybrook Pt.
2. Franklin Milestone, Old Lyme
3. Site of Nathan Hale Schoolhouse, Old Lyme
4. Birthplace of Moses Austin, Durham
5. The Webb House, Wethersfield
6. Silas Deane House, Old Wethersfield
7. Historic District, Old Wethersfield
8. "Charter Oak" Tree, Hartford
9. Colt Mansion and Park, Hartford
10. The Mark Twain House, Hartford
11. Harriet Beecher Stowe House, Hartford
12. Center Church and Ancient Burying Ground, Hartford
13. Old State House, Hartford
14. Elizabeth Park, Hartford and West Hartford
15. Noah Webster House, West Hartford
16. Stanley-Whitman House, Farmington
17. Farmington Grist Mill
18. Site of French Army Encampment, East Hartford
19. Avon Congregational Church
20. Old Newgate Prison, East Granby
21. Site of Birthplace of Jonathan Edwards, South Windsor
22. Enfield Canal and Windsor Locks

B. CULTURAL SITES

1. Hill-Stead Museum, Farmington
2. Connecticut Historical Society and Museum, Hartford
3. Hartford's Art Museum
4. Wadsworth, Colt, Morgan and Avery Memorials, Hartford
5. Goodspeed Opera House, East Haddam
6. Davidson Art Center
7. Elisha Phelps House Muesum, Old Saybrook
8. Capt. Elisha Phelps House, Simsbury
9. The Oliver Ellsworth Homestead, Windsor
10. Dinosaur State Part, Rocky Hill

C. COLLEGES & JUNIOR COLLEGES

1. Trinity College, Hartford
2. Hillyer College, Hartford
3. St. Joseph's College, West Hartford
4. Hartford College, West Hartford
5. Teachers College of Conn., New Britain
6. Wesleyan University, Middletown
7. Diocesan Sisters College, Hartford
8. Hartford Seminary Foundation
9. Holy Apostles Seminary, Cromwell
10. Rensselaer Polytechnic Institute of Conn., Hartford
11. St. Alphonsus College, Suffield
12. University of Hartford
13. Hartford College for Women
14. Holy Family Seminary, West Hartford
15. St. Thomas Seminary, Bloomfield
16. Manchester Community College



AERIAL VIEW OF HISTORIC WINDSOR LOCKS CANAL IN WINDSOR LOCKS, CONNECTICUT FLANKED BY COMMERCIAL - INDUSTRIAL COMPLEX

Corps of Engineers Photo

TABLE II-3 (cont'd) MASSACHUSETTS

A. HISTORIC SITES

1. Longmeadow Green
2. Curtis Tavern, Granville
3. "The Puritan", Springfield
4. Springfield Armory and Arsenal
5. Church of the Unity, Springfield
6. Site of Battle, Shay's Rebellion
7. Duryea's Motor Car, Springfield
8. Storrowton, West Springfield
9. Birthplace of Edward Bellamy 93 Church St., Chicopee
10. Brookfield Inn, Brookfield
11. Residence of Calvin Coolidge, Northampton
12. Wiggins Old Tavern Northampton
13. Manse where Jonathan Edwards lived, Northampton
14. Hadley Green (West St.)
15. Huntington House, Hadley
16. Phelps Farm, Hadley
17. Simeon Clark House, Mill Valley So. of Amherst, So. Hadley Rd.
18. Home of Emily Dickinson, Amherst
19. Birthplace of Helen Hunt Jackson, Amherst
20. Residence of Noah Webster, Amherst
21. Lord Jeffrey Inn, Amherst
22. Home of William Cullen Bryant, Cummington
23. Pelham Town Hall Complex
24. Site of Bloody Brook Massacre, South Deerfield
25. Community of Old Deerfield
26. Bank Row, Greenfield
27. Northfield Green
28. Home of Rev. Dwight L. Moody, Northfield

B. CULTURAL SITES

1. The Quadrangle Museums, Springfield
2. "Stage West", Resident Professional Theatre, West Springfield
3. The Stone House, Belchertown
4. The Carnegie Library, Turners Falls
5. The Westfield Athenaeum
6. The Connecticut Valley Historical Museum, Springfield
7. Springfield Science Museum and Planetarium
8. Pratt Museum, Amherst
9. The Jones Library, Amherst
10. Porter-Phelps-Huntington House

C. COLLEGES AND JUNIOR COLLEGES

1. University of Massachusetts
2. Amherst College
3. Smith College, Northampton
4. Mt. Holyoke College, South Hadley
5. College of Our Lady of the Elms, Chicopee
6. Springfield College
7. American International College, Springfield
8. Westfield State College
9. Bay Path Junior College Longmeadow
10. Holyoke Community College
11. Greenfield Community College
12. Mt. Wachusett's Community College, Gardner
13. Western New England College Springfield
14. Hampshire College, Hadley
15. Northampton Commercial College

TABLE II-3 (cont'd) NEW HAMPSHIRE

A. HISTORIC SITES

1. Holbrook Farm Near Swanzey
2. Old Homstead, Swanzey and the Denman Thompson House W. Swanzey
3. Road's End Farm, Chesterfield
4. Site of first fort and Indian battles, Keene
5. Quaker Meeting House, Acworth
6. Site of "Old No. 4", Charlestown
7. Old Crown Point Road, Charlestown
8. First Roman Catholic Church in N. H., Claremont
9. Union Church, West Claremont
10. Mary had a little lamb House Guild
11. Saint-Gaudens Memorial Vicinity of Cornish
12. Site of "Harlakenden House" Cornish
13. Lockehaven Schoolhouse Museum
14. Bulfinch, Orford
15. Col. Johnston House, Haverhill Corner
16. Covered Bridge, Bath
17. Site of Bretton Woods Conference, Bretton Woods
18. Site of "Republic of Indian Stream", Pittsburg

B. CULTURAL SITES

1. Museum of Old Dolls and Toys, West Chesterfield
2. Clock Museum, Newport
3. Old Meeting House Museum, Groveton
4. Saint-Gaudens N. H. and former home and studio of August Saint-Gaudens, Cornish

C. COLLEGES AND JUNIOR COLLEGES

1. Dartmouth College, Hanover
2. Colby Junior College
3. Keene Teachers
4. Canaan

TABLE II-3 (cont'd) VERMONT

A. HISTORIC SITES

1. Site of Ft. Drummer, Brattleboro
2. Home of Rudyard Kipling North of Brattleboro
3. Scott Covered Bridge, Townshend
4. Farrar-Mansur House, Weston
5. William Jarvis, Weathersfield Bow
6. Old Constitution House, Windsor
7. Covered Bridge, Windsor
8. Old South Church, Windsor
9. Birthplace of Calvin Coolidge, Plymouth
10. President Calvin Coolidge Homestead, Plymouth
11. The Woodstock Green
12. Old Congregational Church Thetford Hill
13. Joseph Smith Monument near So. Royalston
14. Site of Annual Tunbridge World's Fair, Tunbridge
15. Experience Davis House, South Randolph
16. Site of First Normal School in U. S., near Concord

B. CULTURAL SITES

1. Windham County Historical Museum
2. Historical Room, Reading

TABLE II-3 (cont'd) VERMONT (cont'd)

B. CULTURAL SITES (cont'd)

3. Art Gallery at St. Johnsbury Athenaeum, St. Johnsbury
4. Fairbanks Museum of Natural Science, St. Johnsbury
5. Experiment in International Living, Putney
6. Bushnell's museum, Vernon
7. Rev. Dan Foster House Weathersfield Center
8. Woodstock Historical Society D. A. R. House, Woodstock
9. Norman Williams Library, Woodstock

C. COLLEGES AND JUNIOR COLLEGES

1. Marlboro College
2. Windham College, Putney
3. Lyndon State College
4. Putney Graduate School of Teacher Education, Putney
5. Vermont Technical College Randolph Center

PART ONE

CHAPTER III

PHYSIOGRAPHY

CHAPTER III

Section 1 - Natural Resources

A. Surface - Land Forms - Elevation

The Connecticut River Basin is one of the most scenic rivers in the United States and one which has been very prominent in history. It provides an outstanding attractive environment for living, working, study, and recreating. Its land form has been fashioned by the forces of nature over a period of more than one-half billion years, changing from a shallow, narrow sea to a period of great mountain and valley building. Thousands of feet of erosion and deposition were added, stressed by explosive volcanoes followed by a semi-desert condition with herds of dinosaurs, and finally shaped by the great continental glaciers which provided the abundance of fresh-water lakes and tributary rivers as we know them today.

The Connecticut River Basin is located within the Appalachian highlands of North America, which extends from Newfoundland to Alabama. The basin is entirely within the New England physiographic province which is further divided into sections, several of which have portions within the Connecticut River Basin.

Physiography is the primary basis for further delineation of 3 major land resource areas in the Connecticut Basin. Two of the major land resources, namely, the Connecticut Valley lowlands and the New England uplands, are each co-extensive with physiographic sections. The third land resource area namely, the northeastern mountains, is made up chiefly of two physiographic sections, referenced as the White Mountains and the Green Mountains. It also includes the Berkshire hills which are contiguous to the Green Mountains, as well as those mountains and hills in the northern part of the basin.

Within the northeastern mountain delineation one finds elevations varying from 1,000 to 4,000 feet above mean sea level with a few peaks up to 5,000 feet or more. Mount Washington, in the White Mountain range has an elevation of 6,288 feet. In the New England upland section elevations range from sea level in southern Connecticut to about 1,000 feet in the middle portion. Some hills rise to 2,000 feet and there are a few peaks which rise above 3,000 feet. The Connecticut Valley lowland, which makes up the Connecticut and Massachusetts portion of the basin, has elevations which range from sea level between Hartford and Middletown to ridge crest 500 to more than 1,000 feet above sea level. It is in this reach where the area may be found chiefly underlined by triassic sedimentary rocks, sheets of dark colored basic igneous rocks, chiefly volcanic in origin, form resistant ridges above rocks of sedimentary origin. Additional details on physiography may be found in Appendix F and in Appendix O of this report.

B. Geology-Soil-Mineral Resources

The northeastern mountains and the New England Upland sections are underlain by crystalline bedrock which varies widely with regard to structure and rock type. These two land resources are underlain by metamorphic and igneous bedrock as well. The dominant rocks are gneiss, schist, phyllite, slate, and quartzite.

As regards official geology prior to contenintal glaciation natural weathering had formed a thick cover of residual soil over the bedrock. As the ice sheet formed and advanced, it removed first the loose residual soil and then removed blocks of solid rock. Both the soil and the rock were then transported and deposited by ice as glacial till. Glacial streams and lakes produced by the glacier were the sites of water-laid deposition of sediments. However, topography is controlled primarily by underlying bedrock, rather than by surficial materials. Glacial till covers the greater portion of the land area with deposits of varying thickness. The till was deposited directly by ice mass and as such the material ranges from plastic fines to boulders. In contrast to the glacial till are the stratified deposits transported and deposited in glacial streams and lakes. In general these are thicker and occur along the main and tributary valleys, as well as at terraces and winding ridges. These sediments are generally well sorted, consisting of gravels and sands, silts, and clays.

Known occurrences of minerals are numerous. Most of these minerals are located in areas that are not conducive for exploitation, at least under present economic technical conditions. However, there are important exceptions to this namely, beryl, mica, gems, abrasive, feldspar, copper, and dimension stone. Economically far more important are the triassic trap rock which forms an important source of crushed rock. It is used in a number of different projects and as an aggregate for concrete. Also of importance are the blue clays which are used for the manufacture of bricks and drain tile. Sand and gravel deposits are plentiful in the valley particularly below Turners Falls and south to Middletown, Connecticut. Additional details in this regard may be found in Appendix N and in Appendix S plus portions of Appendix O.

Soil condition and physiography of the area have a marked influence on its use. The most intensive agriculture in the basin is in the Connecticut Valley lowland. The silty and fine sandy soils on the high, level flood plains and terraces along the Connecticut River are largely devoted to the production of potatoes, nursery stock, and vegetables. The more sandy and gravelly soils on the till from triassic shales and sandstones are widely used for production of tobacco, potatoes, vegetable crops, and forage for dairy herds. However, because of the favorable topography, and the general use suitability, this lowland area is also subject to greatest competition for uses other than agriculture and it is in this reach where urban pressures are the greatest.

The New England upland is less suited to intensive agriculture than the Connecticut Valley lowland. Much of the present agriculture in this area is based on the bottom and terraced lands of the Connecticut River and its major tributaries included. The upland soils which lie east of the Connecticut River are generally acidic in nature while, west of the river they form from lime-bearing tills to a considerable extent. These soils are less stony and tend to be more productive than the acid soils. Upland farming has been more persistent in these areas and a greater portion of the land has not reverted to forest. The northeastern mountains area, the more rugged and mountainous region of the basin, is about 91% forested and timber and wood products provide an important element in the local economies. Crop and pasture lands are largely restricted to the valleys and the gentler slopes. Soils in the Green Mountains are not as coarse or as stony as on the White Mountains area. However, over the past 20 years there has been a major reduction in the number of farms and the area of croplands. The Soil Conservation Service has provided data on soil conditions concerning degree of erosion, excessive water, or drainage, or other factors affecting capability or limitation. For further details in this regard, attention is directed to Appendix F.

C. Eco-system

Ecology is the branch of biology that deals with the interrelationship between living organisms and non-living organisms and how they function together as a whole or as an eco-system. The eco-system is the sum total of the living and non-living components that support the chain of life. It consists of non-living matter, such as sunlight, water, air, soil, as used by the plants for their growth or support. It consists also of the producers, the green plants which have the power to harness the Sun's energy and combine it with elements from air, water, and rocks into living tissues. Consumers which feed upon the plants follow, these are the herbivores, such as the cows and sheep, and man and other carnivores which feed upon the larger animals and are therefore the secondary consumers. Lastly are the decomposers, these are the bacteria, fungi, insects. They breakdown the dead producers and consumers and return their chemical components for reuse by plants. The entire process is governed by distinct laws of balance and when working properly is said to be an equilibrium. In some areas man has upset this equilibrium and in so doing has endangered all nature including himself. Perhaps his greatest damage has come in the area of pollution, be it water, air, or soil, as well as his introduction of certain herbicides and pesticides and by poor soil practices resulting in large concentrations of mineral salts, and simply from a large amount of solid waste disposal. There are many areas in which this water and related land resource study was not able to touch in the detail that will be required in future studies. Nevertheless, inventories have been made, and judgments can be made of those improvements that are proposed so that balance can be sought in maintaining a healthy eco-system.

D. Biological Productivity

The Connecticut River Basin extends from just inside the southern border of Canada southerly to Long Island Sound. During its trip to the ocean, water in the basin will pass through one or more life zones. The life zones, more fully described below, are those areas which contain a specialized system of plant and animals which have evolved through the years by means of climate and elevation. Being entities, there is little crossover between these zones except where they meet. It is important then to consider each life zone and its plant and animal communities and how man's activities have in the past affected them. Hopefully, future planning will further evaluate the specialized needs of the plants and animals which influence man's planning.

Sub-Arctic Zone - This type of environment is less than 1/10 of 1% of the total area of the basin. It is characteristically a treeless area of heath and bogs. Ground ferns, hardy members of the buttercup family, stunted willows and lichens like reindeer moss are the plants commonly associated with this type of area. The animals normally associated with this life zone are absent with the exception of insects notably a single species of butterfly found on Mt. Washington.

Boreal Forest - At lower elevations we find the taiga or boreal forest, characterized by spruce-fir associations. Snowy owls, Canadian lynx, and moose are the most striking animals associated with this life zone. Less remarkable but most often encountered are the varying hares, red squirrels, and Canada jays. Brook trout, a type of char, are found in the streams.

Temperate Hardwood Forest - The major portion of the basin is characteristically the hemlock-deciduous hardwood forests found in the central and lower portion of the basin. Maple, beech, hemlock, and pines are the dominant tree types in the area. In the woods of the lowest portion of this zone oaks and hickory are frequently encountered. White tailed deer, black bear, gray fox and gray squirrel and cotton tail rabbits are characteristic animals of these forests.

Estuarine Zone - The lower Connecticut River Basin is influenced by the proximity to the marine environment, with tidal waters extending upstream to the vicinity of Hartford, Connecticut, a river distance of approximately 60 statute miles. Associated with this marine affected climate is a community of flora and fauna adapted ecologically.

As influenced by the tide, the streamside meadows and woodlands give way to tidal salt marshes. The grasses and shrubs found here are identical to those found north and south along the coastal estuaries. The marsh animals are characterized by their ability to resist continual changes in salinity and periodic fluctuation in water level. Insects are largely replaced by the crustaceans such as crabs and shrimp, the freshwater clam gives way to the mussels, clams and other shellfish normally associated with estuaries. Freshwater fish species are replaced by species of the coastal waters such as silversides, varigated minnows, tomcods, and flounders.

The three life zones encountered in the Connecticut River Basin are as different in requirements as they are in appearance. The alpine tundra is insignificant in area and conversely unique as well as fragile. It is found for the most part in the confines of the White Mountain National Forest and will be preserved for scientific study and the public use for all time.

The Taiga and the hemlock-deciduous hardwood life zones comprise increasingly greater areas of the Connecticut River Basin. They, together with the aquatic resources in the basin, have the most potential for use or exploitation by man. As we very much desire to make use of these areas we must also take it upon ourselves to insure that our use will not contribute to the degradation and destruction of their values.

Fish

Originally the Connecticut River boasted one of the prime fisheries of North America. Particularly prominent were the Atlantic salmon and shad upon which the Indians depended. For the early settlers who would require a year to clear their land and grow their first crops the wildlife and fish were essential resources upon which they were much dependent. The rivers produced enough salmon and shad to be used throughout the year. These important resources continued until construction of the first dam in 1797 at the mouth of the Millers River, which made ascent into spawning areas located at higher elevations of the basin impossible. Although there was still substantial salmon spawning below Turners Falls, and in the Deerfield, Westfield, Farmington, and Salmon Rivers, as lesser dams on these tributaries occurred, and the construction of the dam at Holyoke, salmon began to reduce markedly in numbers. With the loss of access to spawning grounds, and severe pollution, the salmon and shad nearly disappeared. However, it is estimated that in 1966 one million shad returned to the valley, some fifty thousand of which were lifted over the Holyoke Dam by means of an elevator installed in 1955. State and Federal cooperative programs are under way to restore the salmon.

Wildlife

Profound changes have taken place in the wildlife populations of the Connecticut Valley. Apparently the Indians lived in balance with the wildlife and their practice of burning trees in the lowland kept the countryside open and perhaps favored the deer. With the arrival of the white settler and his clearing for agriculture and potash production, the environment was greatly altered. Certain populations of Virginia deer and grey squirrel increased. Even though the cougar was present in the basin, it disappeared by 1840 in Massachusetts and the last bounty was paid in Vermont in 1894. By the early 1800's the eastern timber wolf was gone and the woodland caribou, originally found in the Connecticut Lakes region became extinct with the clearing of the area. The fox squirrel, originally a tenant of the valley, became extinct. Beaver was common and became a basis of the fur trade, but by the year 1840, these had disappeared from Massachusetts. However, they are abundant in New Hampshire and Vermont, as recent stocking has resulted in their becoming common again. The black bear, another species that was originally plentiful, disappeared from Connecticut and Massachusetts about 1850. Many other species, while exhibiting some response to the changes in environmental conditions have succeeded so that today they are present in healthy numbers throughout all or most of the basin. (See Appendix G.)

E. Land Use

There are approximately 169, 400 acres of water and 6, 957, 600 acres of land in the United States portion of the Connecticut River Basin study area. The distribution is as follows: 79 percent in forests; 9 percent in crop lands; 4 percent in pastures; 4 percent in urban and built-up areas; 4 percent carried in the "other" category. To the year 2020 this land use is projected to grow in the direction of urban and as follows: 79 percent will remain in forests; 10 percent will become urban and built-up; only 2 percent remaining in crop lands; 1 percent in pasture; and 8 percent in and "other" category.

Much of this land that is being removed from crop and pasture will revert to forest and there is a considerable increase in the urban and rural residential acreage. The percent of forest land is not projected to change but there are some shifts anticipated in forested areas. Crop land in the basin is largely used for hay and pasture. Much of the projected decrease results from those changes anticipated in dairy herd management of which more of these farms will become automated.

Presently, over 85 percent of the land is privately owned by individuals or corporations, but the remainder is publicly owned. Farmers own about 1. 7 million acres. Other private owners own about 4. 5 million acres including that land in urban and built-up areas. Public ownership principally forested land, consists of about 306, 600 acres of Federal land in the Green Mountain and White Mountain National Forests and 410, 000 acres of State, County and municipal land. Some 17, 000 acres of Federal land is also found in Corps of Engineers reservoir projects.

An expanding population will require much reconstruction in the city areas, as well as an increase in suburban development and a larger number of rural homes in outlying areas. Together with the facilities for servicing this new population, in the form of commercial centers of activities and highways, there will ensue greater stresses upon better land, especially in the lower portion of the basin.

Adequate planning is essential for this new development to maintain proper land use so that additional flood hazards and other undesirable side effects may be kept to a minimum. The wise use of flood plains in the form of parks and open space or agriculture, the control of erosion and resulting sediment problems from new construction activity should help to maintain an attractive and high quality environment.

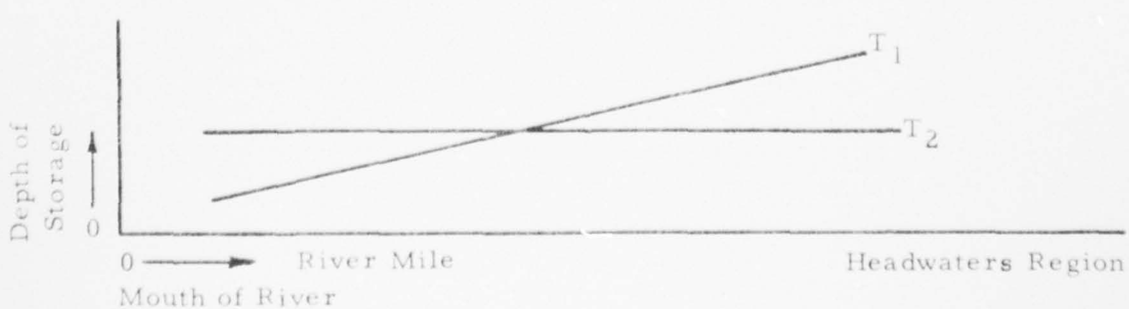
F. Flood Plain Reservation and Use

The flood plain is actually part of a river, a reserve area carved out by the river itself to hold surplus water in times of flood. Damage occurs where man has trespassed on the river. Continuing encroachment on the flood plain tends to offset the gains earned by the flood control dams, floodwalls, dikes and associated improvements. The construction of new developments in flood-prone areas reduces the hydraulic efficiency of river channels. Flood hazards are thereby increased and the effectiveness of existing flood control works is correspondingly diminished.

An analysis of the natural valley storage on the Connecticut River main stem between normal water surface and the standard project flood (SPF) as reduced by the existing 16 flood control reservoirs and additional large reservoirs included in the 1980 plan which contain flood control storage has been accomplished. For example, the reach between Bodkin Rock and Windsor Locks, Connecticut contains approximately an equivalent storage of 550,000 acre-feet. The reach between Mount Tom and Turners Falls Dam, Massachusetts contains an equivalent storage of about 250,000 acre-feet. In addition, there are substantial amounts along the mainstem at upstream location.

It should be noted, however, that natural storages in the basin are not additive as upstream storages will reach their maximum and partially empty before downstream storages reach their maximum. Nevertheless, when one considers that the combined flood control storage in 16 existing dams amount to about 531,500 acre-feet, the significance of maintenance of existing valley storage cannot be overly stressed. The diagram below helps demonstrate the effectiveness of this valley storage.

Note that upstream natural storage will be higher at T_1, (at beginning of flood), whereas downstream storage will be higher at T_2, (later during the flood).



It is also logical that after the precipation stops during a flood, <u>all</u> the water within the Basin is in some sort of storage.

CHAPTER III

Section 2 - Climate

A. General

In addition to normal variation with latitude, the climate of the basin varies to a marked extent with differences in elevation. The Connecticut River Basin lies in the realm of prevailing westerlies, and as such, comes under the influence of cyclonic storms which traverse from the west and southwest. The southern part of the basin is also influenced by warm, moisture laden anti-cyclonic storms. In the winter months, highs from Canada bring arctic air into the basin. Precipitation is moderate and well distributed on an average annual basis. However, monthly rainfall records show great variety from year to year. Individual storms rarely affect the basin in its entirety owing to the elongated character of the watershed. Generally, west to southwest airflow brings the hot dry weather which is responsible for occasional summer drought.

The U. S. Weather Bureau is the Federal agency responsible for the collection and dissemination of the climatology of the basin. Temperature records indicate a warming trend since 1817 of the mean annual temperature by 3°F. Additional details concerning climatology may be found in Appendix C of the Main Report.

B. Precipitation.

Mean annual precipitation over the entire basin averages 43 inches of water and ranges from 36 inches to 74 inches as shown in Appendix C. Run-off, that portion of precipitation left after evaporation and transpiration, as well as deep underground flow to the sea, averaged about one-half or approximately 23 inches. In general, the headwater areas of all major tributaries, except those entering from the east below Bellows Falls, experience precipitation averaging in excess of 60 inches annually. Most of this precipitation in the higher elevations is in the form of snow during the winter periods.

The range between maximum and minimum values of average monthly precipitation is approximately 1 to 2 inches. Precipitation is generally plentiful throughout the year. Most of it occurs as rain in the southern limits with snow making up larger percentages in the higher and northern portions. Serious floods have frequently occurred and the recent droughts have had a pronounced effect upon water quality.

C. Temperature

The mean annual temperature for the basin is about 45°. It varies from 38° at First Connecticut Lake to 49° at Westbrook, Connecticut, near the mouth of the river. Average monthly temperatures vary widely throughout the year from between 63° and 74° in July and August to between 11° and 30° in January and February. Average daily temperatures range from occasional highs in the 100's to infrequent lows in the minus 40's in the northern portion and in the minus 20's in the southern portion. Frost-free periods range from 180 days in southern Connecticut to about 100 days at northern points. Mean monthly and yearly temperatures at selected U. S. Weather Bureau stations may be found in Appendix C, as well as in Appendix F. Records indicate that summer temperatures do not vary as much with latitude as with elevation. Daytime temperatures are generally relieved by average nightly temperature drops of 20° or more. The day to night variation is most pronounced in the higher elevations in the northern portion. Winter temperatures vary strongly with latitude. The average length of the growing season is further depicted in Appendix F with the deeper, higher mountainous valleys having the shorter growing period.

D. Storms and Droughts

There are three general types of storms that cause precipitation over the basin, namely, continental, coastal, and frontal storms. Continental storms originate over the western or central portion of the United States. They generally move easterly or northeasterly in direction and may be rapidly moving intense cyclones or the stationary frontal type. They are not limited to any season or month, but follow one another at more or less regular intervals with varying intensities throughout the year. Tropical hurricanes, the most severe of the coastal storms originate in the South Atlantic or Western Carribean Sea. They usually move in a westerly direction, recurving to a more northerly path near the mainland and then northeast approaching New England. Although the general path is to the south and east of New England they may be drawn over this area by continental cyclonic disturbances, or deflected by a large slow anti-cyclone center, sometimes referred to as a blocking high and generally located to the east of New England. Hurricanes have occurred during the late summer or fall months with a higher incidence in August and September. Extra-tropical coastal storms generally originate near the Middle Atlantic States. They travel northward along the coastline and frequently occur during the autumn, winter, and spring months.

The Connecticut Basin lies within the general climatic zone classified as humid where the average annual precipitation is reasonably well distributed throughout the year. The U.S. Weather Bureau refers to a drought as being a period of 14 days or more in which less than 0.1" of precipitation falls in a 48-hour period. To the agriculturalist, a drought is lack of soil moisture during the growing season. To the hydrologist, a drought is a prolonged precipitation deficiency which seriously affects both river flow and surface water supply. The drought history in the basin before 1900 is rather limited. Since the establishment of gaging stations drought conditions (low flow periods) have been observed throughout the basin at various times. A serious drought ocrurred in the 3-year period between 1930 and 1932. Many communities subsequently used this record of low flow as a design criteria for their water supply purposes. Less severe droughts also occurred in 1941, 1942, and again in 1948, and 1950. The longest and most severe drought in the history of the region occurred in 1961 to 1966. It had a serious impact upon water resources as reflected in its effect upon water supply, water quality, and upon agriculture. It was during this time that a number of water supply facilities failed since they had been designed to handle repetition of the less severe drought of the 1930's. The accumulated deficiency of run-off throughout the basin during the 6-year drought period of record varied from about 25" in the north to almost 50" in the south. These values are equivalent to nearly 1 to 2 years of average annual run-off from the respective areas. Further details on this matter may be found in Appendix C.

CHAPTER III

Section 3 - Water - General

A. Run-off and Water Yield

The discharge records within the basin were analyzed to determine benefits associated with proposed systems. The requirements for flow augmentation, water supply, flood control and other purposes were determined from high and low flow duration and peak discharge frequency relationships.

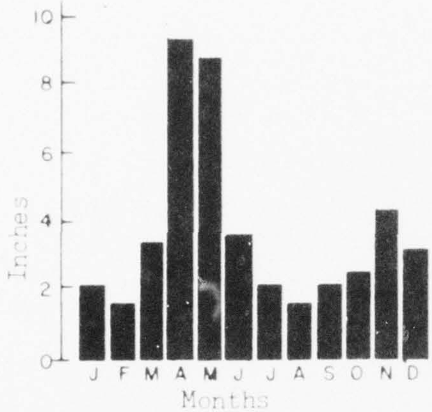
There are significant water resources within the basin which result from an annual precipitation of 43 inches that falls principally upon forested cover land. The precipitation is relatively well regulated and because of the forest cover is generally of outstanding quality, at least to the point where major pollution from human activity becomes a dominant factor. The average annual run-off of about 23 inches provides for an average yield of more than 12 billion gallons per day. This represents about 3,000 gallons per person projected on a 2020 population. Even in the serious drought year of 1965, half of the average yield was realized. Increasing amounts of run-off occur from the eastern slope of the basin to the south with additional increases in the western and northern mountain areas. Least run-off may be found toward the center of the valley between Woodsville and Hanover, New Hampshire. The problems of supplying water are more seasonal than geographical, since the distribution is quite even. Snow cover during the winter months provides a huge water reservoir which is generally converted to stream flow during the months of March, April, and May, when half of the annual run-off occurs. During the growing season evapo-transpiration from plant growth utilizes most of the normal rainfall and consequently stream flow is generally at a minimum in August and September. Attention is directed to Figure III-1. For details concerning high and low flow duration and peak discharge frequency relationship attention is directed to Appendix C to this report.

B. Major Rivers and Streams

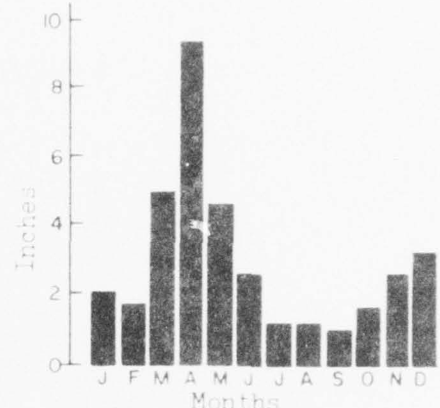
The Connecticut River main stem follows a general southerly course along the approximate center line of its watershed for about 404 miles to its mouth on Long Island Sound at Saybrook, Connecticut. The lower 60-mile reach of the river is tidal having a mean tidal range during low river

FIGURE III-1

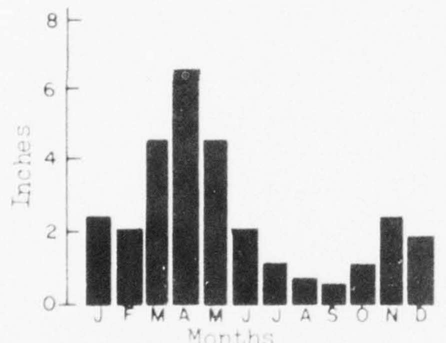
AVERAGE ANNUAL MONTHLY RUNOFF IN INCHES FOR SELECTED GAGES



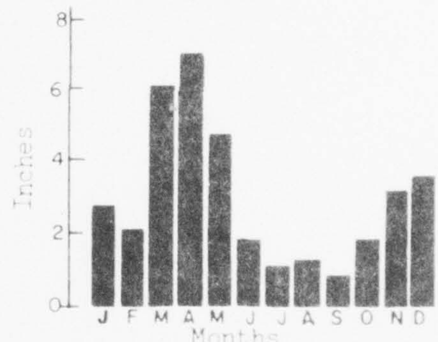
Bethelehm Junction, N.H., on Ammonoosuc River



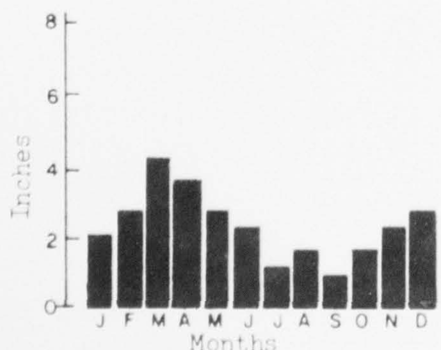
Ottauquechee River at North Hartland, Vermont



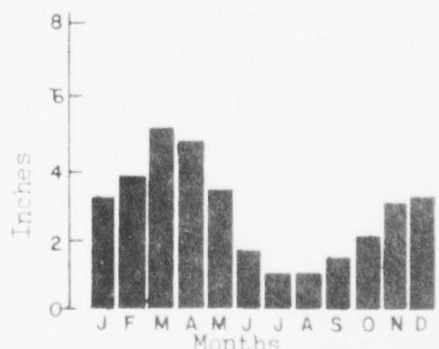
South Branch, Ashuelot River at Webb, near Marlboro, N.H.



West Branch, Westfield River at Huntington, Massachusetts



Scantic River at Broad Brook, Connecticut



Salmon River near East Hampton, Massachusetts stages of 3.4 feet at the mouth and about 1.2 feet at Hartford some 52 miles upstream of the mouth. Wide and extensive flood plains are located at various reaches along the main stem. During major floods, these meadow lands become inundated to varying depths of from 10 to 20 feet, and act as large detention reservoirs which significantly reduce peak discharges at these downstream locations. The most noteworthy natural areas of storage are as follows: between West Stewartston and Lancaster, New Hampshire; a fifteen mile reach between Woodsville, New Hampshire and Bradford, Vermont; in central Massachusetts between Montague City and Holyoke; most extensive flood plains between Windsor Locks and Middletown, Connecticut. The natural storage available in these valley areas are greater than all of the existing flood control storage dams. In its southerly course to the ocean, the Connecticut is fed by numerous rivers and streams entering from east and west. Significant tributaries are contained in Table III-1. The fourteen largest tributaries having watershed areas larger than 200 square miles divide an aggregate total of 6,323 square miles, or 56 percent of the basin area. They are as follows:

Chicopee River	Ashuelot River
White River	Ammonoosuc River
Deerfield River	Millers River
Farmington River	Sugar River
Westfield River	Upper Ammonoosuc River
Passumpsic River	Ottauquechee River
West River	Black River

Further details on these principal tributaries may be found in Appendix C of the Main Report.

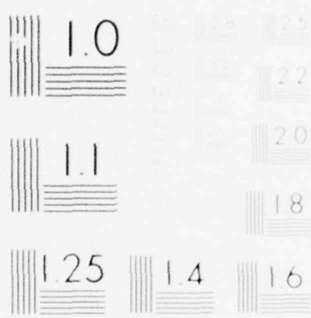
C. Flow and Fall

The Connecticut River main stem is over 400 miles in length. It has a total fall of about 2,650 feet. In the initial 30 miles from its origin at the Canadian border the river accomplishes half of this total fall. From this point, approximately at the First Connecticut Lake, and proceeding to tidewater at Hartford, Connecticut, a distance of about 360 miles, the river accomplishes a fall of about 1,640 feet. In the lower reaches of the river, the average annual flow is approximately 16,000 cubic feet per second, or equivalent to 23 inches of run-off. A review of hydrologic records in the valley indicate that during low flow periods, flows in some

AD-A043 894 ARMY ENGINEER DIV NEW ENGLAND WALTHAM MASS F/G 8/6
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION. C--ETC(U)
JUN 70

UNCLASSIFIED NL

2 OF 5
AD
A043894



MICROCOPY RESOLUTION TEST CHART

of the tributaries dropped to less than .1 csm. and on an average approximate .15 csm. This is contrasted to the average annual average of 1.6 csm. that represents nearly 1 million gallons a day per square mile of drainage area. It can be seen therefore, that summer low flows contrast markedly with average flows and represent about 1/10 of the yearly average flow. Review of the principal tributaries and streams which feed into the main stem provides further evidence for this sharp contrast.

Thirty-eight tributary streams with drainage areas greater than 25 square miles are listed in Table III-1. The Ammonoosuc River has a fall of 4,550 feet while the Deerfield River has a fall of 2,900 feet both greater than the main stem. When fall is compared to stream length on other tributaries many are found to have slopes exceeding the main stem.

Because of the steepness of these tributaries and the major runoff occurring for three months of the year, these tributaries have a tendency toward low flows in the summer, relying almost exclusively on groundwater and those storage releases that are made by reason of water resource developments operated for an array of purposes. It is estimated that these storages in being amount to about 6% of the average annual runoff and are extremely important to the flow conditions now present in the river. Furthermore, the characteristics of the river basin are such as to respond significantly to the inclusion of storages which may later be released for flow augmentation purposes for whatever uses desired.

D. Reservoirs-Lakes-Ponds

The Connecticut River Basin is blessed with numerous bodies of water, some natural and others man-made. For example, there are 172 bodies of water that range in size from 100 to 499 acres. Of this amount 29 are used for water supply purposes and 143 are used for non-water supply purposes. There are several problems associated with the productivity of these water surface bodies. Apart from the problems related to both the quantity and quality of the recreational activities that occur on or near these surface bodies, is the problem of access. For example, of the 172 bodies of water noted, only 61 have public access for recreational use for a broad range of outdoor recreation activities. In addition, the basin has more than 35 water bodies that are larger than 500 acres in size. Of this number 27 are non-water supply purposes and 8 for water supply purposes. Access is provided in 21 of the 35 bodies of water noted. Generally speaking, the management of New England's water supply reservoirs restrict recreation use. However, there are varying degrees of recreational usage at certain water

TABLE III-1
MAJOR RIVERS AND STREAMS - CONNECTICUT RIVER BASIN

NAME	STATE	DRAINAGE AREA (s.m.)	LENGTH (mi.)	APPROX. FALL (ft.)	MOUTH LOCATION	MOUTH CONN. R. MILEAGE*
Perry Stream	NH	30	13	875	Pittsburg	387
Indian Stream	NH	71	16	280	Pittsburg	377
Halls Stream	Quebec, NH, Vt	89	22	830	Beecher Falls	372
Mohawk River	NH	25	11	850	Colebrook	359
Nulhegan River	Vt	151	16	280	Bloomfield	345
Paul Stream	Vt	58	14	940	Brunswick	340
Upper Ammonoosuc	NH	254	40	1350	Northumberland	325
Israel River	NH	135	21	1450	Lancaster	312
Johns River	NH	76	9	200	Dalton	303
Passumpsic R.	Vt	507	23	250	Barnet	280
Stevens River	Vt	49	7	430	Barnet	277
Ammonoosuc R.	NH	402	56	4550	Woodsville	266
Wells River	Vt	100	16	680	Wells River	266
Waits River	Vt	146	24	1950	Bradford	247
Ompompanoosuc R.	Vt	136	20	800	Norwich	225
White River	Vt	712	58	2175	White R. Jct.	215
Mascoma R.	NH	194	34	1000	Lebanon	214
Ottauquechee R.	Vt	222	38	1475	N. Hartland	210
Sugar R.	NH	275	27	800	Claremont	195
Little Sugar R.	NH	31	7	550	Charlestown	187
Black R.	Vt	204	40	1050	Springfield	183
Williams R.	Vt	118	24	1330	Rockingham	176
Saxtons R.	Vt	78	20	1560	Westminster	173
West River	Vt	423	53	1775	Brattleboro	149
Ashuelot River	NH	421	64	1475	Hinsdale	140
Millers R.	NH & Mass	392	45	900	Montague-Erving	126
Falls River	Vt & Mass	36	12	400	Gill-Greenfield	122
Deerfield R.	Vt & Mass	664	73	2900	Deerfield-Greenfield	119
Manhan R.	Mass	106	18	900	Easthampton	92
Chicopee River	Mass	721	17	260	Chicopee	80
Westfield R.	Mass & Conn	517	57	1775	W. Springfield	75
Scantic River	Mass & Conn	114	35	900	S. Windsor	59
Farmington R.	Mass & Conn	609	47	350	Windsor	57
Park River	Conn	78	2.2	15	Hartford	51
Hockanum R.	Conn	82	22	510	E. Hartford	50
Mattabesset R.	Conn	105		180	Middletown	33
Salmon R.	Conn	152	20	520	Haddam-E. Haddam	18
Eight Mile River	Conn	61	9	400	Lyme	9

*Above Saybrook Breakwater Light, 0.5 miles below Lynde Point supplies, generally in the upper part of the basin, whereas recreational use is extremely limited in those water supply systems located in the lower basin.

The analysis of existing water bodies is further contrasted by the fact that there are in existence nearly 730 water bodies which are greater than 10 acres in surface or that would be eligible under the Great Pond legislation that is available in at least three of the four basin States with the exception of Connecticut. A resource inventory performed by the Bureau of Outdoor Recreation reports that in New Hampshire and in the four counties of Cheshire; Coos, Grafton; and Sullivan; there are 322 water bodies 10 acre or larger in size which produce nearly 54,700 surface acres of water. In Vermont and in the five counties of Caledonia; Essex; Orange; Windham; and Windsor; there are 163 water bodies producing 21,300 surface acres. In the three Massachusetts counties of Franklin; Hampden; and Hampshire, there are 130 water bodies producing 33,700 surface acres. Finally, in the State of Connecticut in the counties of Hartford and Middlesex we have 112 water bodies of 10 acres or larger producing nearly 11,000. Figures noted provide a distorted picture of what is actually available versus what is reasonably useful in meeting large scale needs. Recreation planners consider water bodies of less than 200 acres in size to be quite limited in their capability of meeting a broad range of water resource activities. Although it has been reported that we have nearly 700 bodies of water 10 acres or larger, it has also been noted that less than 200 fall in the category of 100 to 500 acres in size, and nearly 2/3 of these are unavailable for recreational use by reason of legislative constraints or insufficient access. Nevertheless, these large numbers of water bodies do provide a reasonably significant base for private recreators and vacation home owners which are located around the perimeter of many of these lakes.

E. Estuaries

The shell fisheries of the Connecticut River estuary are not extensive nor do they support any significantly important commercial enterprise. Oyster operators do a small amount of commercial oystering on beds near the mouth of the river. The harvesting of soft-shell clams and hard clams has not been important in recent years. The major value of the estuary from an ecological viewpoint is that within the estuary the basic formation of the food chain and life cycle of estuarine dependent species occurs. Restoration of Atlantic salmon and the expansion of the existing anadromous shad runs will be intermediate beneficiaries of the estuary's productivity while at sea. Of particular importance in this program is the control of pollution and the availability of appropriate access. The estuary plays a particular role in providing private and publicly owned access to the river and Long Island Sound. There are several privately owned liveries, marinas and boating clubs located along the estuary reach. The estuary's waterfowl value is considerable as well as its capability to satisfy fishing needs in the heavily populated areas of Connecticut.

The towns along the estuary, that is, south from Middletown, Connecticut, although small at present are expanding with residential development. In some cases, this development is in the form of large estates which are less damaging to the river's scene than the more intensive developments. At the mouth of the river there appears to be no end to the land subdivision now taking place. In recent years, the shores of Long Island Sound on both sides of the river have been covered with summer cottages to the point where little open space remains. Much development crowds along the water edge affecting the beauty of the shorescape and contributes significantly to pollution.

The lower river thrives as a recreational boating center. Power boats, sail boats, water skiers, skim over its waters, while its shores provide safe harbor for small and large craft. Marina development is steadily creeping up the river and in most cases is taking place on tidal wetlands, a vital resource to the fisheries. This is one reason why the Coordinating Committee supports the establishment of the Connecticut River National Recreation Gateway unit.

F. Wetlands

The Connecticut Valley is a migratory route for considerable numbers of waterfowl. Many of these birds pass through without tarrying. Principal waterfowl habitat in the upper basin is the main stem of the river; the Ox Bow Ponds, primarily in New Hampshire between Stratford and Lancaster; the numerous natural lakes, ponds, and bogs; and innumerable beaver flowages. The latter are generally small and many of the ponds are relatively unproductive. In the aggregate, they produce a large number of ducklings and support appreciable gunning for black and wood ducks. A number of natural water bodies, beaver ponds, and reservoirs provide some waterfall habitat of varying quality in the central portion of the basin.

There are a number of excellent marshes near the mouth of the river in the Connecticut main stem with heavy waterfowl usage. Great Island, Ragged Rock Creek, Lord's Cove, Selden Neck, North Cove, Essex, Cromwell Meadows, and South Windsor marshes are waterfowl habitat areas receiving heaviest use. Great Island, Lord's Cove, Cromwell Meadows, and Ragged Rock Creek are owned and managed by the Connecticut State Board of Fisheries and Game for Waterfowl. Although some waterfowl hunting is done on the streams, beaver ponds, and marshes throughout the basin, waterfowl hunting of the best quality is generally limited to the marshes near the river's mouth. All of the States involved have made efforts to improve game habitat and provide additional hunting opportunities. Management areas have been augmented by numerous State-leased areas, for stocking and food patch plantings. A number of privately-owned are also managed for game by sportsmen.

All States in the basin have conducted waterfowl surveys. Census have been made regularly to determine population, migration movements, and composition of the population. Habitat has been inventoried for the purpose of classifying and evaluating both existing and potential habitat. Attention has been focused on waterfowl feeding habits. These investigations are providing data for formulating the waterfowl management and development program in the valley. As one approach to meeting the increasing demand for waterfowl, the States have launched programs of marsh development. Improvements in developments have already contributed materially to the welfare of the waterfowl, but the potentials have hardly been tapped. Breeding, feeding, and resting areas have been given primary consideration in enhancement of the habitat. Generally, the most important waterfowl areas are closely associated with the main river and its major tributaries. Areas of considerable size which possess development potentials are located in the State of Connecticut and in the areas noted above consist in the aggregate, approximately 4,000 acres of lands. Northward in the basin, wetlands possessing significant development potential are located in the tributary basins rather along the main stem of the Connecticut River. The basins of those streams entering from the east generally present the greatest wetland development potentials. The Vermont portion of the basin is practically devoid of sites which could be developed into areas of 100 acres or more. The outstanding area offering a potential of this magnitude lies within the area of the North Hartland Flood Control Reservoir. The other extreme may be found in Massachusetts where numerous large wetlands with development potentials do exist. The U.S. Fishery and Wildlife Service has listed 51 waterfowl development potentials ranging in size of more than 100 acres, and of this number 19 are located above the Massachusetts border, the remainder are in Massachusetts and Connecticut.

G. Groundwater

A reconnaissance of the groundwater resource of the Connecticut River Basin has been performed by the U. S. Geological Survey of the Department of the Interior. Designated as Appendix E, it should be referred to for detailed groundwater information for the basin, as well as the tributaries. The report summarized that groundwater is available in large quantities in some of the larger valleys from sands and gravels of glacial-fluvial and alluvial origin. Groundwater recharge is about equal to 1 million gallons per square mile in unconsolidated sandy sediment. Where earth material is underlain in large part by consolidated rock this drops to 1/3 MGD per square mile. The total quantity of groundwater available from the basin is perhaps more than 1 billion gallons per day. The more generous amounts are located in the upper watershed where demands are lightest.

Although current groundwater systems in the area report fairly good quality water, there have been instances particularly in the Groveton, New Hampshire area where mineral impurities have been encountered of sufficient magnitude to not qualify for public health standards. Rather than absorb the additional cost to remove these minerals, and in view of the abundance of surface supplies, some of the smaller municipalities have gone to surface water. In the lower basin where demands are large retrieval is somewhat more difficult and yields nowhere near as attractive. In addition, the systems are so large so as to favor surface water supply use.

First order of priority for the groundwater analysis concerned the making of a groundwater atlas. This map is published and attached to Appendix E. The map is considered to be a groundwater favorability map that provides some indication of the quantity of water available but in general terms. To give substance to the groundwater study in quantitative terms it was necessary to describe briefly every area of glacial-fluvial sediments in the Connecticut River Basin. These evaluations are generalized and should provide helpful quantitative evaluation for those municipalities, industries or others desirous of developing groundwater supplies.


CANADA
VERMONT
NEW HAMPSHIRE
LOCATION MAP
LEGEND
3,000 - 6,288 Feet
2,000 - 3,000 Feet
1,000 - 2,000 Feet

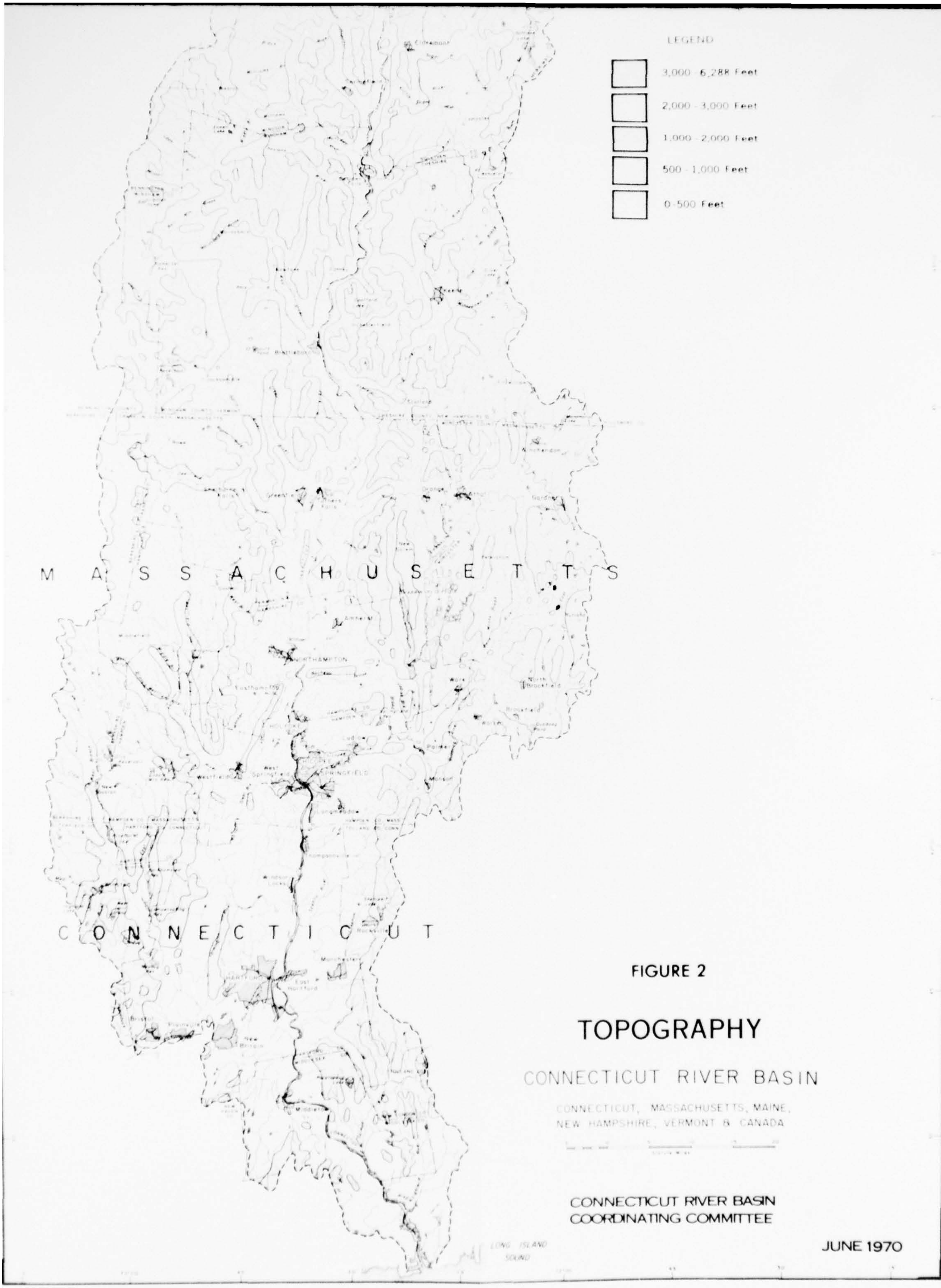


FIGURE 2

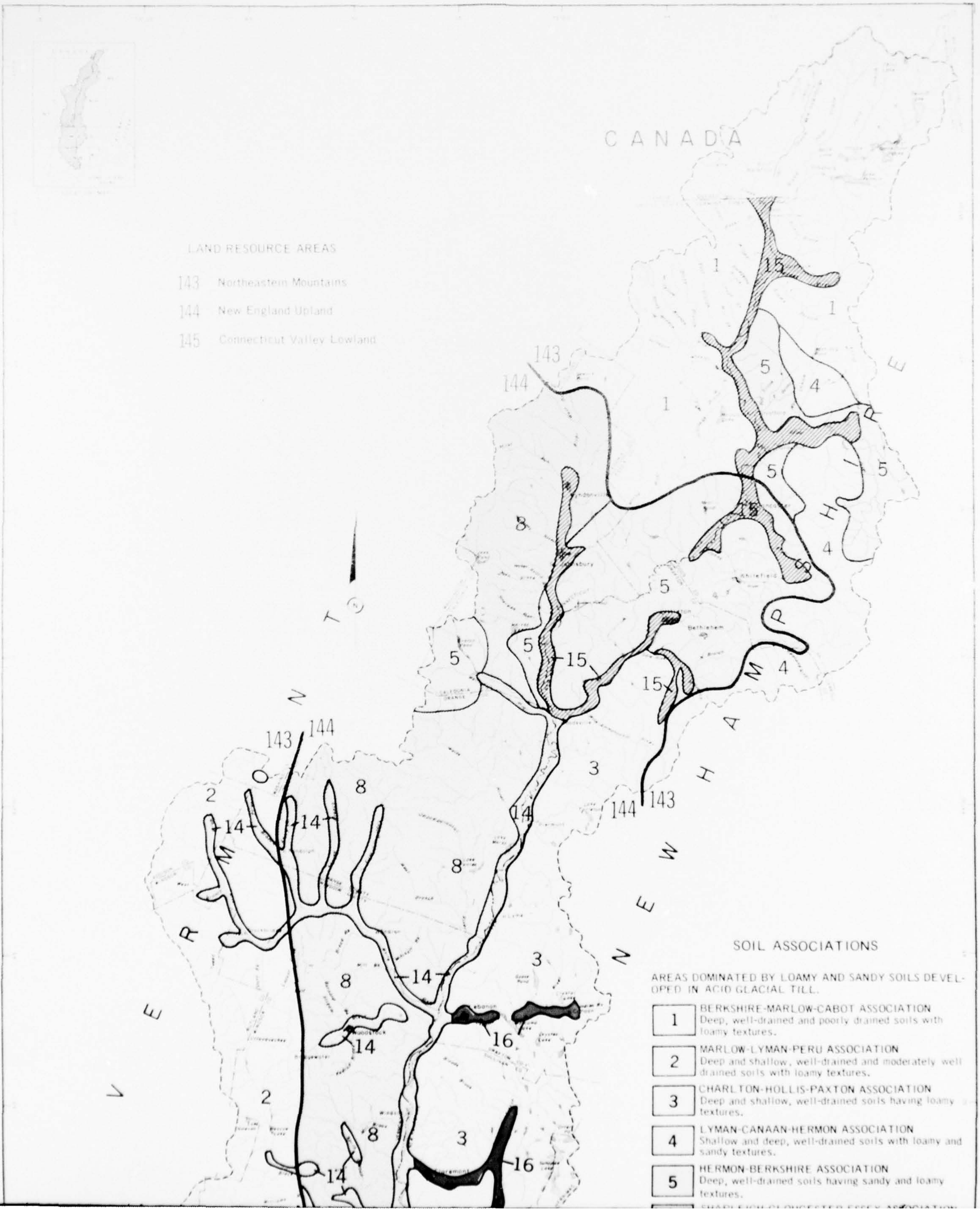
TOPOGRAPHY

CONNECTICUT RIVER BASIN

CONNECTICUT, MASSACHUSETTS, MAINE,
NEW HAMPSHIRE, VERMONT & CANADA

CONNECTICUT RIVER BASIN
COORDINATING COMMITTEE

JUNE 1970


CANADA
LAND RESOURCE AREAS
143 Northeastern Mountains
144 New England Upland
145 Connecticut Valley Lowland
VERMONT
NEW HAMPSHIRE
Whitefield
Bethlehem
SOIL ASSOCIATIONS
AREAS DOMINATED BY LOAMY AND SANDY SOILS DEVELOPED IN ACID GLACIAL TILL.
1 BERKSHIRE-MARLOW-CABOT ASSOCIATION
Deep, well-drained and poorly drained soils with loamy textures.
2 MARLOW-LYMAN-PERU ASSOCIATION
Deep and shallow, well-drained and moderately well drained soils with loamy textures.
3 CHARLTON-HOLLIS-PAXTON ASSOCIATION
Deep and shallow, well-drained soils having loamy textures.
4 LYMAN-CANAAN-HERMON ASSOCIATION
Shallow and deep, well-drained soils with loamy and sandy textures.
5 HERMON-BERKSHIRE ASSOCIATION
Deep, well-drained soils having sandy and loamy textures.

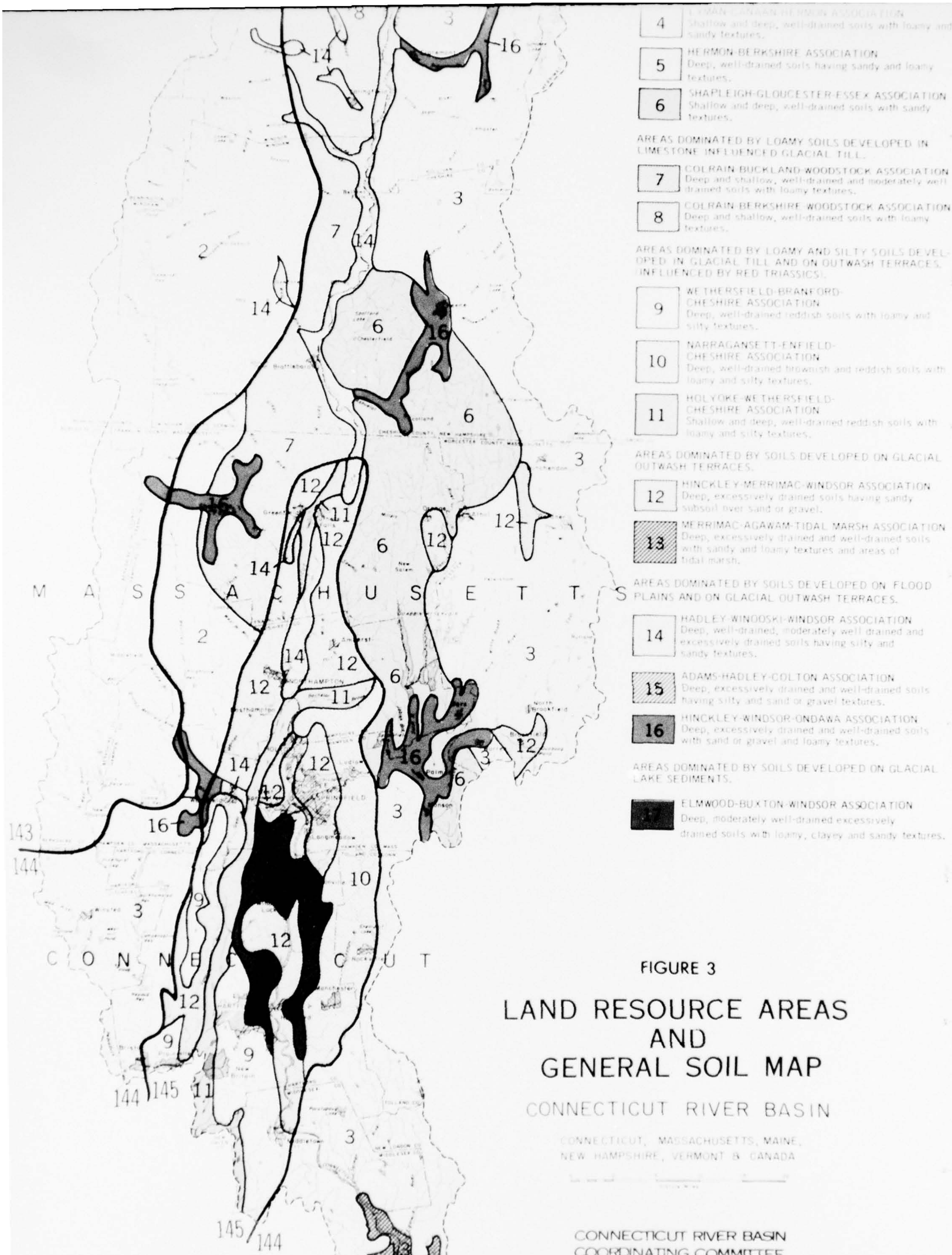


FIGURE 3

LAND RESOURCE AREAS AND GENERAL SOIL MAP

CONNECTICUT RIVER BASIN

CONNECTICUT, MASSACHUSETTS, MAINE, NEW HAMPSHIRE, VERMONT & CANADA

CONNECTICUT RIVER BASIN COORDINATING COMMITTEE

JUNE 1970


CANADA
VERMONT
NEW HAMPSHIRE
LEGEND
National Forests

7

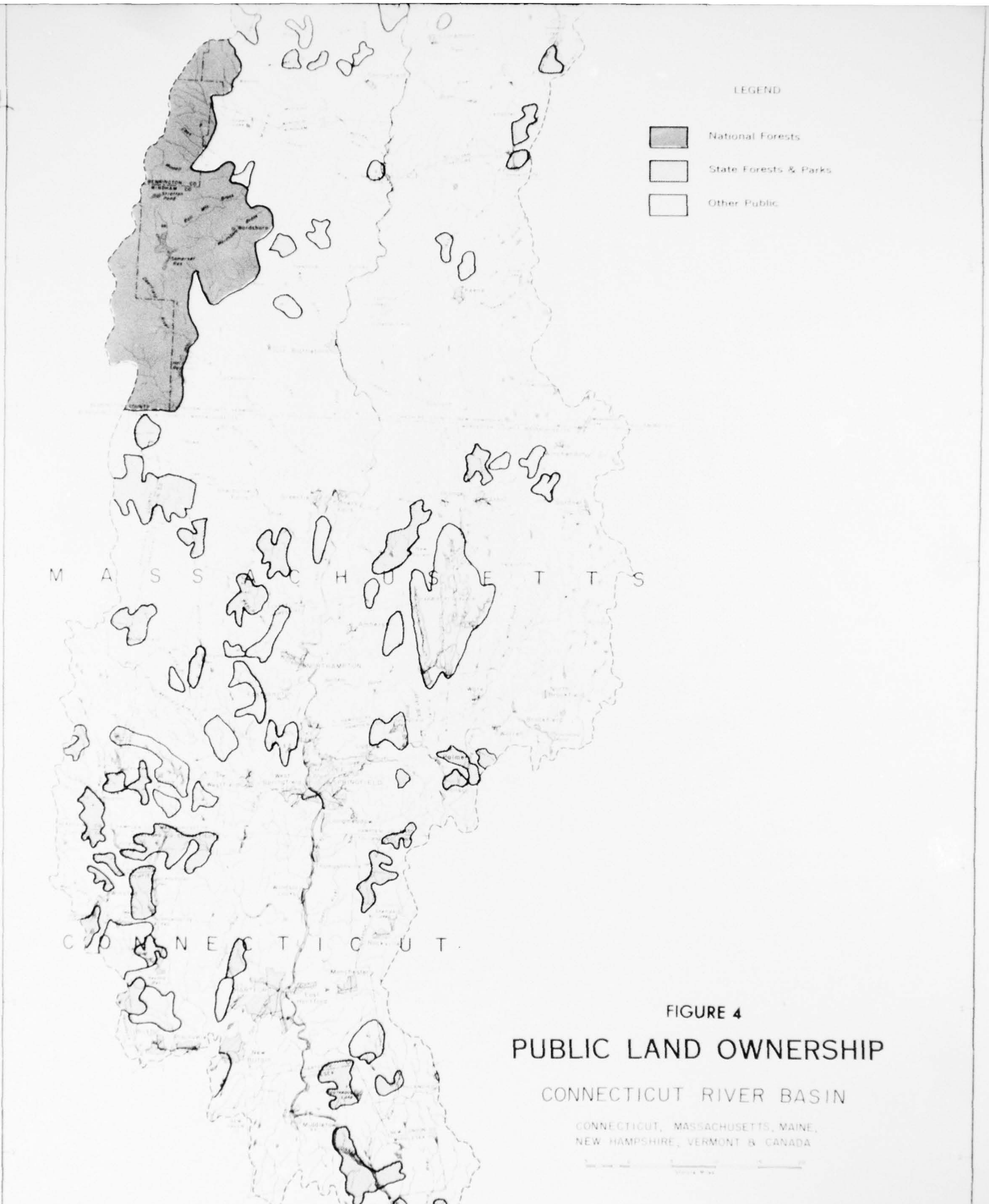


FIGURE 4

PUBLIC LAND OWNERSHIP

CONNECTICUT RIVER BASIN

CONNECTICUT, MASSACHUSETTS, MAINE, NEW HAMPSHIRE, VERMONT & CANADA

CONNECTICUT RIVER BASIN COORDINATING COMMITTEE

JUNE 1970

PART TWO

CHAPTER IV

POPULATION AND ECONOMY

CHAPTER IV

Section I - Population

A. General and Relative to the New England Region

New England's population and that of the Connecticut River Basin has been declining in relation to the population of the United States, but this is not something new but rather a condition of a trend that began as the early colony settlements moved westward away from the Atlantic seaboard. For example, in 1790 New England accounted for 25% of the country's inhabitants. By 1910 this share had declined to 7.1% and in 1960 it stood at 5.8%. It is projected to go to 5% by the year 2020. This continued decline in the region's share of the country's population will be at a rate slower that in the first half of the 20th century. Further, its growth rate would no longer trail that of the United States as a whole particularly as the newer cities begin to mature and lose some of their initial regional and economic opportunities. Because of a generally high quality environment, New England should begin to see a net in-migration with less out-migration. The New England region is expected to increase from 10,500,000 people in 1960 to about 20,000,000 in the year 2020.

In 1960 the Connecticut River Basin had a total population of 1,600,000 people. Best 1970 estimates indicate a current population of about 1,900,000. The majority of this current population, nearly 84% live south of the northern border of Massachusetts in the urbanized areas of Massachusetts and Connecticut. They reside on approximately 4% of the basin's land area. More than 70% of the basin population in these latter two states live in the adjoining SMSA's of Springfield-Chicopee-Holyoke and Hartford. In the 1950-1960 decade, 86% of the basin's population growth took place in these areas. The current density ratios noted in Figure IV-1 are projected to increase. In the northern portion of the basin in the States of Vermont and New Hampshire, there are a few cities and towns with population over 10,000. Density ratios contrast the national average of 50 people per square mile against a New England average of 170 people per square mile, and a basin average of about 160 people per square mile with three to six times this figure in Massachusetts and Connecticut portions of the basin respectively. The impact which these densities places upon natural environments is even more outstanding in the Connecticut Basin, since such a large portion of the basin lands is not suitable to building because of steep slopes, rocky outcrops or annual flood threats.

It can be noted that 50% of the 1960 population of the Basin was located in 13 cities and towns along or near the Connecticut River. Of this number 8 are located on the main stem of the Connecticut River.

The predominantly low density character of the upper and middle basin is indicated by the much smaller population figures shown on Table IV-1. Parts of the upper basin are among the most sparsely populated sections of the northeast. Fifteen town in the Vermont and New Hampshire portion of the basin have less than 100 people in residence and at least 5 towns are virtually unpopulated. An additional 20 towns in the States of Vermont and New Hampshire have populations of between 100 and 200 persons in residence. One reason for this, as recent census of population studies indicate, is that upper basin counties lost considerable population by out-migration, particularly in the age bracket of 20 to 34 years. This has resulted in lower increases of population between 1950 and 1960 than in the resident States of the basin as a whole. The permanent population in the upper part of the basin is, however, supplemented by 20% to 50% seasonal increases during the summer and winter vacation periods and also on weekends. Of particular importance are the non-permanent residents who own vacation homes wherein they spend weekends or longer periods, as well as visits to resorts, lakes and other recreation facilities.

In contrast to the upper part of the basin, the metropolitan centers in the lower portion have had rapid population increases from 1950 and 1960. This increase is not necessarily uniform although most of it has been going to metropolitan areas while central city zones have lost population. The move to the suburban areas is extremely pronounced in the Springfield-Holyoke-Chicopee regions, as well as in the Hartford Metropolitan area, where it is greater than other metropolitan areas in New England and New York.

Land use of the Connecticut River Basin as compiled in 1963, is shown on Figure IV-2 on page IV-7. Of importance as population affects land use is that on less than four percent of the total area of the basin, the bulk of the population resides.

FIGURE IV-1

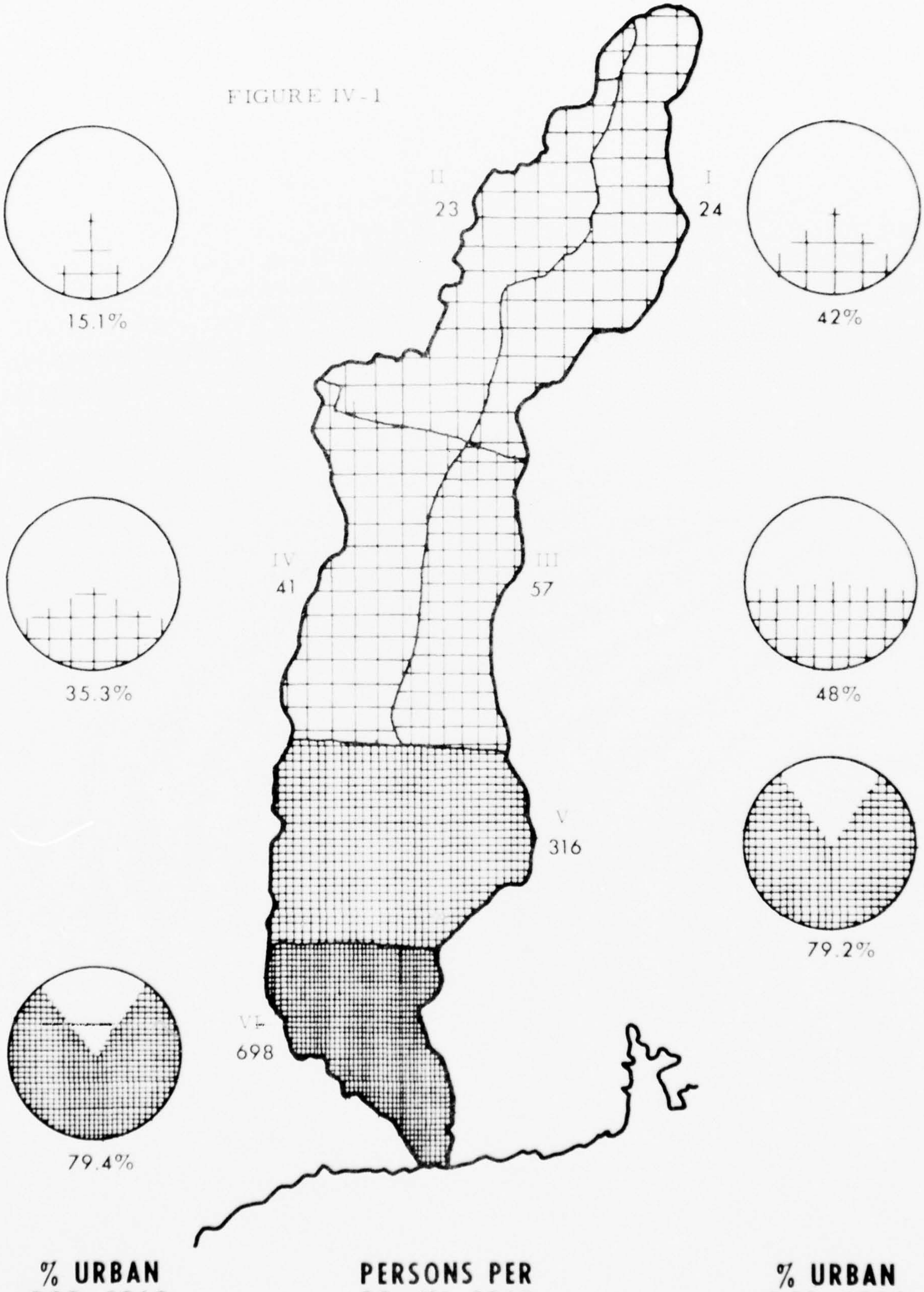

15.1%
II
23
I
24
42%
IV
41
III
57
35.3%
48%
V
316
79.2%
VI
698
79.4%
% URBAN
POP. 1960
PERSONS PER
SQ. MI. 1960
% URBAN
POP. 1960

TABLE IV - 1

ESTIMATED POPULATION AND DISTRIBUTION

April 1, 1970 1/

State	Estimated Population State	Estimated Population Basin	Basin Population Increase 2/ Number	Basin Population Increase 2/ Percent	Percent Distribution of Basin Increase
	(thousands of persons)				
Connecticut	2,990	932	142	18.0	59.0
Massachusetts	5,626	725	63	9.5	26.2
New Hampshire	723	138	22	19.0	9.1
Vermont	438	126	14	12.5	5.7
TOTAL	9,777	1,921	241	14.4	100.0

1/ U.S. Bureau of Census Preliminary estimates.

2/ Prorated at same ratio as 1960 basin-to-state population.

B. Urban

New England has long been more urbanized than the nation and because of this, future growth is likely to be absorbed by ever expanding suburban rings about metropolitan areas. The fringe towns will experience more intensive land use. Because New England has been highly urbanized for so many years, it is somewhat more difficult to project some ranges of urbanization here than in other parts of the country. For example, Massachusetts and Rhode Island, two of the more industrialized States of the region, had over 80% of their people living in urban areas back in 1900, while in the State of Connecticut, which is the fastest growing State in New England, nearly 80% of the people lived in urban areas in 1960. In contrast, in 1960, the urban population of the three less industrialized northern States accounted for only 38% to 58% of the total population.

Topography in the Connecticut River Basin has forced the urban areas of the region to cluster along the main stem of the river and its principal tributaries. Most of the readily usable land for building is in the basin's flood plains or adjacent to them and it is in these areas that cities and towns which housed the main population and industrial and commercial plants which support it have grown. For example, between Hartford and Holyoke, along the main stem, there are 11 towns and cities each of which had populations of over 5,000 in 1960. The municipalities with over 25,000 are Enfield, Connecticut, with 42,400; Springfield, Massachusetts with 174,500; Chicopee, Massachusetts with 61,500; and Holyoke, Massachusetts with 52,700. From Long Island to Hartford municipalities with populations over 25,000 included Hartford with 163,500 people, East Hartford with 53,400 and Middletown with 32,200. The cities noted are large industrial centers, manufacturing a wide variety of products. The principal terminal and transfer facilities for navigation commerce are located at Middletown, Hartford, Wethersfield, and East Hartford. The entire area is speared with a network of fine roads and railroads.

Total urban land area of the basin as defined by all places incorporated or unincorporated of 1,000 or more inhabitants represented 3.7% of the total land area of the basin in 1963. This figure is expected to increase to 6.7% by 1980 and 9% by the year 2000; and to 12.5% by the year 2020. It should be noted that urban population accounts for 72.3% of the Connecticut River Basin's total 1960 population. It is expected that the entire urban population will increase to nearly 83% by the year 2020.

C. Rural

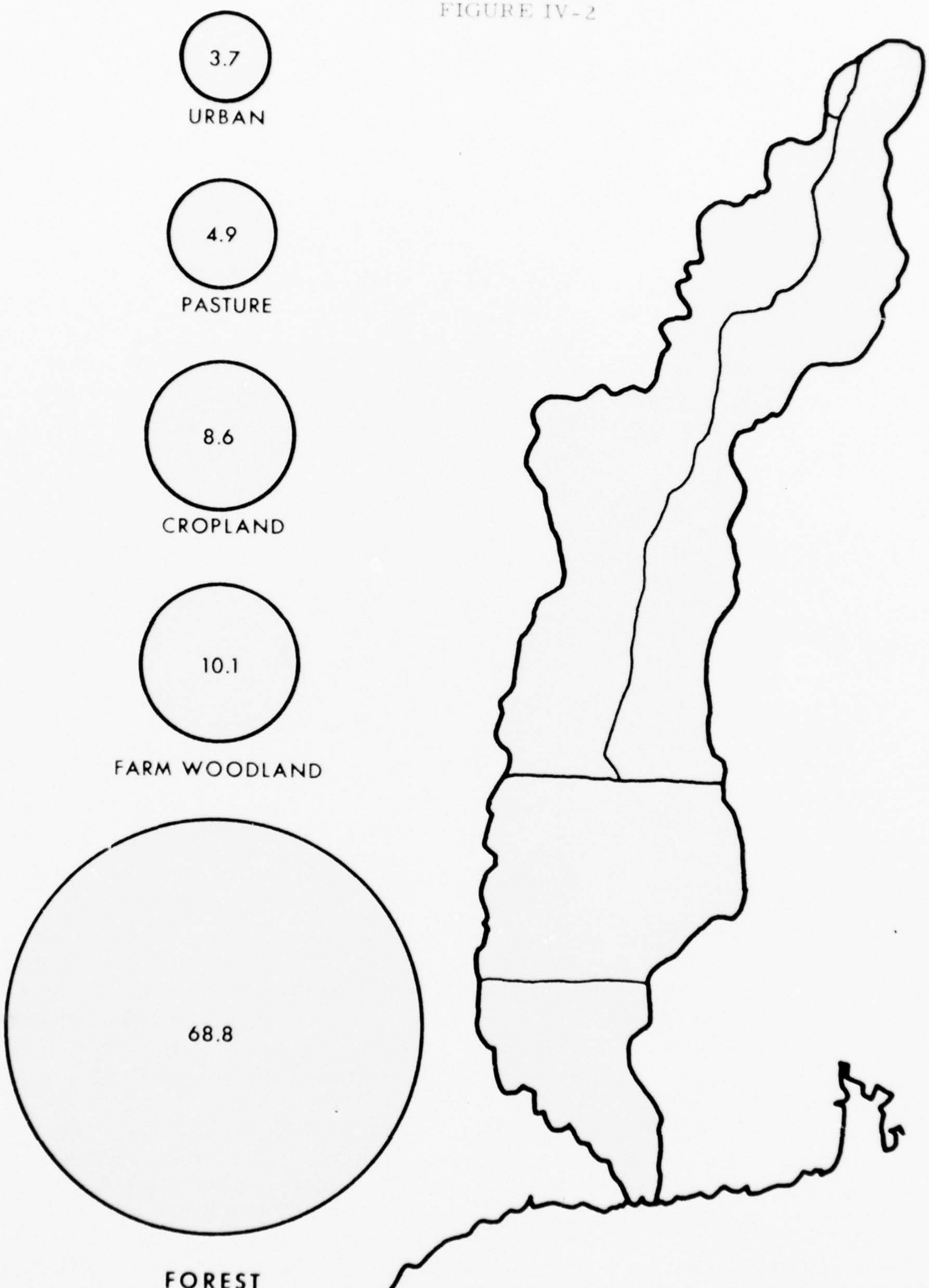
Of the basin's 1960 population of about 1.7 million, 72% live in cities and towns along or near the Connecticut River, and of this number 8 are located on the main stem of the Connecticut. The 28% of the population classified as rural is made up of a farm population of about 50,000 with the remainder of more than 400,000 located in villages of less than 2,500 and in rural non-farm areas.

The out-migration of young adults from rural areas is a continuing national phenomenon and as indicated on page IV-2 the rural areas of the northern Connecticut River Basin prove to be no exception. The non-resident recreators, however, utilizing vacation or "second" homes as well as commercial tourist facilities in these northern areas are becoming an increasing factor of the area's population pressure.

D. Households

The size of the household has been declining on both national and regional levels, and the Connecticut River Basin is following this trend. In response to a more adequate house supply and a rising standard of living, more families have been able to have their own separate dwelling. This has reduced the number of boarders in private households and has enabled older children to leave their families before marriage. It is projected that a continued trend towards somewhat fewer persons per household -- 3.3 persons in 2020 versus 3.37 in 1960. This trend will be delayed in the early part of the projection in response to a sustained high birth rate because of war years and consequent age distribution of the population. The total number of households is projected to increase slightly faster than the population.

FIGURE IV-2



PERCENT LAND USE 1963

CHAPTER IV

Section 2 - Economy

A. General

The Connecticut River Basin is characterized in its entirety by a stable, prosperous economy. The initial European settlements in the Connecticut River Basin were centered around Hartford, Connecticut. Gradual development proceeded in a northerly direction following closely the natural flood plain area of the basin. The ease of construction and the availability of fisheries and more productive farm lands close to the river main stem and particularly the attractive means of commerce made possible through navigation along the river's main stem were incentives for this type of growth pattern. Gradually the colonists replaced the Indian River tribes. During this initial 100 years of development the water and lands of the Connecticut Valley provided access, and food, and its vast quantities of timber provided shelter and fuel. Fish, wildlife and the timber resources became the staples of significant trade and supplemented what was a basic agricultural economy.

The cold winters of the area made a compact form of settlement imperative; homes were clustered around a central green or common and the fields which the settlers worked were scattered nearby. Even though this encouraged sociability, the Puritan farmer preferred to utilize the long winter months in making furniture, harnesses and the many other things needed by his family that his meager income from the toil would not permit him to buy. Thus developed the fabled New England "jack-of-all-trades" whose descendants were equipped to take over mechanical tasks in the early industrial plants which came to the lower valley first as saw and grist mills and later as the first metal working shops turning out tools and guns.

While the growth of such manufacturing was slow at the start, by 1790 it had reached the point that it was one of the decisive factors in the siting of the Armory in Springfield and the valley has been a major producer of small arms to this day. Another harbinger of today's economy which occurred in the post-Revolutionary period was the printing of the first printed insurance policy on record in Hartford in 1794.

Originally oriented toward agriculture and lumbering, the States of the upper basin, Vermont and New Hampshire, were slow to take part in the industrial development which has made manufacturing giants of its southern neighbors, Connecticut and Massachusetts. However, offsetting the early lack of industrial development in the upper basin has been the growth of a thriving recreation, tourism and vacation industry.

The economy of the Connecticut River Basin is based upon a diverse mix of manufacturing, trade, finance, agriculture, tourism and higher education. By far the greatest segment of the economic base consists of a variety of industries, including metal-working, metal using, electronics, electrical machinery and transportation equipment. Personal income derived from manufacturing was the largest element in the basin's per capita income, which in 1959, was 5.8% above the national average.

Value of products added by the basin's industrial complex exceeded 2.5 billion dollars in 1963, the last year for which full data are available. It was growing at an annual rate of 3-1/2%. While the bulk of the product was concentrated in the two southern States, especially Connecticut, value added exceeded 2 hundred million in the States of the upper basin.

The income from farm products was estimated at 150 million for 1964 which represents about 400 million in costs to the consumer. Dairying produced the largest income with poultry, shade tobacco and vegtable crops currently leading all other segments of the farm economy.

B. Employment

(1) Manufacturing

As already noted, manufacturing came early to the lower region of the valley, particularly in the smaller tributary streams where development was centered about water power. Soon the larger tributary rivers such as the Millers and the Deerfield and Chicopee followed, although these have not attained the intensity of the industrial and commercial concentration adjacent to the main stem of the river and located along the short tributary streams. The principal streams from a manufacturing viewpoint located in the upper basin are the Ashuelot and the Sugar Rivers in New Hampshire, and the Passumpsic and Black River in Vermont.

While industrial historians agree that there is generally little connection between rudimentary industries of the first settlers of a region and the current plants that make up its present-day complex, this is not the case in the lower Connecticut River Basin where one finds that metal working craftsmen have plied their trade since colonial times. These early skills, in fact, have laid the foundation of today's great mechanical plants with products ranging from bicycles to helicopters, from pedometers to jet aircraft engines and from machine screws to power hand tools.

Two facets of employment in the Connecticut River Basin are displayed in Figure IV-3: the changing employment mix and the increase in productivity.

Employment in the metal-working trades, SIC[1] groups 19 and 33 through 38 represent 62% of all manufacturing employment in Massachusetts and Connecticut portions of the basin. Even in the upper valley these groups account for 1/3 of all manufacturing employment. Nationally industrial giants are to be found throughout the area.

(2) Trade

In 1963, the last year for which data is available, wholesale trade employed over 31,000 people. It had sales exceeding $2.5 billion. For retail sales, the figures were 86,000 employees and sales of $2.4 billion.

(3) Finance and Insurance

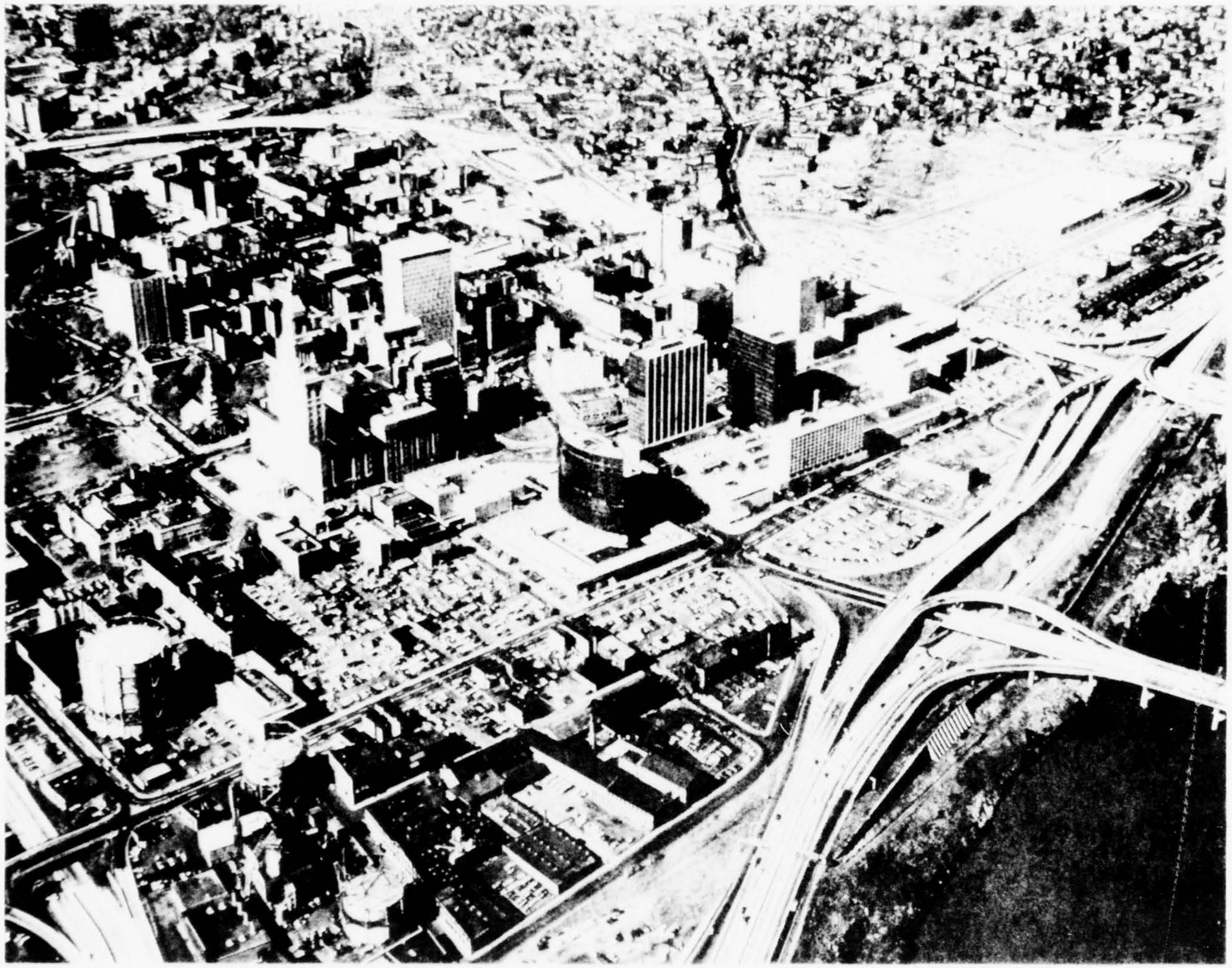
Finance, including insurance, is an especially large employer. Insurance alone accounts for over 5% of the total employment with some 40 home or regional offices of insurance companies in Hartford alone, and 8 more in greater Springfield. This industry provides an important source not only for jobs, but a ready base for investment capital. For example, it was the funds of two Hartford insurance companies which built a $40,000,000 Constitution Plaza and the adjoining $9,000,000 Phoenix Plaza, as part of the Hartford urban renewal development program, when this program began to falter because of financial problems.

(4) Agriculture

Agriculture, which was once the principal means of the valley's economy, is declining relatively, but it is still an important component with total production being fairly stable. From 1939 to 1959, full-time agricultural employees declined in all counties of the basin, and in 1959, full-time agricultural employment was higher in the basin counties located in urbanized Massachusetts and Connecticut than in Vermont and New Hampshire counties. The 1960 agricultural employment totalled 19,182 representing 3% of the total work force. It is expected to decline some 8% by the year 2020.

Employment in the food and kindred products industry has increased throughout most of the basin during the period 1950 to 1960 with only 2 counties showing a decline in employment over this period, namely, Caledonia and Essex County, Vermont. Hartford County, Connecticut had the highest number employed in the food and kindred products industry, totalling 4,245 in calendar 1960. Both Hampden and Worcester Counties, Massachusetts had over 3,000 people

1/ Standard Industrial Classification



REVITALIZED HEART OF METROPOLITAN HARTFORD SHOWING DOWNTOWN RE-DEVELOPMENT AREA - PROTECTED FROM CONNECTICUT RIVER BY EARTH-DIKES AND FLOODWALLS IN RIGHT FOREGROUND ALONG THE RIVER'S EDGE employed in this industry, but none of the other counties of the basin had as many as 1,000 employees.

Forest product industries are found throughout the basin. Over 700 wood using plants were in operation in 1966. In that same year, 2,950 people were employed in harvesting, sawmills, and planing mills. In addition, 890 employees were in veneer and plywood plants; and 6,560 employees were in pulp, paper, and paperboard mills.

Employment in the secondary forest-based industry is projected to increase from over 20,400 in 1966 to over 27,100 persons in 2020. This is broken down further in the lumber related group namely, prefabricated buildings, wooden containers, etc., where employment is expected to decline from nearly 5,000 persons in 1966 to about 3,000 in 2020. The number of persons employed in wood using furniture industry is estimated to increase from about 5,000 to over 6,000 during the projected period. In the paper and allied products group the number of employees is expected to increase from 10,400 in 1966 to over 18,100 in 2020. More than 60% of the employment attributed to forest-based industry is concentrated in secondary manufacturing. The pulp and allied products group has the greatest potential to increase in both primary and secondary sectors, but the increase is likely to be less because of increased automation in the industry.

The paper and allied products industry is experiencing the fastest growth of the wood using industry. In 1966 there were 113 mills which used pulp wood, processed pulp, processed paper, or paperboard for their raw material. The total production of woodpulp is expected to increase over 9 times by the year 2020. Paper and paperboard production in the basin is also expected to increase about 3 times its present level by the year 2020.

(5) Services

Service in the basin is following the national pattern, growing along with prosperity of the region. Receipts from selected services amounted to $319,000,000 in 1963. The growth rate has been in excess of 8.8% annually for some seven years now, and is accelerating. Employment in the selected services category in 1963 totalled 27,000.

(6) Recreation and Tourism

This is an important part of the basin's economy, particularly since natural resources available for recreational opportunities are extensive and varied. Public, as well as private recreation areas have been developed to provide for an array of outdoor recreational pursuits. There are, for example, 55 State parks and 97 State forests along with 16 Federal reservoirs, 65 private camping grounds, and portions of two National Forests. Over 2/3 of a total acreage of 530,000 acres is located in the upper and middle portions of the basin in Vermont and New Hampshire, with some 262,000 acres accounted for in National Forests and 210,000 acres in State Forests. Total expenditures of tourism and recreation in 1967 amounted to over $115,000,000 for the entire basin.

(7) Higher Education

Higher education is an increasing element in the Connecticut Basin. More than 36 colleges are located within the basin. For example, over 25,000 students were enrolled in those colleges in the Massachusetts portion of the basin, together with a faculty over 1,000; and in the Connecticut portion of the basin, over 17,000 students were enrolled in 5 schools with a combined faculty of 1,200, all figures for 1967.

C. Land and Forest Resources

Analysis of the land resource of the basin used for agricultural activities, has been performed by the Economic Research Service, Department of Agriculture. The amount of land demanded for agricultural use is a function of changing consumer preferences, and inter-regional competition, as well as internal technological changes. During the pre-war period changes in consumer demand and inter-regional competition were responsible for the loss of agricultural land in the basin. After the post-war period rapid technological changes were responsible for further decline in agricultural lands. The future of agriculture is expected to follow the same trend since post-World War II. A further decline of 40% in land devoted to dairying is forecast in the valley by the year 1980. Farm population will continue to decline and farm land will increasingly concentrate in those rural hinterlands.

Forests are the predominant land use in the Connecticut River Basin. Nearly 80% of the land is devoted to this purpose. The commercial forest lands provide industrial wood and contribute to the water, recreation and fish and wildlife resources of the basin. The resources that these lands can supply will be influenced, in the future, by the pattern of ownership, by the degree of stocking and composition of the timber stands, as well as the levels of forest management that are applied. Most of the non-commercial forest land is publicly owned and generally managed for recreation with no commercial cutting timber.

The basin encompasses three major forest types. The spruce-fir region, located just south of the Canadian border in the headwaters of the basin, occurs in both highlands and lowlands were agricultural activity is almost non-existent, due to severe climate conditions and limited accessibility.

The northern hardwood region, which occupies over 2/5 of the basin, merges with the eastern hardwood region located in eastern Massachusetts and northern Connecticut. This eastern hardwood region has been an important recreational area. Extensive forest cover is confined to the roughest zones with some smaller forested areas scattered throughout the eastern hardwood region. The eastern hardwood region differences are the result of climate, soils and types of trees characteristic of these conditions. Crop production is concentrated in the Connecticut Valley lowlands.

The production of lumber is the most widely distributed forest product industry in the basin. There has been a general decline in the number of sawmills, although individual mill output has risen. A general decline followed by a partial recovery in lumber production is expected throughout the basin by the year 2000. The most significant aspect of future projections are the movement of the industry away from the lower portion of the basin. The proportion of hardwood lumber in the region's total output is expected to increase steadily as the region loses its competitive position in the softwood market and as the remaining mills turn more towards the production of high valued hardwood lumber.

Concerning the veneer industry, there are now five veneer plants in the basin which manufacture hardwood plywood and container veneer. Although the veneer industry faces competition from other products such as plastics, as well as competition from foreign markets, the price of veneer logs has almost doubled in the last decade due to diminishing supply. The demand for native hardwood veneer is expected to increase.

In 1966 there were 117 furniture and associated products plants located in the Connecticut Basin. The majority of these plants are in

Connecticut and Massachusetts. Over 50% of these plants have been in operation for nearly 30 years. The outlook for continued increases in furniture production is promising.

There are 168 miscellaneous wood-using plants which produce mill work and prefabricated buildings, wooden containers, post, pilings, handles, woodenware, palettes, lobster traps, etc.. The demand for these products is expected to remain constant, while others are likely to decline with new product development. Many other products are harvested from the forests of the basin, such as Christmas trees and Christmas ornaments, as well as maple sap for the manufacture of syrup and sugar products.

D. Manufacturing

The Connecticut River Basin economy remains more dependent on manufacturing than does the economy of the nation, with more than 40% of the area's total labor force engaged in manufacturing industries. Manufacturing or traditional industrial activity is in a potentially strong position for the future, with economic production per employee increasing dramatically. The area's highly skilled labor force and technological inputs from the engineering and scientific communities within close proximity of the industrial developments place the area in a very competitive position to continue its dominance in the manufacturing field. Even in the upper valley manufacturing groups account for more than 1/3 of all employment. Nationally known industrial giants are to be found throughout the area, including United Aircraft's Pratt and Whitney and Hamilton Standard Divisions in the Greater Hartford area; Savage Arms; American Bosch and L. B. Starrett in Massachusetts; General Electric and Jones and Lamson in Vermont, to name only a few. Personal income derived from manufacturing was the largest element in the basin's per capita income and it was 5.8% above the national average in 1959. While the bulk of the product was concentrated in the two southern States, especially Connecticut, value added exceeded $200,000,000 in the States of the upper basin.

E. Service

Employment in the broadly defined service sector is an important element in the basin's economy, averaging 58.6% of total employment, in addition to some 27,000 jobs which are available in the selected service category. The growth rate in the service area continues at

8.8% annually as non-manufacturing employment statistics and projections note the continued importance which this sector has in the economy of the basin. With the pronounced orientation toward the non-manufacturing sector, new concentrations of workers and occupational changes will occur. Construction, finance, real estate, recreation, insurance, and business and private services standout as the more important growth industries.

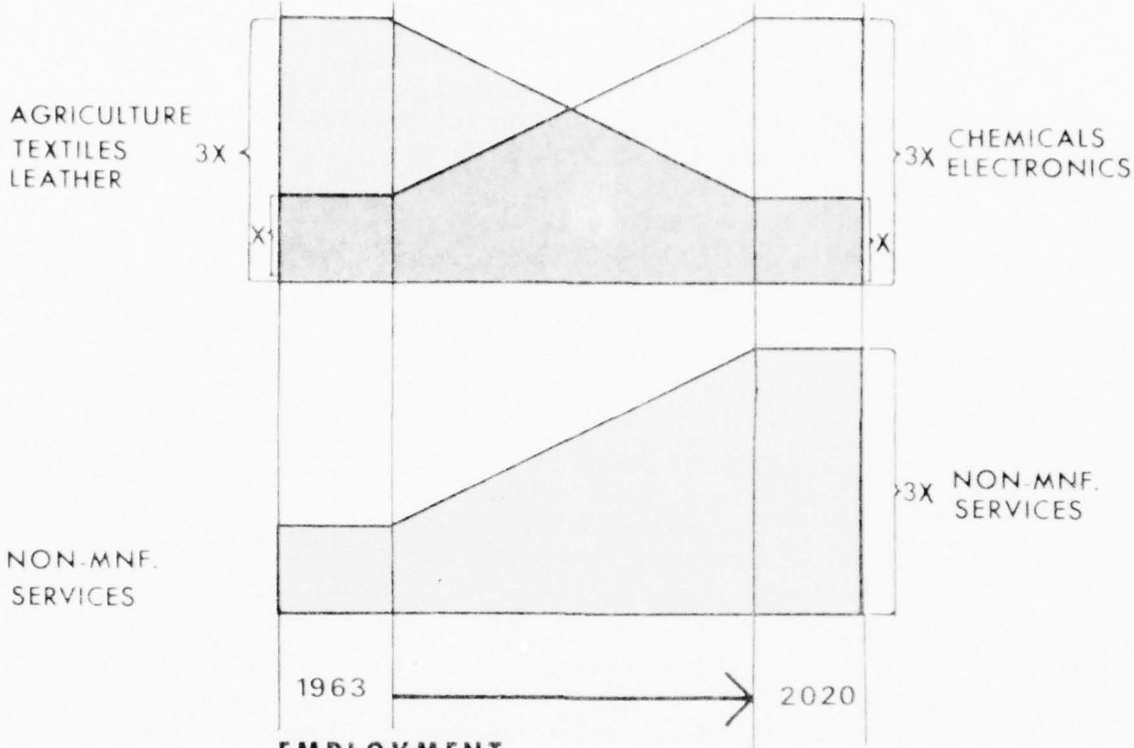
F. Income

The personal income in the basin is higher than that of the nation and is expected to remain so. Total per capita income in 1959 was $2,258 or 5.8% higher than the national average in 1959. Personal income derived from manufacturing was the largest element in the basin's per capita income. Value of product added by the basin's industrial complex exceeded $2,500,000,000 in 1963, the last year for which full data are available, and was growing at an annual rate of 3-1/2%.

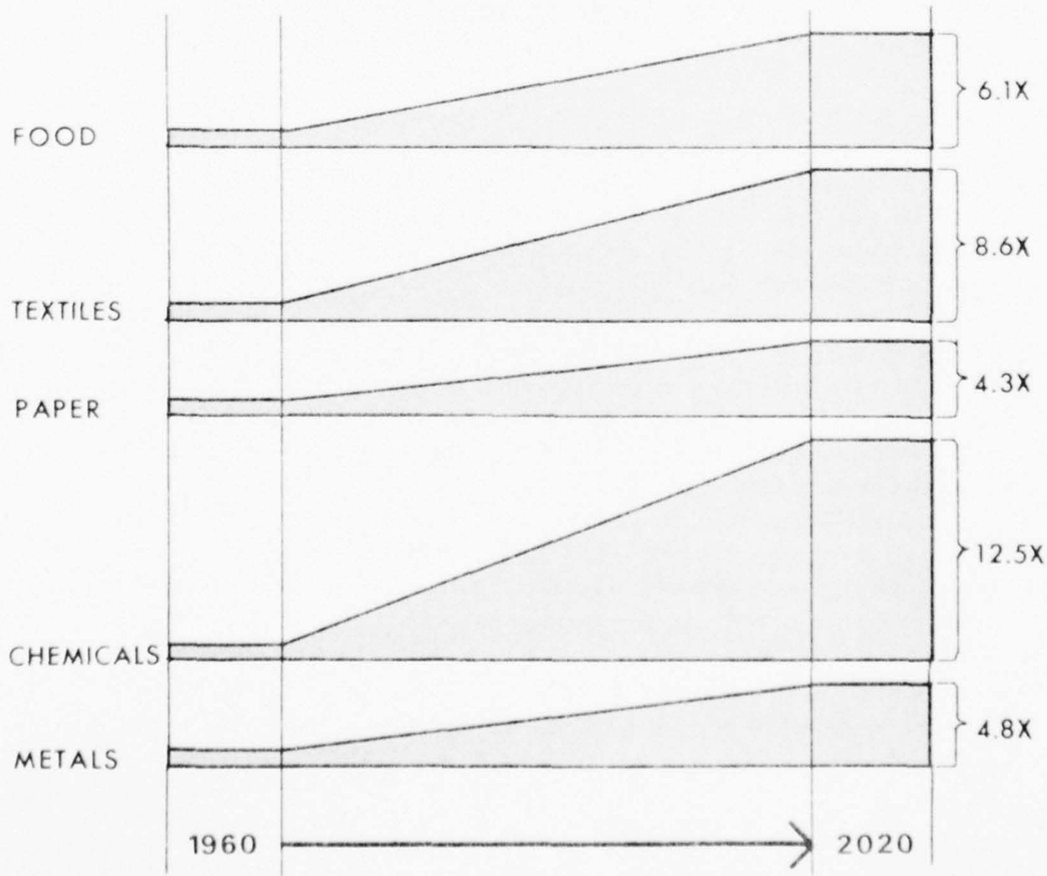
The average weekly earnings in the manufacturing industry, and based on 1967 figures, varied from about $92.00 in New Hampshire to $124.00 in Connecticut; as compared with $103.00 in Vermont and $108.00 in Massachusetts. The New England average weekly total in 1967 was $110.00.

Next in importance of income was that derived from trade where, in the wholesale sector, it had sales exceeding $2,500,000,000 and in the retail sector, sales of $2,400,000,000. Income derived from the broadly defined service sector, including finance and insurance continues to be a major element in the per capita income of the basin and particularly in the lower portions.

As we move upstream, the importance of agriculture, forestry resources, and recreation is very apparent and is produced predominantly by those service sector operations. There is considerable variation in the average level of capital investment in commercial farms between the upper and lower portions of the basin. For example, Hartford County, Connecticut leads all counties in the basin with an average capital investment of $83,782 per commercial farm. No county average in either Massachusetts or Connecticut is less than $33,500, while by contrast, in the northern two States only four counties, all of which border Massachusetts, either meet or exceed this figure. The lowest average capital investment, per commercial farm, is found in Coos County, New Hampshire.



EMPLOYMENT



PROPORTIONAL RISE IN ECONOMIC PRODUCTION/EMPLOYEE

FIGURE IV-3

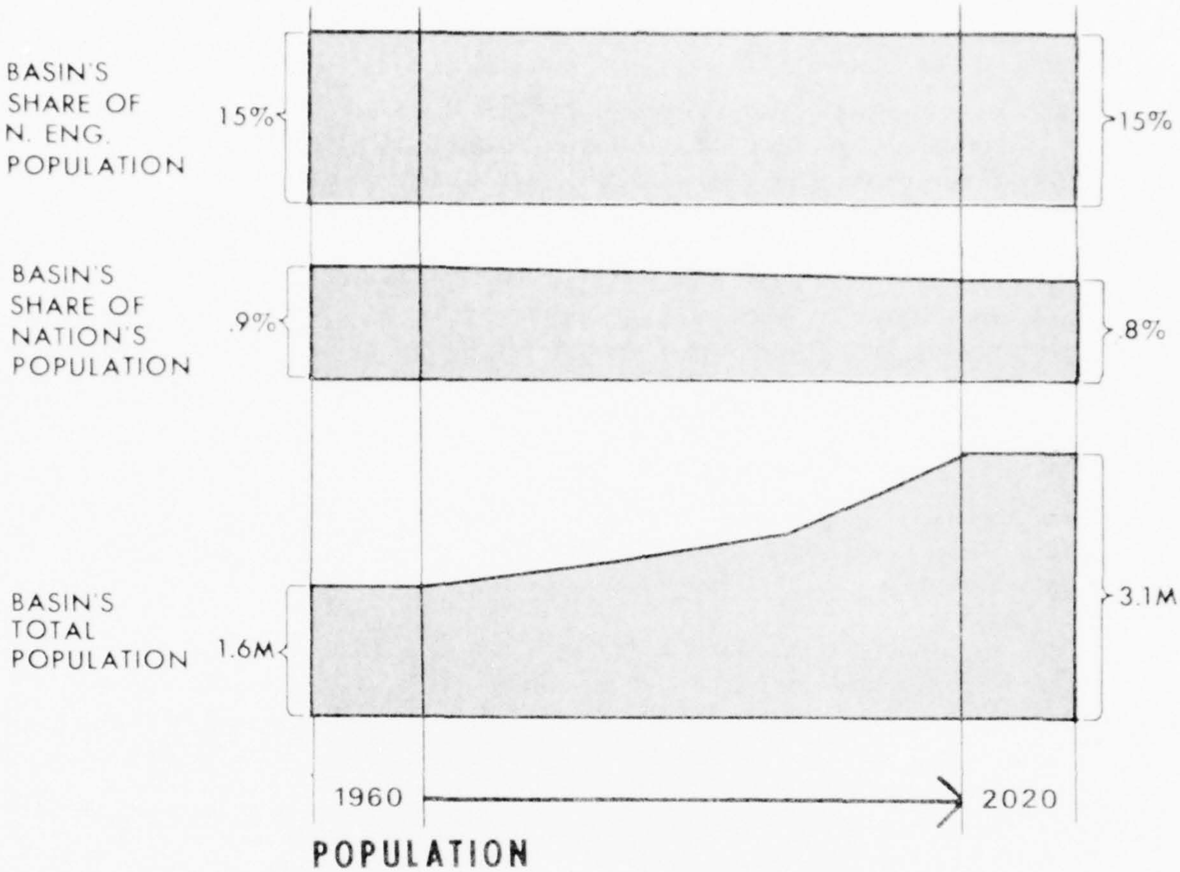
The average income per farm has increased, and with few exceptions, income is higher in Massachusetts and Connecticut Counties. In 1959, three of the five basin counties located in Connecticut showed an average annual income in excess of $4,800 per farm. By contrast county averages in the other three States were approximately $3,800 per farm. Caledonia County in Vermont led the basin counties in the northern two States with an average income of $2,900 per farm. The average weekly farm wage rates during 1965 were $69.75 in Connecticut, $69.25 in Massachusetts, $62.50 in New Hampshire, and $61.00 in Vermont. There were 5,907 commercial farms producing the above income.

In contrast, wage rates in the food and kindred industries were reported in 1966 to be $112.34 in Connecticut and about $100.00 in Massachusetts and New Hampshire.

The primary forest-based industries employed 10,400 people in 1966 who earned over $57,000,000, or about $105.40 per week. These industries shipped products valued at $217,000,000, 80% of which came from paper and allied products mills. The value added in primary manufacture amounted to $102,000,000, when costs were deducted for value of shipments and fuels, chemicals and other items that went into the sectors of the economy. Secondary forest-based industry employed 20,400 persons in 1966 who earned over $96,000,000, or about $91.50 per week. Products valued at over $354,000,000 were shipped from these industries. Value added amounted to $180,000,000 of which 2/3 was in paper and allied products.

A review of the median income of the experienced work force in the basin shows a considerable variance as to type of activity and basin location. For example, a basin average in 1957 of workers engaged in manufacturing pursuits revealed they were earning $81.50 a week, and by 1964 this had risen to $98.00 per week. Those workers engaged in services, in 1957 were earning $55.00 per week, with an increase to $66.00 a week by 1964. For comparison purposes annual average weekly earnings in the Springfield-Holyoke Standard Metropolitan Statistical Area in 1957 for workers engaged in manufacturing was $80.42, and by 1964 had risen to $99.31. Whereas, the sampling of the Sullivan County in New Hampshire indicated that in 1957, those workers engaged in manufacturing were earning $70.50 per week, and $85.50 in 1964. The workers in Sullivan County engaged in the services sector were earning $53.50 per week in 1957, and $67.00 in 1964.

Figure IV-4 displays basin population and personal income during the study period.


BASIN'S
SHARE OF
N. ENG.
POPULATION
15%
15%
BASIN'S
SHARE OF
NATION'S
POPULATION
.9%
.8%
BASIN'S
TOTAL
POPULATION
1.6M
3.1M
1960
2020
POPULATION

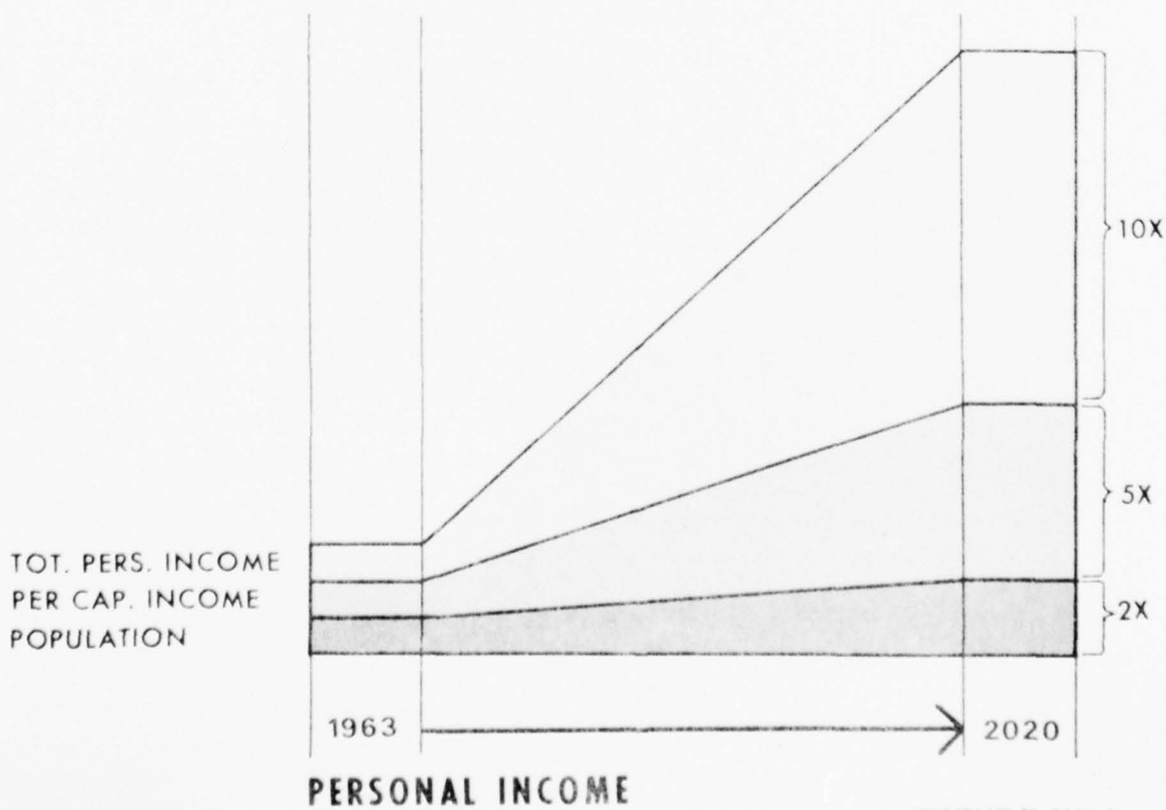

TOT. PERS. INCOME
PER CAP. INCOME
POPULATION
10X
5X
2X
1963
2020
PERSONAL INCOME

FIGURE IV-4

Averages are really weighted figures, therefore it would follow that the SMS area of Springfield should have a broader base and mix of different types of industries and could reflect lower figures than in a locale where manufacturing might be specifically oriented towards one or two types of high valued products. A more appropriate analysis would appear to come from the medium income range shown on Table IV-2. It reflects an array of different activities for the four Basin States. Variance in wages per worker is approximately $10.00 or less per week depending on location. In the instances of certain professional activities, such as public administration, variance is quite small. It can also be noted that manufacturing wages in the Massachusetts and Connecticut areas average about $20.00 more per week than in the upstream States.

A further point of interest concerns the analysis of the family income, and for purposes of demonstration, the Springfield-Chicopee-Holyoke Standard Metropolitan Statistical Area (based on 1959 data as derived from the lower Pioneer Valley Regional Planning Agency) is shown in Table IV-3. The medium family income is reported as $6,235 with 15% making $10,000 or more. A look at the town of Longmeadow, located on the suburban fringes of the SMSA indicates that more than 84% of the families in this community were earning over $6,000, and at least 55% of the families making income of $10,000 and over.

G. Transportation

A rail network links the principal basin communities to each other and to the rest of New England as well as the northeastern portion of the United States and Canada. Rail services are somewhat limited in the lower valley, that is, between Springfield to Hartford to New Haven on the Penn-Central Railroad. However, freight service is available throughout the entire region. In addition to the Penn-Central Railroad, there are operating tracks in the basin that belong to the Boston and Maine, the Grand Trunk, the Canadian National, and the Canadian Pacific Railway companies. Constantly improving highway systems serve the region. These are four interstate highways, namely, I-95, I-84, I-90, and I-89 crossing the basin. Travelling in a north-south direction I-91 parallels the Connecticut River and extends from Rocky Hill, Connecticut to Barnet, Vermont for a distance of 194 miles of which already 147 miles are completed. It then runs up the Passumpsic River to Lyndonville, Vermont on its

TABLE IV-2

MEDIAN INCOME OF PERSONS BY INDUSTRY
EXPERIENCED LABOR FORCE
1959

Males	Vermont	New Hampshire	Massachusetts	Connecticut
Labor Force	$3,740	$4,230	$4,818	$5,258
Agriculture, Forestry, Fisheries	1,842	2,377	2,902	2,819
Mining	3,839	n. a.	5,262	6,864
Construction	3,670	4,099	4,641	5,007
Manufacturing - Durables	4,173	4,549	5,247	5,521
Logging	2,396	2,883	2,680	.....
Sawmills, etc.	2,847	3,235	4,060	4,385
Furniture	3,511	3,958	4,144	4,356
Stone, Clay, and Glass	4,372	4,379	5,520	5,522
Machinery, Excluding Electrical	4,752	4,702	5,251	5,528
Electrical Machinery	4,934	4,943	5,608	5,531
Manufacturing - Non-durables	4,189	4,192	4,640	5,347
Paper and Allied Products	4,601	4,840	5,033	5,492
Printing and Publishing	3,888	4,690	5,200	5,601
Transportation and Communication	4,894	5,166	5,344	5,726
Railroad	5,151	5,313	5,333	5,605
Trucking	4,516	5,228	5,226	5,668
Electric and Gas	5,091	5,291	5,885	6,233
Wholesale and Retail	3,653	3,886	4,339	4,768
Wholesale	4,176	4,593	5,313	5,796
Retail	3,524	3,713	4,033	4,473
Finance and Insurance	5,428	5,750	5,641	6,314
Business and Repair Service	3,327	3,933	4,580	5,118
Personal Services	2,445	3,068	3,345	3,636
Entertainment and Recreation	2,368	2,946	3,094	3,711
Professional	4,152	4,248	4,944	5,266
Public Administration	4,851	4,817	5,280	5,298

TABLE IV-3

FAMILY INCOME, SPRINGFIELD AREA, 1959

	Median Family Income	Per cent of Families with Incomes: under $3,000	$6,000 and over	$10,000 and over
Springfield-Chicopee-Holyoke SMSA	$6,235	12.2	53.1	14.9
Springfield	5,994	14.6	49.9	13.2
Chicopee	6,170	10.9	52.4	12.6
Holyoke	5,755	15.3	46.4	11.8
Agawam	6,816	7.5	62.7	15.0
Amherst	6,198	12.6	52.0	18.8
Easthampton	5,887	10.4	48.2	10.0
East Longmeadow	7,271	6.5	70.3	21.6
Longmeadow	11,116	4.0	84.3	55.2
Ludlow	6,253	9.0	53.4	11.6
Northampton	5,856	12.6	47.7	12.9
South Hadley	6,855	8.9	61.6	19.1
Westfield	6,463	9.5	57.3	15.4
West Springfield	6,726	10.2	59.1	18.8

Source: U.S. Census of Population

way to Derby Line, Vermont at the Canadian border. Of the four interstate highways I-95 and I-90 are completed at the present time and only a small gap remains in I-84 to the west of Hartford. Interstate I-91 is completed in Connecticut but has one 10-mile segment missing in Massachusetts and work is under way at present. It is open to traffic in Vermont from the Massachusetts border to White River Junction, Vermont where it intersects I-89.

One other interstate highway, namely, I-93, which runs generally north-south in New Hampshire, up the Merrimack River Valley enters the upper part of the Connecticut Basin at Franconia, New Hampshire. It will eventually intersect I-91 at St. Johnsbury, Vermont.

Other limited access highways located wholly or in part in the basin include Connecticut's Routes 2, 9, and 15, as well as portions of Massachusetts Route 2, U.S. 5, U.S. 20 and 57. In addition, this excellent expressway network road system is supplemented by a secondary system of highways which varies from excellent in the north to good in the south.

To balance out a fine transportation system the basin supports one major commercial airport, namely, Bradley Field and three regional airports all located in the basin. Bradley Field, in Windsor Locks, Connecticut serves the Hartford-Springfield area and provides service on seven major airlines to other parts of the nation. The Lebanon and Whitefield Airports in central and northern New Hampshire serve the New Hampshire and Vermont portions of the basin. The Barnes Field in Westfield, Massachusetts provides limited passenger service for central Massachusetts.

Other airports with commercial facilities include Brainard Field in Hartford, Connecticut; Orange and Turners Falls Airports in Massachusetts; Claremont Airport in New Hampshire; and North Springfield Airport in Vermont. A large military installation at Westover Air Force Base is also located in the basin at Chicopee, Massachusetts. Transportation via the river is afforded by a 15-foot channel which is maintained from Long Island Sound to Hartford, Connecticut for a distance of 52 miles. In 1968, water-borne commerce on this channel totalled 3,652,000 ton (see Appendix L for further information on the navigation projects).

H. Existing Water and Related Land Resource Development and Programs

Water resources developments of various types abound in the Connecticut River Basin and attest to its maturity in serving so admirably man's needs and desires. For example, there are hundreds of dams which have been built for an array of purposes, most of which lie in the private sectors. Many of the dams associated with these developments have long since ended their intended purposes. In some instances they present a hazard but more generally serve a useful aesthetic purpose, as well as provide control for private water bodies. The greater number are run-of-the-river dams with the exception of those major hydro units. This section presents some of the more active category programs which are producing these developments, as relates to land treatment, conservation, watershed protection, flood control, hydro power, and navigation.

1. Department of Agriculture

The Public Law 566 program provides for watershed protection and flood prevention in the upstream zones, and is administered by the Soil Conservation Service with assistance from the U.S. Forestry Service. Land treatment is the first consideration in planning for watershed projects as the initial phase before channel improvement or floodwater-retarding structures are evaluated. In the Connecticut River Basin 11 PL 566 projects have been completed or are under construction. All of these projects include land treatment measures and 9 include technical assistance funds to accelerate land treatment. Two of the projects include channel improvements only, and 3 projects have channel improvement in combination with floodwater-retarding storage. In the 11 projects there are a total of 34 floodwater-retarding structures including storage for recreation, fish and wildlife, water supply, and water quality.

Soil Conservation Service has entered into an agreement with local conservation districts covering the entire basin to implement a cooperative conservation operation program providing for soil surveys, planning, and application of conservation measures on private lands, as well as assistance in resource planning and development in local communities. Technical assistance is furnished landowners and operators cooperating with soil conservation districts in the application of needed conservation practices and proper land use.

As of January 1, 1970 three resource conservation and development projects have been authorized for operations - the North Country RC&D project covering 1.2 million acres of land in Coos and Grafton counties, New Hampshire; the Eastern Connecticut RC&D project covering 26,000 acres of land; and the East Central Vermont RC&D project which includes the White River and adjacent areas. In addition, the Berkshire-Franklin RC&D project in Massachusetts, covering 600,000 acres of land, is currently being planned.

Cooperative State-Federal forestry program has been under way for almost 50 years in the basin and covers all State and privately owned forest land. Annual forest acreage burned has decreased substantially since 1917 from an estimated 32,000 acres to less than 4,000 acres in 1966. The cooperative forest management program provides technical forestry assistance in the production and marketing of forest products with the purpose of improving management on small forested areas and the operation of small processors of primary forest products. Forest management on the 223,000 acres of land currently in State forests and parks in the basin is under State-directed programs.

National forest development and multiple use programs of the White and Green Mountain National Forests provide timber production, recreation development, and fish and wildlife habitat improvement.

Agricultural stabilization and Conservation Service programs provide incentive cost-sharing assistance to rural land owners carrying out approved soil, water, forestry, recreation, and wildlife conservation practices to assure the wise use, protection and management of rural lands.

Farmers Home Administration Programs include emergency loans to farms because of drought, farm-operating loans to small farmers unable to receive credit from other sources, loans for recreation facilities, forestry practices, and rural housing loans to help farmers acquire or improve farm lands, and loans for soil conservation practices.

This agency may also make loans and grants to provide water supplies and sewage disposal facilities in rural areas with population less than 5,500. Seventeen applications have been submitted by towns in the basin for loans and grants under this authority and are awaiting approval. Five loans and eight development grants have already been made in the basin.

P.L. 566 DAM AND RESERVOIR ON OLIVERIAN BROOK IN BENTON, N.H. SHOWING RECREATIONAL USE OF SEDIMENT POOL, BOAT LAUNCHING AREA ON NEAR LEFT, AND WHITE MOUNTAIN NATIONAL CAMPGROUND BELOW DAM

Courtesy USDA - SCS

This agency also administers loan provisions of Public Law 83-566 through which qualified local sponsoring organizations may secure loans to finance a part of the non-Federal cost for eligible measures.

Cooperative extension programs in agriculture, forestry, home economics, and rural development are provided in a partnership undertaking between the Department of Agriculture and the individual Land Grant Colleges and Universities and in cooperation with local government and people. The Land Grant Colleges in cooperation with the Department of Agriculture conduct research toward problems of importance to the State and the nation, as well as provide leadership for education programs in rural and urban areas.

The Agricultural Research Service conducts research related to production, utilization, marketing of agricultural products, and soil and water conservation. It also conducts regulatory programs involving the enforcement of plant and animal quarantines, pesticide regulation, and control of diseases and pests of animals and plants.

The Economic Research Service has a primary responsibility for economic research within the U.S. Department of Agriculture. The Service provides economic expertise to many of the regional development organizations which are active in land resource management and planning.

The Rural Electrification Program is limited to the States of Vermont and New Hampshire and loans money to various electrical cooperatives to finance the construction of distribution lines, as well as transmission lines and related facilities to 12,220 rural customers.

At the State and local levels there are a number of agencies involved in land and water resource programs related to agriculture. These include:

(1) Conservation Districts - which are organized political subdivisions of the State (generally organized on a county basis) authorized to extend, on request of owners and operators of land, the assistance necessary to carry out an effective conservation prbgram.

(2) Conservation Commissions - a relatively new method by which local levels of government become involved in land use planning and passed initially in Massachusetts in 1957, and in

Connecticut in 1961, and in New Hampshire in 1963. The Conservation Commissions review open space development plans, and co-ordinate activities of unofficial bodies organized for conservation purposes. They receive gifts of money and property in the name of the city or town, with such gifts managed by the Commission. They are charged with the responsibility to keep an inventory of all open areas within the town or city, including land owned by the town, city or State. They also keep an inventory of all open marshland, swamps and other wetlands.

(3) Other Programs

The northern 10 counties in New Hampshire and Vermont are organized into the so-called New Hampshire-Vermont Economic Development District. This program provides proposals for development of the future economy of the upper basin as well as makes possible the qualifications for various forms of financial assistance and grants under the Economic Development Administration of the U.S. Department of Commerce.

2. U.S. Department of the Army

The Corps of Engineers has completed several projects in the navigational area. The main stem of the Connecticut River has from earliest colonial days been a principal means of access and egress into the valley. The earliest reports on commercial navigation were made in 1837 when it was recommended that a channel be dredged 500 feet wide and 12 feet deep at the entrance of the river at Old Saybrook. There are 9 existing navigational projects in being in the Connecticut River and they are as follows:

(1) A 15-foot channel at mean low water 300 feet wide from the mouth to the Lyme railroad bridge and then generally 150 feet wide to Hartford for a total distance of 52 miles.

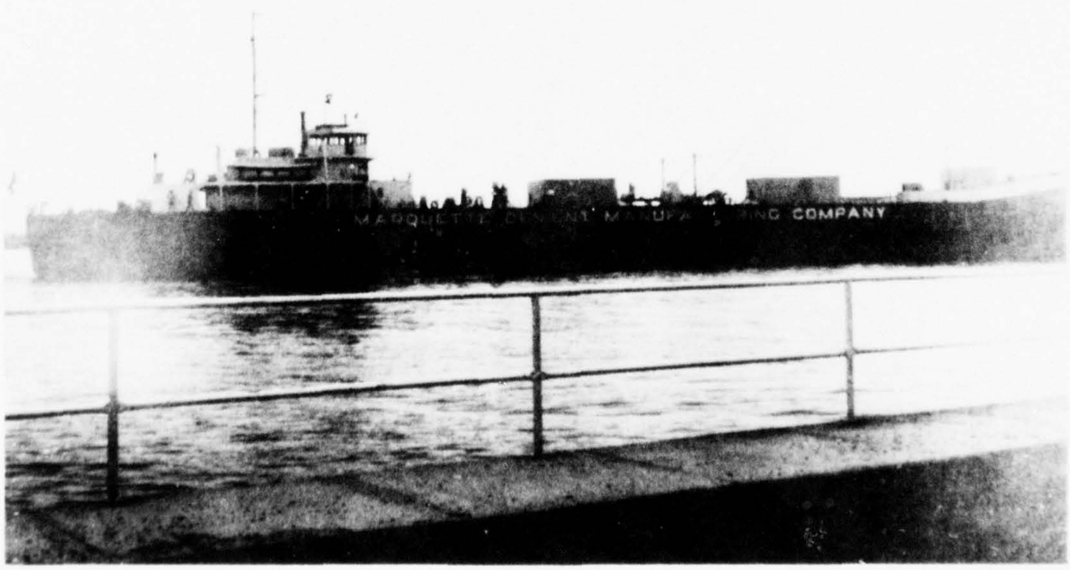
(2) An 11-foot channel 100 feet wide from deep water in the river to anchorage at North Cove at Old Saybrook.

(3) Two anchorages 6 feet and 11 feet deep in North Cove.

(4) Two rip rap jetties at the mouth of the river.

MARINA FACILITY AT OLD SAYBROOK SHOWING EXTENSIVE BOATING DEVELOPMENT IN THE ESTUARY AREA

Corps of Engineers Photo



COMMERCIAL NAVIGATION - BELOW HARTFORD, CONNECTICUT
TYPICAL BULK CARRIER

Corps of Engineers Photo

(5) Dikes and training walls, revetments and accessory works.

(6) A training dike about 3,700 feet long at Hartford.

(7) A channel 8 feet deep and 75 feet wide in the Eight Mile River from the Connecticut River as well as a turning basin and anchorage at Hamburg.

(8) An entrance channel 6 feet deep, generally 60 feet wide, together with anchorage in Wethersfield Cove.

(9) A channel 10 feet deep, generally 100 feet wide at Essex together with anchorages.

The Corps of Engineers' existing projects for flood control improvements represent an investment of over $150,000,000 in the Connecticut River Basin. Of this amount, approximately $120,000,000 is accounted for in 16 large flood control reservoirs, and $30,000,000 allocated in a series of local protection works located along the main stem of the river and principal tributary areas. (See Table IV-4.) The projects noted in the latter Table IV-4 are the result of a specific authorization reports and subsequent legislation as afforded by Onmibus Bills. They are not part of on-going programs such as are accomplished under the 205 Authority of the 1948 Flood Control Act, as amended by Public Law 874, 87th Congress. This authority provides for Federal assistance in projects which can be economically justified but is limited to $1,000,000 Federal participation.

3. Private Power Developments

By far the largest investment in water resource development is presented in the hydroelectric sector where 75 separate hydroelectric projects have been constructed. (See Appendix K - Table 2)

4. State, Local, and Private Developments

There is a major investment in water supply facilities, the largest of which is the Metropolitan District Commission at Quabbin Reservoir, which supplies water to Metropolitan Boston. Second, as regards size, is the Metropolitan District Commission of Hartford Water Supply System, followed by the Springfield Water Works. There are several other medium sized units of water supply such as, Holyoke System, the

Westfield Water System and numerous smaller units which serve individual towns and municipalities. Add to this array of investment those monies invested in collective sewer systems, and one can appreciate the several millions of dollars that have been invested by the public in water resources.

Attention is directed to Appendix J which presents those investments in water resource projects as accomplished by the four basin States. In addition, there are considerable monies invested in the private sector, particularly in the industrial and commercial pursuits which overshadow expenditures in the public sector. These date back to the initial periods of history when the utilization of the Mill Acts were popular and used as a principal means of obtaining natural water power for an array of industrial pursuits.

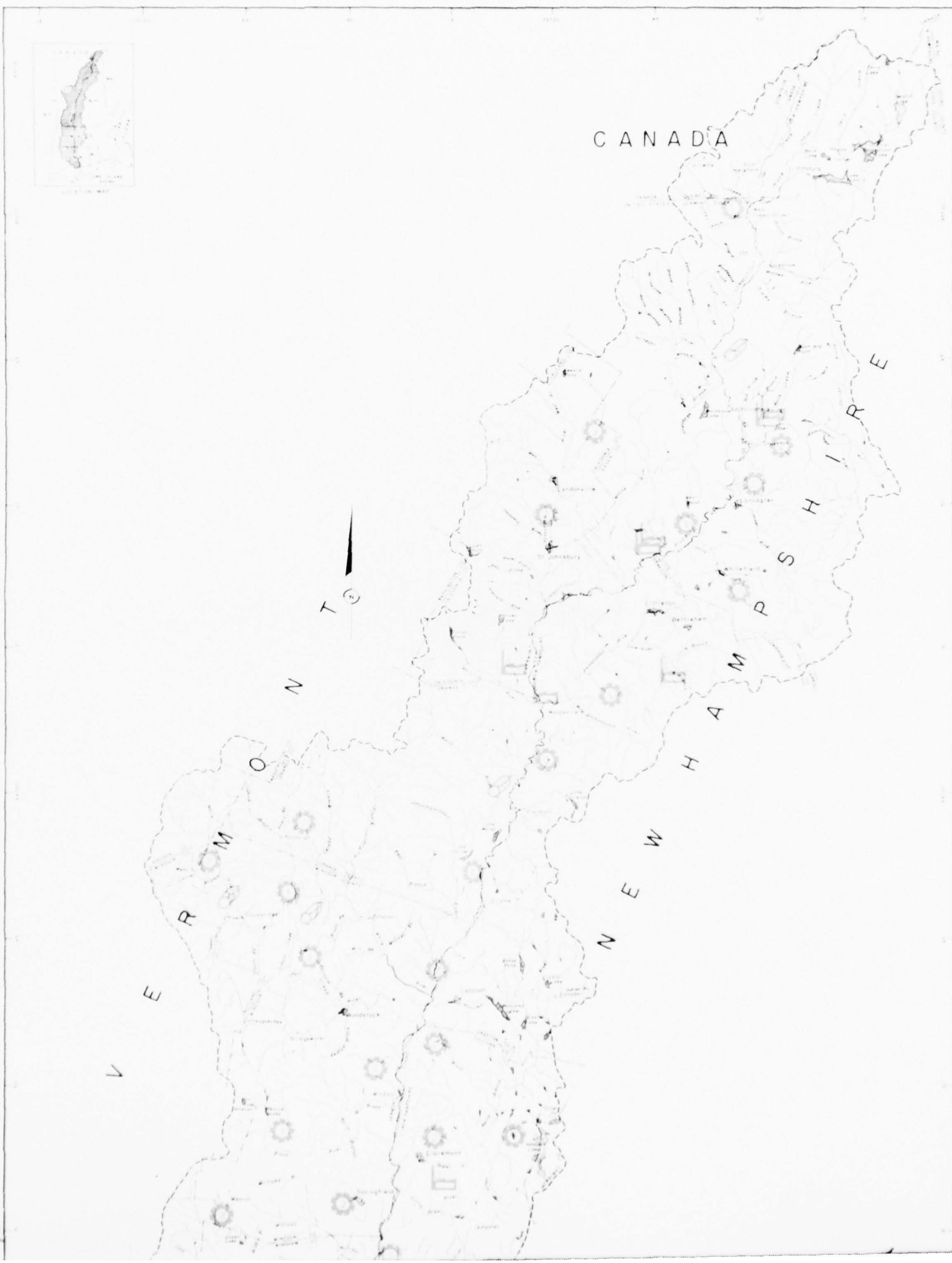
TABLE IV-4

EXISTING FLOOD CONTROL RESERVOIRS

NAME	RIVER AND STATE	DRAINAGE AREA (sq.mi.)	FLOOD CONTROL STORAGE (ac.ft.)
Union Village	Ompompanoosuc, Vt.	126	38,000
No. Hartland	Ottauquechee, Vt.	220	71,400
No. Springfield	Black, Vt.	158	50,600
Ball Mountain	West, Vt.	172	54,600
Townshend	West, Vt.	278	33,200
Surry Mountain	Ashuelot, N. H.	100	32,500
Otter Brook	Ashuelot (Otter Brook), N. H.	47	17,600
Birch Hill	Millers, Mass.	175	49,900
Tully	Millers (Tully), Mass.	50	22,000
Barre Falls	Chicopee (Ware), Mass.	55	24,000
Conant Brook	Chicopee (Conant Brook), Mass.	8	3,740
Knightville	Westfield, Mass.	164	49,000
Littleville	Westfield (Middle Br.), Mass.	52.3	23,000
Mad River	Farmington (Mad), Conn.	18.2	9,510
Colebrook River	Farmington (West Br.), Conn.	119	50,800
Sucker Brook	Farmington (Still), Conn.	3.4	1,480

EXISTING AND AUTHORIZED LOCAL PROTECTION WORKS

	LOCATION	RIVER
Main River	Northampton, Mass.	Connecticut and Mill
	Holyoke and Springdale, Mass.	Connecticut
	Chicopee, Mass.	Connecticut and Chicopee
	West Springfield and Riverdale, Mass.	Connecticut and Westfield
	Springfield, Mass.	Connecticut and Mill
	East Hartford, Conn.	Connecticut and Hockanum
	Hartford, Conn.	Connecticut, Park, Gully Brook and Folly Brook
Tributaries	Weston, Vt.	West
	Keene, N. H.	Ashuelot
	Gardner, Mass.	Millers (Mahoney and Greenwood Brooks
	Ware, Mass.	Chicopee (Ware)
	West Warren, Mass.	Chicopee (Quaboag)
	Three Rivers, Mass.	Chicopee, Ware and Quaboag
	Chicopee Falls, Mass.	Chicopee
	Winsted, Conn.	Farmington (Mad)



CANADA
NEW HAMPSHIRE
VERMONT

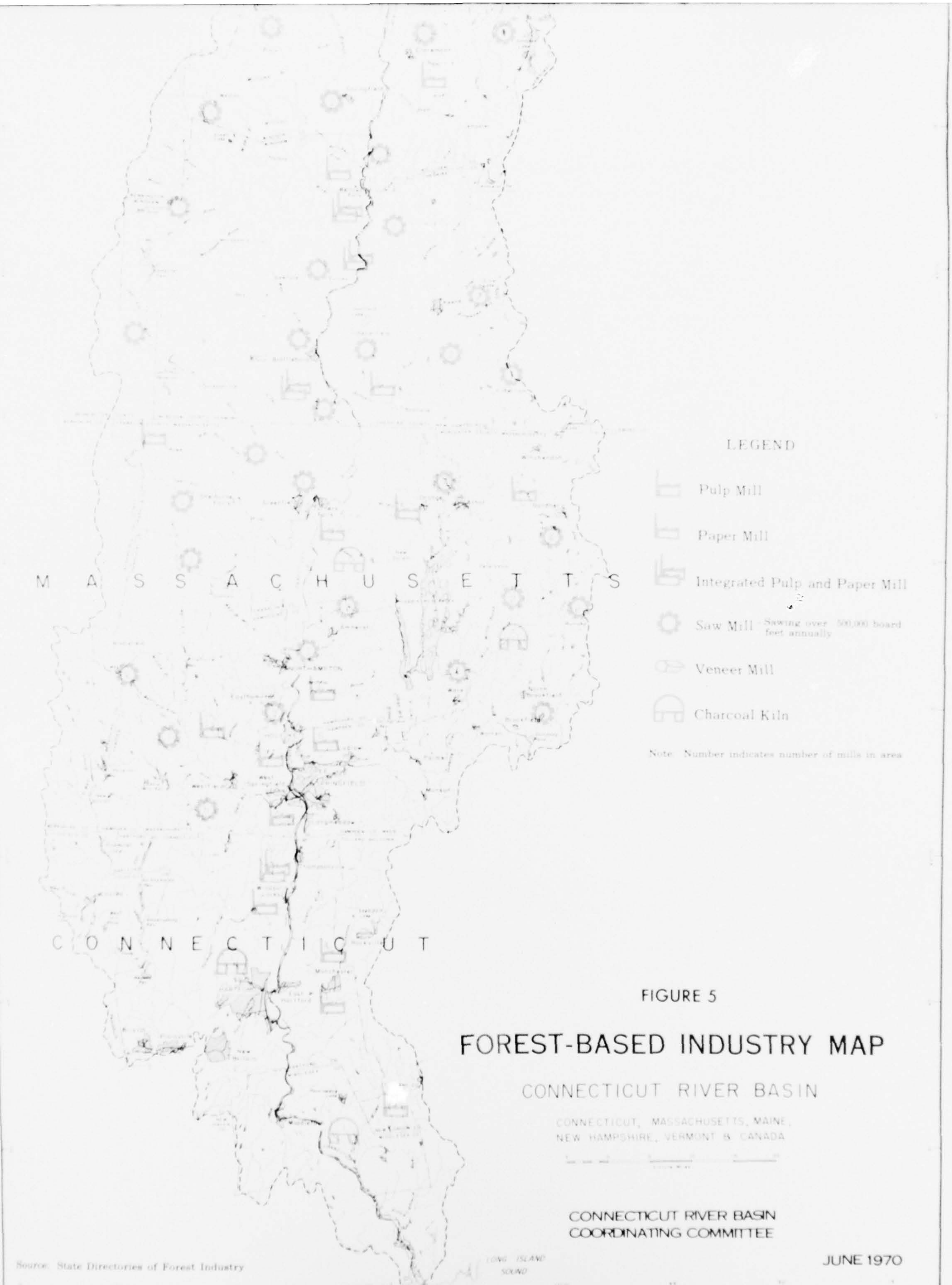


FIGURE 5

FOREST-BASED INDUSTRY MAP

CONNECTICUT RIVER BASIN

PART TWO

CHAPTER V

NEEDS AND PROBLEMS

CHAPTER V

Section 1 - Measurement Tools

A. Projections and Economic Indicators

Management conception draws upon a planners judgment and ideas gained through past experiences and from projections and trends commonly referred to as measurement tools. In simplest terms, a water resources study can be divided into two broad categories; supply and demand, with the planner committed to reconciling the two. The supply represents the resource itself, be it a man-made or natural reservoir, or a groundwater aquifer, or simple open space, whereas the demand represents those desires for the resource as expressed by the people through past trends, as well as latent desires and assumptions as to future individual preferences. Since demands are directly the result of population judgments have to be made as to the future magnitude of population and economic activities. Tools take the form of projections (not predictions) of population and selected indicators of economic activity. Preferences or requirements expressed as units of water, e. g., gallons per capacity, could also reflect judgments to other factors projected, for example income and the strong effect this has in areas of recreation as well. Demand estimates for future water requirements are, therefore, equally sensitive to both the demander projections, and the factors of amount demanded per individual or activity. Both tools are important.

The magnitude projections for the Connecticut Study were prepared under contract by a nationally recognized firm and in two steps: 1/

(1) The New England area; and (2) the States as sub-State areas which make up the Connecticut River Basin. This quantitave guide of population, labor force, households, employment and personal income figures was made for a 60-year period from 1960 to 2020.

Economic projections attempt a view of the future based primarily on present knowledge of foreseeable development and relationship to the past. The projection is not a prediction or a prophsey of the future but rather what might occur if a number of specific assumptions regarding the structure and behavior of the economy were in fact to materialize.

Assumptions made were: (1) the timely availability of water in sufficient quantity and quality to support the projected economy; (2) a high or present level of national employment and activity; (3) no

1/ Projective Economic Studies of New England, Arthur D. Little, Inc. (ADL), Cambridge, Mass., 1965 major depressions or wars; and (4) a continuation of the current relative needs of the civilian economy and the national defense.

The above stipulation, as well as the national growth projections as furnished by the Water Resources Council were carefully followed. In addition, specific industry projections for agriculture, forestry, lumber and wood products and paper were prepared independently by the Economic Research Service and the Forest Service of the U. S. Department of Agriculture.

Tables V-1 - V-6 present projections for the six Reference Subdivisions of the Connecticut River Basin of the four Basin States. The projections present Population, with urban-rural breakdown; Employment, with primary resource industry, manufacturing, and service industry breakdowns; Households; and total and per capita Personal Income. The 1960 populations indicated for the state and sub-state areas were derived from Bureau of the Census publications. Employment and income statistics for 1960 were obtained by using ratios identical to those prepared for the North Atlantic Regional Water Resources Study Type I framework.

The average annual growth rate for the population of the United States has varied widely as determined by the decennial census, first taken in the year 1790, and as annually estimated by the Bureau of the Census. This growth rate has been largely influenced by economic conditions and immigration. In the recent historical period, growth rate increased annually from 1940 reaching a peak rate in 1957. Since 1957 the growth rate declined moderately on an annual basis through 1965. There is evidence that this moderate decline has continued through the present time. The Bureau of the Census had developed four alternative population projection series designated A, B, C and D. Each of these series makes the same assumptions with regard to deaths and net immigration, but they differ in regard to the birth rate, and are as follows:

Series A - 1962-1965 Birth Rate Index
Series B - Moderate Decline from 1962-1965 Birth Rate Index
Series C - Substantial Decline from 1962-1965 Birth Rate Index
Series D - Sharp Decline from 1962-1965 Birth Rate Index

The Office of Business Economics has considered the B, C & D series as their high, middle and low assumptions, respectively. Projections utilized for the Connecticut reflect the Series C range. These new data, when compared with earlier projections utilized in the ADL report indicate that the demographic categories of Population, Employment and Household will increase at a slower rate. It is anticipated

TABLE V-1
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
POPULATION & HOUSEHOLDS (1,000's)

CRB		1960	1980	2000	2020
I	Population	30	33	35	39
	Urban	3	9	13	19
	Rural	27	24	22	20
	Households	9	9	10	11
II	Population	38	38	43	50
	Urban	6	7	10	11
	Rural	32	31	33	39
	Households	11	11	12	15
III	Population	86	94	102	124
	Urban	49	58	66	81
	Rural	37	36	36	43
	Households	27	29	32	38
IV	Population	74	87	109	122
	Urban	25	39	55	65
	Rural	49	48	54	57
	Households	22	26	32	37
V	Population	662	777	899	1132
	Urban	505	623	746	974
	Rural	157	154	153	158
	Households	195	229	264	343
VI	Population	790	971	1212	1643
	Urban	612	786	1030	1449
	Rural	178	185	182	194
	Households	235	286	357	498
TOTALS					
	POPULATION	1680	2000	2400	3110
	URBAN	1200	1522	1920	2599
	RURAL	480	478	480	511
	HOUSEHOLDS	499	590	707	942

TABLE V-2
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
EMPLOYMENT (1,000's)

CRB		1960	1980	2000	2020
I	TOTAL	11	13	14	16
	Resource Ind.	1	1	1	1
	Manufacturing	4	4	4	4
	Other (1)	6	8	9	11
II	TOTAL	14	15	18	20
	Resource Ind.	1	1	1	1
	Manufacturing	5	5	5	6
	Other	8	9	12	13
III	TOTAL	32	38	42	51
	Resource Ind.	3	1	--	--
	Manufacturing	11	12	13	15
	Other	18	25	29	36
IV	TOTAL	28	35	45	50
	Resource Ind.	2	1	1	--
	Manufacturing	10	12	13	14
	Other	16	22	31	36
V	TOTAL	265	318	360	453
	Resource Ind.	6	3	2	2
	Manufacturing	109	104	98	105
	Other	150	211	260	346
VI	TOTAL	316	398	485	657
	Resource Ind.	7	4	3	3
	Manufacturing	130	130	132	152
	Other	179	264	350	502
CRB	TOTAL	666	817	964	1247
	Resource Ind.	20	11	8	7
	Manufacturing	269	267	265	296
	Other	377	539	691	944

(1) Other includes the broad spectrum of service oriented agencies.

TABLE V-3
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
EMPLOYMENT BY STATE & BASIN TOTAL - (1,000's)

State		1960	1980	2000	2020
N.H.	TOTAL	43	51	56	67
	Resource Ind.	4	2	1	1
	Manufacturing	15	16	17	19
	Service Ind.	24	33	38	47
VT.	TOTAL	42	50	63	70
	Resource Ind.	3	2	2	1
	Manufacturing	15	17	18	20
	Service Ind.	24	31	43	49
MASS.	TOTAL	265	318	360	453
	Resource Ind.	6	3	2	2
	Manufacturing	109	104	98	105
	Service Ind.	150	211	260	346
CONN.	TOTAL	316	398	485	657
	Resource Ind.	7	4	3	3
	Manufacturing	130	130	132	152
	Service Ind.	179	264	350	502
CRB	TOTAL	666	817	964	1247
	Resource Ind.	20	11	8	7
	Manufacturing	269	267	265	296
	Service Ind.	377	539	691	944

TABLE V-4
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN

PERSONAL INCOME BY STATE

STATE		1960 (1)	1980	2000	2020
N.H.	PI (2)	212.0	449.6	885.3	1953.1
VT.	PI	204.8	442.5	982.3	2060.9
MASS.	PI	1696.0	3534.6	6847.7	14777.1
CONN.	PI	2024.0	4417.1	9231.8	21447.7
TOTAL	PI	4136.8	8843.7	17947.0	40238.8

(1) Figures for 1960 are based on an interpolation between data supplied for 1959 and 1962.

(2) P.I.: Total Personal Income in Millions (1958 Dollars).

TABLE V-5
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
PERSONAL INCOME

CRB	(2)	(1) 1960	1980	2000	2020
I	PI (3)	54.8	116.8	226.2	467.3
	P/C	1828	3540	646.2	11982
II	PI	69.5	134.5	277.9	599.1
	P/C	1828	3540	6462	11982
III	PI	157.2	332.8	659.1	1485.8
	P/C	1828	3540	6462	11982
IV	PI	135.3	308.0	704.4	1461.8
	P/C	1828	3540	6462	11982
V	PI	1696.0	3534.6	6847.7	14777.1
	P/C	2562	4549	7617	13054
VI	PI	2024.0	4417.1	9231.8	21447.7
	P/C	2562	4549	7617	13054
TOTAL PI		4136.8	8843.8	17947	40238.8

(1) Figures for 1960 were obtained from an interpolation of P/C figures supplied for 1959 and 1962.

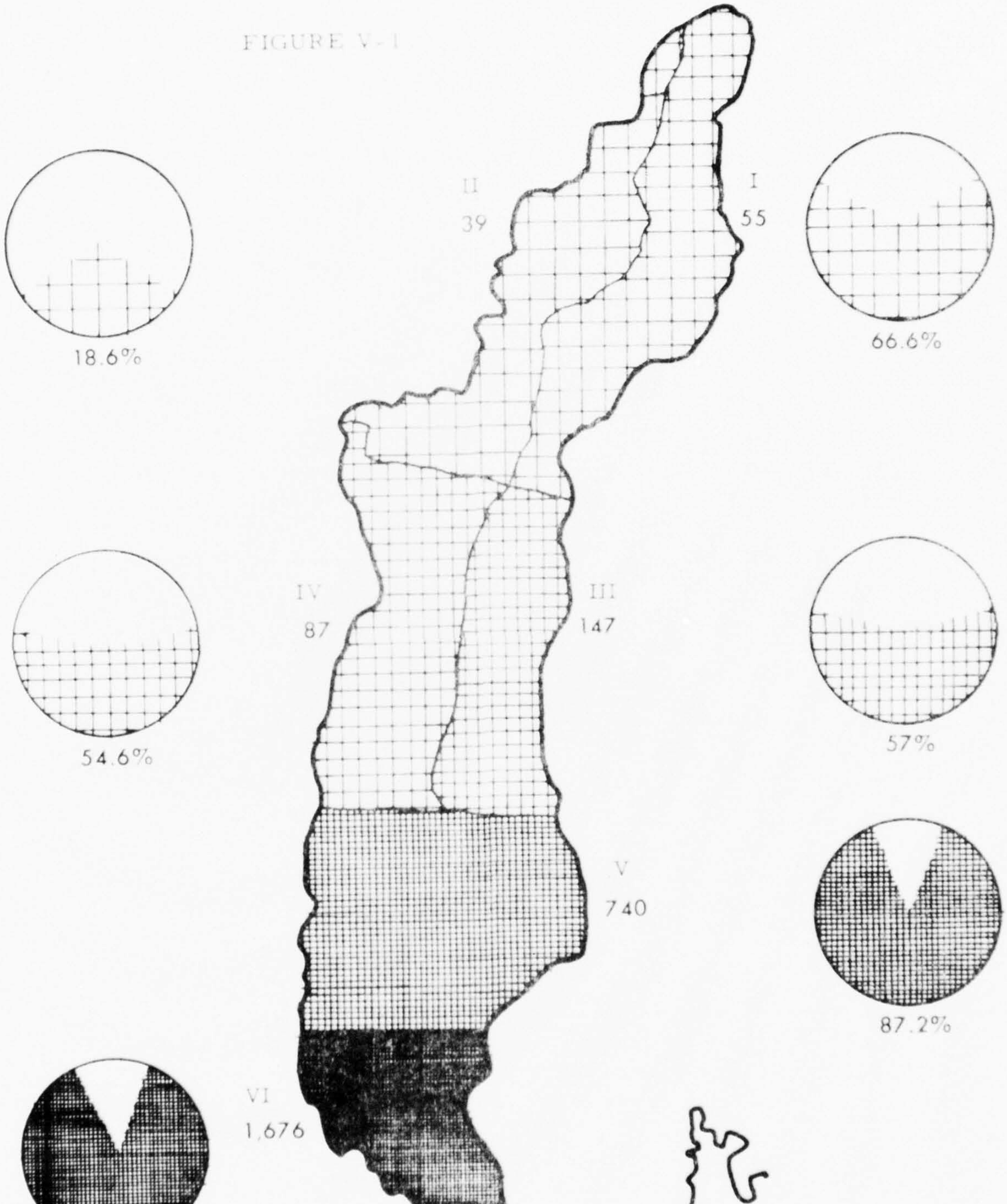
(2) PI: Total Personal Income in millions (1958 dollars).

(3) P/C: Per Capita Personal Income in dollars (1958 dollars).

TABLE V-6
PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
POPULATION & HOUSEHOLDS BY STATE (1,000's)

State		1960	1980	2000	2020
N. H.	Population	116	127	137	163
	Urban	52	67	79	100
	Rural	64	60	58	63
	Households	36	38	42	49
VT.	Population	112	125	152	172
	Urban	31	46	65	76
	Rural	81	79	87	96
	Households	33	37	44	52
MASS.	Population	662	777	899	1132
	Urban	505	623	746	974
	Rural	157	154	153	158
	Households	195	229	264	343
CONN.	Population	790	971	1212	1643
	Urban	612	786	1030	1449
	Rural	178	185	182	194
	Households	235	286	357	498
CRB TOTALS					
	Population	1680	2000	2400	3110
	Urban	1200	1522	1920	2599
	Rural	480	478	480	511
	Households	499	590	707	942

FIGURE V-1



% URBAN POP. 2020

PERSONS PER SQ. MI. 2020

% URBAN POP. 2020

that an increase in the total 1960 basin population of approximately 85% during the projection period is likely to occur, where as earlier data indicated an increase of 146%. In the income category personal income and per capita income are expected to increase more rapidly or about five times from 1960 to the year 2020 compared to an earlier increase of 240%.

B. WEIGHTINGS AS RELATES TO WATER USE AND RECREATION

In the past, water use and consumption has had an almost parallel rise with income. A review of the three largest municipal water suppliers of New England, namely, the Hartford, Connecticut Metropolitan District Commission, the Providence, Rhode Island Water Supply System, and the Metropolitan District Commission of Boston, Massachusetts was made to reflect gallon per capita water demand. Using calendar year 1965 which was a year when restrictions were imposed as it was the high point of the recent 6-year drought, indicated GPCD of 132 for the Hartford system, 140 GPCD for the Providence system and 145 GPCD for the Boston system. Even tempering future demand projections, it appears likely that 1.1 gallons per year per capita increase is a reasonable estimate up through 1980, and .9 gallons per year per capita increase thereafter. With increased water use will come larger effluent discharge. For purposes of this study and as regards domestic waste loading requirements, a weighting of 0.17 lb/oxygen/capita has been used in projecting dissolved oxygen requirements and this unit does not truly reflect the richer industrial waste loading.

In 1962 the Outdoor Recreation Resources Review Commission, (ORRRC) in its final report to the President estimated that nationally 4.4 billion outdoor recreation activity occasions occurred in 1960 and would increase to 6.9 and 12.4 billion by 1976 and 2000 respectively. The ORRRC report, further projected increasing leisure time available using paid holidays and vacations as the indicators. These leisure time indicators for the New England Geographic Division are shown in Table V-7

TABLE V-7
PAID HOLIDAYS AND VACATIONS
NEW ENGLAND GEOGRAPHIC DIVISION

Year	Holidays Days	Vacations Weeks
1960	6.9	2.2
1976	8.9	2.9
2000	10.6	4.0

When these leisure time indicators are considered with the expanding population and its increasing per capita income, together with the trends in mobility, the virtual pyramid of outdoor recreation demand projections become apparent.

The Fish and Wildlife Service, in the 1965 National Survey of Hunting and Fishing, estimated that the average freshwater fisherman fished on 18 occasions each year. This survey further tabulated for geographic regions the participation of the adult population who fished and hunted in 1955, 1960, and 1965. This participation for the New England Geographic Division is shown in Table V-8.

TABLE V-8
ADULT PARTICIPATION - FISHING AND HUNTING
NEW ENGLAND GEOGRAPHIC DIVISION

Year	No. of Persons 12 & Older Millions	Those Fishing & Hunting %	Those Fishing %	Those Hunting %
1955	7.9	4.7	8.0	2.7
1960	8.3	4.2	10.2	2.0
1965	9.3	4.5	11.5	1.8

In order to properly characterize and evaluate the effect of the many variables and indicators that affect demand and supply analyses, the assistance available through use of high speed computers, as well as development of systems analysis, employing mathematical models and simulation techniques was found to be extremely valuable. Mathematical models for the Connecticut River Basin have been developed and reported upon in Appendix C and D. It should be noted that system analysis is the terminal process in planning. That is, all other separate analyses must be done first, whether for integration on high speed digital computers, or through use of linear programming, or simply through use of past procedures. However, the flexibility available through systems analysis programs has permitted us to run numerous trials; change variable inputs, and explore alternatives that would not otherwise have been possible in terms of manpower and time.

CHAPTER V

Section 2 - Water Resources Needs and Problems

A. General

To determine the need for additional development and management of water resources in the basin, the study investigated the present status of each water resource element such as water quality, flood damages, water supply, municipal and industrial, electric power, including power cooling, navigation, outdoor recreation, including fish and wildlife, conservation and land management, open space, mineral resources, solid waste, flow augmentation, flow regulation, and health aspects. Concurrently, the present demands and future demands for each resource area were ascertained by analyzing present and projected population and use trends. Both quantity and quality of resources were examined to determine their adequacy to meet identified needs. The difference between demand and supply was then identified as the need. The following are need requirements as assessed for these respective water resource uses.

B. Pollution and Water Quality Control

Frequent references to land pollution generally relate to concern over solid waste disposal, particularly as produced from urban centers, and the use of fertilizers; pesticides; herbicides and sediment from erosion of land. Farm animal waste comprises the largest solid waste problem not generally handled at the municipal level. The daily waste from a herd of only 200 cows compares with the domestic waste from a community of 3,300 people. Waste from feed lots are additive sources of agricultural pollution. The increasing number of animals and modern automated techniques of raising them contribute to the worsening pollution of waters by animal wastes. The current use of both organic and inorganic fertilizers contributes to the nutrient enrichment of streams and ponds. An early stage of eutrophication in certain areas indicates the need for planning to reduce this problem and to avert its occurrence in other areas. The use of pesticide treatment on the land has also become a measurable problem in the basin. In two areas of the Farmington River Subbasin the amounts of pesticides evidenced in the period from 1959 to 1963 averaged, over the five-year period, in the range of 0.8 lbs/acre to 2.7 lbs/acre of DDT and from 0.87 lbs/acre to 12.4 lbs/acre of total pesticides. These figures are based on the use being

POLLUTION PROBLEMS

BURNING DUMP POLLUTING INLAND WATERS

FISHKILL

OPEN DUMP - ESTUARY

SEWAGE OUTFALL

Courtesy USFWQA

spread over the entire watershed above the sampling points and, therefore, do not reflect the concentrated use on agricultural lands only.

The use of herbicides, in the basin, by homeowners, as well as agricultural interests is known, however, the extent of this use is unknown. Table V-9 shows the maximum range of two nutrients as measured in 1963 and the maximum concentration of three hard pesticides as monitored in several years of the middle 1960 s at three stations on the Connecticut River.

TABLE V-9
MAXIMUM CONCENTRATIONS OF NUTRIENTS AND PESTICIDES
CONNECTICUT RIVER BASIN

Substance	Unit	Wilder, Vt.	Northfield, Mass.	Enfield, Conn.
Ammonia-Nitrogen	mg/l		0.3	1.0
Phosphates	mg/l	0.0	0.2	0.7
DDT	ug/l	0.000	0.000	0.005
Dieldrin	ug/l	0.003	0.017	0.016
Endrin	ug/l	0.000	0.025	0.000

The danger to water bodies from the uncontrolled use of fertilizer, pesticides and herbicides is evident. Further, the rapid rate of their use in the last decade is cause for alarm. A need exists to prepare future plans for their use, or withdrawal from use so that the waters of the basin will best serve mankind.

Water Supply

Water supply, whether municipal or industrial, is directly affected by pollution and water quality control. The water supply resources competes, along with the traditional development trends of the population, for whole watersheds. Historically, and because of smaller populations, less land consumption, slower living modes, and patterns, water supply has met with success in this competition. Large and small watersheds on the local level have been set aside by the action of the State legislatures and in some instances, has required the relocation of small population centers. Such methods have sustained consistently superior levels of water quality for water supplies. However, increased demands upon the yield from present systems and projected demands as shown in paragraph D of this Section indicates that new sources of supply will, in their raw water state, be of lower quality than is generally encountered today. Increased use of treatment facilities will be needed to extract pollutants both suspended and in solution, together with greater safeguards for public health. In general increased unit cost to the user is likely. In 1963, municipal supplies for consumption within the basin were 15% untreated with 25% receiving disinfectant only. The remaining 60% received a higher degree of treatment.

Water Quality Standards

The basin States have adopted water quality standards for most of the rivers in the Connecticut Basin. These standards, which are legally enforceable, specify water use goals for each part of the basin; the minimum physical, chemical, and biological criteria to sustain these uses; and implementation schedules for the construction of waste treatment facilities and other measures required to meet the standards.

The Secretary of the Interior has approved the standards for interstate waters with certain exceptions to be resolved. The implementation schedules established by the basin States provide for completion of secondary treatment facilities in Connecticut and Massachusetts by 1972 and 1974, respectively. The plans submitted by Vermont and New Hampshire provide for construction of a mixture of primary and secondary plants by 1970 and 1977, respectively. The Secretary of the Interior has not yet approved certain parts of these implementation plans but the exceptions are under continuing negotiations. The water quality standards serve as a basic statement of water quality goals, and constitute the primary legal means of determining if the quality of a given body of water is adequate and what improvements in quality are required.

Projected Waste Loads

To determine the need for further water quality control measures in the basin, waste loadings were estimated for 1960 and projected through 2020. Industrial wastes were projected using the growth in productivity and employment, and municipal wastes using population projections modified by the increasing numbers of those with sewerage connections. Table V-10 displays liquid waste generated in the Connecticut River Basin in 1960 and the projected levels for 1980 and 2020. The waste loadings are expressed in pounds of five-day biochemical oxygen demand (BOD) discharged each day and in population equivalents (PE) before treatment (B/T) and that entering the receiving stream after treatment (A/T). The five-day biochemical oxygen demand test measures the potential of waste material to reduce the dissolved oxygen cont of water and is thus an in icator of waste quantity. The 1980 and 2020 loads assume 85% removal biodegradable material for all wastes.

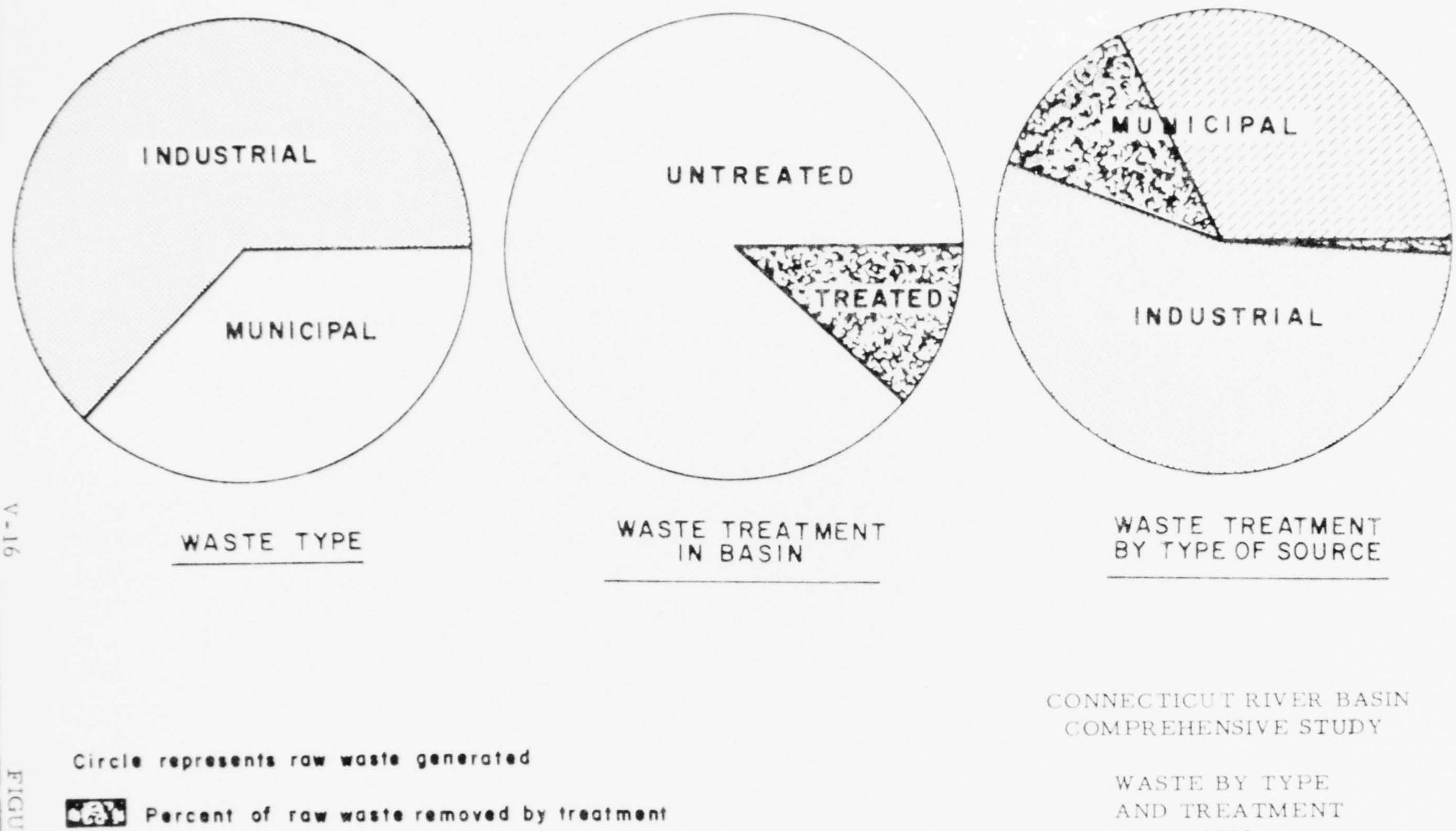
TABLE V-10
1960 AND PROJECTED LIQUID WASTE LOADING
BEFORE AND AFTER SECONDARY TREATMENT
CONNECTICUT RIVER BASIN

	1960	1980	2020
Pounds-BOD_5/Day-B/T	482,000	772,000	1,570,000
PE-B/T	2,840,000	3,860,000	6,280,000
Pounds-BOD_5/Day-A/T	424,800	115,895	235,940
PE-A/T	2,500,000	578,000	942,000

As reflected in Table V-10 the residents and industries of the Connecticut River Basin generated a total raw waste load in 1960 equivalent to 482,000 pounds of BOD. Of this loading, roughly 12% was removed through waste treatment facilities: 11% through primary treatment; and an additional 1% by secondary treatment. On this basis organic wastes approximating 424,000 pounds of BOD_5 were discharged daily into the waters of the basin in 1960, equivalent to the untreated waste from a population residing in the basin in 1960. Approximately 63% of this waste load was contributed by industrial plants which discharged directly to the basin's waterways. The remaining 37% was contributed by municipalities and by industrial waste sources which discharged through municipal sewerage systems. Figure V-2 indicates Type and Treatment for 1960 basin waste loads.

TABLE V-11
SEWAGE TREATMENT IN 1960
CONNECTICUT RIVER BASIN

	B/T PE	Treated PE	A/T PE
Municipal	1,250,000	320,000	93,000
Industrial	1,590,000	20,000	1,570,000
Total	2,840,000	340,000	2,500,000



CONNECTICUT RIVER BASIN
COMPREHENSIVE STUDY

WASTE BY TYPE
AND TREATMENT
1960

FIGURE V-2

For study purposes it is assumed the implementation of secondary or equivalent treatment will provide 85 percent removal of BOD_5 throughout the basin by 1980 and through 2020. This is considered a conservative minimum since removal of 90 percent are commonly obtained in actual practice. Table V-12 shows the population equivalent of the generate loadings (B/T), the treated portion and the projected load entering basin streams after secondary treatment for both municipal and industrial wastes.

TABLE V-12

PROJECTED WASTE LOADS
CONNECTICUT RIVER BASIN

	Municipal PE	Industrial PE	Total PE
1980-B/T	1,860,000	2,000,000	3,860,000
-Treated 1/	1,581,000	1,700,000	3,281,000
-A/T	270,000	300,000	579,000
2020-B/T	3,670,000	2,610,000	6,280,000
-Treated 1/	3,120,000	2,218,000	5,338,000
-A/T	550,000	392,000	942,000

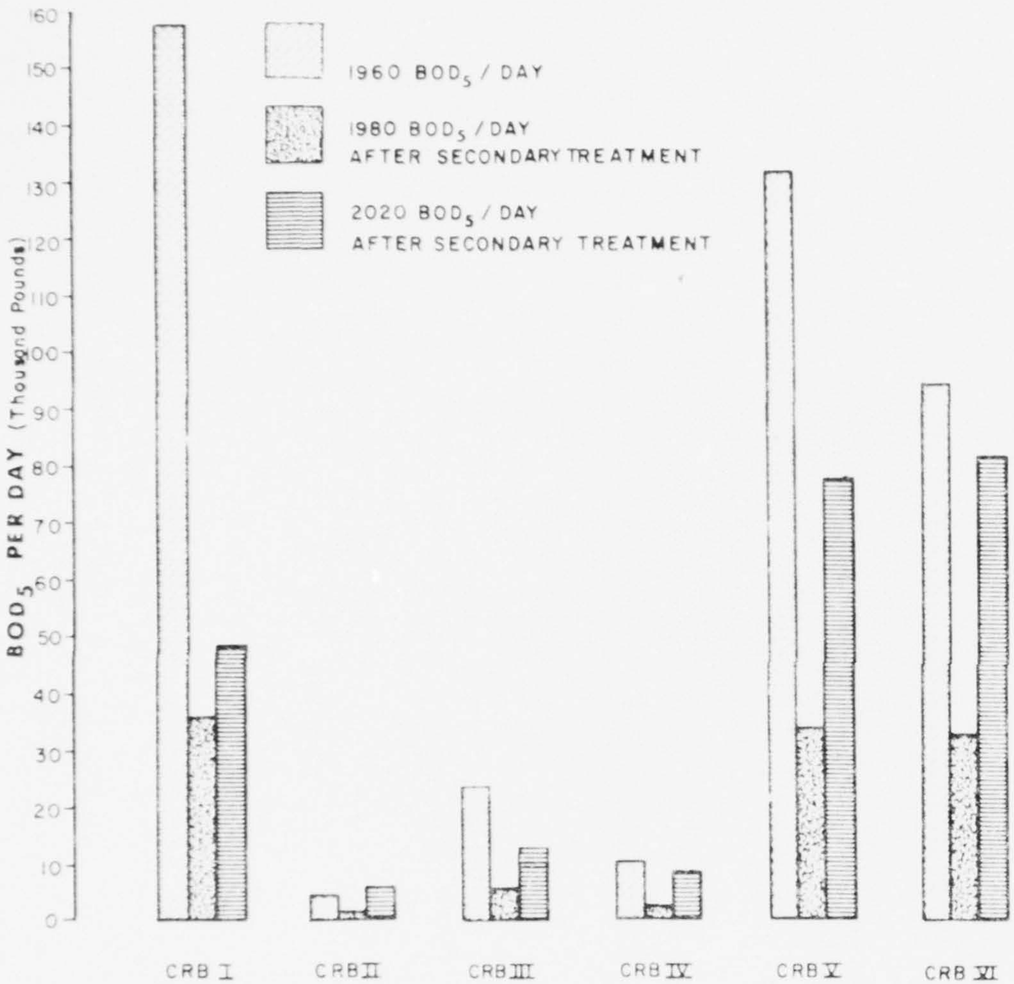
1/ Secondary treatment w/85 percent BOD_5 removal.

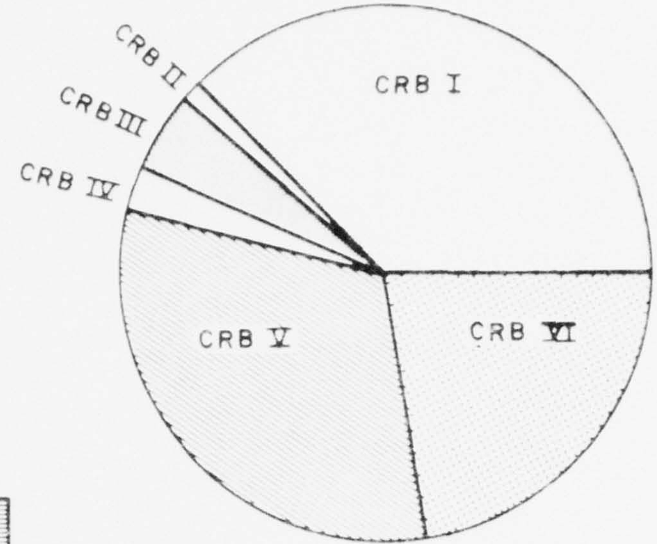
Figure V-3 presents a distribution of the 1960 waste load through the basin's subdivisions and shows projected loadings after secondary treatment.

Water Quality Criteria

Criteria normally used to indicate levels of water quality relate to dissolved oxygen, floating matter, color, turbidity, taste, odor, pH, bacteria, temperature, radioactivity and chemical constituents including nutrients (phosphorous and nitrogen compounds). Secondary treatment, if preceded by pre-treatment measures where required for industrial wastes and followed by disinfection, is normally sufficient to meet criteria for most wastes where flow is substantial. The main exceptions being dissolved oxygen and nutrient levels.

The water quality standards for the basin states, with the exception of Massachusetts, do not contain numerical criteria for nutrient





SUBBASIN DISTRIBUTION

1960
SUBBASIN DISTRIBUTION

Circle represents waste discharged

CONNECTICUT RIVER BASIN
COMPREHENSIVE STUDY

1960 WASTE LOADS
AND
PROJECTIONS
(AFTER SECONDARY TREATMENT
BY
BASIN SUBDIVISION

FIGURE V-3

levels. Specific dissolved oxygen levels for each use classification are, however, contained in all the State standards. For this and other reasons, the level of dissolved oxygen has been used throughout the study as the best single indicator of water quality after wastes have received secondary treatment or its equivalent.

Since organic wastes create a biochemical oxygen demand, reduced levels of dissolved oxygen in water strongly indicate the presence of organic waste matter.

An adequate level of dissolved oxygen is necessary to obtain a suitable fish and aquatic habitat. The control of certain characteristics of a water supply, such as taste and odor problems is easier if the water contains sufficient dissolved oxygen. Although a high level of dissolved oxygen is not required for beneficial uses such as recreation and aesthetic enjoyment low levels can result in septic conditions and obnoxious odors. Also, a poor fish and aquatic habitat make recreation and aesthetic pursuits less attractive. An adequate level of dissolved oxygen, therefore, is a characteristic necessary for some uses, desirable for others, and the most suitable available indicator of water quality. In addition, the relationship between dissolved oxygen and biodegradeable waste loads can be represented and munipulated mathematically.

A criteria of 5.5 milligrams per litre (mg/l) of dissolved oxygen was chosen for the study to test water quality throughout the basin. It is emphasized that this DO study criteria is merely an approximation and should not be construed to be the DO level required under the standards which vary in some cases between states and water classes.

Dissolved oxygen levels, assuming secondary treatment, were mathematically simulated throughout the basin for estimated 1980 and 2020 loading conditions. The dissolved oxygen profile of the mainstem of the Connecticut River, shown in Figure V-4, is typical example. The results of these simulations show the minimum dissolved oxygen criteria of 5.5 mg/l would not be met in many of the basin's streams. These critical areas are listed in Table V-13.

Water Quality Needs

The basinwide study of dissolved oxygen shows that the effect of pollution in one part of the basin, though perhaps not sufficient to violate the criteria in that part of the basin, contributes to water quality problems at distant downstream locations. A high degree of treatment throughout the basin is, therefore, indicated. For the design

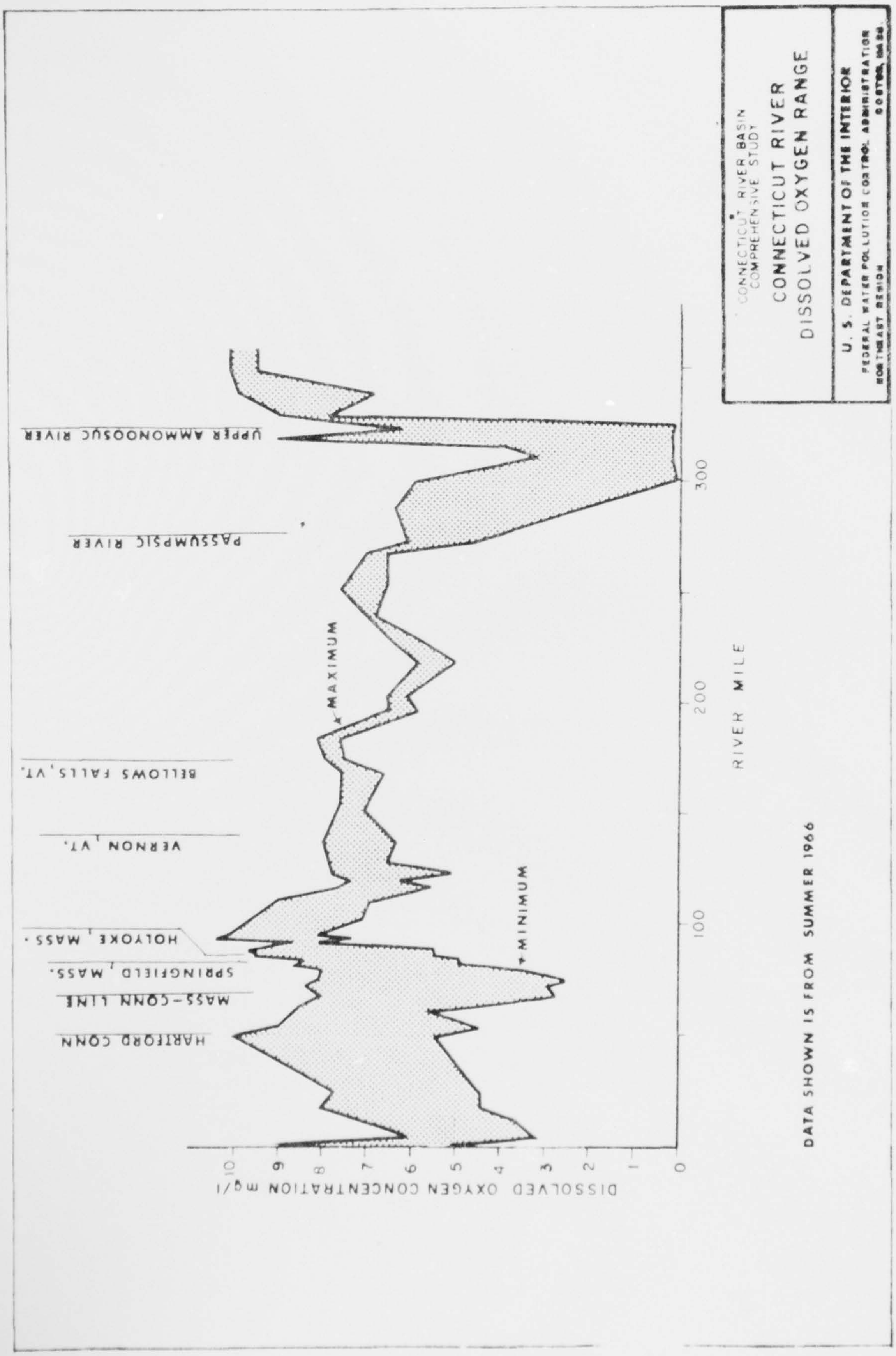

CONNECTICUT RIVER BASIN
COMPREHENSIVE STUDY
CONNECTICUT RIVER
DISSOLVED OXYGEN RANGE
U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION BOSTON, MASS.
DISSOLVED OXYGEN CONCENTRATION mg/l
RIVER MILE
DATA SHOWN IS FROM SUMMER 1966
MAXIMUM
MINIMUM
HARTFORD CONN
MASS-CONN LINE
SPRINGFIELD, MASS.
HOLYOKE, MASS.
VERNON, VT.
BELLOWS FALLS, VT.
PASSUMPSIC RIVER
UPPER AMMONOOSUC RIVER

FIGURE V-4

period of the present generation of treatment facilities, which would end around 1995, a minimum basic level of secondary treatment, supplemented when necessary to achieve water quality standards, is recommended. It sets an entry standard with which all must comply on equal terms if they are to use the river as a public resource for waste accumulation; it minimizes equity and jurisdiction problems associated with the assignment of varying degrees of treatment in different parts of the basin, and provides a minimum degree of protection for the resource that is commensurate with readily available technology.

Further measures beyond secondary treatment will be needed to meet the dissolved oxygen goals and other water quality criteria, including control of nutrient levels, in some areas. The criteria may be achieved by: (a) increasing the degree of treatment; (b) artifically raising the flows during low flow periods; (c) diverting waste water effluent to another receiving stream large enough to handle it; or a combination of the above.

The first mentioned measure involves treatment beyond the secondary level, termed advanced waste treatment. It involves increasing the BOD removal beyond the 85-90 percent level nutrient removal and other procedures dependent upon the nature of the waste water to be treated. The second possibility, artifically raising the flows during low flow periods, is called flow augmentation. This measure can be achieved through drawing water from new or existing upstream storage facilities and involves, in general, re-regulation of the river. The third measure that of relocating the point of discharge of a treated waste water, can be useful where the problem exists on a smaller tributary area and an alternate larger receiving stream is nearby.

Where more than secondary treatment is required, therefore, a second major need is to determine the right combination of advanced waste treatment processes, flow augmentation and/or alternate treatment plant locations and discharge points. Data, presented in Appendix D, has been prepared to show the relationships between advanced waste treatment and varying flow regimes for critical areas. This has served as the basis for providing flow augmentation in some of the reservoir projects recommended in the basin plan.

Further study will be needed as specific detailed water quality management plans are formulated in the basin to examine the costs and benefits of alternate advanced waste treatment processes, locations of facilities and the role of flow augmentation. Since pollution

TABLE V-13

AREAS OF BASIN WITH DISSOLVED OXYGEN LESS THAN 5.5 mg/1

UNDER LOW FLOW CONDITIONS[1]

River	Reach[2]	Time Frame and Magnitude of Deficiency 1980	2020
Connecticut	Upper Ammonoosuc River to Ammonoosuc River	Major-Moderate	Major-Moderate
	Ammonoosuc River to White River	Minor	Moderate
	Westfield River to Rte. 91 (Conn.)		Minor
Ammonoosuc	Littleton, N. H. to Mouth		Minor
Sugar	Claremont, N. H. to Mouth		Moderate
Black	Ludlow, Vt. to Springfield, Vt.		Moderate
	Springfield, Vt. to Mouth	Moderate	Major
Ashuelot	Keene, N. H. to Mouth	Moderate	Major
Otter	Gardner, Mass. to Mouth	Major	Major
Millers	Winchendon, Mass. to Otter River	Moderate	Major
	Otter River to Orange, Mass.	Moderate	Major
North	Colrain, Mass. to Mouth	Major	Major
Green	Greenfield, Mass. to Mouth	Minor	Moderate
Deerfield	Charlemont, Mass. to Mouth	Moderate	Moderate
Quaboag	Seven Mile R., Spencer to E. Brookfield R.	Major	Major
	Palmer, Mass. to Mouth	Minor	Moderate

TABLE V-13(Continued)

River	Reach[2]	Time Frame and Magnitude of Deficiency 1980	2020
Ware	S. Barre, Mass. to Mouth	Major	Major
Chicopee	Ware River to Indian Orchard, Mass.		Minor
	Indian Orchard, Mass. to Mouth	Moderate	Major
Westfield	Woronoco, Mass. to Little River	Minor	Moderate
	Little R. to West Springfield, Mass.	Minor	Moderate
	W. Springfield, Mass. to Mouth		Moderate
Little	Stevens Dam to Mouth	Major	Major
Farmington	Still River to Pequabuck River	Minor	Moderate
	Pequabuck River to Salmon Brook	Minor	Moderate
	Salmon Brook to Mouth		Moderate
Pequabuck	Plainfield, Conn. to Mouth	Major	Major
Hockanum	Manchester, Conn. to Mouth	Major	Major

1. Based on assumed July temperature and 7-day low flow with 10-year return period.

2. Designation of a deficient reach denotes that deficiency is projected to occur within reach and not that entire reach is deficient.

abatement involves a rapidly changing technology as well as changes in the assimilative capacities of receiving waters, the selection of future alternates can be based on better and better information as new treatment facilities are constructed and their effect on stream characteristics and water quality is evaluated. These evaluations must include the effects on all water quality parameters, including nutrients, viruses, new exotic wastes and aesthetics.

Water quality management alternates must also be evaluated with respect to all water resource and related land uses. Choices must take full advantage of multiple-purpose opportunities and carefully weigh the degree to which they reinforce or detract from the various uses and needs that are to be supported within the basin.

In addition to the above general water quality management needs, certain specific needs where special efforts are required should be mentioned. These are:

(1) Improved control of combined sewer and storm water discharges is required in highly urbanized areas of the basin to prevent degradation during high rainfall periods. Intense rainstorms in these areas result in the periodic discharge from these systems of solids and bacteria. The frequency and unpredictability of these discharges requires that swimming be prohibited and water uses restricted. The costs of preventive measures, however, are high and at the present time efforts to correct the problem are sporadic although an increasing amount of research is being done. In the final analysis, it appears careful and detailed investigation of each individual system is required to determine the relative costs and benefits of intermediate corrective measures as compared to complete treatment of the discharges.

(2) Surface runoff from rural and urban watersheds brings a variety of pollutants to the river which also affect water uses. Eroded soil particles increase turbidity, oil scums create hazardous and unsightly conditions, organic and inorganic fertilizers contribute to nutrient enrichment, herbicides and pesticides can cause both immediate and accumulative toxic effects, and with the trend towards larger dairy herd concentrations, farm animal waste disposal is a growing problem. In addition, street litter and improperly disposed solid waste can be washed into streams or affect water quality by leaching action. The relative seriousness of these problems and the actions by which they can be best controlled require further investigations. Solutions are most likely to be found in the areas of soil conservation and land management, subdivision regulations, construction practices, spraying restrictions and controls improved solid waste

disposal and technological advances. Numerous public and private interests are currently involved in these problems and are meeting with some success. A major obstacle, however, is the tremendous diversity and number of sources there by making surveillance and policing action extremely difficult. While Federal and State agencies can provide technical assistance and some enforcement activity, enlightened and responsible action by individuals and local authorities is essential for proper control.

(3) Another source of sediment which can affect the stream biota by hindering light penetration and covering valuable food areas and spawning zones are eroding stream banks. Increased turbidity also degrades aethestic and recreational uses of the river. An evaluation of the degree to which water uses are impaired and the need for bank stabilization practices are required for water quality as well as land preservation purposes.

(4) Slow moving waters behind dams allow large volumes of solids to settle and accumulate on the reservoir bottom. Where the dams are located below major effluent sources, these deposits often contain a high percentage of organics and create a continuing oxygen demand on the overlying waters. In some cases these sludge lands so deplete oxygen levels that anaerobic decomposition occurs under septic conditions and obnoxious odors are given off which affect wide areas.

With improved treatment, the supply of organics will be greatly reduced and some of the present deposits may ultimately be removed during flood periods. New deposits, some of which will be fr from natural causes and other different sources, cannot, however, be entirely eliminated and many existing sludge lands will remain. The severity of this problem and the need for corrective measures cannot be accurately predicted at this time. Future needs, however, may require remedial action such as removal of the deposits or covering them with sand or other inert material.

(5) Thermal discharges, primarily from thermal electric generating stations, result in increased river water temperature at several locations along the Connecticut River. Further expansion without control, will cause an increase in the amount of thermal energy that is dissipated in the water, and the length of river affected by it. Problems associated with thermal discharges are varied. Raised water temperature increases the metabolic rate of aquatic organisms which

in turn raises their dissolved oxygen needs. Simultaneously higher temperatures decrease the availability of oxygen in the water. Adverse combinations of oxygen and temperature can cause death, poor reproduction, retarded development and disease in varying degrees in different species. The same adverse combinations also inhibit the river's waste assimilative capacity and require higher waste treatment costs to achieve a given water quality standard.

The largest user of cooling water, the electric utility industry, will experience the largest burden in preventing thermal problems. These burdens, mainly monetary rather than technical, are expressed in Table V-14 showing a comparison of thermal plan cooling systems. In recognition of the problem, the power companies are conducting environmental studies in the vicinity of nuclear plant sites at Vernon, Vermont and East Haddam, Connecticut. Major cooling facilities to reduce the amount of heat discharged to the river are also included at the Vernon plant. Currently, available information from the environmental studies is not conclusive. Some temperature effects on the biota have been observed, but these have not been thought to be cause for serious concern at the present time.

A recent investigation by the University of Connecticut in the vicinity of the Connecticut Yankee plant at East Haddam documents several biological shifts which may or may not be due to the power operation. One of the shifts is a tremendous increase in the number of phytoplankton which, through photosynthesis action, are contributing to wide daily fluctuations in dissolved oxygen levels. This phenomenon also occurs elsewhere in the river. There is, however, a possibility that heat, along with nutrient enrichment, added in the estuary and at upstream points acts as an additive stimulant or trigger to this excessive biological growth which depletes oxygen levels in the river at night and on overcast days.

The cause of this and other possible environmental effects are usually not the result of one force which can be pinpointed, but stem from a combination of natural and man-made factors. Further investigations are needed to better understand and predict these interactions and to better determine where and what corrective measures are required. These investigations must consider the accumulative effects of all thermal and all waste discharges within the basin, and ways of planning and implementing coordinated action among all responsible parties. In the absence of more exact information and reliable prediction techniques, the water quality standards will provide the primary control on the amount of heat that may be discharged to the basin.

VERMONT YANKEE NUCLEAR POWER STATIONS UNDER CONSTRUCTION AT VERNON, VERMONT

Courtesy NEPCO

TABLE V-14

COMPARISON OF THERMAL ELECTRIC COOLING SYSTEMS

Parameter of Comparison	Once Through Fresh Water	Once Through Estuary-Marine	Cooling Lake	Cooling Tower Wet Natural Draft	Cooling Tower Wet Mechanical Draft	Cooling Tower Dry-Natural or Mechanical Draft
First Cost	Lowest	Moderate	High	Higher	High	Highest
O & M Cost	Lowest	Moderate	Moderate	Moderate	High	Highest
Efficiency	Highest	High	Low	Low	Low	Lowest
Consumption	Low	Low	Moderate	High	High	None
Aesthetics	Neutral	Neutral	Good	Poor	Very Poor	Extremely Poor
Environmental Effects	Many	Many	Few	Moderate	Many	Few
Multi-purpose Use	Minor	Some	Many	None	None	None
Average Cost Incremental from Once thru Fossil $/KW	0	1.00	2.50	5.00	4.00	27.00
Average Cost Incremental from Once thru Nuclear $/KW	0	1.50	3.50	7.00	5.50	35.00

C. Flood Damages

The Connecticut River Basin has experienced numerous floods in the recorded past, several of which have taken the lives of basin residents and brought huge financial burdens to bear upon them. A summary of experienced losses from four of the most disasterous floods is shown in Table V-15

TABLE V-15
FLOOD LOSSES OF FOUR HISTORIC EVENTS
CONNECTICUT RIVER BASIN

Date of Event	Number of Lives Lost	Reported Monetary Damage
November 1927	21	$ 29,000,000
March 1936	11	66,400,000
September 1938	8	48,600,000
August 1955	34	119,000,000

A recurrence of the flood of record (March 1936) without the existing flood control system, would produce monetary losses in the amount of $223 million with untold death and suffering.

After the 1936 flood the Congress of the United States directed the Corps of Engineers to develop plans for flood control protection for those areas of the country that had been devastated that spring. The Connecticut River Basin was one of these areas. The first comprehensive flood damage reduction plan for the Connecticut River Basin was submitted to and approved by Congress in 1938. This plan consisted of a system of 20 flood storage reservoirs with 10 alternative sites which would control 25% of the basins' drainage area above Hartford and to be supplemented by local protection works at the more important damage centers. The supplemental local protection works, with their design elevations predicated upon the completed reservoir system, have been constructed, however, only seven of the 20 reservoirs authorized in the 1938 plan have been built and not one of the alternates specified in the 1938 plan has been constructed.

On several occasions, since 1938, the system of reservoirs, as authorized, has been modified. For example, seven of the reservoirs have been dropped from the authorized list. In 1941 the Sugar Hill site

MARCH 1936 FLOOD AT WEST SPRINGFIELD, MASSACHUSETTS LOOKING EAST OVER THE WEST SPRINGFIELD RAILROAD YARDS. (PRIOR TO CONSTRUCTION OF LOCAL PROTECTION WORKS.)

Corps of Engineers Photo

on the Ammonoosuc River was specifically substituted for Bethlehem Junction authorized in the 1938 Plan. In 1944, Sugar Hill was deleted in favor of an unspecified alternate in the Ammonoosuc River Basin.

The Newfane-Williamsville site on the West River was replaced with an eight- reservoir complex in 1944 which in 1954 was replaced by three sites. Six additional reservoirs were authorized in the 1941 through 1954 period.

Studies following the great lower-basin tributary flood of 1955 resulted in the authorization of five additional sites in the lower basin area and in 1968 the Beaver Brook project was authorized for construction in the New Hampshire portion of the Basin.

In summation there are at present twenty-seven specified and one unspecified (alternate to Sugar Hill on the Ammonoosuc River) authorized reservoir projects in the Connecticut Basin, and of this number 16 have been constructed. Five of the constructed projects, those authorized after the lower-basin tributary flood of 1955, were designed to meet tributary flood control needs and have limited effect on the Connecticut River main stem. The Beaver Brook project will also meet a local need, when constructed.

The eleven constructed flood control reservoirs, designed for maximum flood water stage reduction at the major main stem damage centers, control 1,370 square miles or 12.9% of the watershed above Hartford. The additional five constructed reservoirs, designed primarily for tributary protection, control and additional 200 square miles for a total controlled area equalling 14.8% of the basin above Hartford. The control of 25% of the drainage above Hartford was the design criteria used to size the dikes and walls which protect the major damage centers. Floods of lesser magnitude than the design flood could overtop the dikes and walls and would produce enormous damages and additional potential loss of life.

The need is very great to control an additional 10% of the basin's drainage area above Hartford, or to consumate alternative means of giving the originally planned degree of protection to the locally protected area. The existing threat of overtopping must be eliminated.

In 1953, in enabling legislation directing the four Connecticut Basin States of Massachusetts, Connecticut, New Hampshire and Vermont to enter into an interstate agreement called the Connecticut River Flood Control Compact. The 25% drainage area control thesis is in the legislation explicitly prescribed to and continued support with regard to this extent of control through storage has been received from the Connecticut River Valley Flood Control Commission, the agency responsible for the administration of the compact.

Due to the placement, within the basin of the principal damage centers--primarily located on the main stem of the river between the Hampshire-Franklin County line in Massachusetts and the natural downstream control at Bodkin Rock in Middletown, Connecticut--maximum dollar reduction of main stem damages per unit of storage occurs with the point of storage located in the vicinity of the Hampshire-Franklin County line. The configuration of the basin near this county-line and the existing state of development and use of this area prohibits serious consideration of flood storage at this point. However, reaching into the major tributaries above this point the need to control an additional 10% of the river's drainage area above Hartford may be met. Existing natural average-annual losses along the main stem of the Connecticut River are estimated to amount to $15.9 million.

Existing and substantial losses also accrue to the major tributaries within the basin. Certain built-up areas along these tributaries have been severely damaged by the floods of record and although some of these areas have been given considerable protection by some of the recently constructed reservoirs on lower-basin tributaries there still exist areas of substantial potential loss.

Eight local protection projects of varying sizes have been constructed along tributaries of the Connecticut River and four additional projects are either authorized or were approved as small flood control projects without need for specific authorization by Congress. Project authorization recently expired for a local protection consideration in Westfield, Massachusetts as project assurances by local interests had been withdrawn although the project had been considered feasible, justified and needed by the Corps of Engineers. One of the above mentioned four additional projects, that at Ludlow, Vermont on the Black River tributary, is not considered feasible or needed at this time; however, there is definite need for the projects along the Park River in Hartford, Connecticut in St. Johnsbury, Vermont along the Passumpsic River and on the White River in Hartford, Vermont. There are additional local losses in the basin and there is need to consider upstream storage or direct protection to reduce this damage. Existing natural average-annual losses in the downstream tributary reaches of the Connecticut are estimated to amount to $7.6 million.

The flood plains of the basin, the rivers' natural extensions on each side of the normal watercourse, have long been the scene of man's most concentrated economic growth. Because of the ease of construction and the nearness to man's most needed and useful resource- water-

WINSTED, CONN. - INUNDATION OF MAIN STREET DURING THE RECESSION OF THE AUGUST 1955 FLOOD

Courtesy USDA - SCS

WINSTED, CONN. - DEVASTATION OF THE SAME AREA OF MAIN STREET, AFTER THE MAD RIVER WENT ON ITS RAMPAGE

Corps of Engineers Photo

the cities and towns grew fastest on the very lands nature provided to handle excess river flows, lands carved from the hills by the excess flows themselves. These lands, or those that remain largely undeveloped, might best be zoned and managed as flood plains, allowing only those activities which would not suffer significant flood losses when inundation occurred. There is need to prepare plans for flood plain management in those main stem and tributary reaches where the extent of existing development will not be stifled by this zoning and management.

Existing undeveloped flood plain lands often include areas of important natural resource values which are not ruined by occasional inundation. The flood storage available at these points are of value in that removal of a significant amount of such lands from this use of natural flood storage would increase the present needs for additional artificial flood storage via reservoirs to beyond the 10% control of the drainage area above Hartford, Connecticut as expressed earlier.

In a design flood, slightly larger than that of March 1936, the existing flood storage, in natural flood plain areas along the lower main stem, would amount to almost 800, 000 acre-feet, principally in the reaches from Middletown to the dam at Enfield, Connecticut and from Holyoke to Montague in Massachusetts. This volume is half again greater than the total storage available at the 16 existing flood control reservoirs in the basin.

The existing natural average-annual flood losses in the Conecticut River Basin estimated at $23. 5 million ($15. 9 million main stem--$7. 6 million tributary) is conservatively projected to reach $25. 8 million by 1980. This projection, approximating an annual growth rate of 1%, is arrived at without discounting the future losses as its purpose is to indicate the flood control needs directly attributable to the year 1980. Future flood losses, for anticipated damages to be suffered beyond the year 1980, are discounted to show their worth in 1980. The projected 1980 value of the natural average annual flood losses for the 100-year period (1980 to 2080) are estimated to be $36. 1 million.

Average annual upstream floodwater and sediment damages are currently estimated at $2.1 million shown in the four basin States as follows: $0.7 million in New Hampshire; $0.8 million in Vermont; $0.5 million in Massachusetts; and $0.1 million in Connecticut.

D. Water Supply

Projections of municipal water use in New England in its entirety indicate that by the year 2000 requirements will be double the 1100 mgd as utilized in 1960. These projections of the Connecticut River Basin and based upon previous per capita consumption, as modified by current trends indicate that water use to meet municipal needs in the Basin will be two and one-half times the 178.6 mgd per day use level by the year 2000, 3.7 times as large in 2020. The Connecticut River basin's immediate water use i.e. 1980 is projected to be over half again as large as the 178.6 mgd used in 1960. TableV-16 displays the 1960 community water use by basin subdivision together with bench mark years; 1980, 2000 and 2020 respectively.

TABLE V-16

COMMUNITY WATER SUPPLY REQUIREMENTS
CONNECTICUT RIVER BASIN

Basin	Average Daily Requirement in MGD			
Subdivision	1960	1980	2000	2020
CRB I	4.2	5.9	10.1	15.6
CRB II	2.9	4.5	7.6	11.9
CRB III	7.5	12.1	20.9	34.9
CRB IV	5.4	10.0	17.0	26.5
CRB V	84.5	122.1	183.2	274.5
CRB VI	74.1	124.2	193.2	300.5
Total Basin	178.6	278.8	432.0	663.9

Existing municipal water supplies within the basin have been evaluated and a listing of the present minimum safe yields by basin subdivision is shown in Table V-17 as well as the additional supply increments necessary to meet the projected demands.

TABLE V-17

COMMUNITY WATER SUPPLY NEEDS
PRESENT MINIMUM SAFE YIELD & PROJECTED
ADDITIONAL SUPPLY
CONNECTICUT RIVER BASIN

Basin Subdivision	Minimum Safe Yield of Present Systems MGD	Additional Supply Increments by Bench Mark Year 1980	2000	2020
CRB I	4.4	1.5	4.2	5.5
CRB II	3.5	1.0	3.1	4.3
CRB III	6.4	5.7	8.8	14.0
CRB IV	11.9	--	5.1	9.5
CRB V	134.5*	--	48.7	91.3
CRB VI	86.8	37.4	69.0	107.3
Total Basin	247.5	45.6	138.9	231.9

*Does not include out of basin needs total which is greater than in basin total shown for this area of Massachusetts. For example, at present, MDC has developed facilities with a total "safe yield" of about 190 MGD within the basin which serves the Boston Metropolitan area.

While in basin subdivision IV and V have existing supplies which are adequate to meet internal 1980 needs, an early-action program will be necessary for out of basin diversion from Area V as well as in the remaining four subdivisions to meet the projected requirements. A substantial need is shown in subdivision VI one of the high growth areas of the basin in the State of Connecticut where programs are being planned by local municipalities to meet needs. New demands will be placed upon the basin's water supply capability through the presently considered additional diversions to Quabbin Reservoir which provide for a flood skimming operation from the rivers main stem which will not affect the existing minimum yield of the basin's streams for the basin's internal use. In this plan spring freshet flows in the Connecticut River in excess of 15,000 cfs (9700 mgd) of flow at Turners Falls would be diverted at a rate of 375 mgd to storage in Quabbin Reservoir. It is estimated that diversions would occur 70-80 days per year when this water is surplus and would otherwise flow unused to the ocean. The additional yield to the MDC system, on an average annual basis, would be 72 MGD. Flood skimming diversions would also have a negligible effect on future water supply plans of the State of Connecticut. If Connecticut should decide at some future date to use the main stem of the Connecticut River as a source of municipal water, adequate water volumes will be available to satisfy this need, even with all current and foreseeable diversions considered. Other diversions from the Connecticut Basin are made to meet the needs of Berlin and Newbury, New Hampshire and Ashburnham, Massachusetts. An industrial user in Fitchburg, Massachusetts is currently considering additional diversions in the Ashburnham area.

Whether the water use from the main stem is direct in-basin use for the Hartford or Springfield areas or out-of-basin supplement to water sources will govern the degree of treatment which must be provided upon withdrawal from the river. Direct in-basin use will require conventional water treatment, probably chemical coagulation, filtration, and disinfection or modifications thereof.

Privately supplied industrial water supply requirements within the Connecticut River Basin are projected to increase by 10% from 1960 to 1980, with an over-all increase from 1960 through 2020 of 42%. These increases do not include the water supply requirements of the mineral or thermal electric generation industries. Although projections of water use by the mineral industries are unavailable present use estimates were made of the sand and gravel and the stone industries. They account for over 99% of the mineral industries water use and in 1962 this estimated use was as shown by State in Table V-18

TABLE V-18
MINERAL INDUSTRIES WATER SUPPLY USE - 1962 IN MGD
CONNECTICUT RIVER BASIN

State	Sand & Gravel	Crushed Rock & Dimension Stone	Clay & Shale	Total
New Hampshire	2.14	--	0.005	2.15
Vermont	0.63	0.02	--	0.65
Massachusetts	6.97	0.20	0.013	7.18
Connecticut	2.40	0.39	0.059	2.85
Total	12.14	0.61	.077	12.83

Water requirements for thermal electric generation have been projected for 1980, 2000 and 2020. The estimated requirements are shown in Table V-19.

TABLE V-19
ESTIMATED IN-STREAM FRESHWATER USE
THERMAL ELECTRIC GENERATION
CONNECTICUT RIVER BASIN

YEAR	Cooling Water Requirement MGD
1960	1050
1980	1300
2000	3300
2020	6500

The remainder of the privately supplied industrial water supply requirements is shown in Table V-20. In the base year 1960, approximately 8% of the used water supply quantity was for boiler feed purposes, the remaining 92% is utilized equally between process uses, cooling and air conditioning. Future uses are not anticipated to vary significantly from these percentages.

TABLE V-20
PRIVATELY SUPPLIED INDUSTRIAL
WATER REQUIREMENTS
CONNECTICUT RIVER BASIN

Basin Subdivision	Average Daily Requirement in MGD		
	1960	1980	2020
CRB I	40.3	42.3	76.2
CRB II	4.4	8.6	21.6
CRB III	25.4	25.4	31.1
CRB IV	3.8	7.7	18.9
CRB V	106.8	115.0	158.6
CRB VI	145.9	160.9	153.3
Total	326.6	359.9	463.7

The sources of water for the municipalities and their industries are generally adequate to meet present needs. The good to excellent quality of these present sources pose few problems for the water supply managers.

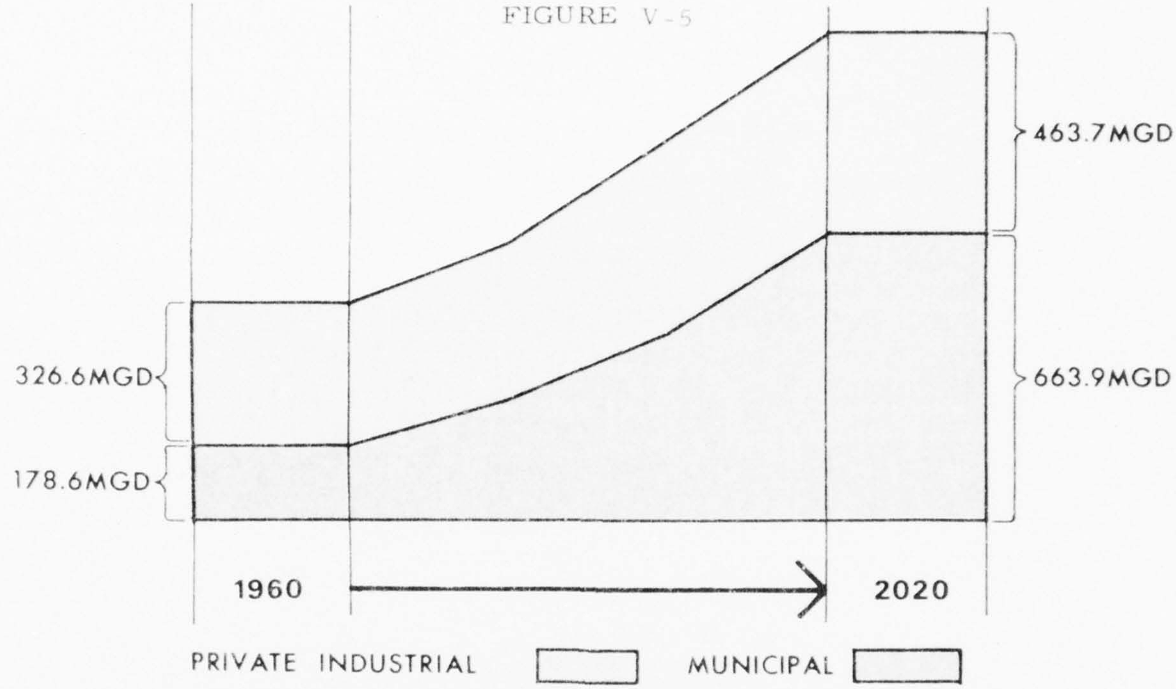
Problems may arise in the future when these present sources become overtaxed because of increases in both population and per capita consumption. This will necessitate going to other possibly less desirable sources, at least from a water quality standpoint. Water quality monitoring for water supply sources is becoming increasingly important.

Present water quality monitoring programs are aimed primarily at monitoring for pollution control, not future water supply (except for the monitoring program at Northfield by the Metropolitan District Commission of Boston). In order to determine what amounts of trace metals, algae, fish and organic material there are in the auxillary sources thus indicating necessary treatment, intensive year-round monitoring for these materials of all potential sources should begin.

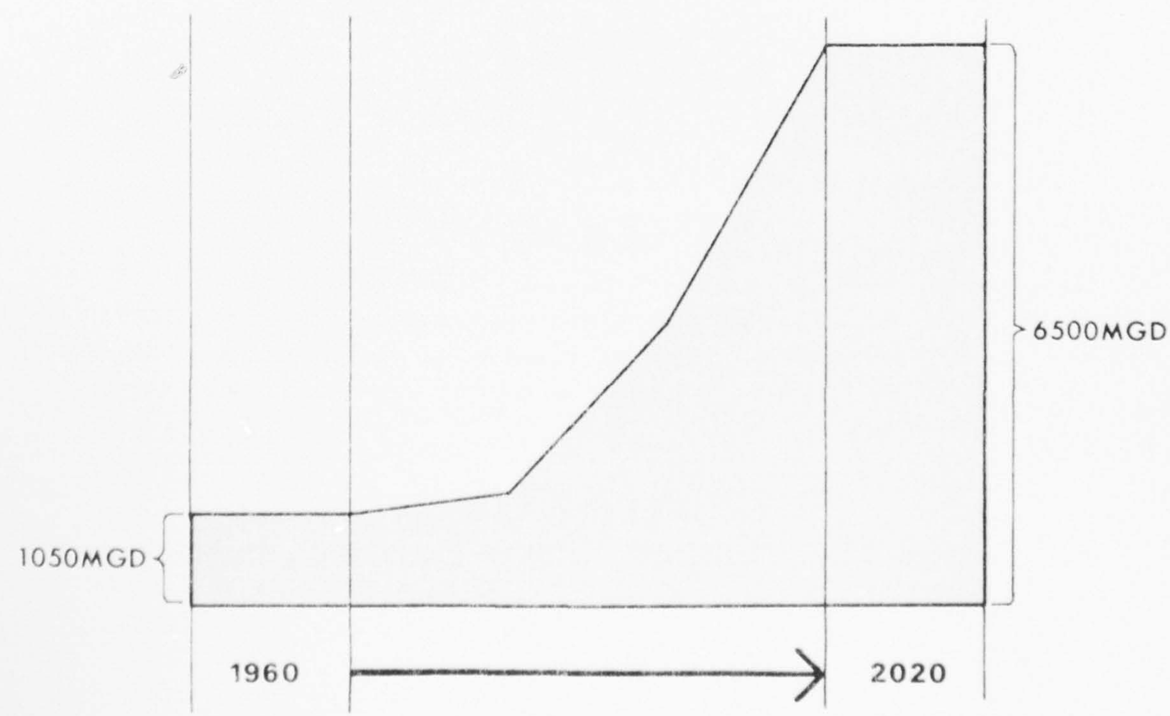
Future demands will necessitate the development and use of water supply sources not hitherto utilized. The generous yield from the basin's streams and aquifers present no serious problems with respect to future demand. Certain municipalities growth may be curtailed where the pattern of local water supply systems continues and the locality is in a tributary headwater reach. These problems could however, be surmounted by adequate regional planning and including recycling.

Figure V-5 graphically presents the present and projected municipal and industrial water supply needs in the Connecticut River Basin through the year 2020. Also presented in Figure V-5 is the estimated in-stream freshwater use for thermal electric generation cooling in the basin.

FIGURE V-5



INDUSTRIAL AND MUNICIPAL WATER SUPPLY REQUIREMENTS CRB
(NOT INCLUDING MINERAL INDUSTRY)



INSTREAM COOLING WATER REQUIREMENTS BY THERMAL ELECTRIC GENERATORS CRB

E. Electrical Power

Power requirements within the Connecticut River Basin are currently met by a group of utilities who are inter-connected throughout the New England Region and whose operations are coordinated to meet a common need. Power is, therefore, exchanged between existing systems, with 90% of the total energy required accounted for by these privately owned companies. The remainder is controlled in publicly owned systems which also purchase a substantial amount of power from the private sector. Until recently, the basin has been exporting peaking power, providing large blocks of power from the hydroelectric plants at Moore and Comerford, New Hampshire to markets as far south as Boston. In 1967 energy needs of the Connecticut River basin were approximately 10 billion kilowatt hours representing about 25% of the New England total. Peak demand was on the order of 2.5 million kilowatts. Now that the basin's own energy demand has increased, it consumes essentially what it produces although it still exports peaking power. In future years, the Basin will have to import energy, both baseload and peaking, in contrast to its historical export role.

Assuming the same rate of growth as the New England power market, basin energy requirements may be expected to soar to 23 billion and 200 billion kilowatt-hours in 1980 and 2020 respectively; with corresponding peaks in the order of 5 million kilowatts and 40 million kilowatts, respectively. It is estimated that Basin demands in 2020 will be far more than the Basin's available economic supply.

The electric power resources of the Connecticut River Basin are committed to assist in serving the load of all New England and because of the makeup of the power market area of the six states with its interconnections and power interchanges, the Connecticut River Basin power demand is not usually treated as a separate entity. As noted, the basin exports peaking power from its hydroelectric installations and will likely continue to do so in the near future. However, the basin will be depending more and more on baseload energy generated outside of the watershed. The following table reflects the estimated total power requirements for the entire market area together with that protion of the supply which is estimated to be provided by the resources of the Connecticut River Basin the locally provided supply also being shown on Figure V-6.

TABLE V-21

ESTIMATED TOTAL POWER REQUIREMENTS FOR THE NEW ENGLAND MARKET AREA (megawatts)

Required Generation for	1967	1980	2000	2020
	10,288	27,825	92,825	232,825

ASSUMED ALLOCATION OF POWER SUPPLY TO THE CONNECTICUT RIVER BASIN

	1967	1980	2000	2020
Conventional hydro	621	709	859	1,009
	(24%)	(12%)	(6%)	(4%)
Pumped Storage	--	1,600	3,600	5,900
	(0%)	(26%)	(25%)	(21%)
IC/GT	80	338	1,500	5,000
	(3%)	(6%)	(11%)	(17%)
Fossil steam	1,103	901	674	1,435
	(43%)	(15%)	(5%)	(5%)
Nuclear steam	785	2,498	7,500	15,000
	(30%)	(41%)	(53%)	(53%)
TOTAL	2,589	6,046	14,133	28,344
Total as % of market	25.2	21.7	15.2	12.2

In the past, the power required for the more or less constant base load was provided by fossil steam fuel plants. The intermittent surges or peak demands were provided by operation of conventional run-of-the-river hydroelectric plants. Due to the recent changes in technology, it is expected that nuclear powered steam plants will replace the traditional function of fossil-fuel plants, and pumped storage hydro-installations will supplant the earlier run-of-the-river hydroelectric plants. Such a shift in composition of the power system is evidenced in Table V-21 and in Figure V-6.

By the year 2020 the Connecticut River Basin will increase its power supply to 11 times 1967 capability, while conventional hydro declines from its present role of about 24% of the total power to 4% in the year 2020. Pumped storage will increase from 0% at present to 21% in the year 2020. Fossil-fuel steam plants which currently provide base generation capability will similarly be affected. They are expected to decline from 43% of the total power capacity to 5% in the year 2020 while during the same period, nuclear fuel plants will increase from 30% of the present capacity to 53%.

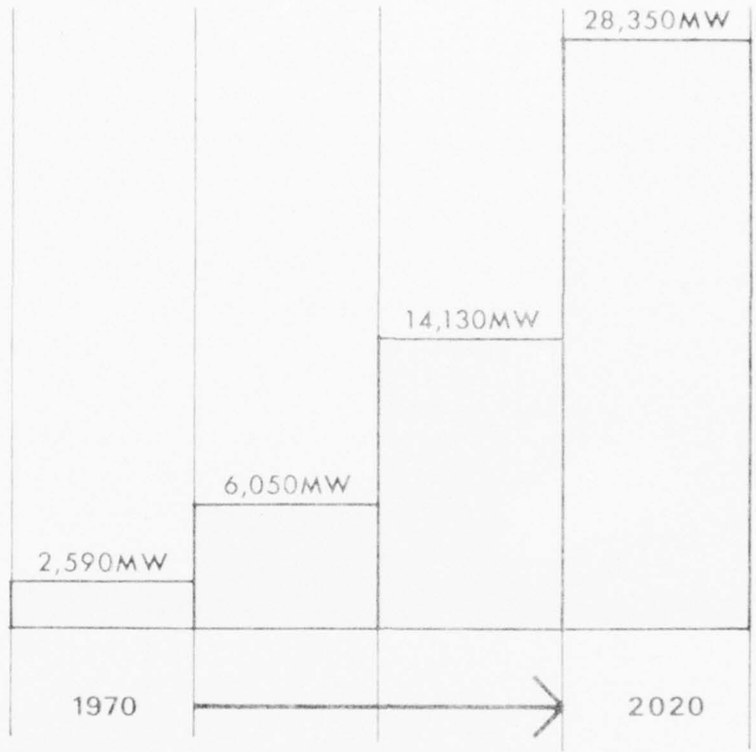
In meeting the needs for future power there will be many environmental obstacles to overcome for all major types of power plants - conventional hydro, pumped storage, fossil-fuel or nuclear - are large users of land or water. Fossil and nuclear operations require controls to dissipate heat before discharging to receiving water bodies, while fossil may also foster air pollution problems. The siting problems will also be among the most difficult facing the industry, and the pressure to resolve them perhaps even more critical in future years. Careful planning during site selection is necessary to avoid aesthetic and ecological problems as well as the application of technological advances to eliminate or minimize adverse effects on the environment. A comparison of advantages and problems affecting different forms of energy and limiting factors in siting are as follows:

Hydroelectric power stations' chief advantages over fossil and internal combustion power plants are: low operation and maintenance costs; no contribution to air pollution; adaptability to remote control; automatic operation and use for spinning reserve; long life; low charges of depreciation; high reliability; a constant renewable resource; and low rates of outages. Secondary benefits also accrue when hydroelectric power is combined with other uses such as recreation, water supply, and flood control within the project reservoir. Conversely, there are varied environmental restrictions imposed on potential hydroelectric developments. Diurnal water releases may impose burdens on downstream riparian users by affecting flows. Impoundments will change the ecological balance of the inundated stretch of river from a lotic (living in actively moving water) to lentic (living in still water) environment that may or may not be desirable to other uses, such as anadromous fisheries or canoeists. The aesthetic quality of a river reach may be impaired if severe drawdowns cause bank erosions and land resources are lost. Such conditions must be examined and evaluated to insure that they are properly considered and accounted for.

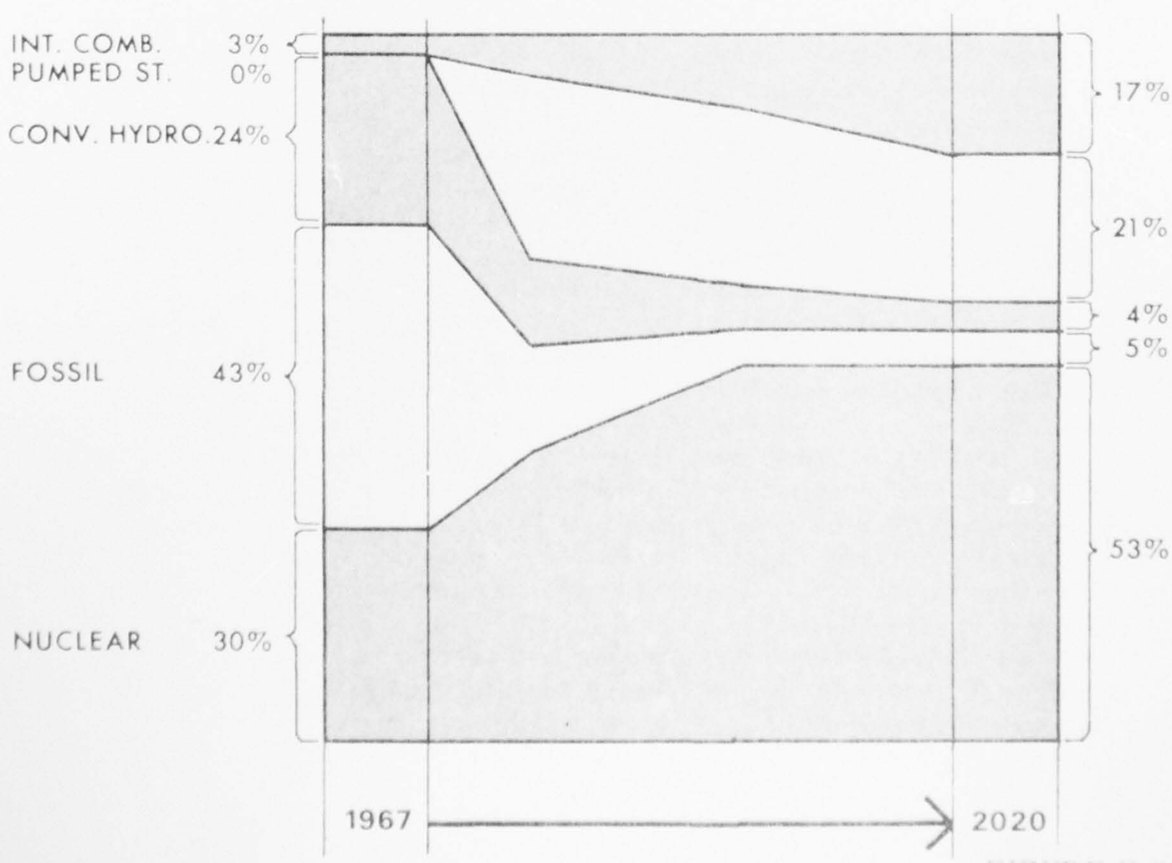
The pumped storage project which includes a pumping generating unit operating between an upper and lower storage pool, generates energy during system peak load periods by release of water through the units from the headwater pool. During off-peak load periods, energy from some other continuing base source is used to pump water from the lower pool back into the headwater pool. In this manner, the system operates as a more or less closed unit, passing essentially the same water back and forth from the upper to the lower pool. While this arrangement consumes more energy than it produces, its economic advantage comes from converting low value off-peak energy to high value on-peak energy. A further advantage of pumped storage hydro is the elimination of on-stream water surges which can upset river flow regulation, for example, during peak operations of a conventional hydroelectric project. Essential to the construction of a pumped storage project is the availability of pumping energy at low cost. The large thermal generating plants currently being constructed in or near the Connecticut River Basin will make available off-peak pumping energy. Another advantage of pumped storage plants is the ability to combine them with existing hydroelectric reservoirs, using the existing reservoirs as the lower pool and adding an upper reservoir at a convenient location where high head differential may be found. The natural topo of the Connecticut presents numerous such opportunities. Principal disadvantages lie in the shifts in natural current patterns which can greatly affect migrating fish unless deflecting barriers or baffles are constructed.

The largest, but non-consumptive, industrial demand on the water resources of the basin is that of thermal electric generation. Steam plants withdraw more water than any other industry in the basin - currently well over 2 billion gallons per day. Nearly all of the withdrawals are for condensing the steam used to produce electric energy. The cooling water circulates through the power condensers and absorbs enough of the heat retained by the steam after it leaves the turbine to condense it for return to the feed water heaters and boilers. The heated cooling water is returned to a stream with insignificant consumptive losses but the heated water contributes to thermal pollution through the reduction of the water's capacity to hold dissolved oxygen.

The reduction of dissolved oxygen reduces the stream's ability to assimilate waste loads and may cause adverse effects on plant and aquatic life. Thermal plants, therefore, require that they either be located close to a source of large quantities of water for cooling as is the case in these units now in the basin; or that they use expensive and aesthetically unattractive cooling towers. The present lack of thermal plants above the Massachusetts border is not due to the shortage of either sites or water, but rather to the demands imposed by load centers as well as the present adequacy of installed hydro capacity. As the region continues to grow, new electric generating plants will likely be required over a greater length of the river. As this divergency takes place, the reliance on once-through cooling will become impractical, particularly when the demand for water exceeds the stream's flow. The larger thermal electric plants currently envisioned for the future will have to be limited to the tidal sections of the river and to main portions of those hydroelectric station ponds where circulating water systems can be used unless cooling towers or combinations thereof with cooling ponds are employed.



POWER SUPPLY WITHIN BASIN



COMPOSITION FUTURE POWER SUPPLY

FIGURE V-6

F. Navigation

Since the year 1614 when Adrian Block sailed the Connecticut from Long Island Sound at Lynde Point to the head of natural navigation at Enfield Rapids, history has recorded the growth of river trade. Even before the coming of the Europeans, the American Indian used the river in their cyclic migrations.

In 1837 the Federal interest in navigation on the Connecticut River was cemented with its first recommendation for construction of navigation aids. In 1968 nearly 3.7 million tons of commerce were handled in the Long Island Sound to Hartford navigation improvement. Approximately 99% of this tonnage was in petroleum products. Projecting the trend of the most recent ten year period indicated that by the year 2020 facilities will be needed to handle 11.5 million tons of cargo. At present, the cargo is handled by both self-propelled craft and towed barges, with the barges being the more economic. The existing navigation improvement can handle barges of 3,000 ton capacity, whereas barges that can carry up to 4,000 tons are considered as more economical by the operators. The mean low water control dimensions of the existing improvement include a draft of 15 feet and a channel width of 150 feet. To fully utilize the more economic 4,000 ton barges a draft of 16 feet with a minimum channel width of 250 feet is needed between Hartford and Lond Island Sound.

A major need in the Long Island Sound to Hartford reach is to locate suitable spoil areas for placement of dredged materials. Current maintenance of the existing navigation project produces an average annual spoil volume of 140,000 cubic yards. The needed channel improvement consisting of deepening and widening will require the excavation of 1,100,000 cubic yards of river materials. Future maintenance of this needed improvement will add an estimated 50,000 cubic yards annually to the present quantities of spoil. The need to identify permanent spoil areas is as important to the best multiple use of the waterway as is the need to identify and preserve valuable riverside, wildlife associated wetlands and marsh areas.

The existing navigation project has been modified to include several features specifically designed for recreational boating. At present, approximately 3,500 boats make up the recreational boating fleet moored or berthed on the river below Hartford. About 3,000 trailer-based boats and 500 transient craft from other harbors or waterways increase river traffic on peak weekends. Considerable growth is anticipated in recreational boating and provisions will be needed from both private and public sectors for handling a greatly enlarged fleet in future years. A secondary system of navigation aids will be required in the future to delinent areas navigable by recreational boats which are outside the existing commercial channel. Widening of the commercial navigation improvement from 150 to 250 feet will also generally enhance recreational boating opportunities. In the Hartford to Holyoke reach limited recreational boating activity is currently experienced due to the four following problem areas:

(1) Major shoal areas in the river between Hartford and Windsor Locks, Connecticut

(2) Problems associated with the 5.3 mile Windsor Locks Canal including the 2.3 feet controlling depth of the lower locks.

(3) Above the canal in the Enfield pool a controlling depth of 3 feet exists just above the dam.

(4) There are no navigational aids identifying the natural channel in the broad river.

There is need for major enhancement of the existing recreational boating capability in the Hartford to Holyoke reach. The boating pressures above Hartford will likely accelerate particularly with the effective implementation of the pollution abatement and improved flow regulation and flow augmentation programs included in this report. Aids to navigation are needed to identify safe channel sections in the pools associated with the Holyoke, Turners Falls, Vernon and Bellows Falls power dams. Minor ledge and shoal removal and some smallboat channel excavation is needed in the Holyoke pool as well as channel improvements upstream to Greenfield, Massachusetts.

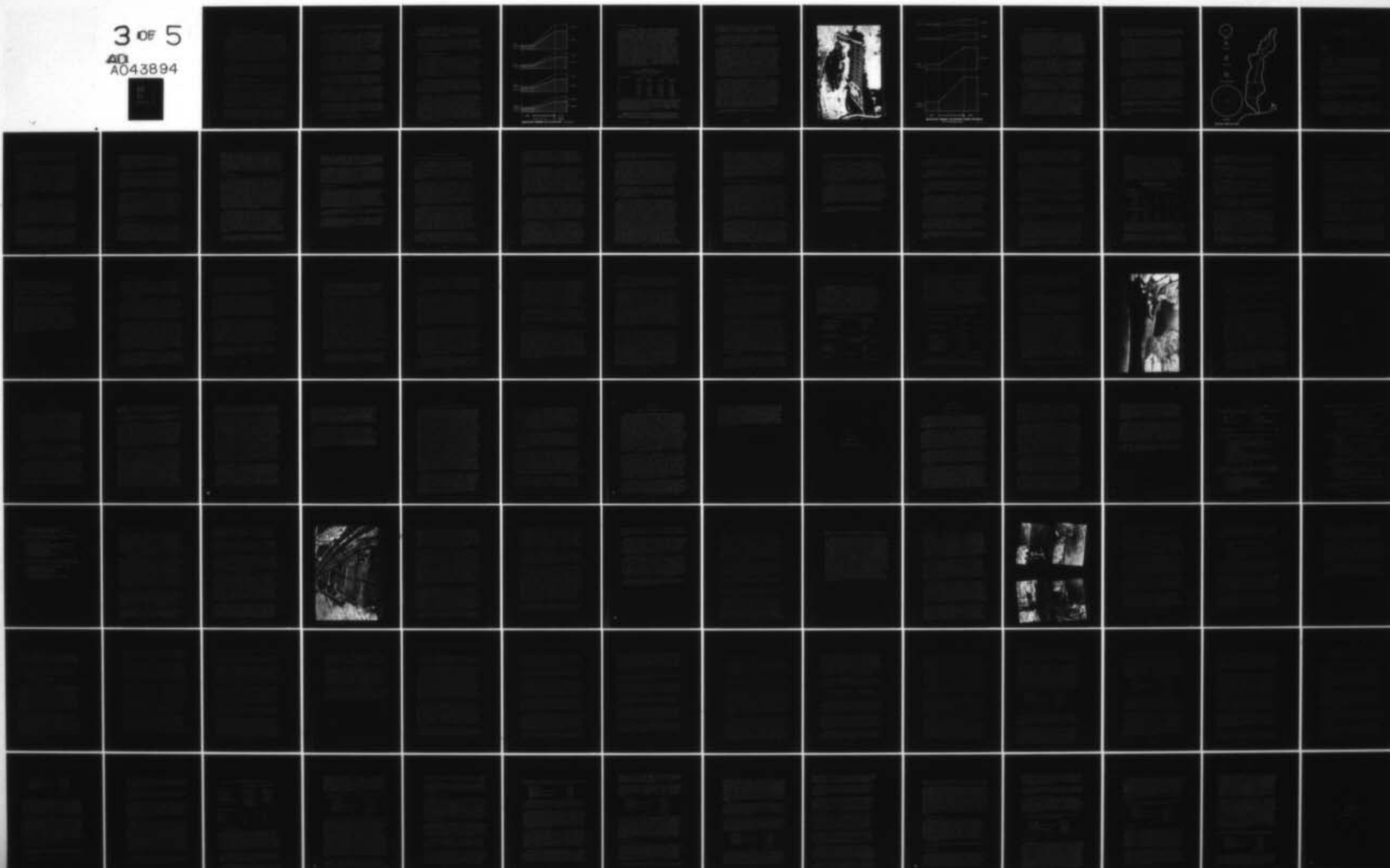
There is a need for publicizing identification of canoeable reaches and limited extension of the white-water canoeing season. Commercial navigation in general, provides a less expensive means of transportation for bulk commodities and is needed where feasible and desirable, in the Basin. Recreational boating already one of the most popular leisure time pursuits has been projected to grow to many times the present use figure.

Detailed information with regard to navigation problems and projected needs is found in Appendix L.

AD-A043 894   ARMY ENGINEER DIV NEW ENGLAND WALTHAM MASS   F/G 8/6
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION. C--ETC(U)
JUN 70

UNCLASSIFIED   NL

3 OF 5
AD
A043894




1.0
2.8
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

G. Outdoor Recreation

Federal Public Recreation Opportunities

The largest single ownership of forest acreage in the basin is found in the National Forests which have contributed significantly to the economy in the basin in several ways. The sale of timber, and the value added by reason of the services connected with harvesting, hauling and manufacturing of the forest products account for the greatest dollar value. Twenty-five percent of the total revenue from timber sale and other revenues of National Forests are paid to the counties in which the forests are located, and in 1967, $93,000 was distributed to 8 counties on this basis. But of even greater importance are the numerous outdoor recreation opportunities made possible by these public forests which are free or nearly so. Day use fees are charged generally for certain developed areas with 25% of these monies returned to neighboring counties for school and road purposes.

In addition, the existing 16 Federal flood control structures provide a wide variety of free public outdoor activities managed in cooperation with State Fish and Game and State Park agencies. Nominal fees are paid for those developed facilities such as camp sites. The Public Law 566 upstream watershed program of the Department of Agriculture provides further opportunities in several local areas of the basin.

State Public Recreation Opportunities

State outdoor recreation developments consist of 55 State parks, 97 State forests, 27 fish and game lands units and 38 boat access sites. More than half of these are located outside of the State of Connecticut.

The 38 publicly owned or State operated boat access sites intended for hunters and fishermen, have an average size of one acre with modest shore frontage. There are numerous informal access sites along public and private lands. Of some 838 miles of main stem river frontage, some 9% or 77 miles are at present in public ownership of which 17 miles is part of flood control levees at the Springfield-Hartford areas. The public also has use of launching and docking facilities at 63 privately-owned liveries, marinas and boating clubs.

There are a varied range of hunting opportunities for the recreationist with forest and farm game species, as well as migratory waterfowl, available during the hunting season. While no Federal wildlife areas exist along the river, State-regulated public hunting is permitted at a number of Federal reservoirs. Some State forest and game lands (in New Hampshire and Vermont) and State parks are open to the public for hunting. However, the major portion of available hunting land is privately owned.

At present about 57% of the river's main stem length supports productive sport fisheries; another 35% is classified as marginal and the remainder is devoid of fish life because of heavy pollution. The best shad fishing area is currently at Enfield Dam, where 16.700 catches were recorded in 1964. The cold water habitat in the upper portions of the river basin provides excellent trout fisheries. First, Second and Third Connecticut Lakes are intensively fished for native lake and brook trout and introduced land-locked salmon. Below White River Junction, Vermont, the river takes on the character of a warm water stream and supports a variety of warm water species.

Swimming in the main stem of the Connecticut River has been severely restricted by pollution, hazardous currents and unsuitable water temperatures. At present the only section of the river with water quality suitable for contact recreation is a 28-mile stretch between the river's source above Fourth Connecticut Lake and a point just above the community of Pittsburg, New Hampshire. Of the river's 36 major tributaries only 12 reach the main stem with a quality level permitting water contact recreation. There are no designated public swimming areas on the Connecticut River itself.

As regards trail use, extensive utility camping lands, railroad rights-of-way, flood control levees, and old logging roads offer good opportunities for development of foot, horseback riding, and bicycle trails. The possibility of tie-ins with major existing trails such as the Appalachian Trail and Long Trail merit consideration.

The valley's best camping potentials are located along the forested frontages of the reservoirs on the river's main stem and particularly in the northern portions, as well as at undisturbed islands, coves, and flood plains. Water oriented camping is limited at present because of pollution, or the lands adaptable for such use are in private ownership and unavailable for the public use. Majority of camp sites are found away from the river in the forested uplands.

Picnicking along the Connecticut River is severely limited by lack of facilities. Although most parks offer some picnic facilities, they are too few in number to meet the growing need. Many more picnic opportunities could be provided along scenic stretches of roads and in conjunction with major recreational developments.

Unsatisfied demand for outdoor recreation as measured in acres of water and land is shown in Figure V-7.

Driving for pleasure is popular because of the diversity of scenery. The changing seasons provide beautiful settings and there are numerous historic, architectural, cultural and industrial sights that can be observed from secondary roads with broader panoramic views available in the interstate highways.

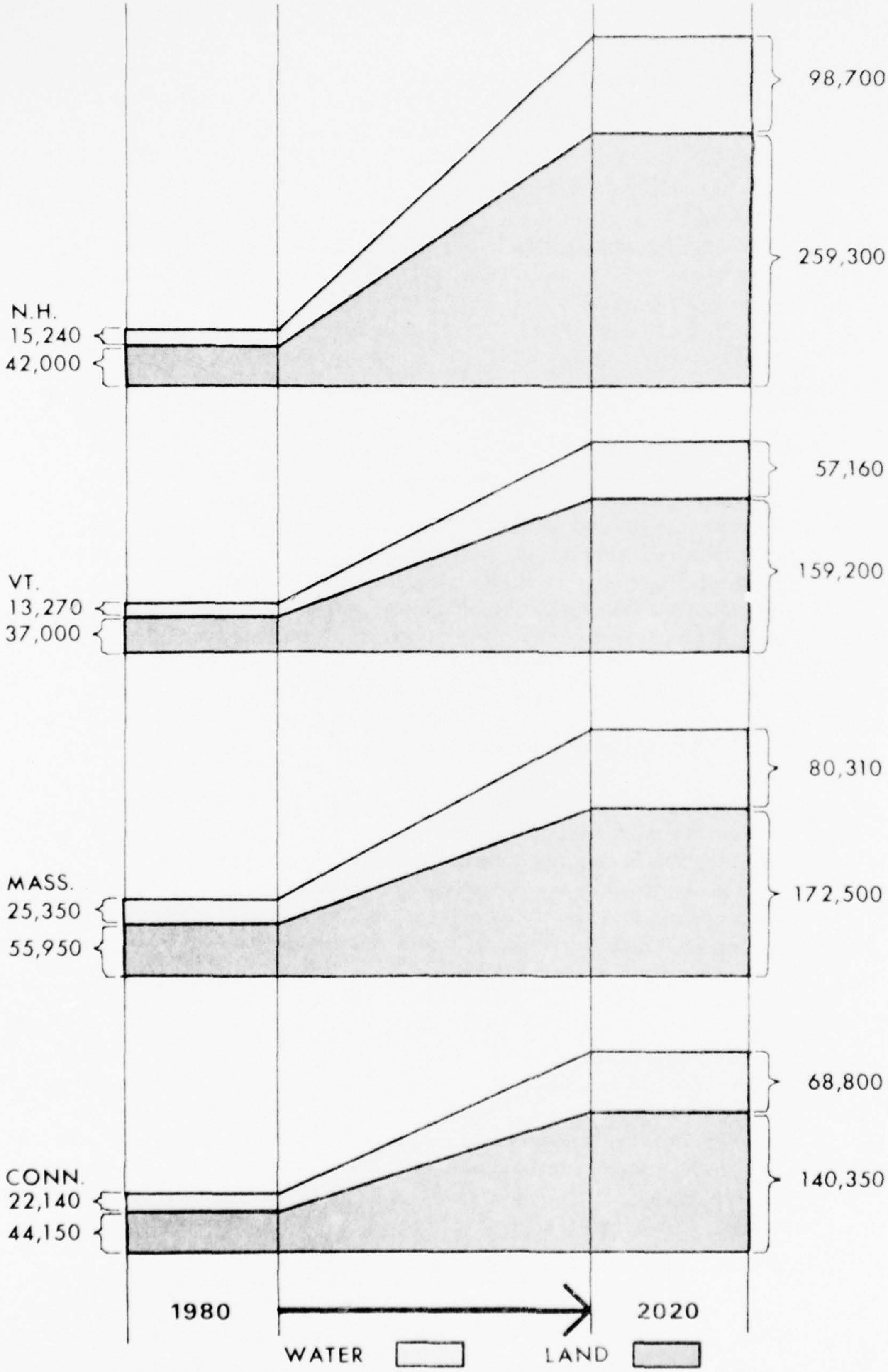
In 1967, 2,600,000 visits were made to these parts of the National Forest area within the Connecticut Basin. Based on the Chilton Survey Report, it is estimated that these visits generated over $9,000,000 in local expenditures. In addition, the passage of the Land and Water Compact of 1964 permits financial assistance for units of local government in acquiring public recreation areas.

Private Recreation Opportunities

The contribution of private investment in outdoor recreation in recent years has increased substantially, and if projected demand for outdoor recreation materializes, private investments can be an important factor in supplying many of these services, and is already a major factor in upper States where vacation homes have significantly broader economies in smaller towns. There are currently 326 commercial firms providing outdoor recreation activities, and of this total, 34 provide swimming facilities with 22 of these located in Massachusetts. Generally, swimming facilities are made available as part of the more generalized recreation development

Commercial camp grounds are one of the most popular types of private investment in outdoor recreation. In the 17 basin counties included in a recent inventory performed by the Department of Agriculture, there were a total of 147 privately-owned camp grounds supplying 7,497 individual camp sites. New Hampshire was the leader among the States with 67 camp grounds, but Massachusetts led in the number of campsites available with 2,969.

Privately-owned commercial picnicking areas were most common in Massachusetts. In Middlesex and New London Counties of Connecticut, farmers were also providing services associated with boating with access to Long Island Sound. New Hampshire was the second as regards firms providing boating services, where Vermont had the fewest. The public and private sectors each provided about 1/2 of the boat launching facilities available to the public in the Connecticut Basin. The private contributions varied from less than 12% of the total Vermont group of counties to 64% for the Massachusetts group of counties. In Connecticut counties which had the most boat launching areas than all of the other counties combined, 57% of the facilities were provided by private investment. A total of 268 boat laundhing areas are available in the Connecticut River Basin.



UNSATISFIED DEMAND FOR RECREATION (IN ACRES)

FIGURE V-7

H. Fish and Wildlife

There are many problems and needs currently affecting the full utilization of the basin's fish and wildlife resources. Those particular needs affecting the fish resource and the wildlife resource sometimes differ and even conflict. Those problems and needs associated with the fish resource include: distribution of the resource with respect to the demands placed upon it; proper access to resource areas; the current state of stream and pond pollution and the existing natural and man-made stream regulation; inadequate fish production for "put-and-take" fishing management of the resource itself; the lack of fish passage facilities for migratory species; restoration of anadromous fish through much of their historic range; creation of new recreational water bodies for intensive fishery use; further utilization of existing and future water supply reservoirs for fishery programs; and control of riverbed mining for sand and gravel production. The existing distribution of the fishery resource and its relation to today's and projected basin resident population points up the inequalities of fishing opportunity. The projected per capita acres of surface water and miles of stream available by subbasin area for 1980 and 2020 are shown in Table V-22.

TABLE V-22
PER CAPITA FISHING OPPORTUNITY
CONNECTICUT RIVER BASIN

Subbasin Area	1980		2020	
CRB	Lake Acres	Stream Miles	Lake Acres	Stream Miles
I	0.439	0.024	0.372	0.020
II	0.271	0.018	0.206	0.013
III	0/166	0.006	0.126	0.005
IV	0.081	0.011	0.058	0.008
V	0.042	0.001	0.029	0.0009
VI	0.007	0.0005	0.004	0.0003

The lack of proper access for the public to some of the great ponds within the basin is a major problem to fishermen. There is need to acquire access lands and develop adequate access facilities to optimize the recreation values at these ponds. Many miles of superb stream fisheries presently exist without proper access. A program is needed to insure development of this access.

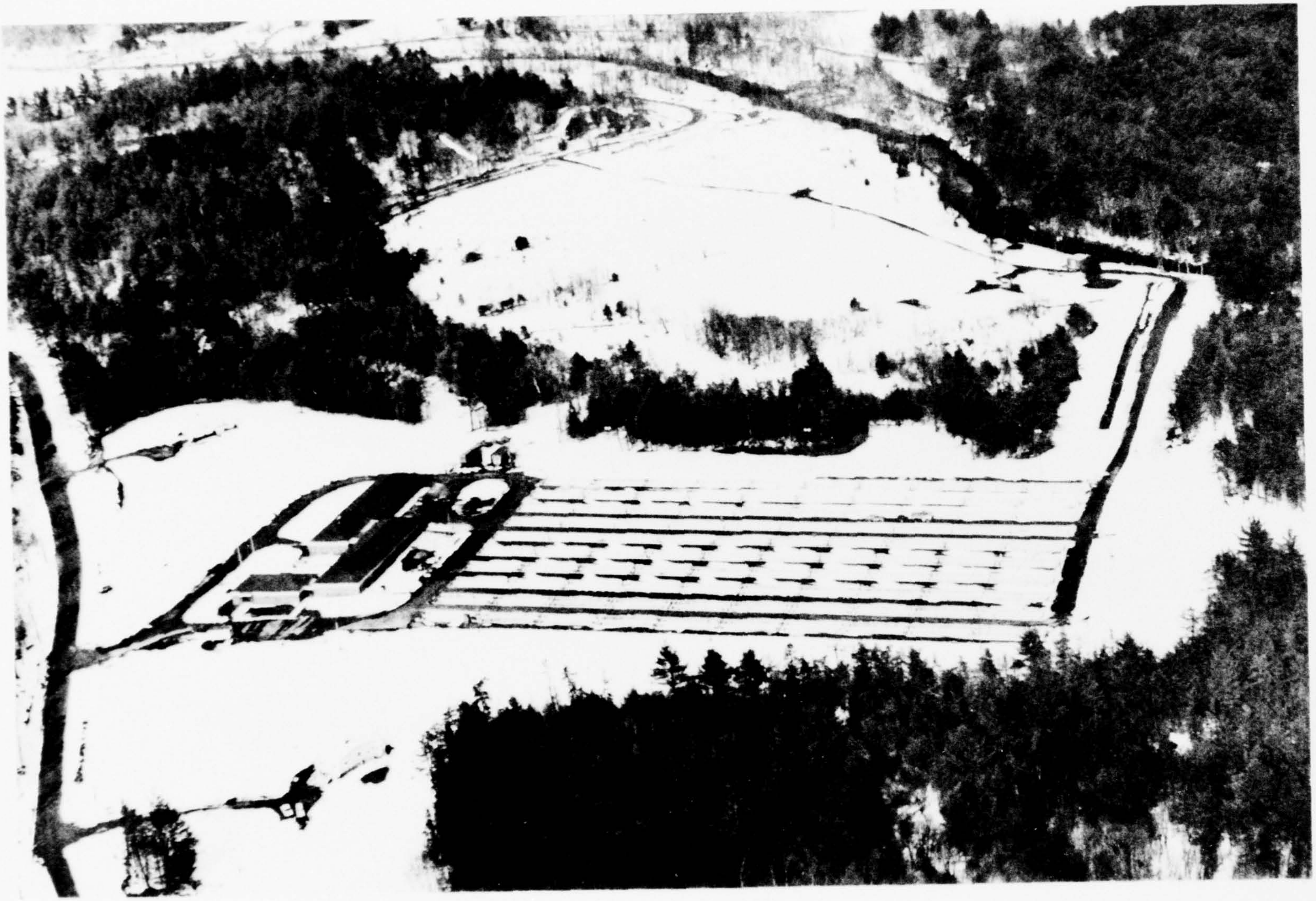
A general recommendation of this comprehensive study will be to abate pollution and achieve the in-stream water quality standards as approved. Implementation of pollution control programs will open up significant stream and pond fisheries not now attractive. A flow management program through augmentation from new storages and re-regulation of existing impoundments throughout the basin will be a most effective way to enhance stream fishing.

There is need for an enlarged fish stocking program through increased hatchery production. It is estimated that with the total implementation of reservoir development considered for the early action plan that 420,000 catchable sized fish and 6,876,000 fingerlings will be needed for stocking purposes each year.

There is immediate need to improve the existing fish passage facility at the Holyoke dam and to provide for fish passage at the Turners Falls and Vernon power dams on the Connecticut main stem. Tributary dams also require passage facilities. Future needs include provision for fish passage at the Bellows Falls and Wilder power dams. Restoration of anadromous species throughout most of their historic range has become a major goal of the basin plan. Atlantic salmon hatchery facilities will be needed to supplement natural reproduction. The current shad run ranges between 500,000 and 1,000,000. Up to 2,000,000 shad are anticipated entering the river each year when, facilitated by fish passage devices, reproduction in the upper reaches reinforces present production from spawning areas now available. The creation of new recreational water bodies is needed to provide fully managed lake facilities for the basin and increased fishery utilization of water supply reservoirs will provide added opportunities near urban regions.

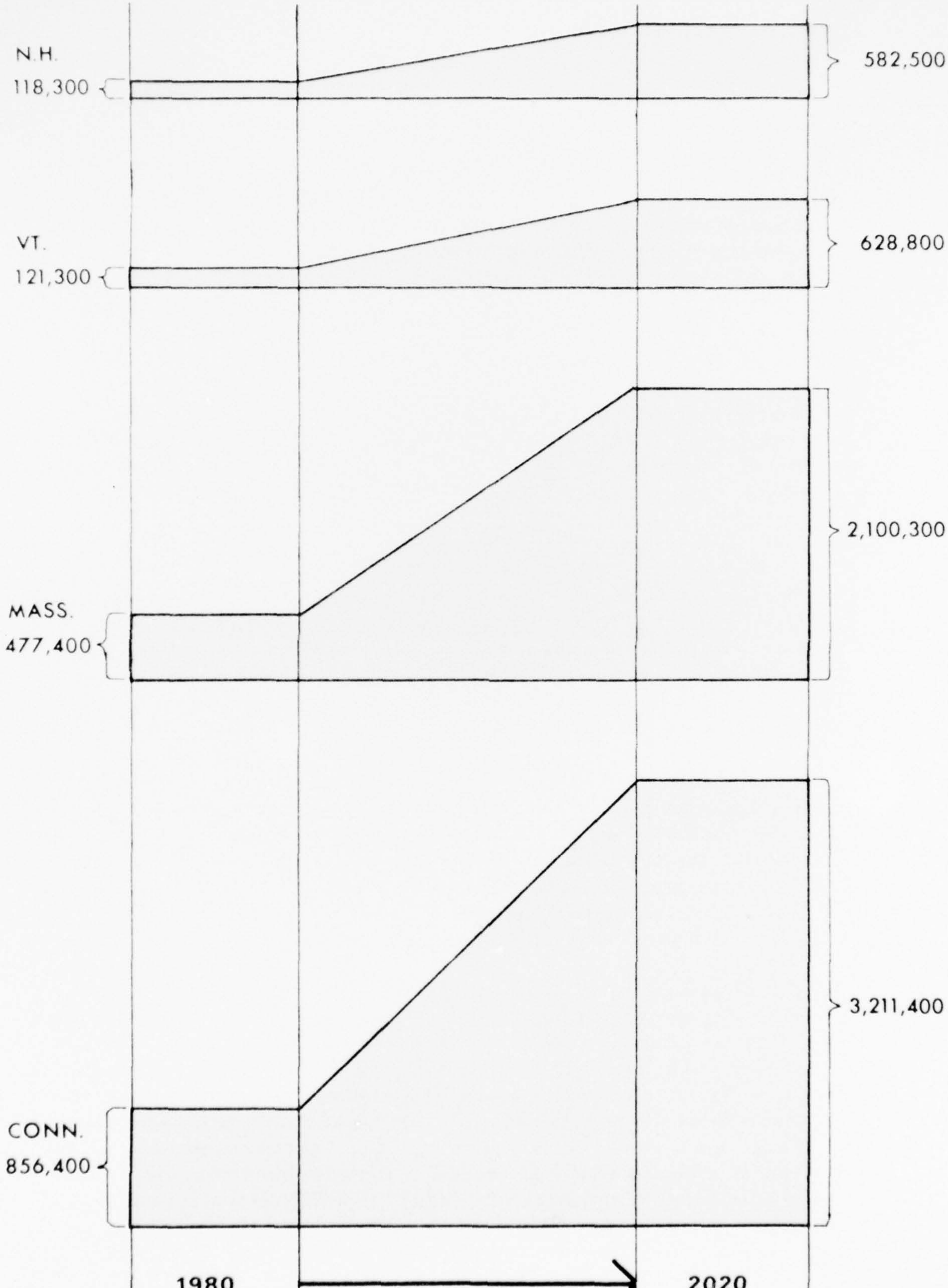
The wildlife resources pose equally pressing problems and needs. With each acre of land removed from the raw state for development to meet other needs there remain fewer acres to support the wildlife that is left. There is little opportunity to create new or additional wildlife habitat with the exceptions provided water associated animals and fowl through reservoir development. Wildlife productivity can be improved through use of new management techniques in upland game areas. Certain presently unprotected wetland and upland areas that offer larger opportunities for wildlife resources need to be acquired or zoned for wildlife purposes. Identification and acquisition of access to favorable wildlife areas is needed to improve opportunities for the recreational hunter. Areas exist within the basin where waterfowl habitat improvement is needed. Additional waterfowl habitat acreage will encourage increased use by migratory flocks in the Atlantic flyway.

Figure V-8 lists the unsatisfied demand for resident fisheries resources in the basin.



AERIAL VIEW OF TROUT HATCHERY LOCATED ON THE SWIFT RIVER BELOW THE QUABBIN RESERVOIR DAM.

Courtesy Commonwealth of Mass.



UNSATISFIED DEMAND FOR RESIDENT FISHERY RESOURCES

(IN FISHERMAN DAYS)

FIGURE V-8

I. Conservation and Land Management

The increasing people-oriented pressures being placed upon the Connecticut River Basin's limited and fixed resources clearly indicate the over-all need to conserve, develop, and manage the Connecticut's water and related land in an orderly manner, utilizing wherever possible the techniques of multiple use. Major problems exist in all areas in planning a desirable allocation of these natural resources. Problem areas include a deterioration of environmental quality both in and around our cities and now reaching into the smaller towns; the increasing upstream floodwater and sediment damage, generally degrading hydrologic characteristics in the urbanizing regions; improper timber management; increased risk and severity of forest fires; and continuing and significant erosion on intensively cultivated croplands.

The Federal census of 1960 showed that over 70% of the basin's residents lived in urban areas. Population projections, prepared for this comprehensive study indicate that while the total basin population will nearly double by 2020, the urban segment will increase to almost 85%. This urban growth will still center on the Hartford, Connecticut and Springfield, Massachusetts metropolitan areas. It will continue to encroach upon valuable wildlife habitat within the cities' environs as well as remove additional open space in favor of urban and related uses.

Many State, community and private land areas are deteriorating rapidly because of over-use. The land use practices contaminate surface and groundwater and there is a lack of knowledge of the principles of resource management to protect and improve the environment. Unless a strong program is undertaken to stop further deterioration of natural environment, particularly for land areas of high density population, the cost of correcting such situations will be extremely high.

Sound principles of land management and treatment must be adhered to if these problems are to be solved and similar problems prevented in the future. This can only be accomplished through public awareness of the need for, followed by the establishment and administration of local, State and Federal land use regulations based on sound resource data. To accomplish this, new legal authorities are needed. Standards must be developed against which land use proposals can be evaluated. Specifications for works of improvement concerning land use should supplement these standards. Specifications regulating the type and quality of materials used in small village improvements as well as in State regulations concerning such problems as the shaping and revegetation of huge borrow areas are needed to support various standards. Those features of landscape contributing to quality environment need to be identified at the Federal, State and local level. Action must be taken to see that these features are not destroyed.

Presently, considerable erosion occurs on intensively cultivated soils in the Connecticut Valley lowland, as well as on those steeper slopes of the upland regions that are not permanently protected. The total flood plain acreage that would be inundated by the 100 year flood in the basin's 141 upstream watersheds is estimated at 59,000 acres. Of this total, about 26,000 acres are currently in agricultural use and 1,900 are urban, the remaining 31,100 acres being either forested or considered idle land. A limited quantity of land in agricultural production has a problem of excess water. These are usually portions of otherwise well drained acreage.

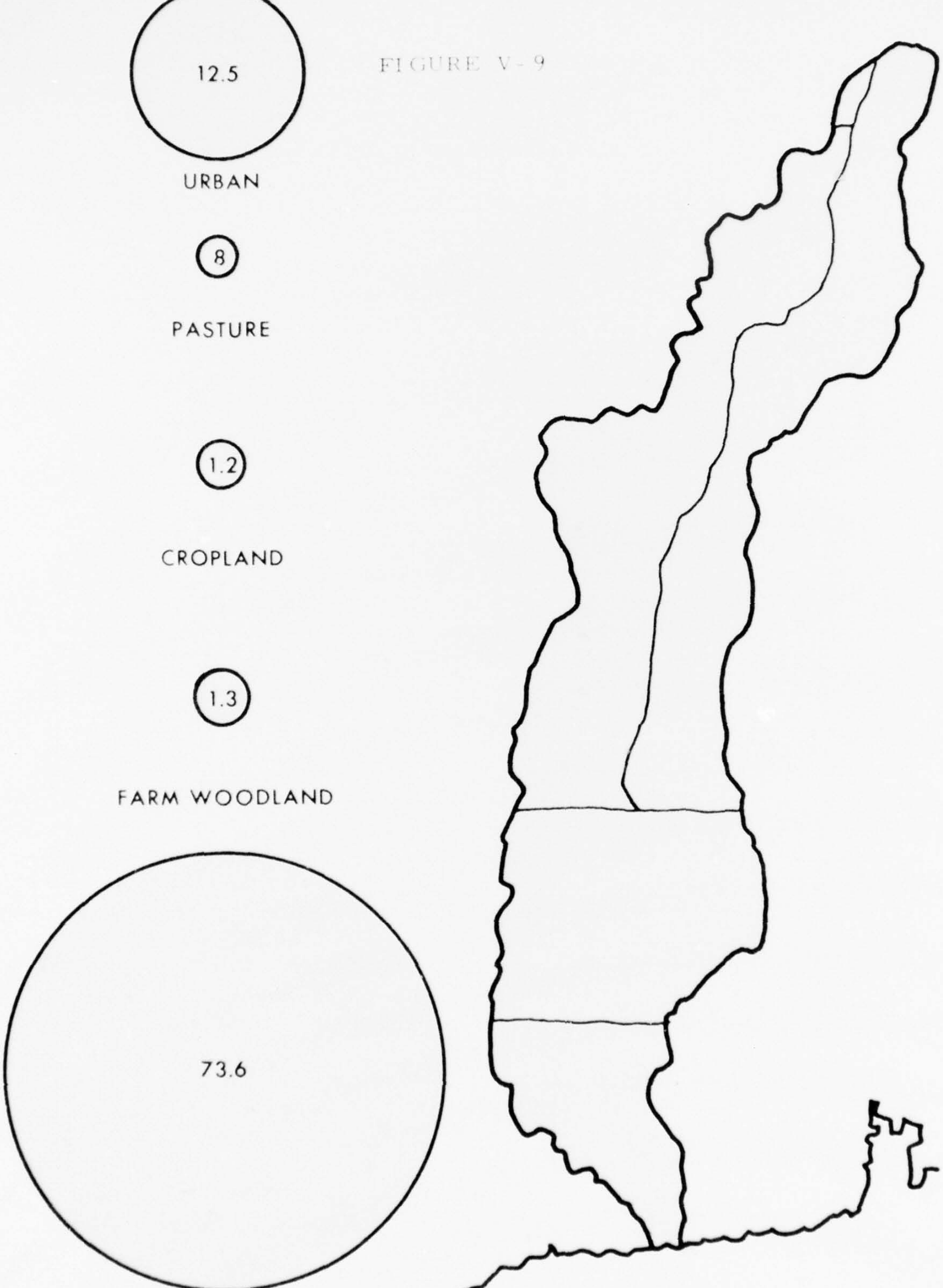
Over one-third of the forest land is in poor to very poor hydrologic condition; however, the potential to improve is generally high. Multiple-use management and protection is needed to realize these potentials as well as the continued yield of high quality water and better regulated run-off. Timber quality is low, land values and related taxes are becoming excessive. Moreover, many forest landowners are more interested in the recreation and aesthetic uses of their lands rather than timber production.

Changing land-use patterns will cause problems related to agriculture as well as to other resources. Some of the finest cropland in the basin exists in the valley lowlands encompassing the basin's major cities. The expanding urban pressures will remove some of this land from agricultural use. Although the phasing-out of shade-grown tobacco in the basin is projected and the adoption of more intensive agricultural techniques will generally reduce over-all cropland needs, a major need is to reserve land well adapted for agricultural uses to satisfy future agricultural and environmental quality needs so as to avoid using more marginal lands to meet these agricultural needs.

A display of projected land usage is found in Figure V-9. These 2020 projections should be compared with land usage as measured in 1963 and shown in Figure IV-2 on page IV-7.

As a further example of shifting land-use patterns, Table V-23 expresses the estimated projected needs for pasture and haying lands in the basin.

FIGURE V-9



PERCENT LAND USE 2020

TABLE V-23
PROJECTED PASTURE LAND NEEDS
CONNECTICUT RIVER BASIN
(1,000 Acres)

	1965	1980	2000	2020
Vermont	160.0	96.5	33.4	3.1
New Hampshire	50.2	36.1	13.5	1.6
Massachusetts	85.7	6.7	1.4	0.5
Connecticut	44.9	5.9	1.7	1.0
Connecticut River Basin	340.8	145.2	50.0	6.2

These land use projections indicate that pasture land as a traditional piece of the New England rural landscape will practically disappear unless measures are taken. It has been suggested that an important piece of that which is visually pleasing in the basin will be removed. It is further projected that most of this land will revert to forestland, replacing forestland taken for other uses. The projections of forest cover as a percent of the basin remain fairly constant throughout the study period as demonstrated on Figures IV-2 and V-9.

There is a need for a land acquisition program in the Green Mountain National Forest in Vermont and the White Mountain National Forest in New Hampshire to make these forests cohesive units and more useful for watershed protection. Recreation opportunities are provided by these tracts under the principle of multiple use. Nearly 70,000 additional acres are required.

Complementing the needs of larger forest areas is the need for establishment, protection, development, and management of trees and related plant communities in suburban and metropolitan areas.

J. Mineral Resources

Mineral commodities currently produced in the Connecticut River Basin are sand and gravel, crushed stone, principally traprock, clay, talc, feldspar, mica, crushed quartz, dimension sandstone, dimension granite, and peat. Other commodities which have been produced in recent years include copper, gold, silver, and pyrrhotite as a by-product of copper mining, beryl, as a by-product of feldspar mining; garnet, dimension marble, sharpening stones, and manganese.

Sand andgravel and stone continue to be the principal commodities produced. In 1962, the commercial production of sand and gravel in the basin was nearly 13 million tons, and that of stone over 3-1/2 million tons, which accounted for about 95% of the value for minerals produced in that year.

There is a continuing need, generally proportional to population density throughout the basin, for the major mineral resources found in the area. These resources consisting mainly of sand, gravel, and stone have become in relatively short supply and particularly in the heavy-use urban sections. Spurred on by increased building and highway requirements for concrete, pavements and a complete spectrum of building materials. The President of the National Sand and Gravel Association has stated that on a national basis, and on the basis of current demands, sand and gravel resources will be exhausted in 18 years. There is need to identify those untapped supply sources suitable for exploitation. There is further need to develop those environmental controls, as relate to mineral resource use, that will be necessary for mineral use to become more compatible with the total needs of the basin and its population. Additional details may be found in Appendix S.

K. Solid Waste

The needs and problems associated with solid waste are, with the presently practiced state-of-the-art, large and burdensome to the communities of the Connecticut River Basin, as elsewhere. The existing solid waste disposal programs are in many cases inadequate, and at worst, genuine nuisance generators. In certain instances additional water pollution results from improper dumping procedures. Air pollution is aggravated by the burning of rubbish materials both in open dumps and inadequately controlled incinerators. The needs are for judicious land planning and allocation with adequate zoning as well as physical and management control applied to sanitary land fills and incineration. State-developed solid waste management plans are being considered and regionalization of current local operations may result.

Very few communities in New England have more than a 10-year program for the adequate disposal of solid waste so that it is difficult to bring the aspect of solid waste management planning into the 50-year period associated with water resources planning. However, all of the New England States now have Federal grants for the development of State solid waste management plans. These plans are presently being developed and will incorporate regional operations as an alternative to individual community solid waste disposal programs.

The all-prevalent open dumps with open burning are being outlawed and replaced with sanitary land fill operations. Land area requirements are increasing under present practices, but developments in volume reduction through re-use, improved incineration, and shredding and compaction, and containerization will tend to stabilize if not lower land area needs for final disposal and make for more economic transport of solid waste.

The urban areas such as Hartford and Springfield will probably have the greatest difficulty in obtaining land fill sites in the future. The additional cost for long distance hauling of solid wastes away from these urban areas could give economic justification to the establishment of local facilities which would provide a high degree of volume reduction before transporting the wastes to a land fill. The rural areas in the basin will probably be able to dispose of their solid wastes in rural land fills without encountering insurmountable land acquisition problems.

In the way of research, the container industry today, is researching self-destructing packages. Edible containers are being considered for the food industry. Today's "throw-away-bottle" may become the "buggy whip" of the year 2000. This research has been fostered by the pressures exerted by the problems evident in our present waste disposal practices. More detailed planning measures must be taken to avert needless pollution of our ground and surface waters through improper land allocation for satisfying solid waste disposal needs. Educational programs must be mounted to discourage capricious dumping. The growing awareness of the individual's stake in his environment will help in this area. The ogre of man's self burial in his own rubbish must be made nothing more than a humorous line or two in tomorrow's history books

L. Flow Augmentation

Flow augmentation needs in the Connecticut River Basin relate to the whole spectrum of water resource uses and functions. With the advent of a flow augmentation program, each of these resource uses and functions would present altered problems and needs. Low flow augmentation would improve water quality by lowering average water temperature and by increasing the availability of dissolved oxygen. It would increase water supply alternatives, allow for increased use for thermal-electric cooling, provide for deeper natural channels for navigation purposes and less maintenance dredging cost. Low flow augmentation would allow for more widespread recreational use of the rivers of the basin owing to increased quantities of flow; improve and stabilize fish and wildlife habitat for all aquatic species; provide for more constant year-round flows thereby stabilizing the natural channels and decreasing the erosion; and improving the over-all health aspects of the basin. Augmentation flows would come from new storages that would hold spring freshets for later release and have the multiple purpose effect of lessening spring flood control problems proportionately. Additional flow augmentation could also come from re-regulation of existing storages.

M. Flow Regulation

The Connecticut River Basin exhibits an abundance in water resource, that is quantitatively, and when viewed on an average annual basis. The annual run-off cycle, however, provides for excess flows every spring and deficient flows in the July through October summer period. Natural high and low flow periods are greatly altered with reference to low flow periods by the present operation of hydroelectric power stations. These hydroelectric units are presently operated for maximum peaking power production. They allow for hourly flow variations by responding to the power demands of the working day and into the early evening and essentially shutting down, and allowing little or no flow to pass the dams throughout the balance of the 24 hour day. On weekends during the summer, power production is generally not needed beyond the levels provided by the base load thermal plants. Therefore, the hydroelectric stations store what water enters their pond, until full, and generally do not release flows at all over weekend periods.

The outstanding needs in the area of flow regulation are for a basin-wide approach to minimum releases from power storage facilities. A minimum flow program for the Connecticut River Basin would provide widespread benefits. Such a program would reestablish historic flow levels in all portions of the basin; would allow for enhancement of the present fish and wildlife resource; and assist in restoring habitat suitable for native anadromous species such as Atlantic salmon. It would reduce the daily fluctuations in water quality due to variable flow; provide a sustained base flow to more adequately meet the recreational boating needs; and assist in the assimilation of thermal loadings upon the river.

Historic low flow levels were compiled using gaging station records from eight unregulated tributaries, having periods of records and which measured a total drainage area of 1,592 square miles. These tributaries contributed an average of 0.18 cubic feet per second per square mile of drainage area for an average 7-day low flow period. Interestingly enough, the three largest of these eight stations with 1,236 square miles or 77% of the considered drainage area, experienced an average 7-day low flow of over 0.2 cubic feet per second per square mile.

Compiling, on a 10-year basis the annual 60 and 90 day low flow averages for the eight stations resulted in 0.19 and 0.22 cubic feet per second per square mile respectively. As a result of this analysis it is considered that the requirement of a flow of 0.20 cubic feet per second per square mile is an appropriate measure of historic low flows for the Connecticut River Basin and that the need to reestablish historic low flow levels should use a flow of 0.20 cubic feet per second per square mile as a minimum instantaneous flow criteria.

N. Health Aspects

Needs as relates to health aspects reflect upon the well being of the basin's population. There is need for a comprehensive water quality monitoring program of the Connecticut River Basin's main stem and tributaries, particularly for those areas indicated for possible in-stream water supply diversion. With the increasing demand for water-based outdoor recreation there is a need for study on the effects of extensive and intensive recreation activities on water supply reservoirs including the cost to the using public for both single and multiple-purpose facilities to meet these two resource needs.

Close coordination is needed to maintain strict isolation between existing (and proposed) waterbodies (surface and groundwater) and solid waste disposal sites.

Continuous surveillance, in season, is needed of recreation facilities from a health standpoint and there is need to integrate vector control problems with over-all water and related land resource development. Akin to this requirement is the need for more detailed data concerning water-borne diseases.

CHAPTER V

Section 3 - Factors of Change

A. New Patterns of Population, Employment and Income.

Future population growth will be absorbed principally by the already heavily urbanized and industrialized Hartford-Springfield area. The Hartford area alone, including Hartford and Middlesex Counties in Connecticut, is expected to experience 140% rise in the number of inhabitants and thereby increase its share of the basin population from 47-1/2% to 60-1/2% by year 2020. The outward pressure of growing urban population will be felt primarily in the suburban fringe areas where land is certain to become more intensively used.

Growth will continue to occur in the flood plains and areas adjacent to them because of, in some cases, the scarcity of other suitable land available for development. The overriding factor explaining the productive growth in the floods plains is, however, not the degree of upstream flood protection which some interests have stated has encouraged growth in the flood plain, but rather the ease of development made already possible in the way of existing social overhead facilities. Specifically such as municipal services, highways, utilities and accessible modes of transportation, as well as schools, hospitals and commercial and financial centers that have been established in the older and more mature areas.

Based upon a diverse mix of sustaining economic sectors, the economy of the Connecticut River Basin will continue to expand and prosper through the projection period year 2020. As in the past, it will continue to export valuable services and manufactured goods. Changes within and among the various economic sectors will play a dominant role in determining the region's growth path. Human dynamics, especially population, urbanization, employment, personal income and the nature and composition of the industrial and business mix on the economy will be of special relevance to the complex water resource problems and needs of the basin. As population, income and general economic activity expands so will the demand for wider range of public and private uses of water resources.

The history of the economic development of the Connecticut River Basin follows a pattern similar to New England and to the nation, except that its transition from an "extractive" to a "process" and now to a "service" economy has occurred earlier than in most other areas of the country. In addition, the service sector of the economy is being carried beyond the national stage of development. For example, 50 years ago the manufacturing sector of the region's labor force was nearly twice as large relatively as in the nation's labor force. Today this sector is still proportionately more important regionally than nationally but the gap is closing. It is likely that the basin will expect manufacturing to claim a declining share of the total labor force.

Whereas the basin population is expected to almost double by the year 2020, total personal income is projected to rise over ten-fold and per capita personal income is anticipated to rise over five-fold. Per capita personal income has always been higher in the Connecticut River Basin than that of the nation and it is expected to remain so, although to converge somewhat toward the national. Differential between the basin and the national average of 5.8% higher in 1959, is expected to rise to 6.7% by 1980, and then to decline to 4% by 2000, and 3.3% by the year 2020. These differentials are attributed to higher rates of labor force participation, 0.398 for the basin as compared to 0.370 for the nation in 1960, as well as substantial property income and a larger-than-national share of employment in manufacturing. For example, 40% in the basin versus 27-1/2% for the nation in 1960.

As noted, the Connecticut Basin has already completed its process of transition from an extractive to a processing economy and is now proceeding toward a serviced-oriented economy. This trend is documended by manufacturing and non-manufacturing employment statistics and projections. The economy remains more dependent on manufacturing than does the economy of the nation, but this sector is declining and is projected to decline even further, relative to non-manufacturing sector as a source of employment. For example, by the year 2020, it is estimated that 24% of the work force will be engaged in manufacturing, a drop of 16% for the 1960 total, although total employment in manufacturing is expected to increase by 17%.

Manufacturing appears to be in a potentially strong position for the future in spite of this decline in its sector of employment. Economic production per employee is expected to increase dramatically during the projection period. This will, in great part, be a result of the changing mix of manufacturing industries from the labor-intensive to the capital-intensive. The region's highly skilled labor force will assist the productive gain by the application of technological inputs from engineering and scientific communities to a small volume of raw materials whereby a highly valued finished product will result. Figure IV-3 on page IV-16 exhibits the projected increase in productivity and gives some idea of the changing mix in manufacturing employment.

In general, the structure of the basin manufacturing sector is shifting away from traditional textiles and agricultural industry and moving to a more diversified base.

Employment in manufacturing is now relatively more concentrated in industries with greater growth prospects for the future, although this shift does make regional employment more vulnerable to cyclical fluctuations. Although metal-working along with electrical machinery industry will maintain their important position in manufacturing, absolute employment growth is expected to be held back by future productivity due to the nature of their production processes. Those manufacturing industries expected to increase in absolute employment and which are heavy water-using industries are chemicals, paper, food and allied products. Paper and chemicals are projected for significant growth in the lower region, although somewhat of a less magnitude in the upper valley.

Industry such as agriculture will undergo further employment declines with agriculture in the lower basin projected to decline but at a slower rate than for the upper basin. Textiles will also continue further employment declines, however, at a faster rate in the lower basin than in the upper basin.

With the pronounced orientation towards the non-manufacturing service sector, new concentrations of workers and occupational changes will occur. Construction, finance, real estate, recreational and businesses as well as private services stand out as the more important future growth industries. A growing population with higher per capita income is likely to spend a larger share of its income on non-commodity items such as recreational activity, medical and health services, and businesses and educational services. For this reason employment in the services is projected to grow faster than in any other industrial group. Job opportunities in the broadly service sector is expected to increase by a factor of 3 by the year 2020 and should more than offset losses in agricultural and manufacturing industries. The general trend towards increased leisure time and greater mobility will place a future impact on recreation expenditures in terms of income originated and its equivalent in employment. Expecially noteworthy is the impact on the upper valley which possesses a high attractive and abundant environment for summer and winter outdoor recreational pursuits. The already high percentage of employment accounted for by the service sector reveals the importance of recreation - related activity in this region. For example, in the counties of Grafton and Coos, New Hampshire, 61% of the total employment in 1960 was accounted for by the service sector and principally in the recreational industry. This figure is expected to rise to 74% by the year 2020. In addition to the naturally attractive environment, the good accessibility of the upper basin to major population centers assures a continuance of current thriving recreation, tourism and vacation industries particularly since interstate highways, I-91, I-89 and I-93 are all scheduled to be completed by 1972. Even now, with the partially completed interstate system travelling time to the ski slopes and other major water bodies in the upper regions have been cut from 2 to 3 hours from major urban zones in southern New England as well as New York metropolitan areas. In reality, these highways have served to open up the southern and central New Hampshire and Vermont portions of the basin for increased winter and summer recreation-related activities.

B. New Patterns of Agriculture and Forestry

There are 1,100,000 acres of productive agricultural land suitable for cultivation although not all currently used for agricultural purposes. This land is currently experiencing only minor problems from erosion or other competing uses. A major future problem will be to reserve land well adapted for agricultural use so that it will satisfy future agricultural and environmental quality needs and to avoid use of those lands for agriculture which have inherent problems. For example, about one-half of the current crop and pasture land utilized for agricultural pursuits does not fall in the category of good agricultural lands. Current lands used for crop and pasture are projected to decline from a total of 938,000 acres in 1965 to 400,000 acres by 1980, and 138,000 by the year 2020. These changes will be the result of expected urban expansion as well as the phasing out of shade-grown tobacco, and the adoption of more intensive agricultural techniques. As part of this change, there will be a shift of the less productive agricultural land to forest, and there is indication that these shifts in land use are already under way.

It is estimated that multiple-use management and land treatment measures are needed on about 4,500,000 acres of private non-industrial forested land. In addition, a greater conservation education training program, and incentive program for the land owners are required if the forest resources are to be fully developed and utilized. Many small municipal watersheds are not under management, and technical assistance and land treatment measures are also needed. The environmental-quality provided by trees and other vegetation, particularly in the many urban areas and communities, is currently deteriorating, and at a time when the importance of these trees and other vegetation is often inadequately considered in the development of new communities. Community action and planning, as well as management of trees and other vegetation, is needed not only for aesthetic qualities but for microclimate control.

The acreage of forest land is expected to remain fairly constant during the projection period. Indications are that open land reverting to forest cover will keep pace with, or perhaps exceed the acreage lost to urbanization, highway and other construction. Many areas of forest land which have traditionally been used for timber production, will, however, not meet the challenges of the future. Multiple use management on public forests has demonstrated that most areas of forest land can be utilized for timber production, as well as recreation, watershed management and fish and wildlife habitat without having serious conflicts among uses.

In general, it is expected that much of the basin's forest land will be available to meet future timber demands, as well as watershed, recreation, fish and wildlife and aesthetic needs. However, the availability of small tracts of non-commercial, privately-owned forest land for these purposes is expected to be hindered by changing land owner interests and attitudes. Forest hydrologic survey findings show that there is physical potential in the basin forest lands for hydrologic improvement. Continuous protection and management of the hydrologic condition of these lands should improve to a generally good condition by the year 2020.

Your attention is again directed to Figure IV-2 on page IV-7 and Figure V-9 on page V-54 for a comparison of existing and projected land usage.

C. Water Quality

Past trends and present projections indicate that water quality patterns will continue to change. Such changes will undoubtedly occur both in those factors affecting water quality and the demands which will be exerted for water of high quality.

The future growth of the basin's population and industries will exert a continuing challenge to cope with increasing quantities of waste without violating the environment. Major emphasis will be required in the urban and suburban areas where population and industrial expansion will be contrated.

Concurrently, the expanding population with increased leisure time and per capita personal income will place greater importance on an improved water quality to meet the higher demands of recreation, aesthetics, water supply, and fish and wildlife activities. Associated with these pressures will be the likelihood that water quality standards will be upgraded.

In the area of water quality control, factors of change include both technical and management facets. The one water resource area undergoing the most technological change is pollution abatement. Treatment methods yielding higher removal of pollutants than is afforded by secondary treatment methods have been in development stages during recent years and, therefore, furnish an additional potential to meet future water quality demands and improved standards. As the cost-effectiveness of new methods are demonstrated, the broad application by municipalities and industries of those advanced methods which prove successful will become more common.

In concert with technological advances in water quality control, future management or operational techniques can reinforce technical achievements. Incentives and regulations, for instance, can encourage redesign or modification of present plant processes, recovery processes and pretreatment measures that could substantially reduce the volume or the effect of discharged wastes on the receiving waters.

Additional management measures which can direct actions toward better total planning should be considered in future and on-going basin planning. Among these measures are regional approaches and land use planning.

Regional planning in many parts of the basin is currently underway or planned. Such planning, is rapidly developing land use and utility schemes to meet the future needs of the area and includes consideration of the best configurations, locations and design of waste treatment and water supply facilities. An additional major objective of regional planning activities includes the development of land use plans compatible with the region's needs.

Future changes in land use will play a major role in determining the location and magnitude of future waste sources and methods of treatment required to maintain a suitable water quality. Projections indicate that substantial growth will be experienced in the urban areas of the basin. The effects of such urbanizations and probable decrease of farmland and woodlands will tend to further concentrate waste loads in the urban portions of the basin. Urbanization, including increased land use for roads, parking areas and homes will also result in a tendency toward warming of the basin's waters and increases in sediment and wastes associated with run-off. Uncontrolled use of rural land for urbanization and industrial growth without judicious control could result in unforeseen problems in the future water quality management needs of the basin.

Future zoning measures could effectively foster growth patterns and land uses consistent with water quality objectives and future zoning, subdivision controls, scenic easements, water quality standards and other water and land use policies can support water quality and related environmental objectives.

Every effort should be made to schedule acquisition of access rights and protection of the riverbank and corridor concurrently with the implementation of water pollution control measures. This will insure that the public has the opportunity to truly enjoy the uses and benefits of the river contemplated in the water quality standards.

D. Control of Floods

The damages caused by past floods in the Connecticut River Basin have been enormous. After the 1936 flood, the Corps of Engineers was charged by the Congress to review the problems and develop a plan to minimize future damages. Evolving from that review was a plan for the Connecticut River consisting of 20 reservoirs and several local protection projects at major damage centers. Sixteen reservoirs and 15 local protection projects have been constructed to date. The seven major local protection projects along the main stem of the Connecticut River were designed and built assuming that all 20 reservoirs would be available to reduce flood flows. The absence of these dams, authorized but not constructed, makes these local protection projects deficient as they could be overtopped in the event of a design flood referenced to as a standard project flood.

A standard project flood is a synthetic flood used by the Corps of Engineers to measure the flood potential of a river basin. It is derived from assuming a severe combination of meteorological and hydrologic conditions that are considered reasonably characteristic of the region. The rainfall rates, duration and areal coverage are prescribed by the U.S. Weather Bureau and are based on analyses of past storms of record that have occurred in the northeast United States. It is assumed that these experienced storms can be transposed to other areas with proper allowance being made for change in latitude and other meteorological variables. Some statistics on the standard project storm (SPS) for the Connecticut River basin, compared with the "Diane" storm of August 1955 are as follows:

MAXIMUM AVERAGE DEPTH
OF RAINFALL IN INCHES

Area in Square Miles	Duration of Rainfall in Hours 6	12	24	48
17-20 August 1955				
200	7.9	11.7	18.2	19.6
1,000	6.2	9.2	12.4	16.2
5,000	4.0	6.3	9.5	12.6
10,000	3.1	5.0	8.0	10.6
Standard Project Storm				
200	8.0	9.0	10.0	11.6
1,000	7.0	7.7	8.2	9.7
5,000	5.8	6.1	6.2	7.7
10,000	4.8	4.9	5.0	6.5

The isohyetal storm pattern for the standard project storm which was centered over the Williams-Saxton-West River watersheds in Vermont is considerably less in total rainfall than experienced in 1955. The rainfall varied from a 24-hour total of 10 inches for 200 square miles near the storm center to about 5 inches over the entire watershed.

Although floods like 1927, 1938, 1943 and 1955 can produce record discharges in localized areas, the March 1936 event with rainfall plus snowmelt was the greatest basin-wide flood. Consequently, the standard project flood was assumed to occur during the snowmelt period in the spring, with concurrent runoff from the melting snow added to the storm runoff. Flow in the river from snowmelt was based on analyzing the records of spring runoff, particularly years without rainfall in order to evaluate the flow from melting snow alone.

The standard project flood (SPF) was derived by applying applicable unit hydrographs to the SPS to obtain tributary rainfall hydrographs and assuming a concurrent snowmelt hydrograph equivalent to a 1 or 2-year frequency. The two hydrographs were added together for each tributary and ungaged local area, and then routed downstream to determine the hydrographs for the main stem of the Connecticut River.

The SPF discharge at Thompsonville, Connecticut which is an index of flows in the Holyoke-Springfield area, is 443,000 cfs, produced by 355,000 cfs of runoff from rainfall and 88,000 cfs from snowmelt. The SPF at Thompsonville is 58 percent in excess of the 1936 flood peak of 282,000 cfs. It is interesting to note that at that date the 1936 flood was nearly 50 percent in excess of the previous flood of record of 190,000 cfs in 1927. Since 1936, 236,000 cfs were experienced in 1938 and 174,000 cfs in 1955.

The standard project flood is used principally for the following purposes: (a) to establish top grades for dikes and walls in proposed local protection projects; (b) to demonstrate the adequacy and degree of protection provided by reservoirs to existing local protection projects; and (c) as a design discharge for channel improvement.

These three purposes use different characteristics of the SPF, for example, dike grades depend on river stages produced by the SPF; the adequacy of a reservoir is measured by the volume of runoff in the SPF; and the channel design is based on the peak discharge of the SPF. The top grades for walls and dikes are generally based on the highest water-surface elevation occurring during the standard project flood plus 3 feet of freeboard. The water-surface elevation may be determined by either backwater computations or extrapolation of a stage-discharge rating curve. It is assumed the river is flowing freely, unobstructed by debris or ice. The freeboard, usually 3 feet, is added as a safety factor to prevent overtopping from possible wave action, and uncertainties in determining the water surface profile of the SPF.

Jams caused by ice or floating debris are also an important factor in considering the degree of protection provided by local protection projects. The probability of a jam developing and its effect on river stages are both unpredictable and indeterminate. Experiences during the disastrous flood of August 1955 demonstrated that river stages in many localities were superelevated by debris dams at bridges and channel restrictions.

Jams on the main Connecticut River in Massachusetts and Connecticut are less likely to occur than on the more northern sections of the basin where they are a frequent event. However, they can, and have been experienced, notably during the first flood runoff in March 1936. In Water Supply Paper 798 - "The Floods of March 1936," the U.S. Geological Survey notes, "about 6.5 miles above Holyoke, Massachusetts an ice jam formed about 5 days before the major flood, and for a period of 2-1/2 days water was diverted from the river channel, overflowed low meadowland, and returned to the normal channel at a point some distance downstream. This ice jam, which apparently formed a complete barrier across the river, broke at about 7 p.m., March 15 and passed over the Holyoke Dam at a stage of 9.5 feet above the crest.

The ice on the Connecticut River at Hartford, Connecticut had an average thickness of 15 inches just before the first flood. At South Windsor, Connecticut, a great ice jam formed, raising the water 7 feet to a stage equal to that reached by the flood of November 1927. Considerable property was inundated by backwater from the huge jam, but on the whole the damage from this earlier flood in the lower Connecticut River Valley was not great.

Many highway bridges have been constructed across the Connecticut River during the past 20 years. Each bridge, with piers located in the river channel, creates a potential hazard for development of jams from ice or massive debris. Thus high river stages may develop from a rare flood comparable to the standard project flood, or they could be caused by a smaller flood coincident with jams of ice and/or debris. These intangible and indeterminate factors have to be considered in evaluating the protection provided by a system of reservoirs and local protection projects of walls and dikes.

An array of flood discharges may be analyzed statistically to determine probabilities of occurrences. The smaller more frequent events give reasonable reliability for 20 to perhaps 50 year floods, but beyond this the reliability begins to lessen. Floods classified as 100-years and less frequent have a questionable degree of dependability and may vary considerably with the type of plotting paper, or the skew coefficient considered applicable. For example, the March 1936 record flood in the Connecticut River at Thompsonville would not even fall on a frequency curve derived, say in 1935. Similarly the 1955 flood for many rivers in southern New England would not be on the frequency curves in 1954. The SPF is in a similar category - it is a rare flood, it has not occurred yet, but it could happen with a combination of hydrologic events, and when and if it develops, it will then be found on future discharge frequency curves. Because of this fact, hydrologists are reluctant to even estimate the frequency of the SPF.

The probability of high river stages thay may jeopardize the protection provided by walls and dikes is also indeterminate as high stages may be caused by high discharges, or a combination of lower discharges with concurrent ice jams or debris trapped at bridges.

Although the possibility of overtopping the existing protective works is remote, the consequences would result in catastrophic losses. Economic protections point to increased development contiguous to the existing urban complexes, portions of which are now protected. Current and future development is taking place because of factors and externalities other than flood control protection. In addition, there are large areas of these urban complexes which lie outside of the existing local protective works and which are not conducive to flood plain zoning programs. Because of these factors the Coordinating Committee in its judgment has recommended that the lower portion of the basin, which represents the economic heart of the valley, should be protected to the SPF levels, and have the added degree of insurance which this level of protection provides.

E. Flood Plain Management

There is a consensus among most agencies that the magnitude of future flood damages and the loss of life will be determined primarily by the nature and extent of development in flood plains. Structural measures have been used to prevent flood losses and will continue to do so. However, in many cases, structural measures are not feasible, or economically justified, or politically acceptable. The alternative in such cases is non-structural measures or more properly identified as flood plain management.

It is recognized that flood plains often have high value uses other than commercial, residential, industrial, of public development which could be subject to flood damage. In many instances, the valley storage in the flood plain acts as a natural reservoir, thereby reducing downstream flood damage. Flood plains can be of value for a variety of outdoor recreation activities, are generally scenic, and provide ribbons of green and open space in both rural and urban settings. Streams and associated wetlands of the flood plains constitute critical fish and wildlife habitat, often to the degree that preservation of wetlands is fully justified for these purposes, quite apart from flood damages.

Flood plain zoning is viewed therefore as an effective means of resolving flood problems in some areas of the basin. In other instances however, and particularly where extensive developments already exist on the flood plain, it is not considered a practical alternative. However, flood proofing or other management techniques can be applied in these instances to complement other flood control structural devices. If man were to indiscriminately encroach upon the flood plain and in an unwise manner, such action would more than offset gains earned by flood control dams, flood walls, dikes and associated improvements. It is for this reason that the Committee strongly urges the States and the local municipalities, upon whose shoulders rest the primary responsibility for the initiation and implementation of flood plain zoning, to carefully consider these alternatives and to introduce such measures wherever possible and practical in reducing flood control needs.

Section 206 of the Flood Control Act approved 14 July 1960 (P. L. 86-645), as amended, authorizes the Secretary of the Army, through the Chief of Engineers, to compile and disseminate information on floods, flood damage potentials and general criteria for guidance of Federal and non-Federal interests and agencies in the use of flood plain areas. Under this authorization the Corps of Engineers carries out its Flood Plain Management Service program.

Information, guidance and advice on flood hazards are made available to Federal, State and local governmental agencies which will permit them to proceed with such planning, engineering studies, construction and other action as may be necessary for wise use of flood plains. Application of such information and guidance by these agencies is intended to help in planning and regulating the use of flood plain areas to reduce flood hazards and flood damage potential which otherwise could arise from unwise flood plain development.

The program includes preparation of flood plain information reports, provisions of technical services and guidance in the interpretation of basic data, preparation of flood plain regulations and application of concepts such as structural flood-proofing of new and existing buildings, preparation of guides and pamphlets, conduct of related research and long-range comprehensive flood damage reduction planning. These activities are being coordinated with related programs of other Federal and State agencies. Guides and pamphlets are distributed for use by State and local governments, private citizens and Federal agencies in planning and taking action to reduce their flood damages or damage potential.

Comprehensive flood damage prevention planning, at all appropriate governmental levels, is the composite and ultimate objective of the Flood Plain Management Services program. It is not a separable activity, but takes place through preparation and dissemination of flood plain information reports, through provision of technical advice and other forms of assistance to persons and governmental entities concerned with flood hazard problems, and through continuing research on means for dealing more effectively with flood problems. The purpose of these activities, taken together, is to encourage and guide the best and safest use possible of flood plain lands for the benefit of the national economy and welfare. The program provides a direct complement to other flood control efforts by the Corps of Engineers and other agencies.

Flood Plain Insurance Program. The Housing and Urban Development Act of 1968, Public Law 90-448, Section XIII of the 90th Congress authorized a program for flood insurance. The purpose is to determine Federal programs which could provide financial assistance to those suffering losses in floods.

F. Increased Water Use

In the past, water use demands were low due to smaller populations and fewer daily per capita demands both in direct response to a much lower standard of living than we now enjoy. Today the average housewife uses about 30 gallons of water each day doing the household wash. New sanitary facilities require as much as four gallons per flushing cycle. These activities have caused water use demand curves to rise at a more rapid pace.

Historically, water was viewed from its capability of producing power, initially as part of a manufacturing operation, then later for a hydroelectric use and now for large cooling requirements for thermal power plants or industrial cooling. The water requirements for the power industry are shifting. Hydroelectric developments in the Connecticut Basin are nearly double the national average, but the power units are located in series so that much of the same water is utilized several times. New innovations, particularly as relates to the emergence of nuclear power as a predominant means of developing electri cal energy will likely require changes in the historic patterns of river regulation. Whereas in the past, hydro units were used in a peaking operation, that is, to meet those surge loads produced at key hours of the day. These same type operations can be accompanied by the more flexible pump storage projects. Nuclear and fossil-fuel generation plants can be utilized to provide a steady base load. The hydroelectric operations will be a declining but significant share of peak energy as they are gradually replaced by the more powerful and flexible pump storage facilities. One of the largest such projects in the northeast is currently being constructed at Northfield Mountain in Massachusetts, with a second license request approved at Bear Swamp in the Deerfield Valley of Massachusetts. The need for water for the power industry will be significant and particularly as relates to cooling water, even when appropriate cooling towers are introduced. Most industrial water which accounts for nearly 90% of the total municipal and industrial water is obtained directly from the river with consumptive use about of about 7%.

As part of the clean water restoration program, industrial organizations are being required to clean up wastes and as a result of this program they are finding that the re-cycling of water is not only an economical means of meeting this requirement of meeting established standards, but result in economies of supply from s omewhat limited industrial water resource base. It is envisioned that in future years many of the industrial ponds will phase out for other competing purposes and particularly as industries move towards a closed-system type operation. Such a move will help restore water quality and produce smaller industrial water supply. Nevertheless, in spite of such innovations, the additional amounts of products required to meet a burgeoning population will, in the total, require more water for industrial uses than in the past.

Irrigation water in the Connecticut River (a totally consumptive use) plays a minor role relative to farm production, with those operations requiring some being located along main tributaries and being supplied by direct pumping. Food processing industries use extensive amounts of the water and these are generally supplied by municipal systems. Water used in association with forested land industry is largely confined to the production of paper and its allied products. Water requirements for manufactured products from forestry resources vary not only by the produce but by the processes used. Lumber mills producing 5, 000, 000 board feet or more per year average about 1, 000 gallons of water per thousand board feet of lumber produced. The average sawmill produces about 500, 000 board feet and uses 10 to 20 gallons per thousand board feet of lumber. A typical veneer plant may use 5, 000 to 10, 000 cubic feet of water per vat per week if water is used to heat logs. Here two such operations have to be located along major tributaries.

In comparison, the pulp and paper industry is dependent upon adequate supply of high quality water for continuous operation with storage developments necessary. Large quantities of water are required for separating celluloid from non-fibrous constituents of the wood and comparable volumes are needed to produce paper and paper board from wood pulp. In addition to these processes, the industry required water for steam generation and cooling purposes. The amounts of water used varies widley from mill to mill, from a minimum of 1, 000 gallons per ton of pulp for the ground wood process, to a maximum of 144, 500 gallons for the sulfate and soda processes per ton. Improved waste water processes are, however, reducing these amounts for between 1954 and 1959 the water required per ton of pulp and paper decreased by 14. 2%, and this trend is continuing.

Water use for domestic consumption is on the rise and will continue to be so unless there are major changes in social preferences. The advent of the outdoor swimming pool has added additional burdens to municipal systems. Per capita demand curves indicate an increase of 1. 1 gallons per day per year through period 1980, with a slight tapering off from there on to year 2020.

As part of the requirement to meet larger domestic and industrial consumption, it is apparent that historic modes of developing individual local type water supply systems will not suffice in the future and principally for two reasons, namely, the pressure coming from competitive land use, and the larger and more costly conveyance capability required. Since two-thirds of water supply costs are involved in distribution and conveyance, major economies can be effected through regional type systems. As many of the municipalities are already heavily stressed from schools, police protection and other social services, many do not possess the financial resources to meet the cost of the larger systems alone. As regards those existing larger units, they are finding that the added increments of supply present larger cost increments, and are, therefore, closing their doors to neighboring customers.

Closely allied to this problem of regionalization is the question of inter-basin transfers and the political and social consequences which this move introduces. On-going studies as part of the Northeast Water Supply Study reveal that inter-basin diversions are feasible in the New England area and can be accomplished largely as part of a multiple-purpose flood skimming operation timed during the freshets period of three months of the year when waters are excess to other stream activities and use.

G. New Patterns in Recreation

As relates to winter recreation, the private sector plays the major role in providing facilities principally through the construction and operation of ski areas. The better centers are located in the Green and White Mountain areas and some upon Federally leased lands. One of the chief beneficiaries of the improved highway system is the skiing industry and particularly in the upper basin with annual receipts in the millions of dollars. In addition to improved accessibility, the advent of "snow making" or production of artificial snow, not available before 1950, has meant the difference between profit and loss for many of the basin slopes, especially in the warmer climates of Massachusetts and Connecticut. Since man-made snow lasts up to three times longer than natural snow it has been possible to extend the length of the skiing season and in some areas, snow-making equipment has resulted in a nearly six months ski season.

Another winter recreational activity also producing a heavy impact in the north country is the relatively new sport of snowmobiling, having already become the second most popular winter activity. Its present growth rate assures that the job of providing new trails and other support facilities will be a high priority item in the future recreational development of the basin.

To balance out an extensive winter recreation activity there is in the basin an even broader based summer recreation economy which is growing in phenomal proportions in recent years with "vacation homes" leading the way. For example, the "Northern New England Vacation Home Study indicated that some three hundred million dollars were spent by vacation home owners industry alone in the basin in the year ending August 1966. The annual expenditures of these second homes reflects the year round occupancy of many of the newer dwellings. Although the economic significance of the "vacation home owners" cannot be overly stressed, they do bring with them the"land lock syndrome" with greater fencing and posting of lands which up till now provide major base for hunting and fishing opportunities. If such trends continue at current rates it could indeed produce a land locked resource with the consequence of only the more affluent sectors of the basin population able to participate. The need for more public land areas for a growing population which is caught between the confronting stresses of continuing mass urbanization and sprawl and the social desires to share in the natural environment.

Key summer season activities are water-oriented with swimming, camping, picnicking and boating preference patterns leading the way. Land available for outdoor recreational use in the northern portion of the basin is more than twice that available in the southern portion and is generally contained in larger parcels. State parks and forests and Federal recreation areas, although fairly well distributed but some distances from heavy demand centers of the southern basin. Public and private camping opportunities individually and collectively, provide a significant outdoor recreation supply and have potential for further development. At present, however, there is a lack of sufficiently developed water areas as relates to the public sectors and particularly when one removes those water supply reservirs areas not open to public use or in a very limited one. Whereas potential capacity of lakes and streams in the basin is high, the degree of development of such resources is very low owing to land ownerships and access patterns. To meet projected recreation participation considerations must be given to adding new opportunities as well as increasing the level of development at existing water resources.

H. Historical and Cultural Resources

On a varied and attractive landform of exceptional scenic landscape man has created a pattern of town, field and forest possessing great variety and visual appeal. But urbanization and industrialization have been destructive of both the natural features and the physical remains of man's past.

The New England Region has been a cornerstone for cultural development and social and economic progress and the Connecticut River area has shared and contributed much in these endeavors. Many of the landmarks associated with total development of the United States are rooted within the basin's boundaries. Some of these have become submerged in the physical growth that demarcates the urban places of today while others without appropriate safeguards taken now may become submerged tomorrow. There is need to identify these historical landmarks and there is further need to preserve those worthy of more than memory.

With a growing population which continues to consolidate with ribbons of access into a northeastern megalopolis region there is developing a public concern with regard to protecting existing natural areas and historical resources. If this heritage is to be preserved, it will require a major commitment of the part of the valley citizen working closely with local, State and governmental agency programs. The use of the Historic Preservation Act of 1966 should be utilized in encouraging appropriate State agencies to evaluate the historical and archeological described in Appendix O of this report. The natural resources of the basin, in many ways the finest mirrors of natures violent past found in the entire northeast quadrent of the county, have been inventoried and many sites have been categorized as having value. Most of the truly important of such sites are either already protected by their location in public and private parks, forests or reservations or they are scheduled for such protection through complimentary recommendations referred to in this comprehensive report. Many other sites of more local significance, are in need of identification and protection at the local level.

Where there is no local agency capable of acquiring and managing such areas there is need for the States to encourage their formation. There is need to consider protection for those of the archeological resources in the basin described in this report that may be of significance together with further planning efforts to determine how this might best be accomplished.

I. The Role of Existing Storages in the Connecticut River Basin

Different interests have asked during the course of the comprehensive study what could be done with existing storages in the Connecticut Basin in providing flood control or low flow augmentation that is, if these existing reservoirs were operated in a manner different than their current pattern. Studies were made of all dams and reservoirs in the basin which effect control upon 50 square miles of drainage area or greater. The significant storages as utilized in the production of hydroelectric power and particularly those situated along the main stem of the river owing to their strategic location were given major consideration. The units considered to be most significant (i.e. greater than 7,000 AF) in this regard, all of which are non-government operated, together with their useable storage (not total storage) and by this we mean that volume which can be regulated by some mechanical means, are noted below:

MAIN STEM STORAGE

Dam & Reservoir		Useable Storage in A.F.	
1. Second Conn. Lake		11,600	
2. First Conn. Lake		76,400	
3. Lake Francis		99,300	
	Sub-total =		187,300
4. Moore Reservoir		114,300	
5. Comerford Reservoir		29,400	
	Sub-total Upstream of Woodsville		143,700
6. Wilder		13,400	
7. Bellows Falls		9,600	
8. Vernon		12,000	
9. Turners Falls		10,500	
	Sub-total		45,500
10. Holyoke		7,000	
	Total		383,500

Of interest is the fact that more than 86% of the useable storage on the main stem is located above river mile 274.4 and at this point affects an upstream drainage areas of about 2,200 square miles or slightly less than 20 percent of the total basin drainage area. It is also worthy to note that as concerns snow melt Moore reservoir representing the largest single useable storage area on the main stem is annually drawn down some 40 feet to capture runoff from upstream snowmelt source. However, analyses of all major floods that have occurred on the central and lower parts of the main stem of the Connecticut River indicates the floods are caused by the tributary discharges emptying into the main river downstream of the narrow "neck", located in the vicinity of Woodsville, New Hampshire. The significant reason for this is due to the fact that peak flood runoff from the northern areas does not synchronize with the central and southern peak discharges but comes on the receding side of these flood hydrographs.

TRIBUTARY RESERVOIRS STORAGES

Those unites of storage considered to be most significant as regards to tributary rivers of the Connecticut are as follows:

Mascoma Lakes (4 Lakes)		24,400	
Sunapee Lake		19,800	
	Sub-total		44,200 a. f.
Somerset Reservoir		57,400	
Harriman Reservoir		116,000	
	Sub-total		173,400 a. f.
Quabbin Reservoir		1,235,000	
Borden Br. - Cobble Mt.		77,900	
Otis Reservoir		17,900	
W. B. Farmington - Hogback Reservoir		20,100	
B. Farmington		9,000	
Barkhamsted Reservoir		93,000	
Nepaug Reservoir		28,500	
Shenipsit Reservoir		11,100	
	Sub-total		1,492,500 a. f.
	Total		1,710,100 a. f.

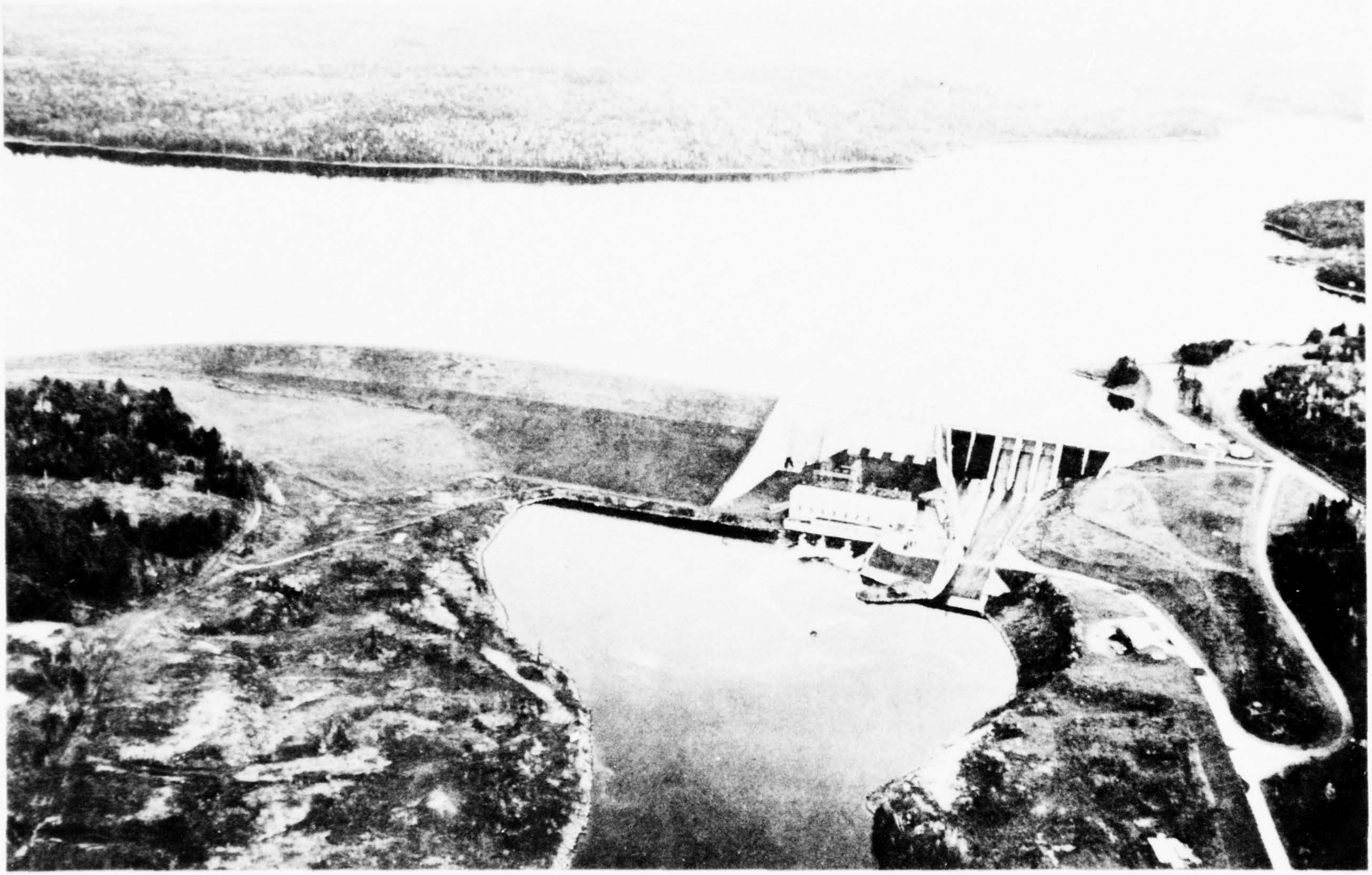
Although tributary storages are significant more than 87 percent are utilized for municipal water supply systems operated on a near full basis with nearly 73 percent diverted outside of the basin. Those more important storage contributions are located in the Deerfield River representing 173,400 AF of volume. It can be said that tributary reservoirs also play a significant role in dampening the more frequent minor type floods but are generally ineffective in major floods with the exception of Quabbin Reservoir which provides major control of runoff from the Swift River tributary of the Chicopee River Basin.

OPERATION OF RESERVOIRS

The existing hydro-electric operations are used principally for peaking power-needs and operation is keyed to Moore Reservoir so that when this operation is transferred to all downstream units which have far less storage capabilities, they function as run of the river operations. To establish the degree of efficiency of current power operation and as part of the Connecticut River Basin study a doctoral dissertation was prepared by R. M. Males in September 1968 and documented in his thesis entitled "OPTIMAL OPERATING RULES FOR MULTI-RESERVOIR SYSTEMS".

Dr. Males' work provides for optimal operation of reservoirs through a combination of dynamic programming and simulation models. His initial studies were made by setting reservoir priorities at all the main stem storage reservoirs at low levels, and power priorities at high levels, so that reservoir operations would respond to power demand only. Result of simulation runs yielded extremely low power benefits, and in particular, the loss of head at Moore and Comerford Dams, the more valuable peaking units in the basin, was severe. The maximization of power benefits could not be achieved internally by the operating procedure of setting high priorities on power. Investigations showed further that the achievement of high head levels at Moore and Comerford was a major factor in yielding high power benefits, and that an appropriate balance had to be found at these two sites between energy and reservoir priorities. This balance was found to exist away from the regions of extreme priority values. Further results indicated that selection of high power priorities for the smaller downstream run-of-the-river plants such as Wilder, Bellows Falls, Vernon, Turner Falls caused depletion of upstream reservoirs without yielding commensurately greater benefits. The current operation of the three upper Connecticut Lakes was found to be a significant factor in achieving power targets at Moore and Comerford. Dr. Males' studies concluded:

1. Maximum benefits for power could not be achieved through high power priorities and low reservoir priorities.



SAMUEL C. MOORE HYDROELECTRIC POWER STATION AND RESERVOIR AT UPPER FIFTEEN MILE FALLS IN LITTLETON, N.H.

Corps of Engineers Photo

2. Achievement of high head levels at Moore and Comerford was a primary physical objective for generation of high power benefit.

3. Power priorities could not be set uniformly throughout the basin, since Moore and Comerford were the most significant producers of energy, and the downstream run-of-the-river plants would draw too much from the upstream reservoirs if power priorities were set on a level with Moore and Comerford.

4. At Moore and Comerford sites, the balance between reservoirs and power priorities was significant.

5. The three upper lakes could best be operated to regulate flows for Moore andComerford reservoirs, responding to downstream power priorities but exerting some dampening influence due to moderate priority levels at their own sites.

Questions have been asked whether additional outlets could be installed at existing dams with a view to obtaining bottom discharges of cooler waters for fisheries. From an engineering point of view, this could be accomplished, but there are water quality problems in some of these storage pools. Moore Reservoir currently traps paper mill wastes from upstream pollutors. Over the years sludge deposits have resulted in nearly a total depletion of oxygen. Drawing the waters from this pool could introduce water quality troubles to the reaches immediately downstream. In other instances main stem pools act as lagoons where combined storm sewers' runoff are retained. Assuming improved water quality through treatment plants in future years consideration could be given to incorporating bottom discharge release at main stem reservoirs. Storage on tributary stream, that is other than those used for water supply purposes, is available, for example, at the four Mascoma Lakes or Lake Sunapee all of good quality. But discharges could alter lake levels and meet with a storm of protect particularly during the recreation season owing to the extensive multiple use of these water bodies.

Existing storages have also been reviewed by the Coordinating Committee with a view to their role in low flow augmentation. The Committee has recommended that in relicensing of existing power plants new permits call for a continuous minimum instantaneous release of 0.2 csm. This release is considered an equitable amount of flow as to what could be expected during low flow periods in the absence of the power dams. This can be accomplished without impairing the useable storage as utilized for power generation. Additional information on this matter may be found in Appendix Q.

PART TWO

CHAPTER VI

SOLUTIONS

CHAPTER VI

SOLUTIONS

Section 1 - Concept of Analysis

A mental image of the Connecticut River Basin as relates to solutions of an array of different needs would perforce draw heavily upon the recent legislation and particularly since 1962 which has affected planning policies as well as cost-sharing as relates to the Federal Government, and also States. Such items as the Appalachian Regional Development Act of 1965, the Land and Water Conservation Act of 1965, The Federal Water Project Recreation Act of 1965, the Water Resource Planning Act of 1965, and the Public Works and Economic Development Act of 1965 have placed strong emphasis toward regional development and those opportunities which may be available to create new employment or to alleviate sufferings from substantial or persistent unemployment or underdevelopment. Add to this philosophy the Water Quality Act of 1965 which established standards and goals to be part of a procedure whereby we would restore water quality in America's rivers.

The Clean Water Restoration Act of 1966, presented further assistance for developing comprehensive water quality control programs as well as abatement plans for various river basins. The introduction of the Department of Transportation Act and the Wild and Scenic Rivers Act, as well as national flood insurance together with the Executive Order 11296 places emphasis on land use through regulation and administrative policy as a means of reducing damages.

The Estuary Act of 1968, an attempt to develop a balance between conservation of natural resources and the natural beauty of the nation's estuarine areas, is another piece of legislation of far reaching consequence. By enacting these laws, Congress has in fact broadened the national objectives to be considered in planning for water and related land resource development. In keeping with this program, our solutions have been broadened. They are multiple-purpose oriented. No longer do we consider solely national objectives which improve the efficiency range of greatest benefits for costs incurred. Objectives now seek a balance between full consideration of development and preservation and the well-being of the people. These items of preservation have been broadened to include environmental quality. We now have, therefore, multiple objectives that have to be introduced in our investment planning. These are the result of the executive and congressional guidance that has developed, particularly over the 1960's.

The Connecticut Study sought to identify all benefits of water use or developments and to measure as best as possible those benefits and costs to be derived therefrom, including so-called intangible effects.

In the past Federal agencies and others were principally concerned with single-purpose, separate project planning. And many of the laws restricted considerations of broader aspects of the uses of water and the associated problems. However, water is not a divisible resource. Anything done upstream in the river basin for one purpose may affect the usefulness downstream for other purposes. The comprehensive planning exercise therefore, requires that we consider the effect of any one activity on all water resources and related land uses. Water management problems, whether related to excesses of nature, such as floods and drought, or to man-made conditions, such as pollution, or to competition for water supplies for cities, industry, and recreation are of concern to the water resource planner.

Studies commence firstly by performing two parallel activities referenced as supply and demand analyses. The supplies refer to the resource itself be it a reservoir or an open stream, or a series of open spaces, whereas, the demand refers to the actual needs which can be either negative or positive. The planner is concerned with reconciling needs and resources, and he does this through a series of devices which could be non-structural in character or structural in character. Structural devices are most commonly understood as being either reservoirs, flood walls or channels, or sewage treatment plants. Whereas non-structural devices may take the form of legislative constraints; zoning; taxation; and other restrictions which limit or prohibit full use activities on lands. Those structural improvements which have regional scope or of sufficient magnitude to affect more than one community have considerable Federal interest. Non-structural proposals generally are bettersuited for local communities, with interest usually narrow in scope, as well as the effects from such measures. Most States have given authority to the local community as regards regulatory control of land, as well as the taxing policy. It can be seen, therefore, the resources which are fixed can be regulated in several ways. Either to effect more use or to reduce use. Further, they can be modified by the introduction of structural measures which could provide for multiple-use activities by reason of the storage of excess water during freshet periods for those times in the year when river flows are greatly reduced.

As part of our concept of analysis, and in keeping with established criteria, multiple objectives have been utilized in the Connecticut Study as well as multiple-purpose planning. Three multiple objectives, namely, Environmental Quality; National Efficiency; and Regional Development were used. The largest monetary cost would be incurred if the Environmental Quality objective were used as a principal means of decision making and plan implementation. The second mostly costly multiple objective was that of Regional Development which provides the area in question with the most regionalized benefits. Lastly, National Efficiency was the least costly of the three objectives considered. Whereas monetary device costs were highest in Environmental Quality objective, the non-monetary interaction benefits were found to be high and the non-monetary interaction costs were found to be low. By this we mean, the effects generated by satisfying one need on all other needs of the resource family. Non-monetary interaction therefore means that you are the recipient of a benefit which is perhaps intangible, that is difficult to measure by reason of someone meeting a specific need for some other resource requirement. Presumably if these non-monetary benefits are high, then you would add to the value of the project development. The reverse of this is true, namely, if your non-monetary costs, principally opportunity costs associated with your project are high you would tend to take away from the value of your project even though from an economic point of view it might very well be justified.

Studies reveal that considering Environmental Quality the greatest beneficial interactions would be obtained by emphasizing demands in six resource areas: namely, recreation, fish and wildlife, liquid waste disposal, flood control, erosion, and visual and cultural requirements. The implementation of these six categories, although producing a high monetary device cost, also brought forth rather high non-monetary interaction benefits and low non-monetary interaction costs. In the instance of the National Efficiency objective, emphasis was given to fish and wildlife, flood control, visual and cultural needs, and power cooling needs. Obtaining these resources produced the least initial cost for the devices but conversely, produced the least non-monetary interaction benefits. In the instance of the Regional Development objective, although initially the costs for this were less than Environmental Quality, greater benefits could be realized in effecting the economy of the general area where the project was to be located. Four resource categories were emphasized under this objective, namely; recreation, fish and wildlife, flood control and visual and cultural needs. Non-monetary interaction benefits were found to be significant but not as high as the Environmental Quality objective. Conversely, the non-monetary interaction costs were lower.

Of the three multiple objectives of which analysis was made the Regional Development objective produced the best mix of benefits and costs without incurring excessively large initial costs. The Environmental Quality objective produced the greatest array of benefits, and intangible benefits but would incur larger outlays, most of which would be assigned to local governments. Utilization of the National Efficiency objective affected non-monetary interaction benefits and foreclosed some areas of Environmental Quality that while difficult to evaluate as market values, generated tourism and as a subsidiary effect enhanced economic conditions.

CHAPTER VI

Section 2 - Single and Multiple Purpose Solutions

There are instances where economies can be effected by utilizing the philosophy of single purpose solutions. As an example, the utilization of local protection works such as flood walls or flood dikes or channels can be an effective way of solving a problem at a particular point of need. It would by reason of its characteristics not provide for other uses such as may be realized by constructing a reservoir which would make unnecessary the flood wall, and at the same time, produce a body of water that could support not only conservation storages for fishery enhancement but also provide for other outdoor pursuits, as well as improve the visual qualities of a particular landscape. In addition, the releases of water from such an impoundment could be of beneficial effect during periods of low flow on the water quality of a particular stream. The multiple purpose reservoir would involve greater costs, initially, but would pick up a larger array of benefits. There are however, instances where such a reservoir might also affect opportunity costs by precluding the use of that particular stream for some other values. In the selection of the reservoirs that are members of the basin plan, consideration was given to the opportunity costs produced by the particular project, and if these were found to be high the project was abandoned. There are instances where single purpose storages could be utilized and in fact, may be the best means of introducing the project because higher storages might very well affect the relocation of upstream properties. In such cases, the single purpose proposal could be recommended because any multiple purpose unit would incur the dislocation of other entities and likely cause the project to be unacceptable. The erection of sewage treatment plants are fairly well single purpose oriented in that other purposes generally cannot be introduced at the site. However, the improvement of water quality that is a result of the liquid waste control, is multiple purpose in that greater uses can be made of the recipient streams.

A good example of the multiple purpose solutions is available when one considers the acquisition of open space, either for the preservation of open space or for a scenic cause, or for the accomplishment of outdoor recreational pursuits. Generally such pieces of property are located close to river bodies and are useful, not only in providing the purposes noted but in keeping additional growth, either commercial, residential or industrial from introducing itself into the flood plain. On this basis, one can see that there are multiple purpose affects to come from such an open space program in accomplishing the control of future damage areas.

Continued expansion on a single-purpose basis requires a larger number of reservoir sites to meet needs and would soon exhaust the land availability. It could preclude only those more urgent and economical developments. In the instance of hydroelectric power storages, a more equitable release pattern would make possible multiple use concept of low flow augmentation, and support such uses as fish and wildlife, waste assimilation and cooling needs. Multiple-purpose considerations, therefore, conserve the amounts of land required to produce an end result and can help reduce the high cost of going it alone. In providing for a wider use at a reservoir site because of larger size, added flexibility in operational procedures could be achieved.

Generally, multiple-purpose developments afford us a way to optimize our resources of water and land and to maximize benefits while conserving natural resources. Optimization of benefits is occasioned because of lower unit costs assigned to project purposes than would otherwise be required to support any single-purpose proposal. More often than not, multiple-purpose development is preferred by local interests, because, a broader aspect of wants and desires can be satisfied and thereby effect acceptability.

Maximizing total benefits through inclusions of as many purposes as possible usually produces more attractive total benefit-cost ratios. It should be done with care because in some instances it can result in added disruptions and relocations of local facilities and therefore, must be compatible with local attributes and desires. The proper analysis of all alternatives affords the planner his best guide. In viewing these alternatives one must recognize that in many instances, topographical and locational factors could limit or restrict practical alternatives. For example, a particular stream may be of high quality but of insufficient magnitude to effect any sizeable range of use. Thus, quality without volume is of limited consequence as moderate flows of a lower quality may, in this instance, permit greater use than lower flows of a high quality.

Multiple-purpose solutions have several ramifications whether they are structural such as reservoirs controlling high or low flows; or non-structural such as open space, that can meet array of other needs. Add to the picture of multiple-purpose the item of complementary solutions and we find an even more flexible means of meeting water resource requirements.

CHAPTER VI

Section 3 - Complementary Solutions

Complementary solutions are those added elements which complete a particular needs requirement. For example, let us consider flood control needs and the control of future damages. Whereas a particular reservoir may be used to reduce flood stages without the incorporation of downstream encroachment lines, or, for that matter, adequate flood zoning measures, we might find that future growth could negate the benefits that would come by reduced flood stages. Only through the implementation of the flood management program would we then have a solution to the control of flood damages. In such a case then, the introduction of flood plain management would be classified as a complementary solution. Elsewhere in this report flood plain management has been noted as an alternative means of controlling flood damages. In instances where local support is lacking for protective measures of other types, this particular means should be pursued, but it is recognized that by means of storage of flows, we are, in effect, permitting a wider use of land resource by making possible the enhancement of land which would otherwise be inundated or have to lay idle for those periods when inundation would take place. Complementary solutions also occur in the instance of reservoirs whether they be large or small.

The larger reservoirs are designed for major urban areas and to effect flood stage reductions over longer distances. Whereas, the small multiple-purpose upstream program provides a means by which the upstream landowners and communities can obtain protection which would not be afforded by the larger dam designed for downstream areas. The programs of the Corps of Engineers and the Soil Conservation Service are therefore designed to complement each other and a good example of this case is in the Sugar River where a 10-reservoir, Public Law 566 watershed plan will provide much needed protection in the upper part of the Sugar River and in the lower reaches of the Sugar River as well as the main stem of the Connecticut River protection is afforded by the larger multiple-purpose Claremont Dam and Reservoir.

Complementary solutions can also be effected at the site of a particular reservoir by the installation of hatcheries to take advantage of improved water quality discharges from a new reservoir or the cooler water releases. Then too, complementary solutions may take the form of a more aggressive stocking program used to complement native species in a particular lake or stream. Complementary solutions can be employed at the various new treatment units that are planned initially for secondary levels of treatment, providing for 85% removal of BOD. The incorporation of additional treatment measures in the future will likely increase removals to the 90% range and such additions would be considered as complementary to the waste treatment operation. In the instance of low flow augmentation, which can only be introduced for Federal consideration after adequate levels of treatment, the added low flow is considered as a complementary means of obtaining a water quality objective. There are several areas in the basin plan where complementary solutions have been introduced and these will be discussed in the following Chapter.

PART TWO

CHAPTER VII

ALTERNATIVE PLANS

CHAPTER VII

ALTERNATIVE PLANS

Section 1 - General

One of the more important provisions of established policies and standards is the requirement that our report present alternative solutions, and that we articulate alternative ways of meeting goals or water resource needs. In this manner, reviewing authorities and the Congress may weigh advantages and disadvantages as brought out in the process of hearings, as well as provide further consideration of various proposals.

Alternatives would be considered from the standpoint of whether the cost of departure from a strictly optimum economic solution is justifiable in order to accede to the desires of the people. It might be also that the solution in question will preserve an area for those who would rather enjoy scenery than to see additional economic progress. Planning must not only be optimum, but must demonstrate alternatives that would take into account the views of others who may object to one or more features of the plan so that judgment can be exercised and so that there will be a realization of what is at stake if alternative courses of action are taken.

Consideration of alternatives requires that we define the nature of the alternative as to its ability to produce a given end product and that we do not confuse alternatives with options. The alternatives may differ in the means but not in the degree of satisfying particular wants. Alternatives are nothing more than combinations of on-going applied means of solving problems, or application of new techniques, or the changing of social desires.

The alternatives chosen in the Connecticut Basin Study are a mix of actions which are directed to the five generally broad program areas of Restoration, Preservation, Conservation, Development, and Utilization of water and related land resources. Further, one or more alternatives chosen may only satisfy one or two of the programs noted. For example, the alternative to provide open space could satisfy the category area of preservation, and simultaneously encompass new developments with the open land space to support some outdoor recreational needs. The alternative may not necessarily provide for the utilization category or for the restoration category. In resolving a particular resource category need there will likely be within the alternatives presented a hierarchy of levels of accomplishment, principally based upon the required investment. To clarify this point, a major tributary reservoir may very well produce sizable flood control benefits in its tributary basin, as well as effect major flood water reductions downstream on the main stem. In such instances it would be necessary to tabulate the costs and benefits involved for the large unit, as against those involved for the alternative of producing a series of smaller units, so as to distinguish which solution offers the best gain, considering all opportunity costs and opportunity benefits.

Alternative solutions vary considerably as to type, number and nature, and depending upon the resource category. For example, protection from flood waters may be achieved structurally by storage reservoirs in both large and small categories, or by local protection such as flood walls; levees; diversion canals, deepening and widening channels and pumping plants. In the non-structural category we can prevent or reduce damages by use of flood plain management, encompassing such items as flood plain zoning; flood proofing; flood insurance; or legal constraints such as restricted taxation; permanent easements, and other inhibiting regulatory controls affecting land use. A further alternative would be early warning measures up to complete evacuation of flood prone areas perhaps as part of an urban redevelopment project. Of the means noted, only two are in the non-structural category, flood plain management and early warning measures. Early warning measures, in addition to allowing evacuation, also provide the necessary time to organize men and material to make local protection effective.

In the instance of water quality and pollution abatement programs, current practices and Federal and State grants are directed to control of pollution at the source and generally by structural measures, namely treatment plants producing various degrees of treatment from primary, secondary, advanced, up through tertiary. Alternatives to this type of treatment are diversion of waste to larger streams having greater assimilative capacities, lagooning of waste, in-stream aeration, or complete re-cycling of wastes with possible recovery as a resource.

Other possibilities that have been considered include technological breakthroughs, reduced production, or plant shutdown. Tax measures, either as incentives or restrictions which are non-structural in character can be used to ultimately require the implementation of some structural in character device to reconstitute, stop, or negate pollution. The augmentation of flows, made possible through storages, as well as flow regulation require structural measures and is considered a complementary measure to balance a sound water quality management program. On this basis one can see that there are few known non-structural devices which can be applied in resolving pollution problems, at least at this time. However, dependable forecast of natural stream flow, while not a solution to the pollution problem, can be quite useful as a means of reducing both the frequency and severity of pollution. Discharges of pollutants can be timed to coincide with higher natural stream discharge rates if reliable and accurate stream flow forecasts are available.

A sharp contrast is evident in the use of non-structural measures in meeting outdoor recreation needs, although much reliance is placed on reservoir utilization in meeting boating and water contact demands. For example, an "open space" or "scenic river taking" preserving a scenic landscape can, at the same time, provide ready access to a stream or body of water, thereby opening the door, so to speak, to a host of other outdoor recreation opportunities. Here the acquisition of lands represents the major cost in resolving needs, although it might least affect the ecology of an area, such programs could affect long term growth, or upset capital base and tax structure of a community.

In summary, alternatives vary in number, type, and application, and what is good for one area may not suffice for another. Further, there is, in fact, a hierarchy of performance levels among alternatives as relates to degree of benefits and costs

CHAPTER VII

Section 2 - Project Solution by Resource Category

Alternative solutions have been considered by the Coordinating Committee in the following eight resource groupings:

1. Water Quality
2. Power
3. Outdoor Recreation
4. Fisheries
5. Water Supply
6. Navigation
7. Watershed Management and Erosion Control
8. Flood Control

Available in each of the above resource groupings are the following array of solutions:

1. Water quality needs may be met by the following methods, all of which are structural except for items (6), (7), and (8).

(1) Treatment up through tertiary if necessary.
(2) Diversion (to alternate treatment sites and to larger streams with greater assimilative capacity).
(3) Dilution (either through flow regulation or flow augmentation).
(4) Lagooning of waste.
(5) In-stream aeration.
(6) Influence plant or pollution source locations.
(7) Alter production processes to reduce effluent loading.
(8) Control of streambank littering and dumping and non-point sources.
(9) Technological breakthroughs.

2. Power needs may be met by various combinations of the following eight methods. Item (8) would represent a non-structural solution, and item (7) would be largely non-structural insofar as the Connecticut River Basin is concerned.

(1) Hydro-conventional type.
(2) Pump storage (hydro - generally for peaking).
(3) I/C gas turbine (generally for peaking).
(4) Fossil-fuel (generally base energy).
(5) Nuclear fuel (generally base energy).
(6) Chemical fuel cell (or other technological innovation).
(7) Importing power.
(8) Curtail demand.

3. Outdoor recreation needs could be met by the following of which three are in the non-structural category.

(1) Reservoirs (new and developments at existing water bodies).
(2) Streams and rivers.
(3) Land oriented pursuits oriented toward:

A. Forests - Federal, State and private.
B. National Recreation Area - open space preservation through a river valley concept.
C. Wild and Scenic River Areas - preservation of natural river areas for recreational pursuits

(4) Control Outdoor Recreation participation.

4. Fisheries enhancement to meet needs could be accomplished by the following solutions:

(1) Intensification of habitat management.
(2) Expansion of fish and wildlife husbandry programs and facilities.
(3) Construction of facilities to create additional lake or stream habitat.
(4) Control of water quality to restore or improve productivity of existing habitat.
(5) Provisions for public access to develop full use of existing and newly created resources.

5. Water supply (municipal and industrial) may be met by some seven methods either in part or total, of which items (4) and (7) are considered to be non-structural.

(1) Reservoirs - surface supplies.
(2) Groundwater - sub-surface supplies.
(3) Desalinization and other technological breakthroughs.
(4) Weather modification.
(5) Diversion from other sources.
(6) New processes such as re-cycling or closed systems.
(7) Control demand through pricing or other restrictions.

6. Navigation - commercial and recreational boating can be realized by the following four items, all of which require implementation of a structural device.

(1) Other modes of transportation.

(2) Channel excavation and development of locks.
(3) Flow augmentation to increase draft.
(4) Navigation upon existing or new reservoir areas.

7. Watershed protection, management and erosion control needs can be met by the following non-structural items:

(1) Land treatment practices.
(2) Drainage controls to effect productivity and land use.
(3) Vegetation planting and management.
(4) Structural terracing, slope excavation and stone protection to control erosion.
(5) Technological breakthroughs.
(6) Regulatory control affecting land use.
(7) Public Law 566 projects.

8. Flood control needs can be met in part or in total by the following measures, of which items (3) and (4) are considered non-structural.

(1) Flood plain management including zoning, flood proofing and flood insurance.
(2) Flood storage reservoirs (large).
(3) Flood storage reservoirs (small).
(4) Local protection projects.
(5) Evacuation of areas subject to flooding, including early warning measures.

Resource Group #1 Water Quality

General - A number of alternate methods may be employed, either singly or in combination, to meet the water quality needs within the basin. The basin is hydrologically capable of providing additional flow during critically dry periods to improve water quality. Presently known treatment methods are capable of providing higher than 85% BOD removals. Also methods such as limiting waste discharges either by recycling or using other methods of disposal, lagooning of treated wastes, piping of treated effluents to larger streams and instream aeration can further increase the basin's effective waste assimilative capacity. Non-structural measures in the form of plant process changes and selective land use planning and zoning can also reduce waste loads

(1) Advanced Waste Treatment - Treatment methods yielding higher removals of pollutants than is afforded by secondary treatment methods have been in development stages during recent years and, therefore, furnish an additional potential to meet future water quality demands. These newer methods, termed advanced waste treatment, consist of methods which are either technologically new or which employ older methods in a manner not usually practiced. Included in the spectrum of advanced waste treatment methods are foam separation, absorption, electrodialysis, ion exchange and evaporation, as well as older methods such as coagulation, sedimentation and filtration. Advanced waste treatment methods are capable of removing a wide range of constituent pollutants, including nutrients, inorganic salts and non-biodegradable organic material. In addition to these higher efficiencies of removal, advanced treatment methods have an advantage in that most of the advanced unit processes may be added to the secondary unit process on an "as-needed" basis.

For the immediate future it is probable that advanced treatment methods would be applied to secondary treated effluents. Conceivably, however, present conventional processes may be displaced entirely by some form of advanced treatment. In this respect, research and development are currently in progress to determine the feasibility of going from primary processes directly to advanced processes utilizing physical-chemical methods, thereby omitting the secondary treatment phase and effecting over-all cost reductions.

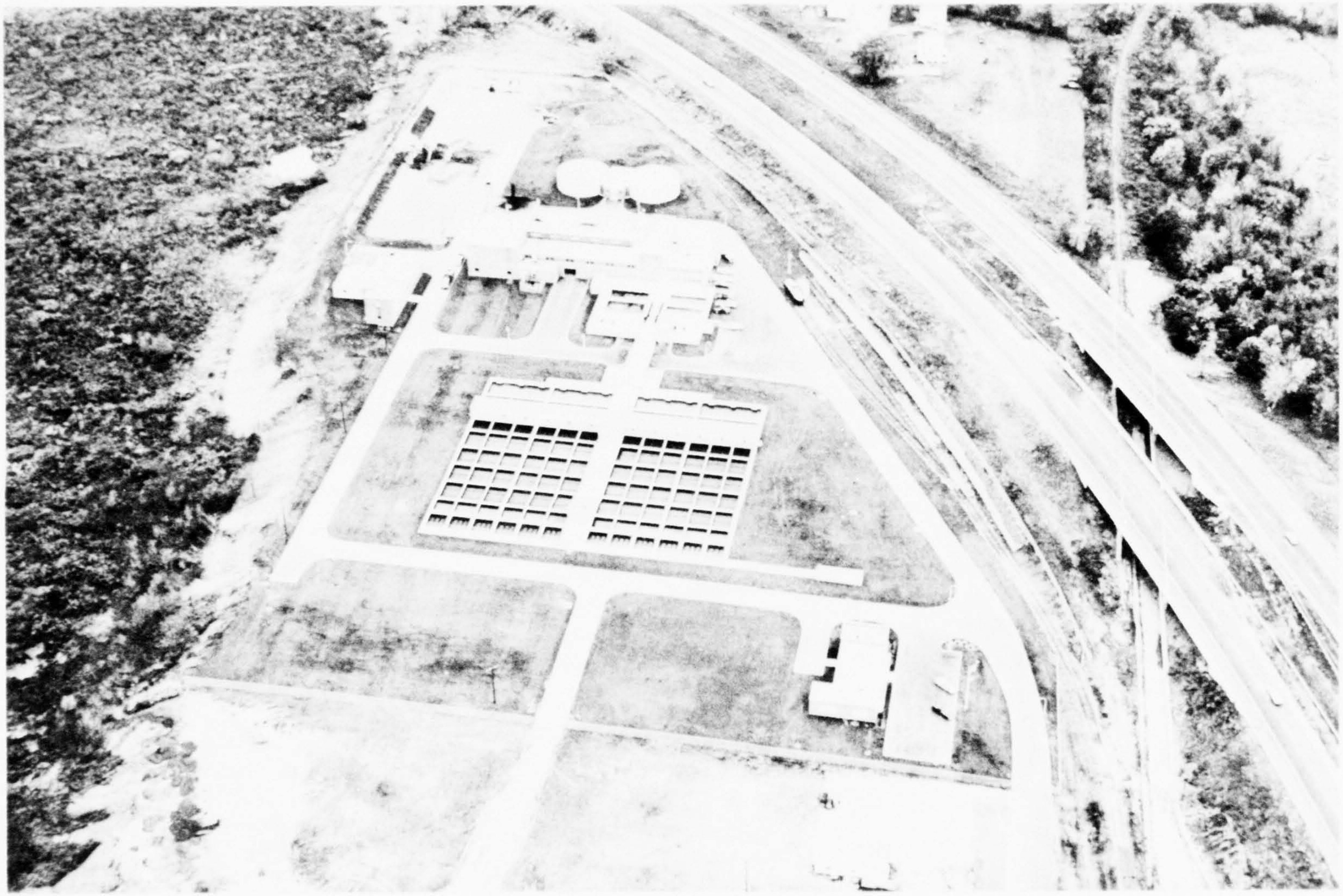
Developments, largely supported by Federal grants, have been stimulated by realistic experiments which have demonstrated new and improved techniques of pollution control. Demonstrations of improved technology currently in progress are aimed at determining from operational-scale examples the effectiveness, reliability and the costs of a number of advanced treatment processes; they serve as practical operational-scale examples to other users. As the problems resulting from pollution continue to grow and the effectiveness of new methods are demonstrated, the broad application by municipalities and industries of those methods which prove successful will become more common.

At present, the cost of advanced treatment processes is relatively high as compared with the cost of secondary treatment. In general terms, estimates indicate that the cost of advanced treatment would be on the order of two times the cost of secondary treatment alone. Future refinement of some methods and technological innovations may affect cost reductions.

Investigations of substitute processes and systems now in progress may reduce costs. For example, the powdered activated carbon process could conceivably replace both coagulation sedimentation and granular carbon absorption at about half the cost. Other factors which may affect the cost of advanced waste treatment include changes in future technology, in-plant changes in the waste source, either through reductions in organic or hydraulic waste load and possible net cost reductions by re-use of portions of the treated waste for water supply.

(2) Diversion - The transportation of secondary treated wastes to portions of the basin, with more ability to assimilate the treated wastes, was considered as a potential method of improving the quality in tributary streams. This alternative presents advantages and disadvantages. Advantages are that the wastes would be completely removed from the tributary stream and further, the collection of wastes from a number of sources could effect treatment plant savings through economies of scale. Disadvantages include the preemption of the use of the removed water to downstream water users, a possible "shock" load in the area where the wastes are finally discharged, and cost allocation when one piping system is utilized by a number of waste producers. Analyses of the Connecticut River indicate that the discharge of all tributary wastes into the main stem after secondary treatment would not significantly change conditions which otherwise exist.

(3) Dilution - The provision of additional river flow furnishes one potential by which projected water quality conditions may be improved. It was not, however, considered a substitute for treatment of all wastes to at least the secondary level, before discharge to the river. Additional river flows can be made available through the re-regulation of existing structures or by the provision of additional storage at existing or potential reservoir sites. Augmentation during periods of natural



AERIAL VIEW OF MATTABASSET DISTRICT WATER POLLUTION CONTROL PLANT IN CROMWELL, CONNECTICUT.

Courtesy NEIWPCC

low stream flow to maintain dissolved oxygen levels provides additional advantages. Among these advantages are: 1) additional dilution of non-degradable or noxious wastes and nutrients; 2) increased river stages which may be desirable for improved aesthetic and recreational pursuits; 3) higher stream velocities which may inhibit detrimental aquatic growth; 4) an improved flow regime, at all downstream locations, which could more readily assimilate treated wastes regardless of unforeseen loading conditions and patterns; and 5) dilution of wastes emanating from diffuse sources that are not capable of collection and treatment.

(4) Lagooning of Waste - The temporary storage of secondary treated wastes during periods of low river flow was considered as a potential method of water quality control. Seasonal storage of waste can be accomplished by structures such as excavations, dike embankments, permanent storage tanks or the newly developed inflatable devices. The seasonal storage of treated wastes involves intangible disadvantages and advantages. Among the disadvantages are the possible removal of land from tax rolls, added water supply costs which may be incurred by pre-empting the use of water to downstream users and the possible aesthetic or social stigma which may be associated with the presence of a holding lagoon. Among the advantages is the probability of a certain amount of additional treatment which would result during the holding period. Further, the construction of holding basins would have a tendency to encourage in-plant changes which would minimize the amount of wastewater and, in turn, the water supply requirements. Holding lagoons and the gradual quality improvement of the stored water, could become an integral part of water re-use systems by certain of the basin's industries.

(5) In-stream Aeration - Additional exygen may be introduced to a stream by the installation of floating aerators, diffused air devices or post aeration of waste effluent. Applications of these devices to improve stream quality have been limited and generally confined to situations where anaerobic conditions would otherwise exist. The quantity of air which can be transferred to the water is affected by many variables including: 1) the efficiency of the device to transfer oxygen; 2) temperature of the water; 3) dissolved oxygen deficit of the stream; 4) waste constituents in the water; and 5) the desired dissolved oxygen level the devices are required to provide. Research is in progress to better define these variables and the effectiveness of aerating devices.

Limited studies have been performed to date which reflect the relationship between these many variables and more importantly from a planning viewpoint, the economics of this alternative. In August 1969

Rutgers University completed a demonstration project supported by the Federal Water Quality Administration and the State of New Jersey. The results of this project, conducted at a Passaic River site, concluded that induced aeration was a practical method of increasing dissolved oxygen levels in a stream. A comparison of the alternatives and aeration indicated that the cost of aeration was approximately 25% of the cost of advanced treatment. Another advantage to in-stream aeration, in addition to cost, is the relative ease of installation and portability of the units. Aerators therefore, can be used on a temporary basis to alleviate critical problem areas while permanent corrective measures are being undertaken.

Although the cost of providing aeration appears to offer an economical advantage to other alternates, aeration does not provide end results completely comparable with other alternates such as treatment or low flow augmentation. For instance, aeration does not affect the concentration of degradable and non-degradable pollutants in the stream. It treats the symptom rather than the disease.

Stream aeration may have associated costs which are intangible. The National Recreation Study by the Bureau of Outdoor Recreation, for instance, has recommended that a portion of the upper Connecticut River be designated as a Scenic River Unit. The presence of aerating devices in such an area could create an adverse aesthetic effect. The location of aerating units, in areas where near constant surveillance is impracticable, could present a safety hazard to inquiring youngsters. Aeration, in comparison with treatment at the source, would present administrative problems. The occurrence of a water quality problem often occurs many miles downstream of the introduction of waste and a critical point in a stream could be the net result of wastes from a number of sources. Also, if aerators are used on a temporary basis in lieu of required measures, administrative control is necessary to insure their use will not work to delay the permanent installation. Provisions for aeration, therefore, could require the development of inter-municipal agreements for the cooperative resolution of cost apportionment; or new State, Interstate or Federal authorities for participation and assistance.

(6) Other Alternatives - Although not structural in nature, additional alternatives exist to aid in providing adequate water quality. Basically, such alternatives involve management and operational modifications of those factors affecting water quality. Incentives

and regulations, for instance, can encourage redesign of present plant processes, recovery processes, pretreatment measures, and land use practices that substantially reduce the volume and the effect of discharged wastes.

Further, zoning measures could effectively channel future industrial activity to areas of the basin which could more readily assimilate treated wastes. Allied to the subject of zoning is the alternative of imposing restrictions on the quantity of wastes discharged through curtailment or modifications in production. Lastly, social and economic pressures can precipitate research leading to technological breakthroughs in either the manner in which our wastes are ultimately disposed of or in the factors affecting the quantity of wastes produced.

Summary of Alternatives - In considering alternatives, recognition must be made that no two are truly alike since they each produce a different net effect on the water resources and may influence options that will be available for future development and use. Each alternate, thus, has a series of environmental, economic, and social advantages or disadvantages which should be considered. Assuming unchanged hydrological conditions, there are a series of alternatives which are practicable from an engineering viewpoint. For comparative purposes, the costs and some of the more apparent advantages and disadvantages associated with the alternatives considered are carried in Appendix D.

The estimated cost of secondary wastewater treatment plant construction to resolve first priority water quality problems through 1980 is shown in Figure VIII-1 on page VIII-9.

Resource Group #2 - Power

There are five general types of generating equipment currently being used in meeting electrical power requirements in the Connecticut River Basin, and three other ways to balance load and supply were considered in the studies (see page 208). One of the methods - load limitations - is non-structural. It would be impractical to attempt to meet all power needs with any individual one of the seven structural methods, since some are designed for peaking needs and others for base load needs. The power complex in the Connecticut is structured so that base energy requirements are produced partially by conventional hydroelectric capacity, but mostly by thermal plants. The fossil plants are being augmented now by nuclear energy and in future years the older fossil-fuel units probably will be replaced in large part with nuclear energy base load plants.

The conventional hydroelectric capabilities of the river, already 47 percent developed, are utilized largely for peak energy requirements. Currently two major pump storage power projects are under construction in the basin, and others are being considered. Efficiencies lost by moving water into upper ponds to be returned as peaking energy is economically attractive, because low-value off-peak energy is used for pumping and high-value on-peak energy is generated.

Gas turbine units are utilized principally for short term peaking and for emergency purposes. Their relatively high operation and maintenance costs make them uneconomical for use for more than a few hours per week.

Hopefully, in future years, there will be breakthroughs in some new technologies such as chemical fuel-cells, MHD, or fast breeder nuclear reactors, but these have not yet been sufficiently perfected to materially affect the power supplies for the 1980 target year.

Importing power from outside areas is feasible, but would be more expensive and would deprive local municipalities and States of much needed tax revenue that would be derived from in-basin developments. Power plants have long been considered community assets because, in addition to tax revenues, they provide a relatively well paid and community minded group of management and operating personnel. Environmental problems associated with older plants are now being overcome with improved designs that include better appearing facilities and the best environmental protection equipment that technology permits. New facilities generally include recreation opportunities and other community assets. In spite of these advantages from local generation however, the "import" alternative has been found desirable for a limited portion of the needs during the latter part of the study period.

The alternative of curtailing electric power use was considered and rejected by the Committee on the grounds that it was not a reasonable alternative to meeting the areas power needs. While the Committee agrees that some wasteful uses of electricity, such as leaving unused lights burning, could be avoided, it also recognizes that uses that could be eliminated do not usually occur at the time of system peak, and so are generally a consumer concern, but not a public problem related to the adequacy, reliability or economy of power supply. Anyway, the so-called unnecessary uses constitute such a small portion of total consumption that they are not a significant factor in planning for facilities to meet future needs. The Committee also believes that voluntary slowdown of the economy merely to limit energy consumption runs contrary to the basic premises upon which the study is based - premises that presume that available resources will be conserved and used in a way that will provide optimum benefits, including those from power that the public majority wants. Population growth curtailment may provide some long-range opportunity for stabilizing load growth, but the effects of such a program would not be felt for at least twenty years. The youngsters who will create the new families and new demands of the 70's and 80's are already here. Basically, therefore, the Committee sees no real alternative to providing the capacity necessary to meet projected needs.

Resource Group #3 Outdoor Recreation

Outdoor recreation opportunities can be found in the greater utilization at existing reservoirs, regardless of their ownership; the construction of new reservoirs; improvement to water quality which will restore streams to support other uses; and the purchase of land as part of a scenic or recreation program to maintain aesthetic quality. The purchase of additional lands as part of National Forests, as well as improved accessibility to private lands and the establishment of a new National Recreation Area, and the establishment of wild and scenic river areas, are all directed toward visual and cultural needs. The control of outdoor recreation participation, either through pricing or restricted access is now being utilized in sensitive natural areas where over-use would destroy the integrity of the resource.

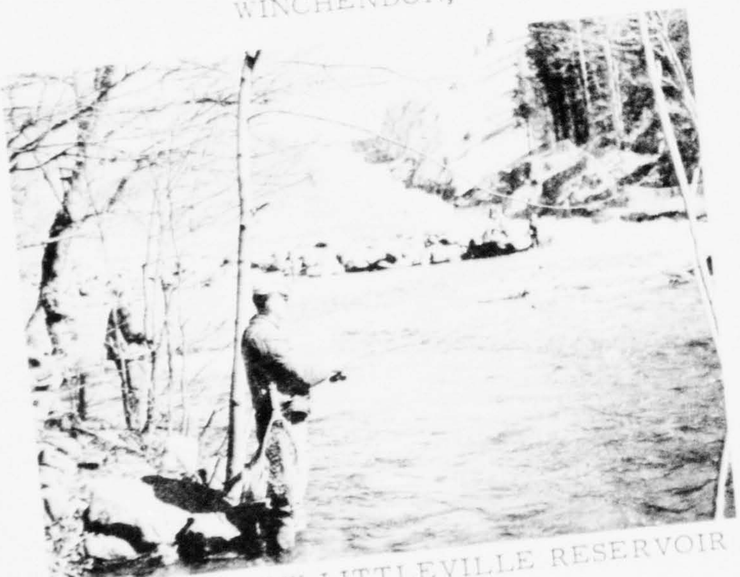
Another possibility could be the curtailment of participation in recreation pursuits. However, this latter technique was not considered to be in consonance with the basic goal of the study, that is, to formulate a plan to meet basin needs, but it is a concern that becomes most obvious at the recreation facility. Uncontrolled use can destroy a recreation area, be it an urban park or virgin forest. Resource management must respond to existing and projected recreation participation but it cannot do so in a way that jeopardizes the integrity of the recreation area. Recreation facilities must be operated on a sustained yield basis.

The study considered the socio-economic and environmental characteristics of the basin in developing estimates of recreation needs. These estimates were used as guidelines in developing the recreation plan for the basin. Efforts were made to satisfy these estimates while still maintaining the quality of the environment. Except in the northern portion of the basin where pressures are lowest and resources most abundant, the recommended plan does not meet the water surface "needs". The recommendations for land acquisition or preservation were made to insure that those areas of significant environmental value are not lost to the pressures of growth, and are made available to the public.

In the selection of new water bodies, all existing water-oriented facilities were evaluated to determine their present and potentially developable capability to meet recreation needs. Afterwards an evaluation was made of all potential sites under consideration for new reservoir construction. Results of this evaluation were integrated with values for other resource uses, in formulating the scale of development of multiple-purpose reservoirs. Particularly in the

LAKE DENISON CAMPING GROUNDS
WINCHENDON, MASS.

BEACH AREA AT TOWNSHEND RESERVOIR
WEST RIVER, VT.



FISHING BELOW LITTLEVILLE RESERVOIR
WESTFIELD RIVER, MASS.

WHITE WATER CANOEING ON
THE WEST RIVER, VT.

northern portion of the basin, reservoirs were not located initially to satisfy a recreation need; however, after selection of a site, because of other considerations, the site was examined to optimize available resources.

Throughout the basin, public access to water courses is low. Implementation of the Connecticut River National Recreation Area Study recommendations can make significant impact on the problem of the lack of public access on the main stem. The present outdoor recreation supply in the basin will not accommodate estimated future demand. Many alternatives exist which individually offered problems of recreation opportunity. However, only through planned and coordinated efforts can an optimum recreation program for the basin be prepared, blending together practicable alternatives.

In the lower portion of the basin the developed urban areas characteristically establish the tempo of land-use and change. Open space around such cities as Springfield, Massachusetts and Hartford, Connecticut is now at a premium and out of reach for certain low income center-city inhabitants. While this study did not attempt to define, analyze, or recommend courses of action for urban recreation problems, it could not pass without recognizing them. Water resources with recreation potential in or near urban centers are analyzed and appropriate recommendations are made to provide additional recreation opportunities for the urban population of the basin.

One major considered alternative which was not recommended for 1980 action is full use of water supply reservoirs. The Committee does recognize the impact that such use would have in meeting recreation needs, as noted in Section V, Table 21, Appendix K, and has recommended that future detailed studies be initiated to determine the ramifications of contact-use of waters at existing water supply reservoirs.

It would be unwise to attempt to meet the needs presented by utilizing individually any of the available methods outlined. The Connecticut Coordinating Committee has recommended a balance of programs with emphasis given to land oriented elements requiring acquisitions either through fee or easement. The improvements gained from an effective water quality restoration program will make possible use of certain streams previously foreclosed.

Resource Group #4 Fish and Wildlife Alternatives

Alternatives with respect to meeting future demands related to fish and wildlife resources - demands for recreational opportunity, food supplies, or industrial products - may first be classified in terms of general approaches to the problems of insufficient supply, as follows:

a. Intensification of habitat management.
b. Expansion of fish and wildlife husbandry programs and facilities.
c. Construction of facilities to create additional lake or stream habitat.
d. Control of water quality to restore or improve productivity of existing habitat.
e. Provisions for public access to develop full use of existing and newly created resources.

Investigation of fish and wildlife problems within the Connecticut Comprehensive Study considered all of the above measures and found that each was necessary, to varying degrees, in formulating the recommended plan. An analysis of each type of solution can be found in Appendix G - Fish and Wildlife Resources. However, a brief summary of the formulation process is contained in this section.

For each of the listed alternatives, there are again several alternatives, either as to the means or measures to be used or the particular procedure selected to achieve a certain goal. The on-going programs of the states and the federal governments will apply each of these in varying degrees with the passage of time. The effect of these on-going programs in increasing capability for meeting future demands was taken into account in determining the needs - that is - the unsatisfied demands - anticipated by the years 1980 and in subsequent years.

Insofar as formulation of a plan for meeting these needs is concerned, alternatives exist primarily in choice of facilities to create additional lake or stream habitat or to improve existing habitat through impounding waters and scheduling releases of water in storage. Reduction in magnitude and duration of floods through reservoir construction can also contribute to improved resources and opportunities for recreational use.

The alternatives open to fish and wildlife preservation and development were considered early in the plan formulation process when over 400 reservoir sites on which data were available from the Corps of Engineers and Department of Agriculture were appraised by fish and wildlife interests in selecting the 85 sites used in formulating the fish and wildlife plan. The elements of that plan were incorporated essentially in their entirety into the Basin plan as finally adopted by the Coordinating Committee.

There are, of course, many additional facilities making up the Basin plan - 209 reservoirs for example as compared to the 85 sites comprising the storage and control aspects of the fish and wildlife plan. Any benefits arising from the fish and wildlife aspects of the additional 124 facilities are largely offset by losses of habitat and use which would accompany their construction. This is evident from the fact that the fish and wildlife plan with its 85 sites would meet 84.2 percent of anticipated 1980 needs; the 209 facilities in the Basin plan (which includes practically all of the above mentioned 85) will meet 84.8 percent of those needs.

The only other alternatives which might warrant further consideration, therefore, would be possible substitution of some of the facilities not among the additional 124 selected for meeting needs other than those related to fish and wildlife for those that were selected, in an effort to accomplish these other objectives with greater development and less loss to fish and wildlife resources and their uses.

Resource Group #5 - Water Supply

The study found that on a total basis there are abundant water resource supplies, both ground and surface, to meet all foreseeable needs of the Connecticut River Basin. There are, however, areas of shortages which could be met by new developments and/or inter-basin diversions. A number of different methods of satisfying water supply demand were considered and include the following:

1. Curtailment of demand through pricing or other restrictions.
2. Desalinization and other technological breakthroughs.
3. New processes such as re-cycling or closed systems.
4. Weather modification.
5. Groundwater - sub-surface supplied.
6. Reservoirs - surface supplies.
7. Diversion from other sources.

Investigation of each method varied in depth depending upon its applicability to the Connecticut Basin Study. Controlling demand through pricing or other restriction was considered and may be feasible in meeting demands beyond year 1980. However, an education program would first be necessary to instruct the public and industry on how to conserve water. Currently, water supply costs are relatively low when compared with other needs of industry or the public. Substantial increases would be necessary before any appreciable demand reductions could be expected. Further, there are social problems that can be created by a pricing policy, as it would hit hardest those segments of the public which can least afford to pay. For these reasons additional studies are considered necessary before this technique is employed.

Consideration was given to the role of desalinization, waste water, re-cycling, and weather modification. The application of desalinization processes is expanding and improving both in this country and abroad. At present, the principal uses of these techniques are in areas where natural fresh water resources are either scarce or of poor quality. Presently, the cost of these operational plants far exceed the development of natural fresh water sources. In addition, desalinization plants produce by-products which may be harmful to the environment. Furthermore, this procedure generally affects larger transmission costs owing to the distance from the source to the point of need. Because of these factors and the nature and location of the problem areas in the Connecticut Basin, as well as the adequacy of more economic alternatives, desalinization was not utilized in meeting 1980 needs. However, as techniques are improved, costs reduced, and environmental problems overcome, the use of desalinization may prove a comparable alternative in meeting long-range water needs.

Waste water reclamation is currently undergoing much research. The application of reclaimed municipal effluent for industrial purposes, salt water barrier use and recreational use has been tried and with apparent success in some sections of the country. The use of reclaimed waste water as a municipal supply is unlisted except in Chanute, Kansas. In addition, the United States Public Health Service drinking water standards do not apply to direct reuse of reclaimed water for drinking. For these reasons, waste water reuse as an alternative method of satisfying water supply needs was limited by the existing state-of-the-art; and the many unknown aspects of this technique from a health standpoint.

The use of weather modification was investigated. Some progress has been made within recent years in obtaining scientific knowledge and engineering skills for the application of cloud seeding, but many questions remain unanswered. In particular, an understanding of the cloud process in order to determine seedability and proper seeding treatment is largely unknown at the present time. The complexity of the problem indicates many years of continued research before the identification of seedable clouds, treatment required, and direction of the precipitation patterns will be understood. In addition, the adverse effects of any modification on the environment must be investigated. Based upon the present state-of-the-art, consideration for the modified use of the atmospheric water resource to aid in meeting the projected water requirements would be premature. But, should progress of this technique be made more rapidly than presently anticipated, the results of weather modification could be adapted for use in future years.

Primary consideration was given to meeting water supply demands through surface water supplied or groundwater supplies. Analyses were made of the natural yield of basin streams to determine their capability to meet projected water supply demands. These are presented in Appendix D. A groundwater atlas is presented in Appendix E which indicates the yield of available sources of supply. It is difficult to make a general comparison between the two sources for a region as large as the Connecticut River Basin because for most communities, the choice between either surface water supply or groundwater supply is an obvious one based on quality required, availability, distribution problems, and economics.

Generally, groundwater supplies are utilized by single community or small water systems. The larger regional systems such as the Springfield or Hartford Metropolitan District Commission rely upon surface water sources.

The study did not attempt to plan water supply sources for individual communities in the basin but sought to determine if there were areas of regional need for the 1980 period which were beyond the capabilities of individual communities. In several instances, local water supply needs were identified which had a possibility of being met through incorporation into a multiple-purpose reservoir development. In these cases an analysis was made to determine if there were a more economical method of meeting the demand which involved estimates of groundwater and single-purpose reservoir development.

Among the major reservoirs, Beaver Brook on the Ashuelot River would have storage included as community water supply for the city of Keene, New Hampshire. Honey Hill would have storage included to meet downstream industrial water supply need as well as the need exerted by a potential salmon fish hatchery. Similarly, the Blackledge site on the Salmon River in Connecticut provides storage as a surface water source for a potential salmon hatchery. The existing Tully flood control dam could be nodified to include storage for a possible flood skimming diversion into the existing Quabbin system.

Some upstream watershed structures also have a potential for meeting water supply needs. Examples are, the Upper Ammonoosuc watershed project which could meet the needs of Groveton, New Hampshire, and the Quaboag watershed project which could provide water for Leicester, Massachusetts.

In addition to alternatives to meet in-basin needs the Connecticut River Basin will probably be called upon to meet projected demands in the Metropolitan Boston area. In a recent parallel study by the Corps of Engineers, referenced as the Northeastern United States Water Supply Study, a number of methods for meeting increased demands upon the Metropolitan Boston region were investigated. The results of this study indicated that further development of the Connecticut River Basin via flood skimming presented an attractive alternative to other methods considered, and particularly for the short range needs. The "NEWS" Study considered only flood skimming techniques in meeting demands exerted on the basin by areas outside the basin. This technique would skim flood waters from a river during the flood freshet period in the spring and divert it into a water supply system. The water diverted would be a small percentage of the total flow and is water that would normally not be used by other downstream residents and find its way to the sea.

Increasing stream flows throughout the basin during low flow periods by augmentation of flows from new reservoir construction was considered. Water released from reservoirs could serve other in-stream purposes and provide water supply for several communities enroute to Long Island Sound. Direct stream diversion from the main stem is a possibility for periods beyond 1980, but not before. Water quality standards would first have to be met. In addition, sufficient time provided for adequate water quality monitoring before any communities would be permitted to use the main stem as a source.

The possibility of in-basin diversions into the Connecticut River was also investigated. Appendix D indicates two areas outside of the basin, namely Jaffrey, New Hampshire and Guilford, Connecticut, which are currently utilized to supply water to the Connecticut River Basin. These into-basin diversions are minor and are not expected to have a significant effect in meeting future basin requirements.

Resource Group #6 Navigation

Two primary recommendations regarding navigation have been considered, namely, expansion of existing commercial navigation projects from Long Island Sound to Hartford, and extension of the recreational boating project from Hartford to Holyoke.

The commercial navigation project was the result of considering a number of alternatives which provided for delivery of petroleum products representing the principal item requiring transportation by various modes of transportation, that is, railroad tank cars, pipe lines and trucks. The use of railroad tank cars from the point of origin (New Jersey) or from intermediate retailing points would require the purchase of numerous new tank cars, the acquisition of expensive lands (if available), and sidings at both ends of the delivery route, more hired labor and attendant costs. Also, an intermediate delivery point would entail more storage facilities and rehandling, resulting in high costs. In addition, many oil company storage tanks in the East Hartford area are located too remote from railroad sidings for direct transfer. Rehandling would be required by truck or pipe line from freight yards or existing storage facilities. Direct delivery by truck from refineries in New Jersey or intermediate rehandling points would also be more costly due to the smaller quantities which could be delivered at each terminal.

The use of pipe lines would not be competitive with the cost of barge delivery because of the number of pipe lines which would have to be constructed. Furthermore, one of the major elements to be transported is residual oil. The high viscosity of residual oil requires that it be kept heated to permit pumping transmission during cold weather. Consequently, an expensive steam-jacketed pipe line would be necessary. Also, the oil companies claim that they cannot transport the numerous types of gasoline with all the special additives through the same pipe lines and still maintain integrity of their products. The number of pipe lines thus required is very high. Delivery of the petroleum products by barge is considered the most economical means of transportation.

Study analysis considered deeper and/or wider navigation channels but the recommended project proved to be the most economical solution. Analysis also considered extension of the commercial navigation project upstream to Holyoke and found that it was not economically justified.

The recommended project assumes that a flow of 2,000 cfs will be available at Hartford to maintain project depths. Consideration was given to providing additional flow in the river above the 2,000 cfs but this proved more costly than channel dredging. However, flows provided for other water resource purposes will also have major enhance-effect on the existing and proposed navigation project.

Curtailment of shipping was also considered but not adopted as a feasible solution as within the foreseeable future petroleum products are needed and in greater volume for the Hartford-Springfield tributary area. All other methods of transporting these products were found to be more costly.

The study investigated a dam and lock with fishways just upstream of the Penn-Central Railroad at Hartford; a dam and lock with fishways at South Windsor just above the mouth of the Farmington River; and channel dredging below and above Windsor Locks Canal to include a navigation lock which would allow boat by-pass of the existing three small, inadequate locks at the downstream end of the canal. Consideration was also given to the possibility of utilizing the existing canal locks so that they might be preserved as a scenic or historical site.

A number of alternative solutions were considered to satisfy recreational boating needs in the basin. Between Hartford and Holyoke several different alignments and possible channel improvements were considered. Flow augmentation from upstream reservoirs was considered to improve channel depths. The use of existing or new water surfaces was considered as a means of meeting recreational boating needs.

Above the Hartford to Holyoke project analyses were made of flows and tributaries to ascertain whether navigation, chiefly canoeing, could be enhanced by flow releases from reservoirs. In general this was not possible as the reaches of stream in which canoeing is favorable are usually too steep for reservoir releases to increase channel depths unless very large volumes of water are discharged which brought about undesirable drawdowns and problems of erosion. In most cases flow augmentation for canoeing was not found feasible.

None of the alternative navigation alignments between Hartford and Holyoke were found to be as favorable as the recommended project. Alternatives involved new structures across the main stem of the river, that would be both expensive and disruptive to resident and anadromous fishery programs. The curtailment of the demand for recreational boating was considered as was the satisfaction of this demand in areas outside the basin; for example, along the New England coastline. All projections indicate that the demand for boating is far beyond the capabilities of those improvements recommended in this study, and, in addition, available opportunities along the coastline are currently saturated with heavy boat uses.

Resource Group No. 7 - Watershed Protection Management

Watershed protection, management, and land resource planning and treatment should be a first consideration in the conservation, development, and utilization of the basin's resources.

Watershed protection and control of erosion may be accomplished through sound land treatment practices, vegetation planting and management, drainage controls to improve productivity of land uses, as well as halt erosive actions, structural terracing, slope excavation, stone slope protection and retarding structures. These items are generally part of Public Law 566 - Watershed Projects.

The principal non-structural alternatives lie in the area of significant technical breakthroughs and more important, the utilization of regulatory controls by local governments to effect land use changes in an orderly manner.

Increasing pressures of population and the changing trend in the pattern of land use have created other environmental problems throughout the basin. The scenic attractiveness associated with diversified land use is being diminished through the construction activities of man and the natural process of succession. In many areas, the desirable balance among water, forests, and meadows that once typified the New England landscape has been or is in the process of being lost.

Consequently, if we are to protect and maintain the environment of the basin the non-structural measures which fall into this resource category have no alternative solutions. They should be recognized as playing an important role in the array of solutions outlined in the other resource categories in this Chapter.

Resource Group #8 - Flood Control

Approximately 1, 200 large and small reservoirs were inventioned as to their ability to control flooding. Of this number, 700 could be classified as being in the small category. Nearly 100 potential local protection projects were also investigated to consider solution of local flood control needs. An extensive screening process eliminated all but 10 of the large reservoirs, and 78 smaller reservoirs included as part of the Public Law 566 program. Five local protection projects have also been selected.

Many of the reservoirs were dropped from further consideration because of adverse physical, economical or social problems. Others were eliminated simply because there was a better way of doing the same job. In addition, there are 118 other reservoir sites in the small category, that would be available for purposes other than flood control.

Local protection projects can be considered as alternatives to flood control reservoirs. For example, the expansion of the existing local protection projects on the main stem of the Connecticut River to meet present and projected flood control needs was evaluated. An estimated cost of $40, 000, 000 was computed for modifying six of the seven existing local protection projects on the main stem, namely, East Hartford, Connecticut, Springfield, West Springfield, Holyoke, Chicopee and Northampton, Massachusetts. In addition to these modifications, local protection projects would be required at six other major damage centers along the rivers main stem, namely, Glastonbury and Wethersfield, Connecticut, North Chicopee, Hadley, South Hadley and Agawam, Massachusetts. The cost of this additional work is estimated at $65, 000, 000.

The existing projects were designed and constructed to afford protection for all floods up to a magnitude equal to the flood of March 1936. Although a higher degree of protection was desired at the time of construction, a system of reservoir was already authorized by Congress, and these reservoirs along with the six local protection projects noted would provide a high degree of flood protection. Since part of the authorized system remains unconstructed, six communities remain in jeopardy as their protective works could be overtopped. The seventh local protection project at Hartford, Connecticut was designed to protect against major floods, including the Standard Project Flood. The Standard Project Flood at Hartford is about 9 feet higher than the 1936 flood and at Springfield, Massachusetts it is about 6 feet higher.

If these six local protection works are to be considered as an alternative to the flood control storage contained in seven of the ten large reservoirs which have flood control as a primary project purpose in the basin plan, they must be modified through raising and extension. However, apart from an estimated cost of $40 million, many other scattered damage areas all along the Connecticut River main stem would remain unprotected. In addition, protection would be lost on those tributaries where the seven dam sites are located. More important, any extensive new diking along the main stem would result in loss of natural valley storage and produce higher river flood stages in those areas upstream of such diking.

For ease in displaying alternatives viewed in arriving at the seven large flood control reservoirs, all of which are discussed in detail in Appendix K and Appendix M, the six tributary basins wherein they are located, and noted below, are presented individually and are as follows:

A. Passumpsic River Basin
B. Ammonoosuc River Basin
C. White River Basin
D. Sugar River Basin
E. Ashuelot River Basin
F. Deerfield River Basin

A. Passumpsic River Basin

In considering alternative solutions to water resource needs in the Passumpsic River tributary, it was found that there is need for both regional and local flood protection. A combined solution, including ten complementary upstream impoundments of the Soil Conservation Service, the Victory Dam, and local protection was found to offer the best mix of solutions.

Alternative proposals to Victory Dam and three of the Soil Conservation Service dam sites may be afforded by a reservoir at East Burke, on the East Branch, Passumpsic River, as well as the remaining seven Soil Conservation Service impoundments noted above. Studies revealed that East Burke Dam was more than twice as costly as the Victory Dam, and produces fewer benefits for other water resource purposes.

Flood plain management, if undertaken, will prevent the situation from worsening, but will not reduce flood damages to existing development. The cost of purchasing or removing existing development from the flood plain is prohibitive.

Local protection, as an alternative to Victory, is physically possible but far from practical. For example, diking would be required for a total length of 13,000 feet on the Moose River in Vermont for the municipalities of Concord and St. Johnsbury. St. Johnsbury and Passumpsic would be diked for a total length of 10,000 feet on the Passumpsic River in Vermont. On the Connecticut River local protection would have to be provided over a total length of 74,000 feet in Barnet, East Ryegate, Wells River, Woodsville, Fairlee, North Thetford, White River Junction, Windsor, Bellows Falls, and Brattleboro, Vermont; and a total length of 23,000 feet in Oxford, West Lebanon, Springfield Junction, and North Walpole, New Hampshire. In total, approximately 23 miles of diking would provide substantially the same protection in Vermont and New Hampshire as the Victory project, as well as pumping plants at designated points to handle interior drainage. In addition, extensive mileage of the Boston & Maine and the Canadian Pacific Railways would still be subject to damage, as sections of tract are so widespread that protecting them is impractical. The cost of undertaking all of this extensive local protection was found to be far in excess of constructing the Victory project.

Flooding from the Moose River causes damage in the three communities of Concord, East St. Johnsbury, and St. Johnsbury, Vermont and contributes to flooding along the Passumpsic River in St. Johnsbury and neighboring Passumpsic, Vermont. The Victory Reservoir, together with the ten upstream watershed impoundments would all but eliminate flooding in these areas. As part of the recommended 23 reservoir flood control system, Victory would also help reduce flooding for those communities located along the main stem of the Connecticut River in all four basin States.

Victory Dam is one of the original Connecticut River Valley Compact projects. It would be located on the Moose River, 17.2 miles above its confluence with the Passumpsic River and 15 miles northeast of St. Johnsbury, Vermont. The project provides multiple-purpose uses of flood control, major recreational development keyed to the regional development objective, conservation storage for fisheries, releases for downstream hydroelectric power facilities. The earth-rolled fill dam would have a top elevation of 1,208 feet msl, a length of 930 feet and a maximum height of 90 feet above stream bed. A 75-foot spillway would be situated at the right abutment having a sill elevation of 1,196 msl. At this elevation the dam would impound

45,000 acre-feet of storage. A recreation pool would set at elevation 1,175 msl yielding 2,880 acres of water surface. Flow releases which would be possible during summer periods to enhance fisheries would not affect pool drawdowns more than four feet during a dry year taken as one out of 10 in frequency.

The topography of the reservoir is dominated by a 1,000 acre bog. The dam would require land acquisition of 5,800 acres of woodland of which 85% is equally divided between soft and hardwoods. Wet and brush land which makes up the remaining acreage, total 1,100. The land taking includes 900 acres for additional recreational pursuits both current and future, and a 1,000 acre area on the east side for wildlife mitigation measures. No improvements in the way of housing or business would require taking. In addition, other provisions could be included to establish a State Park under the Federal Water Project Recreation of 1965 as discussed in Appendix K. The project would require relocation of four miles of gravel road to be replaced by five miles of highway to effect access for local residences. The total project first cost is $6.6 million with the following breakdown:

Real Estate	$ 380,000
Relocations	1,080,000
Dam & Appurtenant Structures	2,680,000
Contingencies	770,000
Engineering & Supervision	900,000
Recreation	790,000
Total	$6,600,000

B. Ammonoosuc River Basin

The multiple-purpose Bethlehem Junction Reservoir located on the Ammonoosuc River would prevent a recurrence of major flood damage as experienced in the 1927 and 1936 floods. It would protect the towns of Littleton, Lisbon, Bath, and Woodsville, New Hampshire, all highly susceptible to flooding, and are located downstream of the proposed project.

The dam, would control run-off from an 87-square mile drainage area. It would consist of an earth filled structure having a concrete side channel spillway located on the northerly bank. The top of the dam at elevation 1,400 feet msl would have a length of about 2,100 feet and a maximum height of 190 feet above stream bed. At spilleay crest elevation of 1,379 msl, the project would impound a total of 55,600 acre-feet. A recreation pool of 1,090 acres would be provided for an entire spectrum of outdoor recreation activities. This major water body would herald significant regional development yields to the region.

Land acquisition is comprised of 1,900 acres, located equally in the Towns of Bethlehem and Carroll. Eighty-nine percent of the 1,900 acres is either forested, or idle and reverting to forest. There are presently no active farms in the reservoir area. The project would require the taking or relocation of 18 residential, 20 commercial establishments, a Catholic church, a State Police building, and a State Highway maintenance garage. U. S. Route 302, presently running along the northern side of the Ammonoosuc River, would be relocated for a distance of about 6 miles. The total first cost of the project is $16 million. The cost estimate is divided as follows:

Real Estate	$ 1,620,000
Relocations	3,420,000
Dam & Appurtenant Structures	6,020,000
Contingencies	1,890,000
Engineering & Supervision	2,320,000
Recreation	730,000
Total	$16,000,000

Seven sites were investigated upstream of the Bethlehem Junction site. Each of these alternate dams would be almost as effective as Bethlehem Junction, but each was found to be more expensive to develop, and none produced any advantage over the Bethlehem project. Extensive railroad relocation costs in two of these locations above Twin Mountain were enough to make their development impractical.

In addition, five dams on the Ammonoosuc River located below Littleton would not reduce flood stages at Littleton. Construction of extensive diking and pumping facilities at Littleton would be needed to produce equivalent degrees of protection. One of these five dams, Sugar Hill, located on the Ammonoosuc River, three miles downstream of the confluence with the Gale River, would control 246 square miles of drainage area, or 2.8 times the drainage area control of Bethlehem Junction. This dam would effect greater flow reduction on the Ammonoosuc River. The higher cost to develop Sugar Hill, the fact that it would not afford protection to Littleton, and its poor location for recreational development makes the Sugar Hill project a far less attractive proposal.

A dam on the Israel River, referred to as the Jefferson site might be considered as an alternative to Bethlehem Junction, that is, from a recreation viewpoint. This project, controlling 72 square miles of drainage area, 83% of the Bethlehem Junction drainage area, would provide a lesser degree of flow reduction on the Connecticut River. It would afford protection to the town of Lancaster, New Hampshire, but from a flood control standpoint, all damage areas along the Ammonoosuc would remain unprotected. Flood damage potential along the Israel River is far less than on the Ammonoosuc River.

A system of local protection projects was considered as an alternative to the Bethlehem Junction Dam. Dikes and pumping stations would be required over a total length of 51,000 feet on the Ammonoosuc River in the towns of Littleton, Lisbon, Bath, and Woodsville. Whereas the Bethlehem Junction project also reduces stages on the Connecticut River, this loss of stage reduction could be compensated for by diking. A length of 23,000 feet in the four communities of Orford, West Lebanon, Springfield Junction and North Walpole, New Hampshire would be required. In addition, diking for a length of 57,000 feet in the seven Vermont communities of Wells River, Fairlee, North Thetford, White River Junction, Windsor, Bellows Falls, and Brattleboro would be needed to produce comparable effects.

A Boston and Maine single track line follows the Ammonoosuc River for a distance of 25 miles from Woodsville to Bethlehem. This line was severely damaged by the 1936 flood and is susceptible to damage from a major flood. Although protected by the Bethlehem Junction project, to include it under a local dike would be infeasible due to its scattered and extensive nature.

In summary, about 25 miles of diking would be needed to provide comparable flood protection to that afforded by Bethlehem Junction. Further, if the dam were removed from the system, the alternate plan of modification of the six existing local protection projects in Massachusetts and Connecticut should be considered. The local protection system, apart from being impractical, far exceeds the cost of the Bethlehem Junction Dam.

C. White River Basin

Five alternative means of resolving the flood problem in the White River Basin, including control of the damaging effects of flood waters from this basin to downstream areas were considered and as follows:

(1) Flood storage as provided by Gaysville.
(2) Flood storage as provided by 8 smaller gated upstream dams.
(3) Local protection along the White River Valley.
(4) Flood plain management, including zoning, flood proofing and insurance.
(5) Evacuation of those areas subject to flooding.

Of the above five possible solutions 1, 2, and 4 were considered to be practical considerations and found to provide other multiple use opportunities. An examination of these three alternatives follows:

Gaysville Dam and Reservoir would be located within the towns of Stockbridge, Rochester, and Pittsfield on the White River, about 31.6 miles above its confluence with the Connecticut River. The dam 0.5 miles southwest of the village of Gaysville would control floods from a 228 square mile drainage area. The composite earth filled dam would have a concrete side channel spillway, a top elevation of 825 feet mean sea level, a length of 775 feet, and a height of 190 feet in length to high ground would be located along the northerly abutment of the dam.

The multiple-purpose flood control and recreation project would provide a total storage capacity at spillway crest of 81,800 acre-feet. Following the spring run-off period, and about 1 May, a recreation pool of 640 acres at elevation 745 feet msl would be maintained up through 15 November. Of the 3,200 acres of land acquisition required by the project, 40% is wooded and used for tree farming; 31% for tillage of crops; and 13% for dairying; 4% in residential lands; 1% in commercial; 7% in roads and water; and the balance classified as potentially developable.

The project, because of its sizable drainage area of control would furnish considerable flood control benefits to the State of Vermont both on the White River and the Connecticut River. A recurrence of the record 1927 flood stages on the White River would be reduced by about 5 feet at the White River Junction Area, and 4 feet as far south as Vernon, Vermont.

Upon the request of the Governor of the State, the use of Public Law 90-483, Section 209, as approved on 13 August 1968, could be utilized to effect an equitable resettlement of families, individuals, and business concerns displaced by the project and noted in Table VII-1.

Total cost of the Gaysville project is estimated at $31.6 million with the following breakdown:

Real Estate	$ 3,800,000
Relocations	10,600,000
Dam & Appurtenant Structures	8,200,000
Contingencies	3,800,000
Engineering & Supervision	4,600,000
Recreation	600,000
Total	$31,600,000

Alternate dam sites to Gaysville have been studied by both the Corps of Engineers and the Soil Conservation Service. The SCS has studied 13 sites in the White River Basin, 6 above the Gaysville site and 7 downstream. Sites investigated by the Corps of Engineers were 8 in number and all located downstream of Gaysville. Five SCS sites upstream (sites number 1, 3, 5, 7, and 9) and 1 SCS site downstream of Gaysville were selected as the best suited substitutes along with Corps sites (C-153 and C-157), both located downstream of Gaysville.

All sites were estimated on the basis of having controlled outlet structures and with spillways designed for large discharges. The drainage area controlled by these 8 tributary dams totals 256 square miles versus 228 square miles for the Gaysville project. The larger drainage area control is required since alternate projects are located on tributary streams whereas Gaysville is situated on the main stem of the White River. Flood control storage equivalent to 6 inches of run-off is 81,900 acre-feet for the alternate sites versus 81,800 acre-feet of storage at Gaysville. The total estimated cost for the eight alternate reservoir system amounts to $55,400,000 versus $31,600,000 for Gaysville. (See Table VII-1). The following comments are also made with reference to the alternate dam sites:

(1) Site 153 is disproportionately expensive for the benefits achieved.

(2) Site 157 would introduce hardship through the necessary relocation of two small villages - East Randolph (partially) and South Randolph (completely).

(3) Site 7 upstream of Gaysville would cause relocations in the town of Pittsfield.

(4) One of the important operations of a reservoir is to make discharges compatible with flows on the main stream without increasing flood stages when possible. This is always a delicate operation even for a single reservoir. It becomes measurably more difficult when it is increased by a factor of 8.

(5) There are higher operation and maintenance costs of the 8 dams. Gaysville would require 3 people for operational procedures whereas the 8 dams would require a total of 17. There are added higher maintenance and replacement costs on 8 dams versus the 1 larger dam.

Flood plain regulation is a useful tool in controlling damages within a community by curtailing future development in the flood plain, but has little effect on existing development. However, flood insurance may be called upon to assist existing properties. Currently there are no municipalities in the State of Vermont which adopted flood plain zoning. This is a prerequisite for flood insurance. Other options available to those left unprotected would be flood proofing where possible, or evacuation of supplies.

Local protection works could serve as an alternative for alleviating damages on the White River and along the Connecticut River, that is, downstream of its confluence with the White River. Such local protection works would consist of selective diking and pumping stations in the 8 communities of Gaysville, Bethel, Royalston, South Royalston, Sharon, West Hartford, Hartford, and White River Junction on the White River in Vermont. Equivalent protection would be needed along the Connecticut River to six other towns, namely, Windsor, Bellows Falls, and Brattleboro, Vermont, and West Lebanon, Springfield Junction, and North Walpole, New Hampshire. The total length dikes required in Vermont amounts to about 94,000 feet (17.8 miles) and in New Hampshire 18,000 feet (3.4 miles). In addition, modification to existing local protection as discussed earlier would be needed at damage centers in Massachusetts and Connecticut if local protection solution was to be considered as a comparable alternative, that is, producing the same degree of flood control effectiveness as the Gaysville Dam.

Local protection was found to be far more expensive, more disruptive to inhabitants of the valley, would eliminate valley storage, and not provide regional development objective afforded by recreation opportunities made possible by the Gaysville Reservoir.

TABLE VII-1
GAYSVILLE VERSUS EIGHT SMALLER RESERVOIRS

	8 RESERVOIRS	GAYSVILLE
Drainage Area	256 sq. mi.	228 sq. mi.
Cost	$55.4 million	$31.6 million
Reservoir Area	2,900 acres	1,840 acres
Land Taking	4,600 acres	3,200 acres
Real Estate Costs	$6.2 million	$3.7 million
Road Relocations	25.7 miles	17 miles
Communities Affected	Pittsfield South Randolph East Randolph	Stockbridge
Improvements to be Taken		
Houses	139	133
Commercial	12	10
Industrial	1	1
Public	5	2
Miscellaneous	75	12
	232	158

D. Sugar River Basin

The Claremont Dam and Reservoir was authorized for construction by Congress in 1938. Subsequent investigations concurred in its importance and affirmed its need for the control of floods. The dam would control a drainage area of 245 square miles and the project would be the third largest in the recommended flood control reservoir system. It would incorporate flood control, major recreational pursuits, and low flow augmentation for water quality required some time after 1980. The dam would be located on the Sugar River 1.5 miles upstream from the city of Claremont and 7.1 miles above its confluence with the Connecticut River.

The top of the dam would be at elevation 658 msl with chute spillway having a crest at elevation 638 msl. The dam would impound 90,400 acre feet of storage. A summer recreation and conservation pool of 860 acres would be maintained at elevation 580 msl with pool levels not to exceed a two-foot drawdown.

The project would require the taking of 3,850 acres of land of which about 51% is woodland and 46% equally divided between tillage and pasture land. The remaining balance is in commercial, residential and small amounts of industrial land. Approximately 85 pieces of property would be taken, 72 of which are in Claremont. To help alleviate hardships and following appropriate coordination with the State and local entities, these interests could be relocated under Section 209 of Public Law 90-483. The impoundment would require relocation of 2.9 miles of State Routes 11 and 103, and 1.9 miles of Unity Pond Road would be relocated. A single track of the Claremont and Concord Railway Company would be acquired.

Total cost of the Claremont project, estimated at $20.910,000 is divided as follows:

Real Estate	$ 2,510,000
Relocations	2,090,000
Dams & Appurtenant Structures	9,230,000
Contingencies	2,826,000
Engineering & Supervision	3,054,000
Recreation	1,200,000
Total	$20,910,000

Local protection projects could meet the flood control needs on the Sugar River and on the Connecticut River downstream of its confluence with the Sugar River. In this regard, the Soil Conservation Service has developed an upstream watershed plan for the Sugar which is being recommended for 1980 implementation to meet local flood control needs. The ten upstream impoundments would complement the Claremont Dam, as well as meet a significant amount of other water resource needs. As an alternate, some 21,000 feet of dike, together with pumping facilities could be installed on the Sugar River in Claremont and West Claremont, New Hampshire. Another 13,000 feet of dike would also be necessary on the Connecticut River at Springfield Junction and North Walpole, New Hampshire. In addition, the towns of Bellows Falls and Brattleboro, Vermont would require 26,000 feet of dikes. Dikes totaling 60,000 feet in length would be required to produce comparable protection as provided by Claremont Dam. This alternative was found to be more expensive, cause more disruption to the communities, and eliminate natural valley storage. Modification to the six existing local protection projects in the lower valley as described earlier would also have to be undertaken if the same degree of protection were to be provided.

Other alternative solutions consist of 15 reservoir sites on the Sugar River, 11 of which were located upstream of Claremont and 3 downstream. The 3 sites downstream would not protect the city of Claremont. The sites upstream were found to be more costly to develop than the Claremont site and would produce no advantages. Claremont Dam was found superior for a major multiple-purpose development.

Flood plain management was initially considered but found unsatisfactory in meeting flood control needs as the city of Claremont is already highly developed. Flood plain regulation would however make possible assistance from the flood insurance program, and reduce future damages.

E. Ashuelot River Basin

Development in the Ashuelot River Basin has taken place in what was a natural basin wherein now lies the city of Keene, and contiguous towns. It is one of the faster growing areas in Cheshire County. Topography is such that a large flood plain extends south from the Corps' Surry Mountain project area downstream through the city of Keene, and all the way to the neighboring town of Swanzey. A naturally steep profile of the upstream headwater tributaries produces sudden peak flows. Complicating the flood problem is a naturally flat profile gradient of the Ashuelot River below Swanzey. It produces a sluggish exit of flood waters which gather in the natural storage area where now lie municipalities.

The multiple-purpose Beaver Brook Dam and Reservoir project, currently authorized, would provide local flood protection along Beaver Brook in the city of Keene. The project, which controls run-off from a 6-square mile drainage area, would have limited effect upon stages in the larger Ashuelot River Basin. The Beaver Brook Dam also incorporates future water supply storage for the city of Keene, and in the interim period, will provide recreational opportunities.

The project is located in the city of Keene and Town of Gilsum, Cheshire County, New Hampshire, 2.5 miles upstream (north) of Keene. The dam, an earthern structure, 950 feet long and 60 feet high, controls 6 of the 10 square miles of drainage area of Beaver Brook.

The reservoir at spillway elevation 822 impounds 5,750 acre-feet of which 2,750 acre-feet, or 8.6 inches of run-off is allocated to flood control. A recreation pool of 203 acres at elevation 811 is maintained during the summer months. After the summer recreation period the 3,000 acre-feet below elevation 811 are available for water supply; however, it is anticipated that this storage will not be utilized for water supply until 20 years into the future. At that time the water contact aspects of recreation will probably be curtailed. Project cost is estimated at $1.66 million with the following breakdown:

Real Estate	$ 215,000
Relocations	180,000
Dam & Appurtenant Structures	660,000
Contingencies	210,000
Engineering & Supervision	300,000
Recreation	95,000

The Honey Hill Dam and Reservoir presented in the basin plan would be located on the South Branch of the Ashuelot River. It would be a complementary element to two existing reservoirs, namely Otter Brook and Surry Mountain, and the authorized Beaver Brook Dam.

Honey Hill Dam would provide control from the upstream tributaries of the South Branch of the Ashuelot River. The multiple-purpose, flood control and recreation reservoir, would be located in the town of Swanzey, one mile west of East Swanzey, and 5.8 miles above the confluence of the Ashuelot River. Other multiple uses provide for low flow augmentation for fish and wildlife enhancement, and water quality improvement, as well as industrial water supply. The project was authorized by the Congress in the 1941 Flood Control Act as a single-purpose flood control reservoir.

The earth filled dam would have a concrete side channel spillway located on the westerly abutment, and set at elevation 524 feet, mean sea level, or 21 feet below the top of the dam. The 3,400-foot dam would have a maximum height of 72 feet. At spillway crest the reservoir would impound a total storage of 31,500 acre-feet, equivalent to 8.4 inches of run-off from a 70-square mile drainage area. A recreation pool of approximately 970 acres, and at elevation 511 would be maintained. Controlled drawdowns would not exceed 3 feet during the recreation season.

At the outlet of the existing neighboring Swanzey Lake a dike which would also serve as a relocated road would be constructed, together with a pumping station to handle Swanzey Lake run-off. Land acquisition of 2,070 acres is required, 1,950 acres of which are in the town of Swanzey, and the remainder in the town of Richmond. One-half of the land acquisition is woodland, and 40% classified as open land, used for agricultural purposes. Remaining lands are divided between residential, industrial developments, highways and waterways.. The reservoir would require the taking or relocation of 47 homes, 5 farms, 2 commercial and 2 industrial developments.

Access to the area now provided by State Route 32 which traverses through the reservoir area, would be provided along the easterly perimeter of the impoundment. Approximately 1.6 miles of new road, 2.3 miles of improvement to existing roads, and 4.5 miles of local roads would be required. Cost of the project is $11.1 million estimated as follows:

Real Estate	$ 1,390,000
Relocations	2,450,000
Dam & Appurtenant Structures	2,990,000
Contingencies	1,090,000
Engineering & Supervision	1,380,000
Recreation	1,800,000
Total	$11,100,000

No other sites were found on the South Branch of the Ashuelot River which could reduce tributary flows to a required level. Local protection measures were investigated but found extensive, costly and impractical as they would entail major disturbance and relocation of properties needing protection. The system of local protection would entail the construction of a total of 63,000 feet (12 miles) of dike at Swanzey, New Hampshire on the South Branch of the Ashuelot River and Keene, West Swanzey, Westport, Winchester, Ashuelot, and Hinsdale, New Hampshire on the Ashuelot River. Flood plain zoning was considered, but owing to the extensiveness of the natural flood plain was found to be impractical

F. Deerfield River Basin

The Meadow Dam would control large high peak discharge produced from this mountainous valley tributary which synchronizes nearly perfectly with Connecticut River peak flows. The Deerfield is a major contributor to flood heights at main stem damage centers in Massachusetts and Connecticut. The Meadow Dam is designed to retard Deerfield River flows to a point in time when the Connecticut River peak flows have passed. The project is the single most important element in the basin flood control plan.

The Meadow Dam would be located on the Deerfield 9 miles upstream from its confluence with the Connecticut River and 1.4 miles upstream of Stillwater Bridge, in the towns of Deerfield and Conway. Its reservoir area extends into the neighboring towns of Buckland and Shelburne. The dam would be about 2,100 feet long and would have a maximum height of 260 feet. It is designed to impound 160,400 acre-feet of flood control storage equivalent to 8 inches of run-off from a net drainage area of 376 square miles. The dam affects a gross drainage area of 560 square miles. It would be composed of earth and rock fill containing a chute spillway comprised of two sections. One portion having 4 - 40 x 60 foot tainter gates, resting on a sill at elevation 356 mean sea level. The other section is ungated and would have a fixed crest elevation of 396 msl.

The project requires the removal of two small existing hydroelectric dams, referenced as the New England Power Company Dam #2; and the Western Massachusetts Electric, Gardner Falls Dam. Two small reaches of local roads are to be relocated. The existing Boston and Maine Railroad presents a major cost item, as approximately 8 miles of track requires relocation.

Approximately 1,900 acres of land are acquired for the project, of which 250 acres are classified as productive dairy land and apple orchards. The remaining 1,650 acres of land is heavily wooded with 15% devoted to waterway area. Twenty-seven homes would be taken or relocated. These homes are equally divided among the three towns of Buckland, Shelburne, and Conway. Cost of the Meadow Dam is estimated at $41.4 million and as follows:

Real Estate	$ 3,600,000
Relocation	12,700,000
Dam & Appurtenant Structures	15,650,000
Contingencies	3,480,000
Engineering & Supervision	5,910,000
Recreation	60,000
Total	$41,400,000

Local protection alternatives were considered and none found necessary to afford protection on the Deerfield River. No other dam or system of dams on the Deerfield was found to produce equivalent flow reduction to meet flood control requirements on the lower main stem of the Connecticut River. As an alternate, and in lieu of the Meadow Dam, a system of 6 other major dams located at various upstream tributaries in the Connecticut River Basin was considered. These 6 dams situated some distance from damage centers along the main stem of the Connecticut River in Massachusetts and Connecticut would, however not provide comparable degrees of protection. Furthermore, they involve greater land requirements and produced higher costs.

Other alternatives to the Meadow Dam consist of the modification of the six existing local projects along the lower main stem as discussed earlier. This plan was found to be more expensive, less efficient, and lacked the multiple use opportunities available at the Meadow project.

Flood plain zoning was considered but found unrealistic as an alternative as the damage centers to be protected by the Meadow Dam are already heavily urbanized. Curtailment of future expansion through flood plain regulation would help reduce added future losses. It would not, however, solve the current flood problems but would permit areas currently outside of local protection projects and subject to flooding to receive Federally subsidized flood insurance.

The Meadow Dam and Reservoir would be the single, most important flood control project in the entire system for reduction of floods along the mainstem of the Connecticut River Basin in Massachusetts and Connecticut. This would be due to the size of watershed area controlled by the dam, the significant runoff contribution that the Deerfield River makes to the mainstem, and the strategic location of the project just above the major damage centers along the mainstem of the river in Massachusetts and Connecticut.

Based on the history of floods and the experience gained during the past 30 years at the other reservoirs in New England, it is expected that Meadow Reservoir will be used every year to impound water to alleviate flood damages on the Connecticut River. Generally, this will take place in the spring during the period of snowmelt, but it can occur in any month of the year if the need develops.

The depth, amount of water, and duration of impoundment, depends on the flood. It is estimated that annually, water will be stored to a depth of about 125 feet and cover an area of 500 acres. Although this depth is more than half of the total available height of 250 feet from the riverbed to spillway crest, the volume of storage represented by the 125 feet is only 20 percent of the total. This impoundment would be evacuated within a few days as the Connecticut River flood recedes.

Once in 10 years the reservoir will be filled to a depth of 200 feet covering an area of 1,150 acres, and utilizing about 55 percent of the total storage. It will take approximately 10 days to empty the reservoir. The reservoir will be completely filled approximately once in 50 years. Evacuation of a full pool will take about 15 to 20 days, the time depending on how quickly the flood flows recede on the Connecticut River.

Some critics of the Meadow Reservoir have a misconception of the project and assume that it is only needed to control a 2,000-year flood. This assumption is incorrect. The project is needed and is credited with monetary benefits for its reductions on all floods, ranging from the minor annual events to the infrequent major floods. The reservoir will also increase the degree of protection provided by the existing dikes and walls located at downstream communities on the Connecticut River. With the Meadow and other components in the comprehensive plan for the basin, the communities would have adequate protection against a standard project flood, a design flood derived synthetically to reflect the flood potential of the Connecticut River basin. It exceeds the flood of record. There is insufficient data to statistically determine the frequency of a standard project flood and the estimated 2000 years by others is merely an extrapolated guess.

G. Other Major Dams

Although not part of the system of major flood control dams necessary to provide a high degree of flood protection, there are 2 other major dams which are deserving of discussion, and whose purpose is principally that of meeting recreational needs and requirements for the restoration of the anadromous fisheries. In view of the nature of the migratory fishery resource there is Federal interest in one of the two reservoir proposals, namely Blackledge The other dam, referred to as Cold Brook is considered a major State responsibility as its need is principally wide-based recreation with improved fisheries at the site. It is not a key element to the anadromous program as is the Blackledge Reservoir.

In view of the size of both projects, and their regional scope, a discussion follows.

Cold Brook Dam

The Cold Brook Dam would provide day-use recreation activities and minor low flow releases to enhance resident downstream fisheries. The dam, located on Roaring Brook, lies 3.6 miles above the confluence of the Connecticut River and 2,500 feet upstream of Woodland Street, in the town of Glastonbury, Connecticut. The reservoir, at full pool elevation 270 feet msl, sits in a broad, flat, alluvial plain. The land area surrounding the reservoir consists of low and gentle sloping hills with a maximum topographic relief of about 700 feet, msl. A rolled earth fill structure with a top elevation 290 feet, msl, would be 1,100 feet in length and have a height of 60 feet. A Chute spillway with its crest 20 feet below the top of the dam would be located in the southerly abutment.

A 265-acre conservation pool at elevation 270 msl would be maintained for recreational pursuits. The low flow releases during this summer period would serve to augment the minimum low flows of the river by about 5 cfs.

Land acquisition includes 460 acres. Improvements to be acquired include 3 residences. About 45% of this land is presently wooded and 40% classified as either tillable or pasturable. Developed residential land amounts to approximately 10% with roads, waterways, and swamp accounting for the remaining 5%. Modification and relocation would be required on three local roads, one pipeline, and one high voltage transmission line. Other pertinent data is provided in apendices K and M.

The cost of the Cold Brook proposal is estimated at 4.7 million, a major breakdown of which is as follows:

Real Estate	$ 660,000
Relocations	1,160,000
Dam & Appurtenant Structures	1,090,000
Contingencies	445,000
Engineering & Supervision	600,000
Total	$4,700,000

Blackledge Dam

The Blackledge Reservoir would be developed as a multiple-purpose project for recreation and for fish and wildlife enhancement. The project would be located within the towns of Hebron and Marlborough, about twenty miles southwest of Hartford, Connecticut. The rolled-fill dam situated just upstream of Connecticut State Route 2, would impound Fawn Brook and Blackledge River. The top of dam elevation would be 370 feet, msl. The dam would be 190 feet high with a total length of 4,700 feet. A side channel spillway with crest elevation at 350 feet, would be located on the westerly bank of Blackledge River with an outlet works on the easterly bank of the Blackledge River. The reservoir area would consist of 1,700 acres and provides extensive areas for fishing and general recreation. Storage would be used to augment flows to 25 cfs during the summer months to maintain a suitable salmon habitat.

Real estate acquisition would consist of 2,700 acres of land of which 1,700 acres is located below the spillway crest elevation 350 feet msl. About 2,000 acres of land are located in the town of Marlborough and 700 acres in the town of Hebron. There are 16 improvements to be taken, namely 11 cottages, 2 residential homes and 3 barns. All the improvements except two of the cottages are located in the town of Marlborough. Land area is 90% wooded, 3% swampy, 6 % pasture or tillage, and 1% developed residential. About 160 acres are located in the Marlborough section of the Salmon River State Forest which is owned by the State of Connecticut. Further details may be found in Appendices K and M.

The cost of the Blackledge project is currently estimated as 18 million and a major breakdown is as follows:

Real Estate	$ 640,000
Relocations	1,360,000
Dam & Appurtenant Structures	10,060,000
Contingencies	2,300,000
Engineering & Supervision	2,840,000
Recreation	1,100,000
Total	$18,300,000

Gardner Dam

A water quality problem currently exists on Otter Brook, as a result of inadequate sewage treatment measures together with insufficient flows. To achieve approved water quality standards along this polutted reach of stream, and assuming secondary treatment is provided, advanced or tertiary waste treatment, instream aeration, or a combination of these measures may prove to be less expensive than low flow augmentation from a storage reservoir. The Gardner site would provide significant low flow storages and is included in the Basin Plan as an alternate proposal to such treatment methods.

The reservoir operation would permit variable flow releases throughout the year with normal maximum releases of 55 cfs occurring in the summer and fall months. During winter and spring freshet periods, when flows are not critical, releases would be held to a minimum of about 7 cfs to assure refill of the reservoir by June. Pool fluctuation, necessary to provide the required low flow augmentation for water quality, would limit development of recreational water based recreational facilities.

The dam would be located on Otter River about 10.2 miles above its confluence with the Millers River, or about 500 feet upstream of the new section of State Route 2. The reservoir at spillway crest elevation 947 feet msl, would contain 12,500 acre-feet of storage, of which 9,500 acre-feet would be utilized for low flow augmentation for water quality. This storage would provide flows sufficient to raise the quality of the Otter River to Class C, and assist the downstream portions of the Millers River below the Otter River confluence in attaining a Class B water quality standard. The remaining 3,000 acre-feet of storage would provide a permanent conservation pool to support a warm water lake fishery.

The dam, composed of earth fill, would be 3,500 feet long and 50 feet high, having a top elevation of 965 feet msl. A side channel spillway would be located at the northerly abutment. The 680-acre reservoir at spillway crest would extend into the towns of Templeton, Hubbardston, and the city of Gardner, all in Worcester County Massachusetts. The reservoir land area and a 300-foot horizontal buffer zone running along the periphery of the reservoir would be acquired. Acquisition would include 7 residences, 1 active farm and the Gardner Municipal Airport. The total land acquisition of 1,030 acres is about 51% wooded, 44% swamp, 1% residential and 4% pasture. No road relocation would be required other than providing an access to the dam. Existing secondary roads to be inundated by the reservoir would be abandoned since access required for properties situated along the periphery of the reservoir can be provided by other connecting roads.

The cost of the Gardner Dam and Reservoir development is estimated at 4.1 million and consists of major items as follows:

Real Estate	$ 450,000
Relocations	40,000
Dam & Appurtenant Structures	2,320,000
Contingencies	480,000
Engineering & Supervision	780,000
Recreation	-0-
	$ 4,070,000

The construction of the Gardner project would be a State responsibility. Federal cost sharing is likely to be restricted to a certain percentage, based upon the least costly alternative which, in this case, is viewed as other advanced wastewater treatment methods. Further details may be found in Appendices K and M.

PART THREE

CHAPTER VIII

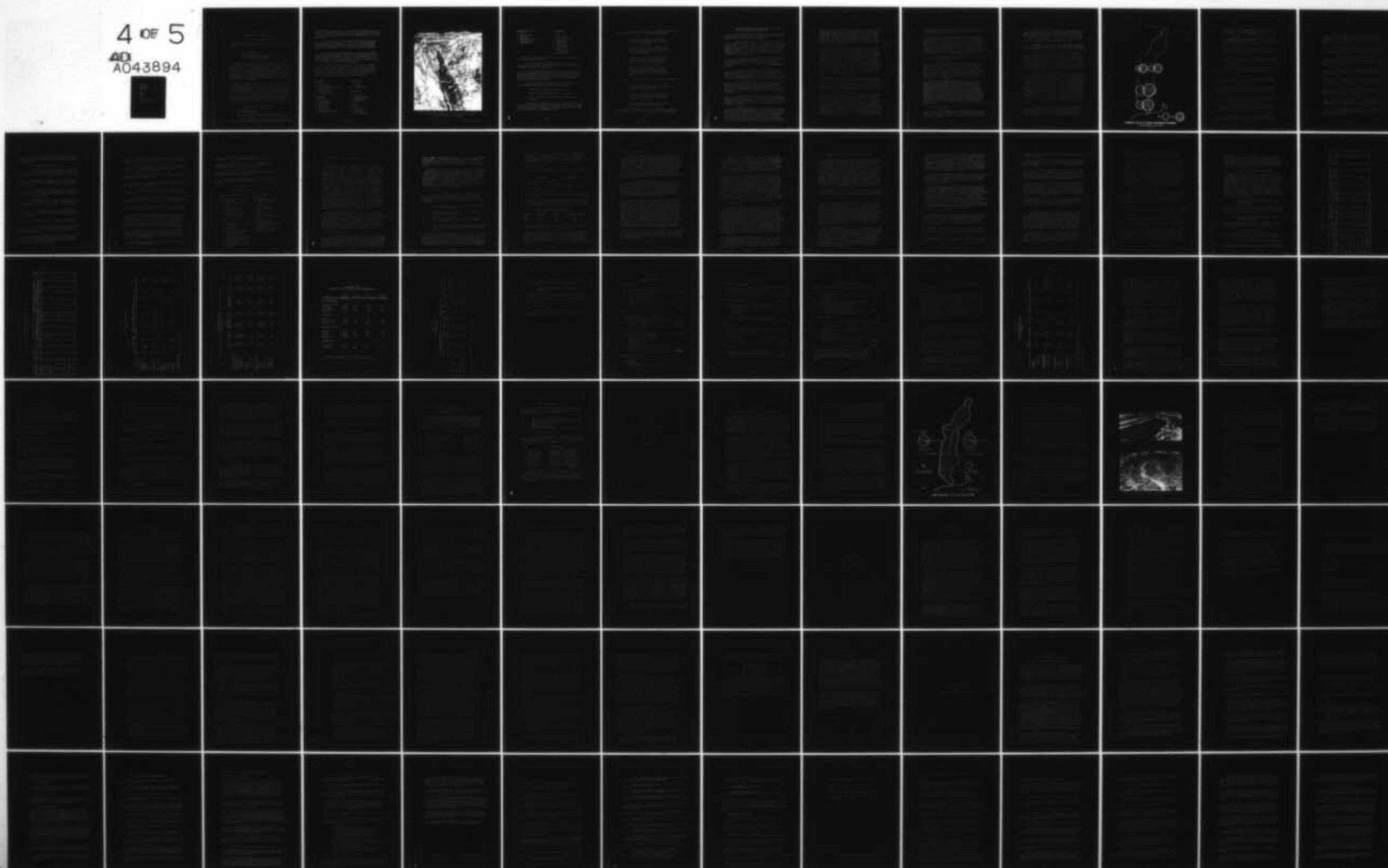
COORDINATED BASIN PLAN

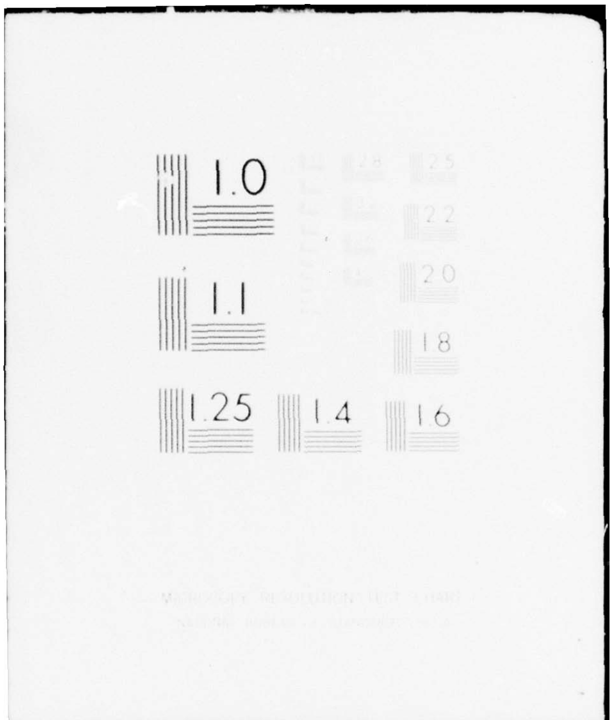
AD-A043 894 ARMY ENGINEER DIV NEW ENGLAND WALTHAM MASS F/G 8/6

COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION. C--ETC(U)

JUN 70

UNCLASSIFIED NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
MICROCOPY RESOLUTION TEST CHART

CHAPTER VIII

COORDINATED BASIN PLAN

Section I - The 1980 Early Action Plan

The 1980 Early-Action Plan has given much attention to a balance of projects that adress themselves to five principal programs and as follows:

I Restoration
II Preservation
III Conservation Management
IV Development and Management
V Utilization and Management

The basin plan also presents a balance between programs that are structural in character, such as dams, treatment plants, walls, sewer lines, etc., and elements that are non-structural in character, such as land acquisition, easements, purchase of open space for aesthetic reasons, trails and other controls to assist in the management of water uses. The basin plan includes elements that would be accomplished through on-going Federal agency programs as well as State agency programs, together with projects that could be accomplished by the individual local municipality.

This Section presents a summary of the Early-Action Plan. It also presents a summary of the Long Range Plan which would address itself to meeting needs through the end of the projection period year 2020. Emphasis was placed on quantitatively meeting the needs and goals of the 1980 time frame. These can be accomplished by the introduction of non-structural measures, principally in the areas of preservation and by areas where management or reallocation of resources would obtain for us greater utilization of those existing projects currently in the basin, be they Federal, State or other. Structural measures for all areas of the water resource categories are also provided.

THE 1980 EARLY - ACTION PLAN

1. Non-structural Measures

A. Areas of Preservation, Conservation and Utilization

(1) Nearly 600 sites of archeological importance and more than 250 sites of either natural resource or historical importance have

been referenced in Appendix O. The Committee recommends that local interests, working closely with the State, and with assistance of on-going Federal programs take the initiative in preserving these areas for future generations.

(2) The acquisition of 69,300 acres of land within the National Forest proclamation boundaries, 4,300 acres in the White Mountain National Forest, and 65,000 acres in the Green Mountain National Forest is recommended for Federal action as delineated in Appendix F.

(3) To prevent further encroachment and reduce future damage zoning of flood plains along over 200 miles of the main stem of the Connecticut River from Saybrook, Connecticut to above White River Junction, Vermont is recommended and this action is to be coordinated with (4) and (5) below and is referenced in Appendix M.

(4) Creation of a basin wide scenic river program to preserve, protect and enhance those reaches of river identified as Wild, Scenic or Recreational is recommended. Statewide action programs will be required to implement this scenic river proposal; and in this regard, priorities for stream acquisition and management consideration by sub-basin include all or part of the following tributaries:

Sub-basin I

1. Indian Stream
2. Upper Ammonoosuc River
3. Nash Stream
4. Phillips Brook
5. Ammonoosuc River

Sub-basin II

1. Nulhegan River
2. Paul Stream
3. Moose River
4. Wells River
5. Waits River
6. Ompompanoosuc River

Sub-basin III

1. Cold River
2. Ashuelot River

Sub-basin IV

1. White River
2. Ottauquechee River
3. Williams River
4. West River

Sub-basin V

1. Millers River
2. Tully River
3. Deerfield River

VIEW OF QUECHEE GORGE ON THE OTTAUQUECHEE RIVER
AT NORTH HARTLAND, VERMONT

Corps of Engineers Photo

Sub-basin V (cont'd)

4. Sawmill River
5. Ware River
6. Swift River (Chicopee)
7. Westfield River
8. Clam River

Sub-basin VI

1. Scantic River
2. Farmington River
3. Sandy Brook
4. Podunk River
5. Park River
6. Hockanum River
7. Ketch Brook
8. Salmon River
9. Dickinson Creek
10. Fawn Brook

Details concerning the above 35 tributaries may be found in Appendix H, and are shown on Plate K-17.

(5) The Committee recommends that streambank acquisition necessary to assure public access to basin fishery resources should be coordinated with items (3) and (4) above.

(6) To maintain aesthetic quality and to provide access and utilization, the establishment of a three-unit National Recreation Area in the Connecticut River Basin generally as described in the recommendations of the Bureau of Outdoor Recreation's "New England Heritage" is recommended and reported as follows:

(a) Federal action is required for the establishment of a three-unit National Recreation Area of 56,700 acres providing for:

- Gateway Unit, Connecticut, 23,500 acres

- Mount Holyoke Unit, Massachusetts, 12,000 acres

- Coos Scenic River Unit, New Hampshire and Vermont 21,200 acres

In addition, a 300-mile long Connecticut Valley Trail and a Connecticut Valley Tourway designed about existing roads to historic, scenic educational, industrial, archeologic and geologic points of interest, and to be a Federal-State-local cooperative effort.

(b) State action is required to complement the three-unit National Recreation Area by accomplishing the following:

- Gateway Unit: Cockaponset State Forest - expand existing holdings to form a contiguous 18,300-acre State forest.

- Mount Holyoke Unit: Mount Tom State Park - expand existing Mount Tom State Reservation adjacent to Mount Holyoke Unit to form a 4,800-acre State park.

- Coos Scenic River Unit: Connecticut Lakes State Park - enlarge existing holdings to create a 14,000-acre State Park at the northern end of the Coos Scenic River Unit.

- Moore-Comerford Interstate Park - joint development with private power company of lands surrounding Moore and Comerford Reservoirs to form a 15,400-acre Interstate Park.

(c) In addition, other State action is suggested for the establishment of

- Glastonbury Meadow State Park - 4,400 acres, and Windsor Locks-King's Island State Park - 250 acres, all in Connecticut

- Turners Falls-Northfield Mountain State Park - 31,000 acres, joint State-private power development, utilizing existing State lands and acquisition in Massachusetts

- Rogers' Rangers Historic Riverway - 27,500 acres in New Hampshire and Vermont.

Further details of the above program may be found in Appendix H and are depicted on Plate 1, Comprehensive Plan of Development.

B. Areas Where Improved Management of Existing Resources Can Help Meet 1980 Needs

The following items lie largely in the local-State areas of responsibility and interest except for the instances of Federal regulatory controls as exercised by licenses.

(1) Re-regulation of flows at existing impoundments to provide adequate minimum releases. At four power projects on the main stem of the Connecticut River, namely Wilder, Bellows Falls, Vernon, and Turners Falls, which are currently up for relicense, a minimum release of 0.2 cubic feet per second per square mile of drainage area is required. (Reference Appendix Q, Report of Subcommittee on Stream Regulation.)

(2) Continued environmental studies into the feasibility of using water supply impoundments to assist in meeting large recreational and fisheries needs as referenced in Appendix D, G, and H. The public health consequences of such action are discussed in Appendix R.

(3) Water quality studies are needed in the areas of storm and sanitary sewer separation; control or elimination of sludge deposits in reservoirs; and excessive run-off and sediment from agricultural and urban areas. Details on this requirement are referenced in Appendix Q, Report of Water Quality Subcommittee.

(4) Land treatment measures on 204,000 acres of crop and pasture land, 823,000 acres of private non-industrial forest land, 64,000 acres of National Forest lands, and analysis on 306,600 acres of National Forest land and fish and wildlife surveys and analysis on 30,500 acres of National Forest land, as referenced in Appendix F.

(5) Acceleration of planning assistance to 180 towns in preparation of resource inventories, town soil reports and interpretations, and flood plain information studies. In addition, soil survey programs, involving 1.5 million acres of non-Federal lands, as referenced in Appendix F.

(6) Improved operation of flood control reservoirs. In this regard the New England Division, Corps of Engineers has established a computerized network of remote river stage data stations. These are mainly composed of river gaging stations operated and maintained by the United States Geologic Survey in cooperation with varopis States, and in some cases with the Corps of Engineers. This computerized network has been established in five major New

England river basins, one of which is the Connecticut. This network reports hydrologic data such as rainfall, river stages and tidal elevations from index locations on important rivers and streams, and in the tidal areas for a more timely and efficient operation of existing flood control reservoirs. The automatic hydrologic radio reporting network consists of 41 remote reporting stations, 5 recording stations, and a central control station at Division Headquarters plus 12 repeater and 4 relay sites.

The network, under computer program control, will immediately provide read-out information which is essential for flood regulation, to the Reservoir Control Center at Waltham. The reporting stations are radio-operated with principal power source supplied by batteries. The recording stations can receive data from the central control station, or individual reporting stations. The central control station at Waltham consists of an interface between the radio equipment and the computer. It will automatically interrogate the entire network or individual stations at selected time intervals and provide a complete print-out in three minutes. The hydrologic network has a capability of receiving technical data required for operation of other water resource purposes, such as low flow augmentation, recreation, water supply, navigation, and fishery enhancement. The network can be expanded to 100 stations.

Although the hydro-net system will operate continuously, its prime mission will be to focus on actual or expected flood situations. Data received is closely scrutinized and added to information received from the Corps' flood control reservoirs and other sources, such as the Weather Bureau at Boston and the River Forecasting Center at Hartford. Decisions are then made for operation of dams and instructions are radioed to operating field personnel.

(7) The Weather Bureau River Forecast Center at Hartford now provides flood forecasting service for the Connecticut River Basin. This service consists of stage and flow forecasts for the principal points along the main stem and its tributaries. Improvement and expansion of this system will be required in order to meet the needs for more detailed and accurate forecasts. Although forecasts are indispensable in saving lives and reducing property damage during floods, it is quite likely that detailed, continuous flow forecasts will prove to be even more valuable. All of the water resources management programs planned for the Connecticut River Basin - flood control, navigation, water supply, power, fish and wildlife, and even

recreation - will be more effective and more efficient when the decision makers have at their disposal a complete and accurate prediction of the behavior of the streams.

In order to achieve this degree of sophistication in streamflow forecasting, automated, detailed, real-time data on precipitation and river stages and current, and predicted reservoir releases must be available as input parameters. The Corps of Engineers network described above, as well as information from satellites and radars will be utilized in the complex reporting network. In addition, the forecasting computations will be made by computer programs. It is also anticipated that the dissemination of the forecasts to the users will be by means of data-links or other high-speed devices.

(8) Programs to inform the public of the availability of flood plain insurance and flood fighting.

(9) There is need to greatly expand current water quality monitoring and particularly at a time when so much interest and concern are being evidenced by the public for environmental quality. In order to know the effect which new improvements will have, one must have proper knowledge of what is available currently and, in many cases, gage control stations are not broad enough to deliver the types of data that are necessary to construct a basic profile of the river's environment.

The use of more sophisticated monitoring equipment at those sampling stations maintained by Federal and State agencies as well as at the additional stations proposed by the Subcommittee on Water Quality will allow for broader surveillance of the rivers' environmental condition. On going programs of many of the Federal agencies include water quality monitoring at resource facilities. For example, the Corps of Engineers regularly samples the inflows, outflows and the ponded water at its water storage projects. These samples are analyzed at its Barre Falls Dam field laboratory and the collected data are used to improve reservoir regulation for the enhancement of water quality both in the reservoir and in downstream reaches.

2. Structural Measures

In order to meet the needs determined as part of the comprehensive study it will be necessary to install considerable structural measures. A summary of these more important structural measures is detailed as follows:

(a) Public and private construction of those waste treatment facilities required to meet approved State water quality standards in the basin as delineated in Appendix D. The estimated cost of providing secondary treatment to point source pollution loadings in the basin, by State, is shown in Figure VIII-1 both for the 1980 Early Action Plan and to fulfill the potential 2020 needs.

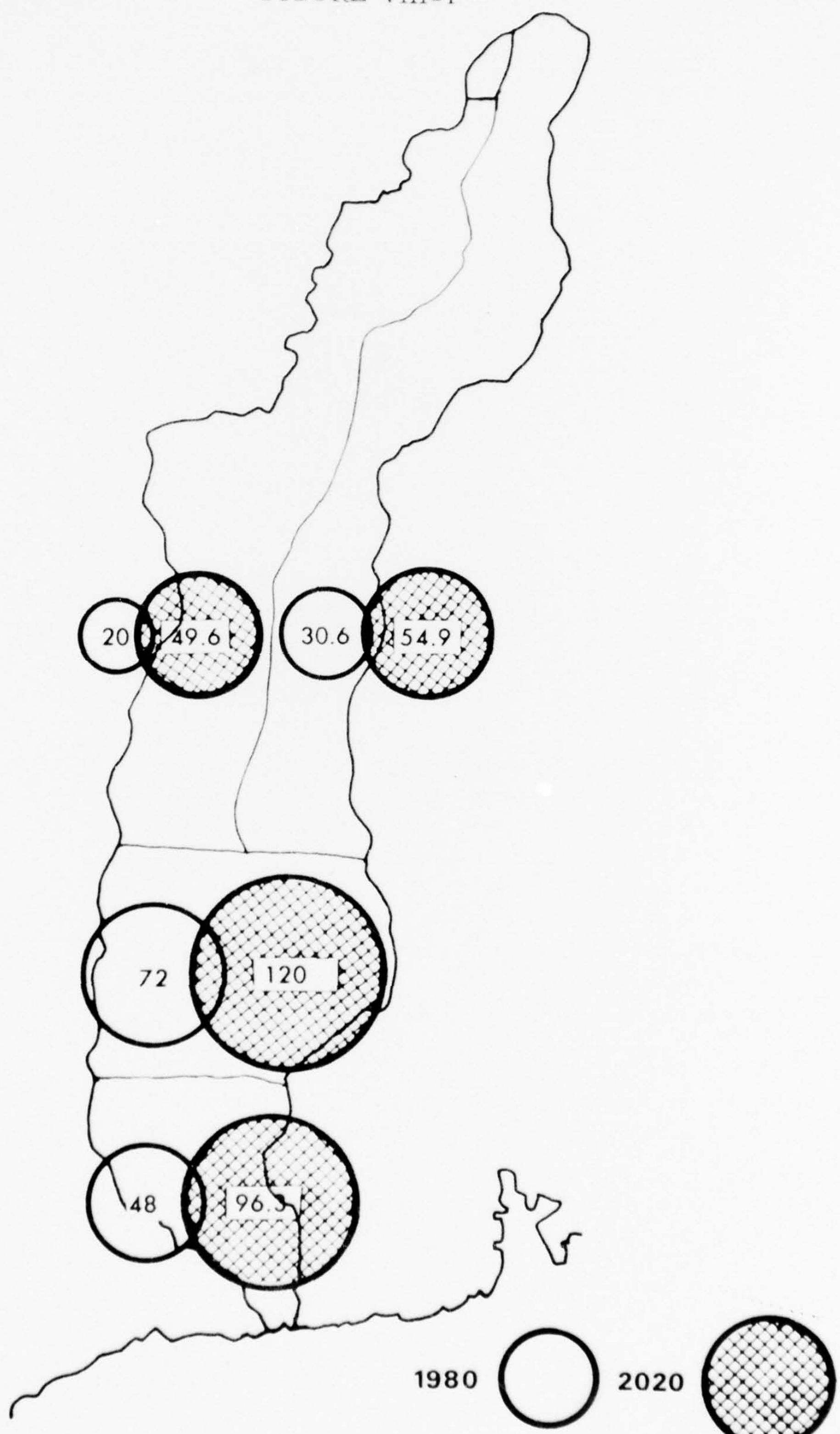
(b) Expansion of the existing basin power supply system by private or municipal utilities to meet those power demands which will be allocated to the Connecticut River Basin, as discussed in Appendix I.

(c) Construction of seven major reservoirs in which flood control is a prime purpose. Included is one project currently in the design stage, Beaver Brook on the Ashuelot River in New Hampshire. Of the remaining six reservoirs, two, Victory on the Moose River and Gaysville on the White River, are in Vermont; three, Bethlehem, Claremont and Honey Hill on the Ashuelot River, are in New Hampshire; and Meadow is in Massachusetts on the Deerfield River. Pertinent data on these projects are reported in Table K-40 and their locations are shown on Plate K-2.

(d) Three other major reservoirs are included in the Early Action Plan. They are Gardner on the Otter River in the Millers River Basin, Massachusetts; Blackledge in the Salmon River Basin and Colebrook in the Roaring Brook Basin, Connecticut. Even though they would be constructed for purposes other than flood control, they would have some effect in reducing run-offs. Generally, pool levels would be lowered somewhat during or after late fall to allow heavy spring rains to be controlled and stored. Essentially, two of the projects, namely Colebrook and Blackledge are required for the enhancement of fisheries and the restoration of the anadromous program in both of the tributaries where these structures are located. In the instance of the Gardner project, this particular proposal is necessary as an alternate means of meeting established State standards. The Gardner project was found to be more economical than advanced or tertiary treatment. In addition, it would provide for other multiple use purposes.

(e) Included in the plan are the modification of four existing Corps of Engineers' flood control dams by the incorporation through modification and reservoir regulation of permanent pools to include allied purposes of recreation, fish and wildlife, and water supply. The projects are discussed in detail in Appendix M.

FIGURE VIII-1



ESTIMATED COST OF SECONDARY WASTEWATER TREATMENT

(IN MILLIONS OF DOLLARS)

- Knightville Dam on the Westfield River in Massachusetts, modifications to include a conservation pool for recreation and low flow augmentation to enhance fisheries.

- Union Village Dam on the Ompompanoosuc River in Vermont and contingent upon the solution to an existing water quality problem on the West Branch of the river would be operated to provide a conservation pool for recreation.

- Tully Dam on the Millers River in Massachusetts, modifications to divert water supply as part of a flood skimming operation and to establish a conservation pool for recreation.

- Barre Falls Dam and Reservoir on the Ware River in Massachusetts, contingent on solution to current water quality problem, could be operated to provide low flow augmentation during the summer months.

(f) Local flood protection projects at five locations in the basin are referenced in Appendix M, and were found necessary to complement other flood control measures in the basin plan. These are as follows:

(1) Westfield, Massachusetts - improvements to provide for 45,000 linear feet of earth dikes, about 1,500 feet of concrete floodwalls, two pumping stations, and 16,000 linear feet of channel improvement on the Little and Westfield Rivers.

(2) Lancaster, New Hampshire - a small ice retention dam and reservoir on the Israel River about one and one-half miles upstream of its mouth, together with 2,800 linear feet of channel improvement.

(3) Hartford, Vermont - improvements of ice jam flooding by excavation of reach for 3,000 linear feet of the White River from the vicinity of Hartford Bridge to the mouth.

(4) St. Johnsbury, Vermont - flood control improvements provide for 1,200 linear feet of protective earth dike and concrete floodwall, a railroad gate structure, and a pumping station located along the Passumpsic River.

(5) Park River, Connecticut - flood control improvements provide for 12,816 linear feet of conduit with headwall and pumping structure along the Park River in Hartford, Connecticut.

(g) Seventeen upstream watershed projects as referenced in Appendix F. These local projects would include 78 floodwater retarding structures of which 60 would be multiple-purpose. Eight projects, currently authorized for planning under Public Law 83-566, as amended, are as follows:

(1) West Branch, Westfield River Project, Massachusetts, comprised of 95 square miles of drainage area with 11 storage sites retained for flood prevention. Approximately 10,150 acre-feet of storage are being considered for recreation and fish and wildlife.

(2) Upper Quaboag River (supplement project), Massachusetts, comprised of 147.4 square miles of drainage area with 5 storage sites planned for flood prevention. Also being considered as part of the project are 3,900 acre-feet of storage for recreation, water quality and water supply.

(3) Wells River Project, Vermont, comprised of 99.7 square miles of drainage area with 6 storage sites planned for flood prevention. Approximately 7,300 acre-feet of storage for recreation is also being considered as part of the project.

(4) Sugar River Project, New Hampshire, comprised of 275 square miles of drainage area with 10 storage sites planned for flood prevention. Also being considered as part of the project for recreational use are 15,400 acre-feet of storage.

(5) Blow-Me-Down Brook Project, New Hampshire, comprised of 28.3 square miles of drainage area with 4 storage sites planned for flood prevention. Approximately 700 acre-feet for recreation is also to be considered a part of the project.

(6) Indian-Mascoma River Project, New Hampshire, comprised of 133.6 square miles of drainage area with 7 storage sites planned for flood prevention. About 23,000 acre-feet of storage for recreational use is also being considered a part of the project.

(7) Gale River Project, New Hampshire, comprised of 91 square miles of drainage area with 2 storage sites planned for flood prevention. Also being considered are 660 acre-feet of storage for recreational use.

(8) Indian Brook Project, New Hampshire, comprised of 2.2 square miles of drainage area with 1 storage site for flood prevention. Also 780 acre-feet of storage for recreational use is being considered.

Nine potential watershed projects are:

(1) Mill River Project, Massachusetts, comprised of 59 square miles of drainage area with 3 storage sites for flood prevention. Included is 3,800 acre-feet of storage for recreation and water supply.

(2) East Branch, North River Project, Vermont, comprised of 39 square miles of drainage area with 1 flood prevention site which include 1,600 acre-feet of storage for recreation and fish and wildlife use.

(3) North Branch, Deerfield River Project, Vermont, comprised of 50 square miles of drainage area with 5 storage sites for flood prevention. Included are 2,700 acre-feet of storage for recreation and fish and wildlife.

(4) Whetstone Project, Vermont, comprised of 28 square miles of drainage area with 5 storage sites for flood prevention. Included are 5,600 acre-feet of storage for recreation and fish and wildlife.

(5) Ball Mountain Brook Project, Vermont comprised of 35 square miles of drainage area with 2 sites for flood prevention. Included are 4,000 acre-feet of storage for recreation and fish and wildlife.

(6) Black Brook Project, Vermont, comprised of 195 square miles of drainage area with 3 sites for flood prevention.

(7) Passumpsic-Moose Rivers Project, Vermont, comprised of 374 square miles of drainage area with 8 sites for flood prevention. Included are 13,300 acre-feet of storage for recreation and fish and wildlife.

(8) Upper Ammonoosuc River Project, New Hampshire comprised of 254 square miles of drainage area with 3 sites for flood prevention. Included are 43,200 acre-feet of storage for recreation, water quality and water supply.

(9) Mohawk River Project, New Hampshire, comprised of 56 square miles of drainage area with 2 sites for flood prevention. Included are 10,000 acre-feet of storage for recreation.

(h) Completion under Public Law 89-796 of four resource conservation and development projects having substantial land areas within the basin (referenced in Appendix F), as follows:

(1) North Country Resource, Conservation and Development Project comprised 1,201,700 acres in Coos, Grafton, and Carroll Counties of New Hampshire.

(2) East Central Vermont Resource, Conservation, and Development Project encompassing 23 towns in parts of Orange, Windsor, Rutland, and Addison Counties.

(3) Berkshire-Franklin Resource, Conservation and Development Project, with some 600,000 acres included in the basin in Massachusetts.

(4) Eastern Connecticut Resource, Conservation, and Development Project including 26,000 acres in Tolland and New London Counties.

(i) Other select upstream impoundments, for purposes other than flood control; 118 dam sites in total as referenced in Appendix F.

These 118 sites would have a total storage capacity of 463,000 acre-feet, of which 68,000 acre-feet would be for floodwater and sediment, 156,000 acre-feet for recreation, 111,000 acre-feet for fish and wildlife, 108,000 acre-feet for low flow augmentation, and 20,000 acre-feet for public water supply. A total of 18,200 acres of water surface area and flow augmentation benefiting 467 miles of downstream fishery would result from these impoundments.

(j) Structural developments on National Forests lands (referenced in Appendix F), as follows: recreation facilities on 555 acres; recreational impoundments amounting to 310 surface acres; 255 miles of roads and trails; 37 fire control heliports; 37 acres of fish and wildlife improvements.

(k) Navigation improvements are needed and are described in Appendix L. They provide for:

(1) Deepening and widening the present commercial navigation project from Saybrook Light to Hartford, Connecticut.

(2) Construction of a 32-mile recreational navigation project from Hartford, Connecticut to the vicinity of the Willimansett Highway Bridge below Holyoke, Massachusetts.

(3) Recreational navigation improvements on the main stem of the Connecticut River behind the Holyoke, Turners Falls, Vernon, and Bellows Falls power dams.

(1) Construction of fish hatcheries, as well as fish ladders to meet requirements of resident and anadromous restoration programs.

SUMMARY

THE 1980 EARLY ACTION PLAN

1. Non-Structural Category

A. Preservation, Conservation and Utilization
   (1) Historical and Archeological
   (2) Forested Land
   (3) Flood Plain Zoning
   (4) Scenic River (35)
   (5) Streambank Acquisition
   (6) BOR Plan, Fed-State

B. Improved Management
   (1) Re-regulation
   (2) Use of Water Supply Bodies for Recreation
   (3) Water Quality - 5 Areas
   (4) Land Treatment Measures
   (5) Technical Planning Assistance
   (6) Improvement and Expansion of Flood Warning System
   (7) Flood Plain Insurance and Flood Fighting
   (8) Water Quality Monitoring Programs

2. Structural Category

(a) Waste Treatment Plants
(b) Expand Existing Power
(c) Construct 7 Major Dams (F. C.)
(d) 3 Other Large Dams
(e) Modification at 4 Corps Dams
(f) Local Protection at 5 Areas
(g) 17 Upstream Watershed Projects
(h) 4 RC & D Projects
(i) 118 Upstream Sites
(j) Improvements on National Forest Lands
(k) Navigation - 3 Projects
(l) Fish Hatcheries and Ladders

Section 2 - Benefits and Cost by Resource Category

General

Benefits were evaluated within the guiding criteria of Senate Document 97, 87th Congress, as approved by the President in May 1962. In general, benefits are defined in this comprehensive report as gains, net of associated costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. The report strived to indicate and to evaluate the benefits of measures considered during the plan formulation process. Where benefits were of an intangible nature they were identified but not given dollar values. Tangible benefits were expressed in dollars where possible, but as noted in the following paragraphs, which describe benefits to specific water resource categories, there are some instances in which adequate data are not available to translate certain tangible benefits into dollar values. The study attempted to quantify the true value of each resource purpose, as more than merely the cost of providing equivalent benefits by alternative means. However, where this was not possible, benefits were considered to be at least equal to the least costly alternative means of accomplishing the same end. Benefits were considered to be those gains in goods and services produced by the Early Action Plan, from 1980 throughout the life of the project element under consideration. Future benefits were reduced to present worth and then converted to an annual basis at a discount rate of 4-7/8%.

Individual multiple-purpose reservoir elements were included in the Early Action Basin Plan, initially and primarily to meet specific water resource needs projected to occur by the year 1980. Once that element was included in the Basin Plan, it was then examined as to its capability to meet other needs throughout the life of the proposed project element. This was to assure that the scope of development maximizes net benefits produced by the Basin's resources, and that there is no more economical means of accomplishing the same purpose which would be precluded by project development.

1. Water Quality Benefits

Water quality benefits are tangible in the sense that adequate quality levels make possible other beneficial uses such as water supply, recreation, fish and wildlife enhancement and aesthetic enjoyment. Enhancement of adjacent land values and corresponding intangible benefits also result. Benefits are most often widespread and not always identifiable to the beneficiary, and in this sense, are usually regional in nature. Higher levels of water quality mean a savings in water supply treatment costs, although the methodology to quantify the extent of such benefit is limited. Appendix D indicates that a correlation can be drawn between streamflow and reductions in advanced treatment costs.

The attainment of fish and wildlife and outdoor recreational goals in the basin are dependent on the availability of adequate water quality. Certain activities are completely dependent upon water quality while others are enhanced by a high water quality. The States and the Federal Government have recognized the inherent value of quality water and because of this have adopted standards to restore and preserve it for the future. It is assumed, therefore, that the costs of meeting the standards are a necessary expense and at least equal to the cost of the most feasible method of achievement.

2. Power Benefits

In its analysis of power benefits the investigation was limited to the study of producing power through either conventional hydroelectric generation or through pumped storage generation. As noted in Appendix C (Hydrology) power studies were based on the following assumptions:

- Future large thermal-electric plans would be the primary source of base load supply.

- The logical role for hydroelectric plants would be in meeting peak power demands.

- Only sites with drainage areas greater than 25 square miles were considered for conventional at-site hydroelectric potential.

- Sites with smaller drainage areas, but with head differentials in excess of 300 feet were considered for pumped storage potential.

An evaluation was made of the effect of proposed reservoir releases on energy output by existing downstream hydroelectric plants. In this instance an energy value of 3 mills was used. Hydroelectric power benefits were based on the cost of providing equivalent power by the most likely alternate source to serve the same market area. Throughout the site screening process, average basin-wide values of $10 per kilowatt and 3 mills per kilowatt-hour for energy were used. In testing for the economic feasibility of adding hydroelectric power to Corps projects the separable costs of the addition were compared with the costs of a publicly-financed pumped storage project. In this latter instance, values of $5 per kilowatt and 3 mills per kilowatt-hours were employed.

3. Recreation Benefits

Benefits for recreation were generally based on Supplement 1 of Senate Document 97 and vary as follows:

Area Type	Value Per Recreation Day
Area I - High Density Recreation Areas	$1.50
Area II - General Outdoor Recreation Areas	$2.00
Area III - Natural Environment Areas	$2.50

Annual benefits for water based projects are based on the number of recreation days use per season multiplied by the value per recreation day.

In general, studies and site screening estimates for recreation facilities cost, exclusive of land, were based on dollar value per recreation day. These estimated capital costs in dollars per acre of developed land are described in detail in Appendix H, and are as follows:

Outdoor Recreation Land Classification

Sub-Basin	High Density	General	Natural Environment
Upper	52,200	9,500	4,000
Middle	58,800	11,000	4,400
Lower	66,600	12,500	5,200

Estimates of facilities cost for those recommended major reservoirs are based on actual preliminary development layouts.

In addition to benefits at water bodies and adjacent land, reaches of streams in the Connecticut River Basin with their associated land, were evaluated to determine their potential to produce recreation benefits. Stream flow was correlated with recreation benefit output for selected stream reaches of the Connecticut River Basin. Evaluations are subject to change in more detailed field studies or refinement of present methodology.

4. Fish and Wildlife Benefits

Fishing benefits were considered to result from new or improved water bodies for both cold and warm water fish species. Enhancement of stream fishing is expected to result from improved quality and quantity of flow. Stocking of fish, improvement of habitat, elimination of undesirable species, preservation of stream bed and acquisition of stream bank are also measures of significant benefit to fishing. For study purposes the measure of resident fishing benefit was the fisherman-day. The unit value attached to fisherman-day varied with type and density of fishing and location in the basin. Reservoir fishing varied from $2.50 to $5.00 for cold water and from $2.50 to $4.00 for warm water. Stream fishing values varied from $2.50 to $5.00.

Creation of additional waterfowl habitat would encourage an increase in waterfowl use by migrating birds in spring and fall and for nesting and rearing young in summer. The increase would enhance wildlife resources and was measured both in value of waterfowl hunter-days provided and in costs of providing similar habitat by the most likely alternative. A unit value of $4.00 per hunter-day was used in this analysis, together with an average annual figure of approximately $30.00 per acre of habitat created.

An anadromous fisheries program was initiated by the State fish and game agencies and the Fish and Wildlife Service subsequent to passage of the 1965 Anadromous Fish Act, wherein Congress recognized the importance of conserving and developing the anadromous fishery resources of the nation. The coordinated program developed for the Connecticut River Basin has as its goals the restoration of American shad and Atlantic salmon fisheries. This on-going program was taken into account during the comprehensive study along with all other factors having potential for contributing to or detracting from resource capability for meeting anticipated needs. Insofar as any features of the Basin Plan were determined to have potential for improving the amount of anadromous fishery resources and opportunities for their use, benefits were computed in a manner similar to that followed in the case of other fish and wildlife resources.

The value of flows required to meet fish hatchery needs was assumed to be at least equal to the cost of the least expensive source of supply. The value of flows to enhance anadromous fishing was determined by the number of fisherman-days provided and multiplied by an estimated $6.00 per fisherman-day.

5. Water Supply Benefits

Benefits from an adequate source of water supply are often taken for granted, and are usually far beyond the costs of development even though the latter is the most common technique used to evaluate water supply benefits. An adequate water supply is vital to the well-being and economic health of a community, and lack of it is usually a deterrent to proper growth. Several important aspects are a healthy climate for population and economic growth as well as protection of life and property by adequate supplies for fire protection.

In lieu of an accurate means of assessing the true value of an adequate water supply, a conservative measure of the tangible segment of the total benefits may be obtained by determining the amount of money that people pay for water. Figures for each of the six sub-basin areas are contained in Appendix D, and include the costs associated with complete operation of a municipal system including development, treatment, distribution operation and administration, and for private utilities a return on investment. With the exception of CRB II (Upper Vermont), the average cost of domestic water was $381 to $455 per million gallons or a total annual cost of from $140,000 to $166,000 per million gallons per day capacity. In CRB II the average cost was $70,000 per MGD. The annual cost of industrial water users range from $46,000 to $150,000 per MGD of system capacity.

6. Navigation Benefits

Navigation benefits were considered to accrue to both recreational and commercial waterway improvements, as well as to such other purposes as enhancement of fisheries and land enhancement. Benefits for recreational boats were evaluated as the net annual return that boatowners would enjoy, should improvement be made, if their boats were on a for-hire basis. The net benefit reflects the difference between the return that could be anticipated based on present restricted use of the waterway and return that could be anticipated based on increased use after waterway improvement. Evaluations were made of the benefits expected to be realized by the existing fleet after the proposed improvement, as well as those accruing to the prospective fleet reflecting both the normal growth that could be expected without the improvement and the accelerated growth that could be expected after improvement.

Benefits to commercial navigation improvements were considered to result from the savings in reduced transportation costs. These savings would be attributable to both the reduced delivery cost per ton made possible by the use of deeper-draft vessels, and also to the savings in travel time because of channel widening and easing of hazardous bends.

7. Land Management and Upstream Watershed Control Benefits

Benefits for land treatment are considered to be public good as indicated by the 1954 action of Congress in adopting the Watershed Protection and Flood Prevention Act (Public Law 566). The Act emphasized the need to halt unchecked soild erosion and excessive run-off on rural land, and to reduce flooding and improve drainage on agricultural lands, in addition to providing other beneficial uses. Accordingly, benefits accruing to land treatment measures on to technical assistance programs are considered to be at least equal to the most economical manner of accomplishment. Similar rationale applies to programs to provide proper land and watershed management on forest land which now makes up about 79 percent of the Basin area. Acquisition of land within the proclamation boundaries of the White and Green Mountains National Forests has been recognized as properly within the public interest in reaches stemming from the 1911 Weeks Act.

Benefit analysis of flood control features of the upstream watershed program (Public Law 566) was done in a manner similar to that employed for the larger reservoirs as discussed in paragraph 8 of this section.

8. Flood Control Benefits

Many tangible and intangible losses are caused as a result of flooding, many of which cannot be evaluated. It should be noted that even when monetary evaluation is not possible, any reduction or elimination of loss should be considered as a project benefit. A list of benefits attributable to flood control are presented in Appendix M and consist generally of benefits due to curtailment of present and future property loss; loss of life, wages and commerce; and loss due to land erosion and sedimentation. Also there is the curtailment of the loss of money spent on flood emergency work. On the positive side there is the enhancement of land use to the removal of flood potential, as well as the establishment of peace of mind and sense of security among the inhabitants of protected areas.

In the case of multiple-purpose reservoirs containing flood control as a purpose, there are benefits not related to flood loss but which are made possible because of the cost sharing advantage of multiple-purpose reservoirs. That is, the savings brought about by combining several water resource purposes together in one project, may make construction economically feasible, whereas, individually they might not have been justified for construction. An example of this latter benefit would be the creation of recreation and fish and wildlife opportunity at a multiple purpose reservoir, and the enhancement of land around the perimeter of the permanent pool.

Flood control measures also act to conserve the land resources of the Basin by reducing erosion and sedimentation and by making land more productive by removable of the flood hazard. There are also ecological, environmental and recreational benefits to proper management of land in flood plains. Although not strictly a flood control benefit, land enhancement around the perimeter of permanent pools and multiple-purpose reservoirs was evaluated. Land enhancement behind dikes was considered but due to the extensive magnitude of the comprehensive report was not evaluated.

Not all of these benefits have been evaluated in a monetary sense in this report. The principal benefits assessed were due to the curtailment of loss to existing structures and goods. The other benefits, although not evaluated, should be considered when deciding priorities among the projects.

The study also took note of the possible adverse effects of flood control measures such as the economic cost of implementation, inconvenience or disruption to people in the project vicinity, possible loss of productive land, as well as environmental and ecological effects of proposed measures. These adverse effects will be minimized or eliminated in more detailed design stages. For instance, every effort will be made to relocate people in the project area to a suitable area in the project vicinity and to ameliorate economic losses. Fish losses will be mitigated by hatchery construction or other means and canoeing although lost in one area may be enhanced in another area by reservoir releases during a normally dry season.

9. Flow Augmentation Benefits

Probably the most difficult area of analysis were those including augmentation benefits. Practically every water resource use pointed to a need for better stream regulation with flows during the summer and fall months. Attempts were made to correlate the increase in value due to improved flow regimen, although not always with great precision.

Values were attached to flows required to meet the water quality classifications adopted by the States. In those instances, the cheapest alternative cost was used as the yardstick for benefit measurement.

Where appropriate, analyses were made of the potential increase in energy at downstream power plants due to higher flows. Increases in energy output were translated into dollar benefits by applying the market value for power.

Improved recreation and fish opportunities, made possible by augmented stream flow, were measured in dollars per user day. Dollar values were based on accepted standards, as directed by the Water Resources Council.

In cases where flow augmentation was used to provide water supply to downstream users, benefits were measured as the cost of the alternative source most likely in the absence of the project. As in the evaluation of water quality, recreation, and fish and wildlife, this manner of benefit assessment is considered conservative.

Several areas of accrued value due to improved flow have not been measured in dollars and cents. One example is the enhanced land value caused by improved quantity and quality of flow. Studies under way by the Corps' Institute of Water Resources indicate that there is a very definite monetary gain attributable to improved flow regimen; however, a precise technique for translating this very real gain into dollars and cents has yet to be developed.

Generally, the Early Action Plan provides for significant flow increases throughout the basin which would provide for new and enhanced uses; it should be noted, however, that benefit assessment due to flow augmentation has been very conservative.

10. Costs

In preparation of this report, efforts were made to evaluate the cost of implementing the entire 1980 Early Action Plan. This was done with the understanding and realization that not all plan elements are susceptible to evaluation at this time. One example is the flood plain zoning program which would be implemented by the local communities and the States. In many instances, the program can be accomplished by zoning without a transfer of money or land title. On other occasions, it may be necessary to acquire land if zoning of required stream reaches cannot be effected.

Another example is the cost of several of the areas of water quality improvement such as separation of combined sewers, and control or removal of critical bottom sludge deposits in water bodies. Extersive design or research is needed in areas such as these before a meaningful estimate can be made.

The project costs are based on recent price levels which are considered adequate measures of value for labor, goods, and services that would be required to implement or construct, operate, and maintain a project.

For major reservoirs, estimated investment costs involving the economic evaluation of projects include first costs, interest during construction for 1/2 the estimated construction period in excess of one year and the present worth of future additional facilities. Annual costs utilizing an interest rate of 4-7/8 percent with a project economic life of 100 years include interest and amortization on the total investment costs, projected annual operation, and maintenance costs and annual equivalent cost of major replacements. Loss of taxes on lands were evaluated on current tax trends and the net loss of productivity on lands was included in certain instances where prior reports identified these economic losses. In authorization reports all such losses will require a complete detailed analysis.

11. Summary of Benefit-Cost Evaluation

As noted in Chapter VII, a benefit-cost analysis was made of each element of the plan where monetary evaluation was possible. Other elements, which did not lend themselves to such analysis, were included in the plan if the Coordinating Committee considered them both essential to the satisfaction of basin water resource needs and compatible with the over-all well-being of the people of the basin.

Economic analyses are considered sufficient to determine whether an element should be included in the plan. Later individual, detailed, project design will refine both the scale of development and the benefits produced.

Specifically, a benefit evaluation has been made of each of the following water resource projects:

(1) Eight Upstream Watershed projects Currently Being Planned

Installation cost of these eight watersheds is an estimated \$18.4 million of which \$12.5 million are allocated to flood prevention; \$1.8 million to storage for water supply, water quality, and fish and wildlife; and \$4.1 million for recreation. Annual costs amortized at 4-7/8% interest, 100-year project life are about \$957,500. Benefits are estimated to be \$1.4 million annually, consisting of

$320,700 from reduction of floodwater and sediment damages, $593,000 from recreation, $122,000 from fish and wildlife developments, $121,800 from redevelopment, $155,500 from land enhancement and $117,000 in secondary benefits. Details of costs and benefits are shown in Appendix F, while the allocation of storage and costs are shown in Table VIII-1.

(2) Nine Potential Upstream Watershed Projects

Installation cost of these watersheds is estimated at $19.3 million of which about $12.0 million will be allocated to flood prevention; $3.5 million to storage for water supply, water quality and fish and wildlife; and $3.8 million to recreation. Annual costs amortized at 4-7/8% interest, 100-year project life, are about $949,000 annually. Benefits are estimated at $1.0 million annually, consisting of $440,000 annually from reduction of floodwater and sediment damages, $10,500 in land enhancement, $77,900 in secondary benefits, $123,300 in development, $116,800 in recreation and $205,700 in water supply. Details of costs and benefits are shown in Appendix F, while the allocation of storage and costs are shown in Table VIII-2.

(3) Seven Major Reservoirs with Flood Control as a Primary Purpose

These projects are discussed in detail in Appendix M. Pertinent data are shown in Table 40 of Appendix K, benefits are shown in Table VIII-3, costs are shown in Table VIII-4 and a comparison of the two is shown in Table VIII-5.

(4) Three Major Reservoirs Where Flood Control is Not a Primary Purpose

These projects are discussed in detail in Appendix M. Benefits are shown in Table VIII-3, costs are shown in Table VIII-4, and a comparison of the two are shown in Table VIII-5.

(5) Five Local Protection Projects

Local protection projects are discussed in detail in Appendix M. A summary of costs and benefits is shown on Table VIII-6

(6) Hartford to Holyoke Recreational Navigation Project

Benefits are expected to accrue primarily to recreational boating although the project would also benefit commercial navigation,

TABLE VIII-1

UPSTREAM WATERSHED PROJECTS CURRENTLY BEING PLANNED

Watershed		Drainage Area	Number of Sites	Control Area	Storage Allocation					Estimated Installation Costs in $1000					
					Sediment	Flood Prevention	Beneficial Use			Flood Prevention	Recreation	Fish & Wildlife	Water Quality	Water Supply	Total
No.	Name	sq.mi.		sq.mi.	ac.ft.	ac.ft.	ac.ft.	acres	cfs						
NH6	Indian Brk	2.2	1	1.5	NA	800	780	120		142	137				279
NH10A2	Gale River	91.0	2	39.3	515	6300	660	50		1540	96				1636
NH13A	Indian-Mascoma	133.6	7	62.8	350	10,040	23,000	1,090		1384	1202				2586
NH14A	Blow-Me-Down Br.	28.3	4	6.7	50	1070	700	70		482	123				605
NH16	Sugar R.	275.0	10	90.5	650	19,690	15,860	1,190		3218	1335				4553
VT8	Wells R.	99.7	6	35.1	280	6550	7,300	430		1427	560				1987
M14B3	West Br. Westfield	95.0	11	33.4	50	9630	10,150	585		1654	606	944			3204
M13D1	Upper Quaboag	147.4 1/	5	45.7	170	14,800	3,900	340		2612	44		740	58	3454

1/ This area is also included under "Projects in Operations Stage."

TABLE VIII-2

SUMMARY OF SITE DATA FOR
POTENTIAL UPSTREAM WATERSHED PROJECTS -
EARLY ACTION PLAN

Watershed		Drainage Area	Number of Sites	Storage Allocation						Estimated Installation Costs ($1000) 1965 Cost Base					
				Control Area	Sedi-ment	Retarding Storage	Beneficial Use			Retarding Storage	Recre-ation	Fish & Wildlife	Water Qual.	Water Supply	Total
Number	Name	sq.mi.		sq.mi.	ac.ft.	ac.ft.	ac.ft.	acres	cfs						
NH2	Mohawk	56	2	25.8	200	4,100	10,000	430	-	989	445				1,434
NH5	Upper Ammon.	254	3	75.0	600	12,000	43,200	1230	200	669	484		1558	507	3,218
VT6A VT6B	Passumpsic-Moose	374	8	122.4	980	19,600	13,300	480	35	2765	921	773			4,459
VT15A1	Black	195	3	36.4	290	7,800				2887					2,887
VT19A2	Ball Mtn.Br.	35	2	16.8	130	2,700	4,000	200	5	456	469	95			1,020
VT20	Whetstone	28	5	18.1	150	3,800	5,600	300	7	1178	687	139			2,004
VBM4A2	North Branch Deerfield	50	5	29.1	460	6,200	2,700	120	4	1933	177	36			2,146
VTM4E1	East Branch North River	39	1	2.6	40	500	1,600	100	2	74	173	35			282
M9	Mill River	59	3	27.1	210	5,800	5,800	150		1100	448			339	1,887

TABLE VIII-3

BENEFITS FOR MAJOR RESERVOIRS
($1,000)

Projects	Flood Control	Recreation General	Recreation F&W	Downstream Beneficial Uses Water Quality	Downstream Beneficial Uses Rec	Downstream Beneficial Uses F&W	Downstream Beneficial Uses Power	Downstream Beneficial Uses Fish Hatchery	Downstream Beneficial Uses Water Supply	Land Enhancement	Total Benefits
NEW HAMPSHIRE											
Bethlehem Junction	325	640	90	3	25	20	7	-	-	200	1,310
Claremont	575	580	30	16	21	10	4	-	-	200	1,436
Beaver Brook 1/	210	33.6	2.4	-	-	-	-	-	22.9	-	268.9
Honey Hill	251	1100	17	35	20	11	2	224	250	400	2,310
VERMONT											
Victory	125	333	57	-	20	3	25	-	-	-	563
Union Village 2/	-	231	-	-	-	-	2	-	-	-	233
Gaysville	1,459	573	90	-	40	40	4	-	-	470	2,676
MASSACHUSETTS											
Meadow	2,679	90	-	-	-	-	-	-	-	-	2,769
Tully 2/	-	666	-	-	-	-	-	-	1,353	-	2,019
Gardner	-	-	30	260	25	20	3	-	-	-	338
Knightville 2/	84	490	90	-	15	-	1	-	-	-	680
CONNECTICUT											
Cold Brook	-	433	65	-	-	2	-	-	-	210	710
Blackledge	-	800	480	-	7	32	-	135	-	640	2,094

1/ Awaiting design funds
2/ Modification to existing Corps of Engineers' reservoir

TABLE VIII-4

COST INFORMATION
MAJOR DAMS AND MODIFICATIONS TO EXISTING FLOOD CONTROL DAMS
(in $1, 000)

	Real Estate	Relocations	Dam & Appurtenant Structures	Contingencies	Engineering Supervision	Recreation	Total
NEW HAMPSHIRE							
Bethlehem Junction	1, 620	3, 420	6, 020	1, 890	2, 320	730	16, 000
Claremont	2, 510	2, 090	9, 230	2, 826	3, 054	1, 200	20, 910
Beaver Brook	215	180	660	210	300	95	1, 660
Honey Hill	1, 390	2, 450	2, 990	1, 090	1, 380	1, 800	11, 100
VERMONT							
Victory	380	1, 080	2, 680	770	900	790	6, 600
Union Village	--	--	420	100	230	550	1, 300
Gaysville	3, 800	10, 600	8, 200	3, 800	4, 600	600	31, 600
MASSACHUSETTS							
Meadow	3, 600	12, 700	15, 650	3, 480	5, 910	60	41, 400
Tully	300	150	12, 490	1, 940	2, 820	1, 000	18, 700
Gardner	450	40	2, 320	480	780	--	4, 070
Knightville	--	--	2, 130	530	590	1, 150	4, 400
CONNECTICUT							
Cold Brook	660	1, 160	1, 090	445	745	600	4, 700
Blackledge	640	1, 360	10, 060	2, 300	2, 840	1, 100	18, 300

TABLE VIII-5

COMPARISON OF
BENEFITS AND COSTS FOR MAJOR RESERVOIRS

Projects	Total First Costs	Total Annual Benefits	Total Annual Charges	Benefit Cost Ratio
	($1,000)			
NEW HAMPSHIRE				
Bethlehem Junction	16,000	1,310	948	1.4
Claremont	20,910	1,436	1,233	1.2
Beaver Brook	1,660	268.9	96.8	2.8
Honey Hill	11,100	2,310	682	3.4
VERMONT				
Victory	6,600	563	439	1.3
Union Village 1/	1,300	233	84	2.8
Gaysville	31,600	2,676	1,850	1.4
MASSACHUSETTS				
Meadow	41,400	2,769	2,403	1.2
Tully 1/	18,700	2,019	1,453	1.4
Gardner	4,070	338	272	1.2
Knightville 1/	4,400	680	253	2.7
CONNECTICUT				
Cold Brook	4,700	710	302	2.4
Blackledge	18,300	2,094	1,080	1.9

1/ Modification to Existing Corps of Engineers Reservoir

TABLE VIII-6

LOCAL PROTECTION PROJECTS
COST SUMMARY

	FEDERAL COSTS				NON-FEDERAL COSTS						
	Construction Cost	Contin-gencies	Engineering and Supervision	Total Federal	Lands ands Damages	Other Work	Total Non-Federal	Total Project Cost	Annual Charges	Annual Benefits	B/C
Lancaster, N.H.	351,000	79,000	70,000	500,000	24,000	-	24,000	524,000	29,000	35,200	1.2
St. Johnsbury, Vt.	715,810	107,190	96,000	919,000	36,000	25,000	61,000	980,000	40,900	47,000	1.15
Hartford, Vt.	168,200	25,600	37,200	231,000	9,000	-	9,000	240,000	10,100	13,600	1.3
Westfield, Mass.	6,950,000	1,150,000	1,590,000	9,690,000	780,000	730,000	1,510,000	11,200,000	603,000	709,000	1.2
Park River, Conn.	25,850,000	6,450,000	5,000,000	37,300,000	780,000	220,000	1,000,000	38,300,000	1,390,000	1,747,000	1.3

Note - Price Level and Interest Rate as Used in Survey Report for Each Project.

fisheries, and land values. Total annual benefits (50-year life 4-7/8%) are estimated to be $1,593,000 and are described in detail in Appendix L. Average annual costs are estimated at $624,100.

(7) Long Island Sound to Hartford Commercial Navigation Project

Benefits are expected to accrue primarily to transportation savings resulting from channel deepening and widening. Benefits and costs are discussed in detail in Appendix L. Total annual benefits (50-year life - 4-7/8%) are estimated to be $1,024,000. Average annual costs are estimated at $400,000.

12. Summary of Costs

A summary of costs for the 1980 Early Action Plan is presented in Table VIII-7. Those items of cost for which present estimates have not been possible are included in the Table without expressed values.

TABLE VIII-7

SUMMARY OF COSTS
EARLY ACTION PLAN

WATER QUALITY

1.	Secondary Level Treatment for 1980	$ 240M
2.	Advanced Waste Treatment for 1980	19
3.	Others (Costs not available)	
	Low Flow Augmentation	
	Combined Sewer Separation	
	Uncontrolled Runoff	
	Diversion of Wastewaters	
	Bottom Deposits	
	Cost	
		$ 259M

POWER

	Installed Capacity 3,660 megawatts	
1.	Conventional Hydro	$ 50 M
2.	Pumped Storage Hydro	210
3.	Int. Combustion/Gas Turbine	40
4.	Nuclear-fueled Steam	400
	Cost (private sector)	$ 700M

OUTDOOR RECREATION

1.	Expansion of Existing Water Bodies		$ 10M
2.	Construction of New Water Bodies		93
	Corps' Reservoirs	$55 M	
	PL 566 Reservoirs	10	
	Other Upstream Reservoirs	28	
3.	National Recreation Area Plan		120
4.	Wild and Scenic Rivers		25
5.	Modification of three existing Corps' Reservoirs		5
	Cost		$253M

PRESERVATION OF SITES

1. Archeological
2. Historical
3. Natural Resource

Cost (* estimate not possible) ---------------- *

TABLE VIII-7 (continued)

ANADROMOUS RESTORATION

1.	Fish Ladders at Five Existing Power Dams ----------	$ 13M
2.	Construction of New Fish Hatchery Facilities --------	7
3.	Streambank Acquisition ---------------------------	5
4.	Provision of Reservoir Flow Releases ---------------	4
	Cost --	$ 29M

RESIDENT FISH AND WILDLIFE

1.	Improved Access at Existing Water Bodies (approx.)		$ 3M
2.	Provision of New Water Bodies --------------------		37
	Corps' Reservoirs	$12 M	
	PL 566 Reservoirs	2	
	Other Upstream Reservoirs	23	
3.	Expansion of Hatchery Facilities ------------------		5
4.	Extensive Streambank Acquisition Program ---------		20
	Cost --		$ 65M

WATER SUPPLY

1.	Northfield Mt. Diversion -------------------------	$ 60M
2.	Expansion of Municipal and Industrial Supplies -------	125
3.	Corps' Reservoirs --------------------------------	19
	Beaver Brook	
	Tully	
	Honey Hill	
4.	Upstream Reservoirs ----------------------------	3
	Cost --	$ 207M

NAVIGATION

1.	Long Island Sound to Hartford, Connecticut project ---	$ 4M
2.	Hartford to Holyoke Recreation project --------------	7
3.	Improvements in Main Stem Power Pools, etc. -------	1
	Cost --	$ 12M

TABLE VIII-7 (continued)

UPSTREAM WATER AND RELATED LAND RESOURCE MANAGEMENT

1.	Land Resource Planning			$ 3M
2.	Land Treatment			33
	Private Lands	$31 M		
	National Forests	2		
3.	Resource and Conservation Development Projects			24
4.	National Forest Structural Improvements			15
5.	Land Acquisition for National Forests			9
6.	Loans and Grants for Rural Water Supply and Sewage Treatment Systems ($110M)			
	Cost (not including item 6 which is contained in costs for Water Supply and Water Quality elements)			$ 84M

FLOOD CONTROL

1.	Corps' Dams				$ 86M
	Victory	$ 2M	Honey Hill	$ 3M	
	Bethlehem Junction	5	Meadow	41	
	Gaysville	23	Beaver Brook	1	
	Claremont	10	Knightville	1	
2.	Seventeen Upstream Watershed Projects (78 dams)				25
3.	Other Upstream Dams				11
4.	Five Local Protection Projects				51
5.	Flood Plain Regulation (*estimate not possible)				*
	Cost				$ 173M

Total Early Action Plan $1,782M

Section 3 of this chapter discusses allocation of project costs and Federal cost sharing for elements of the plan. Due to the variety of available water resource programs and alternatives, it is not possible to determine the breakdown between public and private expenditures or between Federal and non-Federal expenditures.

CHAPTER VIII

Section 3 - Allocation of Project Costs and Federal Cost Sharing

1. Cost Allocation

The costs of major multiple-purpose reservoirs have been allocated to applicable project purposes by means of the "separable cost remaining benefits" method. This assures that all purposes share equitably in the savings of multiple-purpose development and that each purpose produces benefits at least equivalent to the cost of including that purpose in the project. Upstream watershed projects used this method as well as the "alternative justifiable expenditure" and "use of facilities" method. Cost allocation data for major reservoir projects are shown in Table VIII-8, while cost allocation of small upstream watershed projects were shown in Tables VIII-1 and VIII-2. These data were determined to indicate the economic justifications of a project and the magnitude of the scale of development. More refined analyses would be necessary during later design stages.

2. Cost Sharing

Costs of multiple-purpose reservoirs were allocated to project purposes to form a basis for apportionment of costs. Federal projects requiring authorization reports would be refined to reflect Federal and non-Federal cost sharing. Apportionment of costs have been based on current policy expressed in Federal legislation and administrative criteria. A generalized picture of current cost sharing practice by resource category follows:

Cost sharing for municipal treatment plant facilities varies from 30 to 55% for the Federal share and balance generally paid for by the combined State and local community. Cost sharing for flow augmentation for water quality and only after adequate treatment and in lieu of advanced waste treatment can go as high as 100% except in cases where beneficiaries can be identified and when such storages can be made part of a Federal reservoir project.

The Early Action Plan makes no recommendations for Federal investment in power facilities. Costs of power facilities would be accomplished through private investment and reimbursable by the user under the regulatory authorities of the Federal Power Commission.

General recreation is 50-50 cost sharing with credit given for certain items of local participation. In multiple-purpose reservoirs,

TABLE VIII-8

ALLOCATED FIRST COST
$1,000

	Flood Control	Recreation	Water Supply	Fish Hatchery	Flow Augmentation	Flow Augmentation 1/ Purpose
Vermont						
Victory	2,073	3,868	--	--	659	P, R, F& W
Gaysville	23,174	7,684	--	--	742	P, R, F& W
Union Village	--	1,260	--	--	40	P
New Hampshire						
Bethlehem Junction	5,216	10,082	--	--	702	P, R, F& W, WQ
Claremont	9,766	10,546	--	--	598	P, R, F& W, WQ
Beaver Brook	858	466	336 2/	--	--	--
Honey Hill	2,651	5,436	1,345	1,268	400	P, R, F& W, WQ
Massachusetts						
Tully	--	1,094	17,060 2/	--	--	--
Gardner	--	362	--	--	3,708	P, R, F& W, WQ
Meadow	41,300	100	--	--	--	--
Knightville	1,164	3,080	--	--	156	P, R
Connecticut						
Cold Brook	--	4,682	--	--	18	F& W
Blackledge	--	15,683	--	2,009	608	R, F& W, SR

1/ Symbols denote downstream uses: P = Power Energy; R = Recreation; F& W = Fish and Wildlife, WQ = Water Quality and SR = Salmon Restoration.

2/ Future Water Supply

the Federal Government will be responsible for the construction costs of specific land and basic facilities for recreation and fish and wildlife enhancement. Basic facilities are defined as general park-type day-use and overnight camping facilities as opposed to such measures as playground facilities, lodges, or boat rental services. Development in excess of basic facilities would be a local responsibility. Local interests will be encouraged to assume responsibility for operation, maintenance, and replacement. The Federal Government will also participate in that portion of joint-use reservoir facilities which can be allocated to recreation and fish and wildlife enhancement. When recreation is only an incidental part of the project, that is, its inclusion involves no changes in scale of the reservoir, the Federal Government will assume the cost for basic facilities.

Under Federal aid programs administered by the States through the Bureau of Sport Fisheries and Wildlife, the State may receive up to 75% the cost of approved fish and wildlife development or programs.

Under the on-going anadromous fisheries restoration program, cost sharing is assumed to be a total Federal responsibility, with required reservoir and hatchery costs borne substantially by the Federal Government. Stream acquisition programs for recreation and fish and wildlife would likely be accomplished through matching grant programs.

Water supply costs are currently entirely non-Federal and chargeable to the user. All costs allocated to the water supply portion of a multiple-purpose project must be repaid within the life of the project and within 50 years after the water supply is first used. Where water supply is not used immediately, no interest on the investment would be charged up to a maximum period of ten years.

Under the on-going NEWS Study program, Federal cost sharing will be considered as part of a major regionalized system for domestic and industrial water supply. Such cost sharing includes storage reservoirs and conveyance facilities. The degree of cost sharing has not been established at this time and will undoubtedly vary on the basis of development required and the areas serviced.

Navigation cost sharing varies from 50% Federal for recreational boating impoundments to 100% Federal for commercial boating improvements. The cost of navigation aids for both types of navigation facilities are borne totally by the Federal Government. The construction costs of general commercial navigation features because of the widespread or general nature of their benefits, are borne almost entirely by the Federal Government and would include: entrance channels, open anchorages, and turning basins. Operation and maintenance would be a Federal responsibility for both types of boating. State and local interests are required to provide lands, easements and rights-of-way as required for project construction and subsequent maintenance. They would also be required to provide terminal facilities, commensurate depths for berthing areas and relocation or alteration of existing utilities. In instances of land enhancement, local interests would also be required to bear 50% of the cost proportionate to benefits created by the disposal of dredged spoil.

Cost sharing for flood control projects varies depending upon the type of project. The cost of construction is considered a total Federal responsibility where benefits are widespread such as in regional reservoir projects where the cost of construction, operation and maintenance are borne by the Federal Government. Local protection projects are at Federal cost, but local interests must provide lands, easements, and rights-of-way; hold and save the U.S. free from damages due to construction works; as well as maintain and operate the completed works. Cash contributions may also be required when other benefits are provided such as land enhancement.

Costs for flood plain information studies are entirely Federal when requested by municipalities and properly approved by the State.

Under Public Law 566, the Soil Conservation Service provides technical assistance for flood control aspects. Construction costs allocated to flood control are assumed totally by the Federal Government, while the Federal Government will share up to 50% of the costs allocated to recreation and fish and wildlife. Water supply and water quality costs are a local responsibility. A more complete presentation of cost sharing for Department of Agriculture program potentials is contained in Appendix F.

The Federal Government will bear the entire cost of land treatment measures, watershed analyses, fish and wildlife surveys and analyses, and additional acquisition for National Forests. Technical assistance may be provided to towns for resource inventories, planning and soil reports on a matching fund basis. The Federal Government can provide technical assistance for Resource, Conservation, and Development projects and share in costs of elements under its normal authority. Technical assistance can also be provided for land treatment measures on non-Federal land.

The Bureau of Outdoor Recreation through the Land and Water Conservation Fund grants aid to States for planning, acquisition and development of public outdoor recreation areas and facilities. Grants may be up to 50 percent of the cost of a project. Special consideration is given to qualitative aspects of the natural environment and to needs of growing urban populations.

A complete summary of all Federal cost sharing programs is beyond the scope of this treatise as there are many State and Federal programs which can be employed to implement the Early Action Plan. For example, the Department of Housing and Urban Development provides grants up to 50% of land and sewer construction costs for lateral sewers, while the Farmers Home Administration can provide grants up to 50% of the costs of waste systems for rural communities under 5,500 population.

Other HUD programs provide grants for such items as advance acquisition of land, historic preservation, open space, land and community development, and public facilities. Federal sharing varies from provision of interest costs for financing to 80% the cost of planning and technical assistance.

CHAPTER VIII

Section 4 - The 2020 Long Range Plan

The "Long-Range Plan" presents an identification of potential means for meeting needs of the 2020 time period. These potentials would be studied in more detail and brought to the attention of local interests some time after 1980 or as the long-range needs appear to materialize. Future studies or technological innovations may indicate needs other than those identified below that would warrant considerations.

Several of the elements in the 2020 Plan are extension or expansions of those found in the Early Action 1980 Plan.

1. Non-structural Measures

A. Areas of Preservation, Conservation and Utilization

(1) As population expands a more concerted government and private effort will be needed to preserve sites of archeological, historical or natural importance.

(2) There should be a continuing expansion of flood plain management programs particularly on tributaries to the Connecticut River, to prevent further encroachment on flood prone areas and reduce future damage.

(3) As programs are established in regard to early action recommendations for recreation resources, and as other public and private actions develop, basin's resources and the region's socio-economic characteristics will change. A continual program should be established to facilitate early action recommendations to monitor basin resources and socio-economic characteristics and to establish new priorities.

(4) The Streambank acquisition program necessary to assure increased public access to the basin's fishery and recreational resources, will need to be expanded to other tributary areas as determined by future studies.

B. Areas Where Improved Management of Existing Resources Can Help Meet 2020 Needs

(1) Re-regulation - All power of each utility in the Basin should be included under a single license. A minimum flow formula,

such as the 0.20 cfs per square miles of drainage recommended in the Early Action Plan, should be applied through appropriate procedures to all power storage and generation projects in the Connecticut River, with provisions of periodic review and adjustment. Under this review procedure, the advisability of reallocation of existing storage to other purposes should be considered. This is particularly relevant to existing power storage reservoirs if conventional hydroelectric generation becomes outmoded or otherwise discontinued. (Reference Appendix Q - Report of the Stream Regulation Subcommittee)

(2) Land Treatment and Management - Land treatment for target year 2020 will be needed on an additional 3.6 million acres composed of 50,000 acres of crop and pasture; 3.4 million acres of private, non-industrial forest land; and 150,000 acres of urban and other land. (Reference Appendix F.)

(3) Land Resource Planning - By target year 2020, soil surveys need to be completed on an additional 3 million acres and an additional 188 towns in the basin will need assistance in resource planning (Reference Appendix F.)

(4) Water Quality - Additional and continuing assessments are needed in the areas of combined sewer and storm water overflows, as well as eutrophication, sludge deposits, pesticides, land drainage and erosion.

Incentives and regulations should be initiated to encourage redesign of present plant processes, recovery processes, pretreatment measures and land use practices that could substantially reduce the volume of effluent and the effect of discharged wastes.

(5) Water Quality Monitoring Programs - As the population and need for water supply increases, there will be a continuing need to expand water quality monitoring programs, particularly as less desirable watersheds are utilized. Ideally, cooperative monitoring programs including local, State, academic and Federal agencies involved in water quality monitoring should be undertaken in order to minimize duplication of effort, to take advantage of special capabilities, and to reduce cost.

2. Structural Measures

A. Water Quality

Under the presures of future population and industrial expansion, abatement of pollution and the control of its effects must receive continuing evaluation. Facilities will have to be enlarged and controls above basic secondary treatment will likely be required in certain areas of the basin if water quality standards are to be maintained. Regional treatment facilities should also be considered. As noted in Appendix D, the capital cost of providing basic minimum secondary water pollution control facilities sized to meet the 2020 projected waste load is estimated at $321 million and does not include operation and maintenance charges, nor the construction cost of interceptors, pumping stations and collection systems.

Controls above secondary treatment, through complementary actions, including advanced waste treatment and/or flow augmentation, are available and could be provided to assure desirable basin development. In the absence of other supplemental measures, the capital cost of providing advanced waste treatment for the year 2020 is estimated at slightly over $54 million. Of particular note is that the present worth of operation and maintenance for advanced waste treatment computed on a 25-year life of project would cost $111 million.

As the total impact of the planned treatment program on water quality is felt, problem areas that may emerge will be corrected in the light of future growth patterns and technology on a case by case basis. In addition, new water quality advances will be initiated. The process is likely to be a continuing one requiring periodic re-evaluation of the standards; further technical investigations on such matters as combined sewers, overland drainage controls and further treatment arrangements; and a constant awareness of the close relationship between water quality, water use and land use.

B. Power

Assuming a similar rate of growth as the New England power market, basin energy requirements may be expected to climb from 23 billion kilowatt hours in 1980, to 200 billion kilowatt hours in 2020. Corresponding capacity needs would increase from 5 million kilowatts in 1980 to 42 million kilowatts in 2020. On this basis, it is estimated that Basin demands in 2020 will be more than the basin available economic supply.

If present trends continue then 2020 power needs will likely be met, in large part, by nuclear-fueled base load plants and pumped storage peaking plants. Fossil-steam output would decline until the turn of the century, while conventional hydroelectric generation would increase moderately. While the general location of fossil and nuclear steam units is fairly well defined in the basin through 1990, beyond that time siting becomes very speculative. At this time, however, it seems that the larger baseload plants of the future will most likely be developed on the main stem of major waterways, the estuary reaches of major streams, on the shores of large inland water bodies or along the coast.

Appendix I lists 25 conventional hydroelectric units which have potential for future development, as well as 10 pumped storage sites which could be used to meet future peak power demands.

C. Water Supply

Future demands will likely necessitate the development and use of water supply resources not hitherto utilized. Because of the generous yield from the basin's streams and aquifers, no serious problems with respect to future demand are anticipated. Direct stream withdrawal with necessary treatment, may be used in areas where groundwater or reservoir sources are not competitive or available.

In some cases, the growth of certain municipalities may be curtailed where the pattern of local water supply systems continues and the locality is in a tributary headwater reach. These problems could, however, be surmounted by adequate regional planning. One factor which may have a bearing on future water supply demands is the interrelationship between costs of waste treatment and use of water. For example, industries may reduce their use of process water to keep down the cost of waste treatment. (Reference Appendix D.)

D. Flood Control and Allied Purposes

(1) Potential Upstream Watershed Projects - By the year 2020 seven watersheds comprising 667,000 acres in the basin are anticipated to have flood problems and other water resources needs. To meet this requirement, seven Public Law 566 projects, containing 38 structures have been identified as having a capability of 217,000 acre-feet of water storage potential available for multiple-purpose use. The seven projects which are described in Appendix F and shown on Plate K-16 would be located as follows

a. Ottauquechee River, Vermont
b. Williams River, Vermont
c. Saxtons River, Vermont

d. West River, Vermont
e. South River, Massachusetts
f. Scantic River, Massachusetts & Connecticut
g. Coginchaug River, Connecticut

(2) Local Protection Projects - Appendix M states that "No need is foreseen for major structural flood control measures beyond what has been recommended in the 1980 plan. However, as population increased and urban centers become more concentrated, communities which continue to build in the flood plain are likely to need local protection. Out of the many local protection sites investigated by the study, 7 are considered as potentials for target year 2020."

2020 LOCAL PROTECTION POTENTIALS

a. Groveton, New Hampshire	(Connecticut River)
b. Lebanon, New Hampshire	(Mascoma River)
c. East St. Johnsbury	(Moose River)
d. Ludlow, Vermont	(Black River)
e. Windsor, Vermont	(Connecticut River)
f. Bellows Falls, Vermont	(Connecticut River)
g. Brattleboro, Vermont	(Connecticut River)

F. Navigation

In 1968 nearly 3.7 million tons of commerce were handled by the existing Long Island Sound to Hartford navigation improvement. Projecting the trend of the most recent 10 year's period indicated that by the year 2020 facilities will be needed to handle 11.5 million tons of cargo. In addition to commercial requirements, at present, approximately 3,500 boats make up the recreational boating fleet moored or berthed on the river below Hartford. Considerable growth is anticipated in recreational boating and provisions will be needed from both private and public sectors for handling a greatly enlarged fleet in future years.

The boating pressures above Hartford will likely accelerate particularly with the effective implementation of the pollution abatement and improved flow regulation and flow augmentation programs recommended in the 1980 Basin Plan. Boating passage may be required at main stem dams up to and including Bellows Falls. Passage could be accomplished by either marine railway or navigation locks depending on traffic density. Aids to navigation will be needed to identify safe channel sections in the pools associated with the Holyoke, Turners Falls, Vernon and Bellows Falls power dams.

G. Fish Hatcheries and Ladders

By 2020 recreationaul use of the Basin's resources for fishing could increase to over 12 million fisherman days or almost five times the present demand. This need could be met by a continuation of the following:

(1) Creation of new reservoir fisheries
(2) Restoration and expansion of anadromous fishieries
(3) Enhancement of stream fisheries
(4) Abatement of pollution
(5) Provision of access
(6) Establishment of low flow augmentation schedules

H. Multiple-purpose Reservoirs

The Coordinating Committee has identified nine multiple-purpose large category reservoirs which could be utilized to alleviate an array of 2020 water resource needs. These are reported in Appendix K and are shown on Plate 1 of this report include the following:

Site	Tributary Basin
1. Indian Stream	Indian Stream, New Hampshire
2. Upper Jefferson	Israel River, New Hampshire
3. Hammond Hollow	Ashuelot River, New Hampshire
4. Falls River	Falls River, Massachusetts
5. Fort Morrison	Deerfield River, Massachusetts
6. Natty Pond Brook	Chicopee River, Massachusetts
7. Prince River	Chicopee River, Massachusetts
8. Lower Bisbee	Westfield River, Massachusetts
9. Sandy Brook	Farmington River, Massachusetts

In addition there are a number of small upstream water impoundments sites which do not conform to the requisites of Public Law 566. Sixty-three in this category were identified for their potential to meet future storage needs, although allocation of specific storage purposes was not made. These are also described in Appendix F and show on Plate K-16.

PART THREE

CHAPTER IX

DISCUSSION

CHAPTER IX

DISCUSSION

Section 1 - The Impact of the Plan upon the Basin's Economy

It has been noted in many areas of this report that the Connecticut River Basin's economy is established on a very broad mix of activities with major emphasis on the manufacturing and service industries, together with significant utilization of natural resources as they relate to forestry, a declining agricultural industry, and a sharply rising recreation-tourism industry. The Connecticut River Basin economy is water dependent, but not to the degree as are other basins in the country where water resources for irrigation, navigation, mining, and hydroelectric power are of paramount importance and of absolute necessity.

The Connecticut River Basin is not as dependent upon utilization of its natural resources as are some other industrialized regions of the country where the processing of basic raw material for industry is a high point in activity. Neither is it as dependent upon its natural resources as it was in historic times. The reason for this is largely that the Connecticut River Basin presents a process type economy where most of the basic materials used are imported to the basin in a semi-finished state. It is then converted, thanks to an extremely skillful and well trained labor force into a high value, marketable product. However, there are yet substantial activities in the area of forestry, but here too the resource is not really farmed in the manner that would materially alter the vegetation cover pattern of the basin.

Because of the advanced stage of the urbanization already taking place in the Connecticut Basin, and that which is projected, there is great concern as to how to retain what remains of a very fine and high quality environment. Up to this point in time, these high quality natural resources have made an excellent background for good living, working, and recreating (except for water contact recreation on the main stem and certain reaches of principal tributaries). A sampling of the valley residents reveals that it is this aesthetic quality as well as the fine four-season climate and natural beauty and the amenities of life that lure them into this valley.

The Basin Plan seeks therefore, to provide additional outlets and opportunities to permit a continuing expanding population to utilize the natural resources in a wise and efficient manner. It recognizes the severe pressures and competition for use of those remaining limited land forms that allow for certain types of development.

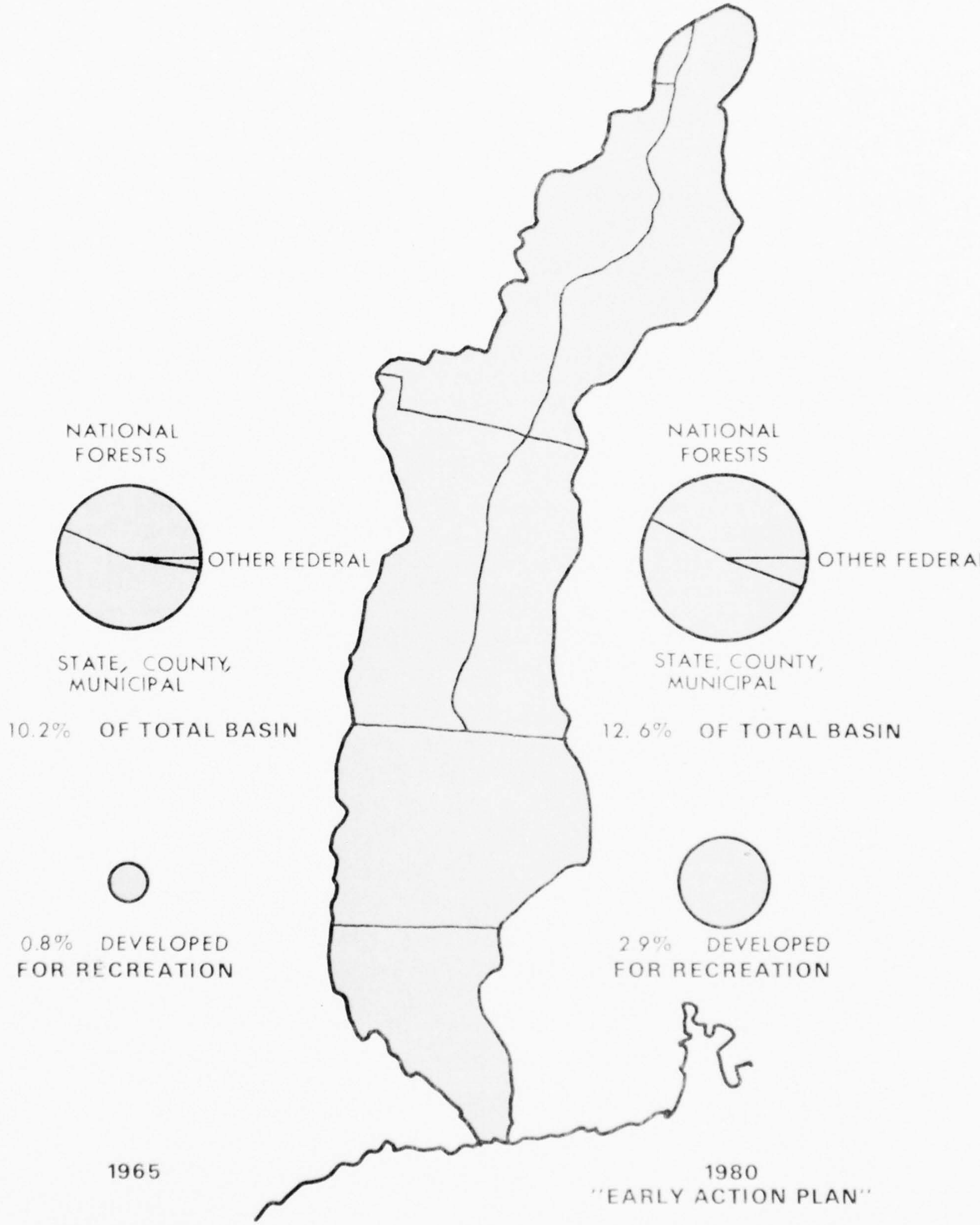
The new interstate highway system has transformed the upper basin into a more attractive growth area and the new roads have also intensified pressures upon the remaining open land along the middle and lower main stem of the river and the principal tributary main stems. Land use planning is a major item of importance in the Connecticut Valley. The current programs to improve the water quality of the basin's streams will also likely produce higher land values and greater desires for utilization as well as participation by the public sector.

Although currently there are significant holdings in the public sector, most of these are currently feeling the pressures from an expanding population, thereby producing higher per capita participation. If additional supplies are afforded, for example, new reservoirs along with improved access opportunities, many of the pressures will be relieved from other available areas, as well as keeping existing private and public recreational facilities from further deterioration.

Figure IX-1, Publicly Available Land, indicates how land acquisition in the interests of public recreation and other public purposes will affect the total basin area upon implementation of the 1980 Early Action Plan.

Analysis of current recreation populations indicates that two-thirds of those participating are basin residents and one-third come from outside areas. Of interest is the fact that the out of basin tourist brings in, through expenditures and income approximately two-thirds more money than does the resident tourist. This source of expenditure and income can produce a significant economic base in the upper watersheds which may alter the current pattern of many of the younger people who are leaving this northern region in order to find more attractive economic opportunities. To be sure, the recreation industry is concentrated in the intense summer months period and that period of the winter ski season. Nevertheless, with creative management, it is likely that a whole line of supporting base-type recreation industries could be formulated around this activity.

The Coordinating Committee feels that the 1980 Basin Plan can produce a course of action or direction for the basin States and local municipalities and other private interests, because it gives some evidence of the type of needs and pressures that are likely to ensue, as well as areas where these can be met. Should they fail to meet the needs that are projected, it is likely that they would then be diverted to adjacent basins, or simply be suppressed.



LAND AVAILABLE FOR PUBLIC RECREATION

FIGURE IX-1

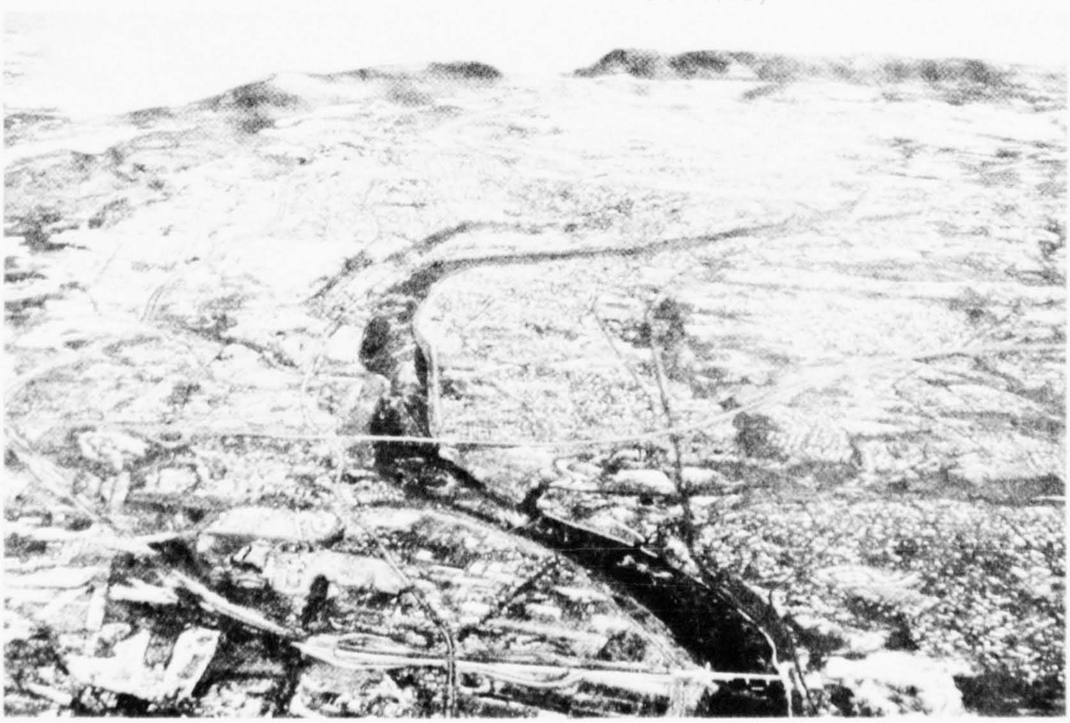
It should be recognized that the impact which the Basin Plan will have upon the Connecticut Basin economy is more limited toward the area of public activities and pursuits than private activities, except in the instance of water quality. In this case, industrial pollution, once abated, will make possible large economies by providing higher quality water for an array of uses by all of the tenants of the valley, with principal beneficiary being industrial and commercial activities.

The basin plan also provides direction by which the States can determine their investment in the public oriented program. As regards the private sector, it is likely that any improvement in the over-all quality of the environment of the basin will make more attractive the introduction of new and important industrial and commercial activities within the basin. Locational factors considered by potential economic activities are more flexible thanks to improved access brought about by the current highway program. When a particular national firm decides to locate in any of the smaller towns within the Connecticut Valley, the impact which such a move would have on the economy of that town or region is far more pronounced than the establishment of a body of water for recreation. Certainly, such industry is not going to locate in areas that are flood prone, or where the threat of future damages, by reason of overtopping of existing works would provide an insidious threat to their growth. Therefore, the introduction of additional flood control units would make possible the stabilization of existing operations, as well as make attractive, the introduction of new activities.

In summary, the basin plan provides incentives for the introduction of other private investments. It recognizes that such private investment would have even greater impact on the economy of the basin than does the 1980 plan. The basin plan, however, should assist in the severe competition that is likely to ensue for that limited but choice land that remains and because of the multiple use and regional character of the improvements proposed, there is likely to be a greater degree of success in their implementation than if the particular municipalities were to proceed on their own.

The plan's extensive investment in the area of water quality, as well as in the area of open space and preservation could secure for all time, those valuable aesthetic qualities as well as the valley's important heritage. In so doing, the plan will contribute to many non-monetary aspects that are not measurable on the open market, but are nevertheless real as they motivate the people to enter the valley and possibly to remain there.

AGRICULTURAL VALLEY - LOOKING SOUTH TOWARD THE HOLYOKE RANGE FROM MT. SUGARLOAF IN DEERFIELD, MASS.
Courtesy USDA - SCS



SPRINGFIELD - HOLYOKE - CHICOPEE METROPOLITAN AREA, LOOKING NORTH TO THE HOLYOKE RANGE

Courtesy Northeast Utilities

CHAPTER IX

Section 2 - Priorities in Meeting Basin Needs

The establishment of water needs is at best a very risky business. These generally follow established patterns of the past which are projected while anticipating certain continuance and changes in social patterns. A review of what has happened just over the last 50 years with major wars and a major economic depression and recession; assertion by industry and labor unions reflects how sensitive are the social upheavals or consequences resulting from these events all of which are outside of the domain of water resources but which most assuredly affect needs projection.

For this reason it has been argued by planners that economic projections should be abandoned and in their place introduce what is called a "series of visions", that would reflect what people would like to see happen. Such visions would be quite different from a continuance of say a 4% growth pattern. Such an approach has inherent the bias of those whose visions are chosen. Can one obtain a broad and representative public view? It has been the Committee's experience that this is not possible at this time.

In view of the instability of economic projections and the lack of any sufficient planning alternates at this time, the Committee recommends that we set priorities on the basis that we meet all current needs and at least 50% of all projected 1980 needs developed by the different demand and supply analyses of the various Federal, State, and local entities. This is considered as a minimum requirement, with larger amounts desirable. There are certain water resource needs areas where we can be more definite about needs projection with examples being that of electric power, flood control, and water quality and water supply. Although some of the other resources areas could be delayed and without seriously impairing economic well-being, such action would present the consequences of further deterioration of those resources that are now addressing themselves to meeting, say, recreational requirements.

In the instance of electric energy, this report has indicated the problems that are faced in the area of electrical energy and the fact that it cannot be produced without the use of water either for hydro or thermal cooling requirements. The introduction of these high value power developments would have major impact upon local taxes and pronounced effect upon economic activities of the industrialized valley if it were not provided. Certain areas of needs, by their nature, have priorities over others (for example, domestic water supply or power) but it is the Committee's recommendation that we meet requirements in the entire resource categories and on a proportional basis, with particular emphasis given to those investments geared to the restoration of natural resources that have been severely violated, as well as in the area of land acquisition so that future developments will not be precluded by reason of other competing uses.

The Committee recognizes the political constraints and difficulties in moving some of these proposals into the implementation stages, but if some form of control is not exercised now, then there is the danger that our better alternatives for meeting needs would be foreclosed. On this basis much emphasis must be given toward the acquisition or implementation of other legal means to hold key lands. When we implement developments is not nearly as important as whether we will have available the option to do so.

CHAPTER IX

Section 3 - Education

It appears there are three critical areas where man must do a better job than he has in the past if he is in fact going to achieve the balance that is being sought between himself and the environment which supports him. These are first, that he control his numbers in some manner; second, that he find better ways to utilize his natural resources to meet his needs but at the same time does not mutilate them in a fashion that they are lost, not only to himself but to future generations; and third, that he find ways in which he will tolerate and permit the sharing of his resources with others. It is common knowledge that there is a disproportionate balance between those who own or who in fact control the resources and those who must rely upon them. To meet the challenges of these three critical areas, we must, in the end, look to a broad based effective program of education.

If people really understood the intricacies of the water resource processes and the true consequences of mismanagement and the promise which can come from willingness to share, it is likely that many of our common problems and needs requirements could be resolved. Education is required at all levels of schooling and on up through higher education and adult education. The tasks should not be left solely to the professionals or well organized groups but should be a much broader based public program with help sought from all segments of our economy. The Federal and State capabilities can be called upon to augment school faculty staffs as could the capabilities of private industry and particularly the news media.

It is encouraging to see the substantial shifts which the various educational centers are now making with greater emphasis on programs which deal with the environment. From such training will come improved credibility between the public, State and Federal agencies who have been assigned the responsibility, and who are accountable for various statutory areas of interest to meet the needs of the people. Learning builds bridges and sets up an atmosphere of common concern. Many new innovations would come from the increased base of knowledge. The education program should be both general and specific to include pure research, applied research, and associated research so more substantive education programs can be developed.

CHAPTER IX

Section 4 - Schedule, Implementation and Operation

The plan, once submitted, will be only as effective as the follow-up or schedule for implementation. There is just so much money to do so many things and we can only schedule as much improvement or expenditures as is within financial capabilities. Proper programming of the Federal components to the plan described and those of the States and local communities should guide commitments of funds. Furthermore, the schedule of work must be so spaced as not to strip available manpower and material and thereby inflate costs. Consideration should be given to those known legislative and administrative constraints, or any social or economic or political constraints inherent in the region where improvements are proposed. Those more urgent developments should have highest priority, and at the same time the elements should be spread within an area so as not to overly endow one region at the expense of another. State interests, particularly, will play an important role in implementation as they will have to work out the finer details with local towns and cities involved.

Viewing what needs to be done first, and how much reflecting upon the desires expressed by the people that attended the many hearings and meetings during the course of this study, the Committee finds that the area of abatement of pollution, and particularly water quality control, would provide the broadest spectrum of uses and at the same time appropriately place the burden of the costs on the polluter. It would make possible restoration of what were once quality streams thereby enhancing fisheries and other contact recreation endeavors.

Because of the competitive nature of available land, and particularly nearby water bodies of suitable size, there must be definite measures taken in the acquisition of land, be it for flood control purposes, scenic rivers, improved access, or as part of a National Recreational Area proposal. Measures in this area should be scheduled early. Closely allied to this requirement are the necessities for advanced acquisition of those dam sites so as not to preclude future options. Much of the land being proposed for reservoir projects could be carried in the interim in an open space category. Such lands should be controlled, purchased, or easements obtained so as to secure their availability in future years.
In viewing the objectives of Environmental Quality, National Efficiency, and Regional Development, flood control was found to be as important to

the Environmental Quality objective, as it is to the National objective, and central to the Regional Development objective. Flood control proposals noted should be carried forward as soon as possible to secure protection, particularly for those urban areas, and not so urban areas, where growth has already occurred and where little else can be done to otherwise protect these entities.

The States, working closely with the towns, should impose flood plain zoning to prevent future damages, to maintain important valley storage and, in instances where no improvements are possible, to provide those interests subject to flood damage an opportunity to purchase flood plain insurance. Relief of those who, through no fault of their own, find themselves in flood prone areas, as well as removing the burden from the general public could result. It is also incumbent upon the States and local governments to develop plans of action to be instituted when damaging or dangerous flood conditions are predicted. Plans of action are necessary to the effective use of flood protection works and in organizing flood fighting and/or evacuation procedures.

In the instance of proposals scheduled for the 2020 time frame, whereas there is likely to be technological breakthroughs which should make possible refinements of needs, and whereas there will likely be changes in social patterns and desires, all part of a dynamic economy, the competitive pressures for land are likely to intensify. The success of a water resource program hinges upon successfulness of obtaining lands. Therefore, as a general rule, much effort should be employed at this time in advanced acquisition. Projections indicate that changing land use patterns by 2020 could drive out of the basin many of the agricultural pursuits which contribute greatly to the valley's attractiveness. The natural forces that are causing these lands to revert either to forested land for recreational pursuits, or for urbanization are too severe to expect the common property owner to withstand the attractive gains that come from speculative adventures. From an aesthetic point of view some of these lands should be held in their current use, and if necessary, by the introduction of subsidies, be they State or Federal. Acquiring these lands for an aesthetic quality will make possible open space of sufficient proportions to reduce density patterns. The utilization of existing programs such as wetlands legislation, legislation as relates to filling in ponds, etc., should be used as another means of keeping open as much land as is possible.

The planning tools and techniques utilized in developing the Connecticut Basin report are continually changing and improving. Current findings will likely shift in future years owing to changes in social preferences. The comprehensive plan, being conceptual in nature, cannot be considered as a complete or final proposal but rather is part of a dynamic process which provides sufficient flexibility for revision, and broadening to reflect social and political changes. For this reason the basin plan should be updated, continually reviewed, and adjusted to the nation's changes in attitudes and subsequent new legislation. Such changes could affect the amount of Federal and State assistance and the attitude of local supporters.

The important task of updating and review for the completed plan should be assigned a central unit. The Coordinating Committee has proposed that within the New England River Basins Commission there be established a Connecticut River Basin Program. Included in this program would be a staff assembled for the express purpose of assisting the various Federal, State, and local agencies who will be responsible for the implementation of the various projects within the plan. As part of the program to implement the plan, citizens advisory committees will assist the Connecticut River Basin group that will be assembled. Those projects where Federal funds are necessary will require specific authorization. Such authorization will require approval of the individual Governors of the basin States.

Many areas of the basin plan will require private initiative, for example, in the area of power, and industrial water supply. Appropriate channels should be used with coordination from appropriate State agencies. Since State representatives would be members of the Connecticut River Basin Program proper coordination could be maintained. Local municipalities will be assigned a key responsibility in implementation, particularly as relates to water quality programs to meet established standards. In those instances where more than one municipality is involved, closer liaison must be maintained with State agencies. Federal counterparts look to the municipalities to bring their desires quickly to the State's attention so that grant programs could be as responsive as possible. The States are moving independently in establishing environmental councils and in some instances amendments to their constitutions such as an environmental bill of rights. These programs, be they private, local or Federal, will require assessment. The Connecticut River Basin Program should provide an efficient process for coordination necessary if all of the different interests working in their areas of responsibility are to effect an orderly process of implementation.

Many of the elements in the basin plan require careful operation. Those agencies whose statutory interests permit them to operate projects such as large flood control dams as operated by the Corps of Engineers, will assume a primary role. In some instances new agencies have to be established, for example, to handle the operation of complex sewer treatment facilities that are part of regional systems for waste control. It is expected that the various operating agencies will, to the extent possible and available, consider the predicted streamflow conditions when making operational decisions.

States are training personnel so that they will be capable of operating complex treatment plants, and to ensure safety against accident spills or interruption of satisfactory performance. In the instance of water quality monitoring devices it may be necessary that these be operated by a group of agencies with agreed upon reporting procedures whereby incidences of improper maintenance, spills, or other violations can be dealt with quickly.

In the instances of water supply systems, these will largely be cared for by municipalities or regional organizations. Following the 1980 time frame, and as existing systems are enlarged, operational assignments will likely be broadened. Local interests will largely be expected to operate their own facilities with appropriate checks by State interests. In the non-structural areas of improvement the operational tasks generally will require clean-up maintenance and security personnel to police against vandalism.

Investments in the various water resource categories will, of necessity, require additional expenditures for operational programs. Necessary maintenance will have to be performed if systems are to perform in accordance with intended design. Maintenance responsibilities will lie largely upon local municipalities, and those interests wherein improvements are located. Federal agencies will be concerned with the maintenance of the larger flood control dams, navigation improvements, as well as Federal lands in the National Forest, and any future Federal elements as part of the National Recreational Area Plan.

CHAPTER IX

Section 5 - Public Communication

Closely related to the needs for education are the requirements for the improvement in public communication. This study expended a major effort in attempting to reach as broad a base of the public, and to obtain their views, as was possible. In spite of this effort, success was limited in communicating with the large numbers of people who in the end are to be the recipients of the basin plan. Their views, reactions, and support are necessary if the conceptual planning, now completed is to materialize into programs. There are several reasons why we failed in reaching the broader based numbers, although we were able to communicate with the well organized and sometimes narrow interest groups. They made know their desires early and often through those members who generously gave of their time and resources. A review of the minutes of more than seventy separate meetings held reveals the steady representation of such groups But public communication is more than holding meetings. The importance of the news media cannot be overly stressed, particularly in the smaller towns. Here local newspapers can do much good or harm in presenting facts in a clear and objective view. The keeping of up-to-date mailing lists, the preparation of radio talk shows, the preparation of press releases were just some of the tools used in the communication program but were not enough. Regional type meetings were of value but the large education process needed was apparent.

Reflecting upon the regional meetings, and particularly the public hearings held on the Connecticut Study, we find that each one was distinctive and yet there were similar and typical areas of concern. For example, most people evidenced that the most single pressing need in the valley was in the area of water quality. Control of pollution was highlighted, as was a feeling that we are not moving fast enough in this area.

The second point of concern was the loss of lands for flood control or recreation or water supply and particularly when these projects were for beneficiaries outside the local area. Many thought that flood plain zoning, if employed, would not require the construction of dams. Here too then is an area where education would help clear up the dilemma that's facing us in those communities which are already developed and are subject to flooding. The people in most instances were not sympathetic to building water bodies for outdoor recreators who they considered out-of-staters. Here too there is a misconception as our own field survey samples indicate that most recreator needs are from the valley residents on a ratio of 3 to 1, whereas the out-of-basin resident brought in expenditures and income in just about the reverse ratio. There was much misunderstanding on the concept of the national recreation area plan. Some had the misconception that the lands would be taken away from them whereas in fact the intent is to permit current use to continue.

On the question of water supply we encountered more emotion and fear founded principally on the misconception that there wasn't sufficient supply to go around. Here too, education would do much to clear up some of these misunderstandings. In addition, we would make known to them the advantages that come from the regionalization of some of these systems by reason of their flexibility both in size and operation.

On the question of electrical energy many seemed to feel that the way to lick the problem was to somehow stop demand as if this could be effectively applied as a turnkey type operation. Many have, for example, forgotten the serious blackout that hit the New England region a couple of years ago, and others seem to think that if there were need for power that we would get it from some other area, not realizing that similar problems are developing almost typically across the country. Therefore, there was much evidence in areas where education and improvement in the area of public communication would do much to eliminate many constraints to the implementation of project proposals.

Assuming in the future the public does in fact come and participate in the selection process, only by way of sampling techniques will we really know how representative a response we are receiving and whether they truly reflect a cross-section of the people in the area that is to be affected. Too often viewpoints are from those not really native to the area who view proposals in their own selective vein. Although this is a desirable expression, some form of weighting must be given to those who are vitally concerned. We have regional problems and regional needs which seek localized areas for their solution. Often times those areas where developments are proposed do not have need requirements and in such cases incentives must be sought if favorable response is to come forth.

It has been suggested that if field offices were set up in those areas where proposals are likely to occur, then the people would have more time and show greater desire to learn what is being proposed, and for what reasons and at what consequence. Such offices would make available a continuing base of information, a source of education and a means where local people could find answers to their many questions and on a continuing basis. Then field staffs could maintain a direct liaison with official planning units to keep abreast of views and to alter planning emphasis accordingly.

The use of citizen panel groups is helpful and has been successful particularly in some of the smaller on-going basin studies and within one State. It is a much more difficult procedure when several States are used. The sending out of notices and reports to local selectmen, and municipal officials, who are burdened with an array of problems, and to expect them to respond by either coming to meetings, or getting limited, and sometimes non-existing staffs to write their views is just not working. That there is a weak link in our communication process is evident even though all procedures and guidelines are being followed.

PART THREE

CHAPTER X

VIEW OF PARTICIPANTS

CHAPTER X

VIEW OF PARTICIPANTS

Section 1 - State

The established study guidelines require that all participants to the comprehensive study, plan and act as one entity. Decisions at several times were reached by consensus and were not always unanimously agreed upon by all participants. It was necessary therefore to present, firstly, a coordinated joint Federal-State plan with the realization that modifications could come about later on, either in the review phase, or actual implementation phase. In Appendix J, all of the States present their views as to their on-going programs and their views as regards elements to the basin plan as they may affect their on-going programs. Each State recognizes its obligation to cooperate in programs which may benefit its neighboring States, but does not necessarily relinquish its prime objective of husbanding the resources of its own State. Attention is directed therefore, to Appendix J, and recommendations of the individual States as relates to the Connecticut River Basin program.

There are several different agencies within State governments having interest in one form or other, in the water resource categories as considered in this comprehensive study. Each Governor selected one member from his water resource family to act as the principal coordinator to the Connecticut River Basin Study. Upon his shoulders laid the responsibility for bringing information and communicating this material to other agencies having statutory areas of interest. Considering the amount of resources permitted for this purpose, State members have done a creditable job in bringing to fellow agencies the findings of this study to derive from them their views as to the consequences of implementation of certain parts of the plan. It is recognized that there will be required much more effort in this regard. The adoption of the Connecticut River Basin program under the New England River Basins Commission will, in fact, permit this to occur.

The information provided by Appendix J presents a beginning toward this end. It delineates the different agencies, their responsibilities, and on-going programs. There are instances where certain functional activities of State agencies should be broadened. These lie principally in the area of outdoor recreation, and as they overlap such items as access for fisheries, or the establishment of flood plain regulation and zoning to permit the establishment of flood insurance programs or other multiple-use activities, such as, scenic corridors for purposes of aesthetic quality. The problem of higher municipal tax revenues and the impact thereon upon public land acquisition needs special attention.

Basin States have passed recent legislation dealing with environmental quality and protection of their natural resources as safeguards against undesirable developments that continue to take place within the basin as competitive land use pressures existing natural resources. Such legislation augmented with restrictions in the way of permits, licenses, reduced access etc., are means which can be used to control what some have stated are the social costs resulting from undesirable development. These actions can also reduce or retard needs or cause them to shift to neighboring States. The use of such control can become reciprocal among States and ultimately at the expense of its citizens. Additional resource opportunity would help to distribute stresses and sustain those existing facilities in a high quality condition.

The Basin Plan presents opportunities by which the needs can be properly assimilated rather than suppressed. The Committee believes development in an orderly fashion would not materially alter the natural environment, and would permit greater yields for its citizens. The Basin Plan provides guidance not directives. A restrictive legislative policy as relates to water resource uses could significantly alter projected needs but its consequences must be carefully weighed against the impact it could have upon the local citizens and regional economies.

In keeping with the current trends of the citizenry who seek a greater voice in the day-to-day operations of the different political units within their State, it will be necessary to merge the views and attitudes of the local citizens into the planning environments. Citizens' committees, to be established as part of the River Basins Commission, will assist in this process and these may have to be extended upon in instances where program elements have far reaching regional effect.

During the formal State review period, the views of those State agencies who, through statutory authority, have interest in water resource areas, will be sought as regards report findings, conclusions, and recommendations. Listed below are views and comments as expressed by study participants from the States of New Hampshire and Massachusetts.

"New Hampshire has participated actively in the Connecticut River Basin Study since its commencement. It has done so with the recognition that the size and diversity of the area in the basin make it a unit for planning which is not homogeneous in terms of physical, economic, or other factors. Further, it is not an area capable of embarking upon a unified program of action, so each of the four basin States must support and implement those portions of the program considered beneficial to its well-being. To be effective, such courses of action must fit the over-all plan designed as a guide in the stewardship of the basin's water and related land resources.

"The New Hampshire representative endorses the plan. This does not imply that all proposals are given unqualified support, nor does it commit any agency of the State government to a particular course of action. It does mean that after weighing all data and opinions presented by agencies and individuals, public and private, and discussing these with other members of the Coordinating Committee, decisions were made by the Committee as a whole, and we support these decisions. The New Hampshire representative interprets this as the obligation of the individual designated to participate in this endeavor.

"During the course of the study, resource agencies, public and private, were kept apprised of progress. Information and views of these agencies were sought and gratefully received. Through individual agency sessions and the Council of Resources and Development, specialized information was presented formally and informally. As reports were developed they were shared and critiques and evaluations requested to assure the fair consideration of New Hampshire's position. Field trips were conducted to lead agency personnel, public and private, to on-the-spot examination of proposed development sites advocated for a variety of purposes by the U. S. Army, Corps of Engineers and the U. S. Department of Agriculture, Soil Conservation Service. New Hampshire advocated and conducted more public information sessions than any other State, and no letter requesting facts on any phase of the study went unanswered.

"The Connecticut River Comprehensive Study represents for the State of New Hampshire a guide deserving of the careful evaluation of all its citizens with a view toward taking those courses of action which can enhance the welfare of the majority."

"In designating the Chairman of the Water Resources Commission as a member of the Coordinating Committee for the Connecticut River

Basin Study, the Governor of the Commonwealth of Massachusetts accepted the Congressional mandate to derive a conceptual plan to meet the short and long range water and related land resource needs of the Connecticut River Basin.

"Appendix J contains a State inter-agency review coordinated by the Division of Water Resources. It purports to identify those elements which, from a comprehensive planning viewpoint, meet the needs identified by the study. It is inevitable that any conceptual plan designed to meet a vast array of needs will contain elements which are not only controversial, but which may, on a local basis, be unacceptable. The planner must, where viable alternatives are not available, recommend such elements if he is to provide a functional plan for the entire basin.

"It is in this spirit that the Massachusetts Water Resources Commission has participated in the study. Whether the plan will, in a substantial way, be implemented, depends on many things: political decisions as to whether certain needs be met; the express public demand, or lack of it; and the recurrence of flood or drought conditions.

"It is not too early, however, to indicate that certain elements of the plan have strong support and should be given priority. The recommendations of the Water Resources Commission for early implementation are carried in Chapter XI."

CHAPTER X

Section 2 - Federal-State

The New England River Basins Commission representative to the Connecticut Coordinating Committee submits the following views:

" To achieve sound water quality, two major aspects should be stressed; namely, restoration of presently degraded waters, and preservation of waters which are currently of good quality, and with special emphasis on existing lakes. The preservation of good water quality is considered more significant in terms of management of the basin water resources than are the restoration aspects. To strengthen the preservation aspects of water quality, additional study is required of local and institutional policies, enforcement, and land use controls. These tools should be made part of the Early Action Plan.

" The basin plan provides major opportunities to improve and expand recreational pursuits, however, special attention should be given to the National Recreation Area Plan as described in Appendix H. The findings of hearings and meetings and discussions held to date on this proposal indicate possible objection to the Coos unit. Alternatives to this portion of the recreation plan may be required.

" Flood damage reductions should give more emphasis to flood plain regulation. More detailed mapping of hazard areas is required. Further emphasis should also be given to utilization of existing power storages, or other storages for flood control purposes in lieu of new large reservoirs. Because of increased urbanization a local drainage code should be established to help offset the drastic changes resulting from loss of undeveloped land.

" A balanced fish and wildlife program should include the enhancement and restoration of anadromous fisheries; the preservation and enhancement of cold water stream habitat, including trout fishing opportunities; the creation of additional waterfowl habitat; additional cold water lake fisheries; and the preservation and development of warm water fisheries and existing wildlife resources. The attainment of these items requires adequate flow of water; assurance of adequate water; provisions for hatcheries and stocking programs; scientifically determined regulation of fishing and hunting; development of new reservoir fisheries with adequate assurance of free passage of anadromous species; and adequate public access. The basin plan as proposed largely provides for a balanced fishery program but more specifics are required in the area of access. Intense pressure from private development along water frontage may well deny benefits from a fish and wildlife plan, or, for that matter, a water quality plan unless adequate public access is provided. Particular attention should be given the main stem and tributaries where the anadromous fisheries are to be restored. Detailed studies will be required to determine the number of acres, and limits of actual parcel taking.

"In the area of flood control, alternatives to the Victory proposal should be considered as part of the flood protection plan for the Passumpsic River Basin. In this regard, further attention should be given to East Burke Reservoir as an alternative to Victory Dam."

CHAPTER X

Section 3 - Federal

There are areas where Federal policies and programs need to be altered; most noticeably in the category of open space, particularly as relates to access, and where such areas are crucial to maintaining aesthetic quality. Future land use will undoubtedly take out of the basin many of the pastoral scenes which provide the diversification and enhance greatly the valley's beauty. Subsidiary programs are needed to on-going agricultural units whereby assistance may be given to farmers to withstand the pressures of the urban growth and recreational pursuits as these lands become commercialized, or revert to forested pursuits to support recreational activities.

There is need to expand further the role which reservoirs will play in providing augmented flows that are considered necessary complementary actions following the implementation of adequate treatment measures. Low flow augmentation will benefit a wide range of interests. It is difficult to single out one particular resource category to assume the maintenance of such flows. If it is decided that flows are in fact required, they should be provided as requirements to meet the over-all environmental quality of the particular stream.

The comprehensive study has considered three multiple objectives, namely National Efficienty, Environmental Quality and Regional Development. Under the National Efficiency objective, all efforts were made to enhance the B/C ratio and to maximize it wherever possible. We found that the views of the people differ greatly about the National Efficiency objective. The public almost uniformly favored the Environmental Quality objective which was found to be more expensive, and in some instances involves projects which could not pass a benefit/cost ratio test. In such instances there need to be adjustments made as to the degree of Federal interest, versus the local and State responsibility.

In instances where Federal projects cannot be justified, non-structural alternatives may be introduced, but these require either municipal or State entities to assume leadership, for example, flood plain regulation. The flood plain area of a particular community is competitively sought for one use or another. When the municipality permits a higher land use, it does so with the realization that it will have certain gains in tax income, however, the long term effects could be adverse as relates to damages. If incentives were provided in the way of taxes or reduced assessments, then much of this flood plain land would be spared from exploitation, and a halt to the loss of the valuable natural storage available in the flood plain would follow.

Federal programs should be expanded in meeting the needs for advanced acquisition of reservoir sites or other open space parcels of land. Although the Housing and Urban Development Act of 1965 provides States and public agencies a means by which they can acquire such land, grants are made in amounts not to exceed reasonable interest costs, and usually for a period of up to 5 years in advance of construction. Although this program is an attempt to assist in the area of advanced acquisition, more is needed.

The views of Federal participants to the study are embodied in their respective appendices. Some of the members of the Committee wished to express supplemental viewpoints. Listed below are some specific views expressed by the Department of the Army, Commerce, and Health, Education and Welfare, assigned representatives to the Coordinating Committee.

Department of the Army

At regional and public meetings, and through newspaper and mails, we have been made aware of the dependence and love which the people of the valley hold for their lands. For this reason, emphasis has been given to maximum utilization of existing developments, such as regulation of present use to include additional purposes. In addition, and where possible, maximum use was made of all existing projects and programs of Federal, State, and local agencies. Four existing Corps' reservoirs are included in the plan for modification to support other uses. Other dams have already been modified as part of our master recreation planning.

An inventory of all existing dams in the Connecticut River Basin which controls a drainage area of 50 square miles or greater has been completed. This inventory consisted of field trips and discussions with individual dam owners to ascertain operational patterns, and general conditions of the structures with a view that these existing dams could be made available in controlling floods, augmenting plans or other uses. Of the 177 existing dams so inventoried in the basin about 15% were found to afford some storage potential for flood control. Most of these were operated by private power companies. To obtain the most efficient operation, the Corps has established a Reservoir Control Center which can coordinate releases during flood periods from existing Corps', as well as private dams.

As a start in the quest for proper regulation of river flow, and as part of the inventory of existing projects, the Committee has filed with the Federal Power Commission, a Position Paper regarding the relicensing of four power dams on the main stem of the Connecticut River, namely: Wilder, Bellows Falls, Vernon, and Turners Falls. This Position Paper delineated in Appendix Q, not only seeks coordination of flow releases during periods of flood flows to augment the effectiveness of existing and future flood control reservoirs, but also advocates minimum instantaneous flow releases of 0.2 cubic feet per second per square mile of drainage, as well as fish passage facilities, and more improved access facilities to help satisfy enormous recreational needs. There would be no repayment for such releases because hydrologic studies revealed that had the dams not been in the basin we could have expected minimum natural flows of this magnitude.

The Committee in its deliberations as to full utilization of power storages with appropriate reimbursement, found that in view of the efficient and almost optimal operation that now exists at these peaking power units, alternative means of flood protection could be provided at more reasonable cost. Furthermore, in order to effect significant flood reductions, we would have to introduce major drawdowns that would, from an aesthetic point of view, damage the environmental quality of the area.

In our coordination with the power interests and through specific studies, it was disclosed that Moore and Comerford Reservoirs have the most extensive storage capability for flood control. However, an analysis of past flood records indicates that flood run-off from this northern area of the basin does not have a major effect on the primary flood peak at downstream damage centers. This is reflected in Appendix C on Plates C-17 and C-18 depicting peak discharges for the 1936 and 1938 floods.

At present, although the large headwater power reservoirs on the main stem are not operated for flood control purposes, they do store much of the run-off during the spring snowmelt period. Reservoirs in this section of the basin are effective in reducing snowmelt stages but would not be contributing factors in storms such as August 1955 which struck south of this area.

River flows in the Connecticut travel from north to south, whereas storm patterns strike the area from the south to the north or east to west as was the case in the instance of hurricane Diane in 1955. It is most likely that storm patterns will continue to produce greater precipitation in the southern portion of the river basin or downstream of Woodsville. As a result of the extreme precipitation experienced in 1955, the Corps was forced to reconsider earlier frequency analysis that had been developed, for many areas of New England where flood flows experienced were twice those that had ever been previously recorded. Hurricane Diane, whose front stalled somewhat along the Holyoke Mountain range, gathered large amounts of moisture from the Long Island Sound area and deposited it as precipitation in the lower Connecticut River Basin. Nearly a similar situation occurred with hurricane Connie as experienced in August 1955. Both of these events are discussed in greater detail in Appendix C.

In regard to the small upstream watersheds, the Department of Agriculture has made a major contribution in reviewing nearly 800 small watershed type upstream dams. Of this number 78 new structures, part of a 17-section Public Law 566 watershed plan, are included in the Early Action 1980 Basin Plan as described in Appendix F. These units are viable flood control complements to the 7 larger dams included in the basin plan. Run-off from the steeper upstream watershed areas peaks quickly. The upstream dam is designed primarily to reduce flood river discharges in the communities immediately downstream. The reservoirs are designed to make controlled releases which are within safe carrying capacity of the upstream river channels. They are successful in reducing discharge peaks in the upstream watershed areas, but because they are discharging continuously during flood periods they do not significantly reduce the volume of flood run-off which is passed to downstream areas. It is this volume reduction which is the important element in major main stem flooding.

Earlier in this report we have discussed the possibility of the occurrence of a major flood referred to as a Standard Project Flood, which would be greater than any experienced to date. Appendix C describes further criteria used to develop this flood. Some people have indicated that this could not happen in our lifetime. Such a flood is a reasonable possibility which should not be expressed in statistical terms as some have done. The Corps believes it has an obligation to make citizens aware of the possibility of its occurrence, and its severe consequences as we have discussed in this report, and particularly since the Connecticut River has such an extensive history of flooding.

Because of the hydrology and topography of the basin, as well as the population distribution, the Connecticut River Study has found that additional flood control measures are needed in accordance with earlier Congressional authorization. The study calls for complementary solutions such as flood plain management, local protection and upstream dams. If land is taken for these measures, fair market real estate values would be placed upon all the holdings within the fee taking areas with the additional inclusion of acquisition and equitable resettlement costs. This assessment takes into consideration money spent to maintain or improve property.

Moreover, in 1953, the four States in the Connecticut River Basin, as signatory parties, adopted the Connecticut River Flood Control Compact by which Massachusetts agreed to reimburse Vermont and New Hampshire 50% and the State of Connecticut to reimburse Vermont and New Hampshire 40% for tax losses and certain economic losses due to construction of flood control reservoirs in Vermont and New Hampshire. The Connecticut River Valley Flood Control Commission, composed of three members from each State, meets annually to decide on the current valuation and required tax reimbursement.

The relocation of communities or local interests for reason of reservoir development can produce hardships beyond those which can be compensated for. It is for this reason that we urge the Governors of the respective States where reservoirs are to be located to make use of the Section 209 of Public Law 90-483 approved 13 August 1968. This legislation provides assistance in securing land or interest therein at the request of the Governor of the State and would be used as a site of resettlement of families, individuals and business concerns replaced by the water resource projects. Development of new sites may follow so as to alleviate hardships and to provide opportunities to those persons who might desire to stay within the area of their earlier home. The additional lands will be paid for by the State with later reimbursement from those interests who would be paid fair market value as part of their negotiated procedures in the acquisition of their land.

As relates to low flow augmentation, it is our view that provisions for flow releases from Federal storages be accomplished after the installations of secondary treatment and following the full assessment the effects of that treatment.

The comprehensive study plan presents what the Committee believes are needs and problems to which the citizens must address themselves. The study's goal is to present possible solutions to these problems and through broad base public involvement hopefully our political process will produce a result with which members of the Connecticut Valley can feel justly satisfied. We are aware of the current climate regarding reservoir construction and it has been made abundantly clear to the public whenever the opportunity presented itself that none of the proposals of this plan would be forced upon them. We ask only that they examine the facts closely and recognize the regional characteristics of the basin plan and the needs of their fellow citizens.

Department of Commerce

"In many respects this report does not cover the operational aspects of the planned program in sufficient depth. Perhaps this is due to the complexity of the interaction among the several program areas. It is likely that operational problems should not be considered until such time as the over-all program is on a fairly firm foundation. Nevertheless, the importance of real-time and near real-time meteorological and hydrological data and forecasts for operational decisions should not be overlooked, even at this early planning stage. Further, when the time comes to consider the actual operational problems, they should be approached with the assumption that detailed and accurate predictions of stream discharges must be available to those making water management decisions. Improvement and expansion of the Weather Bureau's service in this field will provide the necessary forecasts."

Department of Health, Education and Welfare

"The HEW representative stressed the positive benefits to health from proper planning of the Connecticut River Basin. These lie in several areas. For example, flood control measures save lives. Each life saved has a positive contributory effect upon national development. Also, water resource development can reduce or eliminate insects which have a high nuisance potential and a significant hazard to health. Thirdly, the provision of adequate water based recreation may be shown to have a health benefit measurable in dollars and cents because of the increased potential in earning power."

Department of the Interior

The Bureau of Outdoor Recreation believes that reservoir sites at Indian Stream and Hammond Hollow should not be considered for development and that project sites and adjacent streamside areas be incorporated into the recommended scenic river program.

The Bureau also recommends that the following reservoir sites (located by tributary basin) not be considered in the recreation aspects of the Early Action Plan, but be protected by acquisition or other suitable means:

Upper Jefferson, Israel River
Fort Morrison, Deerfield River
Gardner, Millers River
Sandy Brook, No. 2, Farmington River
Falls River, Falls River

The U. S. Fish and Wildlife Service recommends that although site Sandy Brook No. 2 on the Farmington River is not in the Early Action Plan of the Coordinating Committee, the land should be acquired as soon as possible in anticipation of future construction. The Service also recommends that chemical treatment of water supply reservoirs be sufficient to permit public fishing; and that the Basin Plan be modified to provide additional augmentation of stream flows during the period September 15 through December 1, by reducing fall and winter pool levels at proposed impoundments. Finally, the rehabilitation of Moore Reservoir should be studied to develop potential fishery resources.

CHAPTER X

Section 4 - Other

The comprehensive study gave particular attention to Federal and State programs, as well as those municipal programs that are currently on-going, or in a planning phase. It recognizes a large area where private interest and investment makes a major contribution to water resources. Most noticeably, in the area of power, and forest management, as performed by the paper industry, and allied timber products industry. The private sector is currently producing the major segment of the outdoor recreational opportunities. Most noticeably are areas of skiing, private camping, motel facilities, such as lodgings and food for a very mobile public. It will be necessary for each basin State to keep an active file on these pursuits and the contribution which private sector is making in meeting the needs. The effectiveness of this program could make possible future savings in the public investment sector, and could yield handsome returns in taxes.

To facilitate implementation of programs in the public and private categories, greater use must be made of established conservation groups, as well as the newer local citizen valley groups. There is need to coordinate, educate, and communicate with these groups as to what programs are attempting to achieve, and the consequences if proposals are built or abandoned. This is a key element toward favorable political response and maintenance of the strong pluralistic character of the different interest groups that exist in the Connecticut Valley.

PART THREE

CHAPTER XI

RECOMMENDATIONS FOR CONGRESS

CHAPTER XI

RECOMMENDATIONS FOR CONGRESS

Section 1 - Approval of the Coordinated Plan

The 1980 Early Action Plan as developed by the Coordinating Committee for the Connecticut River presents a mix of different proposals for public, State, and local investments. Some items require Congressional authorization, and others may proceed as part of already authorized programs, or established programs. This Chapter concerns itself primarily with elements that will require authorization by Congress. It recommends approval of the total plan. It notes that on-going programs could be expanded, or accelerated to meeting existing needs and project goals.

In keeping with current national policy, much attention has been given to environmental quality. Added costs are required if we are to maintain a high quality environment for the Connecticut River Basin, and if restoration is to be made where such quality has been lost. Public interests participating in this study were concerned that the Environmental Quality objective would not have equal weight alongside of National or Regional objectives where growth is a paramount consideration.

A new social ethic is evolving, and appears to be based upon the view that everyone has an inalienable right to a clean environment. Simultaneously, a new economic ethic is developing looking to a balanced growth, or zero growth if it means the difference of being in harmony with the environment. The current view that expansion does not necessarily equate itself with the well-being of man, strikes home at some established policies which heretofore placed growthmanship as a high ideal. If the quality of life is to be our greatest concern, and reparations are to be made for damages done to water resources, then it is likely that adjustments will have to be made to on-going programs, and particularly as they affect cost sharing. Programs will have to be broadened, financial obligations reassessed , with less reliance given to benefit-cost ratios. Intangible areas which now lack measurement tools, or that are not subject to market influences will have to be assigned some judgmental value upon which cost sharing may be made.

It is probable that the space program may have jolted the public into the realization that earth is a space ship, and with a limited life support system. Stresses of mass urbanization, losses of what was once countryside, to suburban sprawl has brought a demand that environmental quality obtain a higher objective role in old and particularly new programs. It is believed that technological capability is available to resolve the complexities now present in the water resource family, but public communication remains a weak link. It is not so much a question of the means to do the job, but rather the desire, and spirit to join, and share, in natural resources to achieve a balance between the natural conflicts inherent in water uses.

The earlier pioneer or frontier drive to create more may not continue unless stewardship of resources is improved. The Connecticut River Basin has the natural abundance but wise use of it is required to meet growing needs. Whereas, in the past, problems were solved on a piece-meal basis, the basin plan offers a multiple-purpose approach. It presents a beginning of a process that can be refined.

There are signs of an encompassing, integrated viewpoint in the Federal, State, or private entities. States are passing new protective legislation, establishing environmental councils, and adding Environmental Rights to their constitutions. Such actions will, per force, improve coordination and communication. If people and progress have caused the current environmental crisis as some believe, then solutions must be resolved, first by enlightening them as to the intricacies of water resources. The process should be broad enough to encompass areas of social planning. It has been said that the next decade will make the difference in man's stewardship of his resources. If this is true then the timeliness of the 1980 basin plan is apparent. The Coordinating Committee recommends that the 1980 basin plan as presented in this report be approved. Specific project recommendations of study participants as reported upon in their respective appendices follow:

The State of New Hampshire recommends:

(1) Implementation by the State of a flood plain protection program to delineate and regulate the flood hazard areas to achieve intelligent land utilization compatible with the hazard of flooding. This preventative concept, designed to control man's uses of the flood plains, must be implemented and funded by the General Court.

(2) Adoption by the General Court of legislation which recognizes the need for protecting areas of unique scenic and environmental quality.

(3) The appropriation, at all levels of government, of money to implement fully the pollution abatement program designed to attain water quality standards set by the State's classification program.

(4) The requirement that erosion control standards be adopted and enforced by the State to avoid adverse and often irrevocable impacts caused by public and private construction projects.

(5) Advanced acquisition of land at impoundments endorsed by the State, and support of Section 209 of PL 90-483 of August 1968 which provides the Federal Government with the authority to condemn land for this purpose at the request of, and with reimbursement by, the State. These measures are designed to eliminate hardship, allowing sufficient time and monetary consideration for relocation of residential and commercial uses.

(6) The establishment of a quality monitoring network, in the Connecticut River Basin, capable of incorporation into a basin-wide control center such as the Reservoir Center at the New England Division, Corps of Engineers, at Waltham, Massachusetts.

(7) Implementation of the Coordinating Committee's Stream Regulation Subcommittee recommendations with regard to minimum flows at main stem dams.

(8) Implementation of all fish hatchery construction necessary to support resident and anadromous fishery programs.

(9) Support of a National Recreation Area Study based upon a definitive master plan mutually participated in by the National Park Service and the State of New Hampshire. It is further recommended that sufficient Federal funds be provided to enable the State to employ qualified and full-time staff to effect proper coordination with the basin communities and with the Federal agencies involved.

(10) Coordination of efforts of the State resource and related agencies with those of Federal and local agencies, private organizations, and individuals by the Council of Resources and Development to assure the most beneficial effects from programs relating to the Connecticut River Basin.

(11) Study and appropriate action to assure that adequate and quality water supplies will be available for domestic and industrial uses. It is further recommended that the State's Water Supply Study, Phases I & II, be used as a guide for such study and subsequent action.

(12) Appropriation of sufficient funds to pay New Hampshire's share of the Connecticut River Basin Program under the direction of

the New England River Basins Commission. Recommended by the entire Connecticut River Coordinating Committee and accepted by the New England River Basins Commission, this arrangement will provide the required leadership and coordination in carrying out the water and related land resources management programs proposed by the study using existing Federal, State, interstate and local authorities, private organizations and programs as implementing media.

The State of Vermont recommends:

(1) That the State make careful, thorough examination of the recommendations in the Connecticut River Basin plan as they relate to the, as yet, undocumented needs for other areas of the State.

(2) That the State establish and set priorities to meet critical needs areas within the capability of the State.

The State of Massachusetts recommends:

(1) That there be established a continuing planning process, and that the plan be considered a conceptual one, rather than a rigid program outline.

(2) Water Quality

The waste treatment program must be fully implemented. Special low-flow augmentation sites will be considered only if a program of waste treatment has been vigorously pursued and found wanting. Low flow augmentation, where it can be accommodated with other uses without serious damage to other values, may be considered.

(3) Acquisition of Sites:

High priority should be given to the early acquisition of those stream bank areas which will be made more desirable by pollution abatement or by the re-establishment of anadromous fisheries. Reservoir sites which might reasonably be foreseen to be utilized under existing or planned programs should be purchased as soon as possible. Emphasis should be given to multi-purpose sites.

(4) Upland areas should be placed under zoning restrictions or easements to preserve open space and flood plain areas, and to complement the Commonwealth's Inland Wetlands program.

(5) Flow Regulation

All dams of significant capacity should be regulated so as to provide reasonable and continuous flows. Additional regulatory powers should be granted where required.

(6) Anadromous Fisheries

Fish passage facilities, hatchery construction and the previously-mentioned water quality and acquisition programs should proceed according to the earliest realistic time schedule.

(7) Institutional Arrangements

A basin wide planning and coordination agency under the New England River Basins Commission should be instituted. Such an agency could coordinate the planning and management of conventional water resources programs and could formulate new approaches to problems, e.g., devising means to facilitate flood plain zoning, perhaps by indemnifying local governmental subdivisions against suits of parties aggrieved by flood plain ordinances.

Public participation is an important factor in planning studies, and although sought early and continuously throughout the Connecticut Study in the form of scheduled and special meetings, selected mailing lists and routine public status reports, it did not begin to materialize until a plan was formulated. Participation then took the form of reaction rather than positive action. In future studies, means must be developed to obtain an early and positive public contribution.

The State of Connecticut recommends:

(1) The Comprehensive Report be used as a basis from which decisions can be made as to the actions which must be taken by the State to make optimal multiple-use of the river and those surrounding areas.

(2) The Connecticut River National Recreation Area concept become a reality, in a form compatible with the desires and needs of the local residents.

(3) The remaining tidal wetlands be protected.

(4) The proposed restoration of salmon runs in the Valley be successfully completed.

(5) The issue of diversion of water out of the watershed be resolved satisfactorily without detriment to the needs of downstream users.

The New England River Basins Commission recommends:

(1) Establishment of land use zoning and controls by local and State levels of government.

(2) Coordination of planning and management in the Basin through a Connecticut River Basin Program established under the New England River Basins Commission and in accordance with the findings of the Subcommittee on Institutional Arrangements as carried in Appendix Q.

(3) Environmental controls by local governments be included as part of the corridor concept of the National Recreation Area Plan.

(4) Public streambank acquisition for access to basin facilities be identified in terms of area, frontage and stream lengths in future studies.

(5) Public lands should be acquired for recreational purposes around existing water bodies.

(6) There is need for the public acquisition in controlling wetlands and particularly the estuary portions of the Connecticut River.

(7) Public fishing and hunting access to streambanks and those lands acquired in connection with new reservoir development should be an integral parts of the site development whether or not fish and wildlife is part of the project proposal.

(8) Streamflow regulation should consider total environmental flow requirements as well as the assimilative requirements of water sources of pollution. When non point sources of pollution are considered there is no comparable alternative to streamflow regulation.

(9) An equitable property tax program should be established to offset the impact which public land acquisition will impose upon local tax roles.

Recommendations of the Department of Agriculture:

As part of the Early Action Plan that:

(1) The Soil Conservation Service, under Public Law 46 and Public Law 566, accelerate its programs of assistance in conservation farm planning and application of conservation measures in the 27 conservation districts of the Basin. Treatment is needed to control erosion on about 204,000 acres of cropland and pasture; and 150,000 acres of urban and other land. Eight upstream PL 566 watershed projects currently being planned and nine potential upstream watershed projects also require the acceleration of land treatment measures.

(2) Under Community resource planning assistance, funds be appropriated for soil surveys, and interpretive soil reports to include assistance to communities in land resource inventories, flood plain studies and community land use planning.

(3) The Cooperative State-Federal Forestry Program be funded to the full amount of its authorization. Installation of land treatment measures should be an integral part of all Federal impoundment projects to provide acceleration in developing management plans and application of required forestry practices. To augment this program and others, effective, conservation education should be accelerated from kindergarden up through high school.

(4) The Agricultural Stabilization and Conservation Services Program be increased 25 percent above the average annual rate of $882,000 estimated for the basin during the year 1957-1967 in order to fund the additional cost sharing outlined in the report.

(5) Accelerated land treatment measures on 63,700 acres of National Forest lands be implemented as well as soil surveys, watershed analyses, big and small game analyses and stream and lake surveys on 337,100 acres.

(6) Acquisition of 69,300 acres of National Forest lands.

(7) Within the next 10-15 years, State and municipal agencies be encouraged to develop, with Federal assistance, long-range multiple plans for municipal watershed lands.

(8) Farmers Home Administration and other agencies provide assistance for rural water supply and waste treatment systems to 170 rural basin communities having 5,500 population. Funds should be made available to provide a program of loans and grants to develop or enlarge water supply and waste treatment facilities in these areas.

(9) Local sponsors be encouraged to continue to develop the eight watersheds currently being planned under PL 566 with flood prevention as the major purpose.

(10) Nine additional upstream watersheds identified for development in the basin investigation be implemented.

(11) Resource Conservation and Development Projects be accomplished for the total basin. Funds should be at a level to cover the Federal cost sharing portions of projects in both the four existing and the four potential projects.

(12) The 118 other upstream impoundment sites selected for development which fall outside upstream watershed projects and do not qualify under existing criteria, be authorized for development in cooperation with local and State agencies through changes in Public Law 566 criteria, as outlined in the report.

(13) The structural program for the National Forest lands described in the report be implemented.

(14) U.S. Department of Agriculture programs and changed criteria be implemented as described in detail in Appendix "F" providing for the following ten general areas:

a. Modifications of Public Law 566
b. Expansion of a Flood Plain Information program
c. Establishment of an urban and forestry program.
d. Changes in the Agricultural Conservation Program
e. Changes in funding projects on Federal lands
f. Expansion of municipal watershed forestry assistance programs
g. Increased emphasis on conservation and education
h. Accelerating land treatment above Corps of Engineers' dams and other impoundments
i. Increased funding of research activities
j. Acceleration of the installation of water supply and waste treatment systems in rural communities

As part of the Long-Range 2020 Program that:

(1) Funds be made available for soil surveys, town resource inventories and all other land treatment needs on approximately 200,000 acres of private land. In addition, the Cooperative State-Federal Forestry Program should be funded to provide assistance on approximately one million acres.

(2) Because of increasing recreational demands, changed patterns of resource use, additional National Forest developments needed through 2020 be acquired. These changes will require the updating of plans so that the resources within the National Forests will make a maximum contribution to regional needs.

(3) State and Municipal lands obtain additional protection and development as required by 2020. Plans for use of these lands will also require updating for the best allocation of resources.

(4) The 33 watersheds where floodwater and sediment damages are presently significant, be investigated in view of future development and changes in upstream watershed criteria to determine feasibility as PL 566. Seven of these 33 watersheds have been identified as having the greatest potential at this time. Flood plain management measures should be considered as an alternative.

(5) State agencies acquire the land at 63 other upstream sites at which they have already indicated an interest. In addition, 160 other site possibilities should be considered for preservation either through purchase, zoning or other means.

(6) Additional structural development as needed by year 2020, in National Forests be provided to meet recreational needs.

Recommendations of the *Department of the Army*

The Corps of Engineers recommends thirteen areas of improvement as its contribution to the 1980 Early Action Basin Plan, and as follows:

A. Flood Plain Regulation - That flood plain regulation measures be instituted by local interest at appropriate locations throughout the Basin with technical support from the Corps of Engineers.

B. Reservoir Control Center (RCC) - That the recently established RCC continue to be maintained at a high level of efficiency, with future modifications as necessary to provide effective coordination of streamflow regulation and flood control.

C. Communications with Public - That the public be made aware, through an extensive information program, of assistance available to them in the form of planning for flood control flood plain zoning, flood insurance, and emergency flood fighting.

D. Permits on Navigable Waters. - That all related water resource interests be considered in the issuance of permits by the Corps of Engineers along the main stem of the Connecticut River. The river is considered navigable, in fact, upstream to Murphy Dam at Lake Francis, for a distance of almost 380 miles. Such policy to be founded upon the Utilization of the Refuse Act of 1899 and as relates to the dumping of wastes into navigable waters without a permit.

E. That in future years consideration will be given to modification of existing Corps' reservoirs either from an operational basis, requiring no extensive physical changes; or, if found necessary, from a physical basis where definite alterations are found to be necessary. Such policy to be consistent with changes in existing conditions and the desires of the public.

F. The construction of six multiple-purpose flood control, recreation, and low flow augmentation projects as follows:

1. Victory Dam and Reservoir on the Moose River, Passumpsic River Basin in the town of Victory, Vermont.

2. Gaysville Dam and Reservoir on the White River, in the village of Gaysville, Vt.

3. Bethlehem Junction Dam and Reservoir on the Ammonoosuc River in the town of Bethlehem, New Hampshire.

4. Claremont Dam and Reservoir on the Sugar River in the city of Claremont, New Hampshire.

5. Beaver Brook Dam and Reservoir on Beaver Brook, Ashuelot River basin in the city of Keene, New Hampshire.

6. Honey Hill Dam and Reservoir on the South Branch of the Ashuelot River, Ashuelot River basin in the town of Swanzey, New Hampshire.

G. The construction of a single purpose flood control project: The Meadow Dam and Reservoir on the Deerfield River in the town of Deerfield, Massachusetts.

H. The modification of four existing Corps of Engineers flood control dams and reservoirs to accommodate other project uses:

1. Union Village on the Ompompanoosuc River in the town of Thetford, Vermont, for recreation.

2. Tully on the Tully River, Millers River Basin in the town of Royalston, Massachusetts, for recreation and water supply.

3. Knightville on the Westfield River in the town of Huntington, Massachusetts, for recreation and low flow augmentation.

4. Barre Falls on the Ware River in the town of Barre, Massachusetts for low flow augmentation for water quality. This project is presented as an alternate to advanced waste treatment measures.

I. The construction of five local protection projects at the following locations:

1. Lancaster, New Hampshire, on the Israel River.
2. St. Johnsbury, Vermont, on the Passumpsic River.
3. Hartford, Vermont, on the White River.
4. Westfield, Massachusetts, on the Westfield River.
5. Hartford, Connecticut, on the Park River.

J. Federal construction with significant local cost sharing of two major dams and reservoirs providing for general recreation and low flow augmentation for fishery enhancement are as follows:

1. Cold Brook Dam and Reservoir on Roaring Brook in the town of Glastonbury, Connecticut.

2. Blackledge Dam and Reservoir on Blackledge River and Fawn Brook in the Salmon River Basin in the town of Hebron, Connecticut.

K. Federal construction with significant local cost sharing of a single purpose project providing low flow augmentation for fishery enhancement and referred as the Gardner Dam and Reservoir on the Otter River in the Millers River Basin located in the city of Gardner, Massachusetts. This project is presented as an alternate to advanced waste treatment measures.

L. Navigation Improvements

1. That commercial navigation facilities be improved by widening and deepening the existing channel from Long Island Sound to Hartford.

2. That channel improvements and construction of locks be undertaken to provide passage of recreational craft from Hartford, Connecticut to Holyoke, Massachusetts.

3. That a channel be provided for recreational boating between Holyoke and Hatfield, Massachusetts, within the Holyoke power pool.

4. That Federal technical assistance be provided, for recreational boating, to local communities that contemplate future development of access channels, and marina and turning basins.

For the Long Range 2020 Basin Plan, the Corps of Engineers has identified a number of potential improvements which should be considered in future evaluations of water resource needs and problems. Measures to be included in future planning evaluations are:

(1) Continued evaluation and necessary expansion of the flood plain management program.

(2) Periodic review and adjustment of stream regulation requirements at existing projects, particularly with reference to new and existing licensing of power projects.

(3) Consideration of local protection for 7 communities as noted in the 2020 plan.

(4) Extension of the commercial navigation project to Holyoke, Massachusetts.

(5) Recreation improvements along the Connecticut River to include boat passage facilities at existing dams.

(6) Multiple-purpose reservoirs which are identified in the 2020 Plan.

Recommendations of the Department of Health, Education and Welfare:

(1) Comprehensive water quality monitoring programs for likely water supply locations on the main stem and tributaries be instituted to ascertain the quality of the water before it is necessary to use it for water supply. This program also should include a system to make the data available to all who need it.

(2) Recognizing the great need for water-based recreation, cooperative studies on the use of existing water supply reservoirs for recreation be considered, which would place primary emphasis on assuring a safe water supply.

(3) When new reservoirs are in the design stage, coordination with solid waste management programs of respective states should be made to determine if the quality of the impounded waters will be adversely affected by completed, existing, or planned landfills.

(4) An assessment of individual water supply sources in the four basin states be made to determine the extent of poorly constructed and contaminated wells.

(5) More emphasis be placed on continuous surveillance of recreation facilities from a health standpoint throughout the summer season.

(6) Vector control programs be an integral part of water resource design and development of recreation areas to eliminate the risk of disease outbreaks and nuisance conditions. The vector control potential of flood control projects should also be recognized.

(7) More intensive data on waterborne diseases be gathered for the Connecticut River Basin.

(8) A continuous effort is needed to reduce the air pollution levels in the basin by reducing contamination from commercial, public, and industrial installations; such as fossil fuel power plants, inadequately controlled incinerators, and open burning dumps.

(9) In addition to built-in safeguards, an alert notification system be set up with nuclear power plant personnel and downstream water supplies in the event that an accident occurs releasing radioactive material to the watercourse. An alert notification system such as this should also be established for water supplies which might be subject to contamination by spills of oil or other hazardous materials.

(10) Adequate state regulations be adopted and enforced to prevent pollution from recreational and commercial boats.

Recommendations of the Department of the Interior:

The Bureau of Mines recommends that a report be made on the mineral industry and resources, and their importance to the economy of the area, to include projections of mineral production and land requirements for future target dates; collection and evaluation of data of the impact of increasing urbanization upon the mineral resources industry.

The Bureau of Sport Fisheries and Wildlife recommends that:

(1) Losses of fish and wildlife resources be mitigated as recommended by this Bureau and the appropriate State fish and wildlife agency.

(2) Public access be provided to all reservoir sites.

(3) Appropriate restrictions of public use of reservoirs through time or space-zoning, and/or limitations on boating activities where necessary be applied at reservoirs to promote safety or maximum quality of public use.

(4) Pre-impoundment species-control programs be made an integral part of project planning.

(5) Hatchery(s) for the production of 125,980 lbs. of catchable size and 85,950 lbs. of fingerling salmonids for stocking new reservoirs and improved streams be provided at Federal cost.

(6) Lands acquired in connection with reservoir development be open to public access for fishing and hunting and that fish and wildlife resources thereon be managed by appropriate State agencies.

(7) Public access to streambanks be made an integral part of project planning.

(8) Each dam intended to hold a recreation pool, or a pool for low flow augmentation, be constructed in such a manner as to permit regulation of flows released from the dam, and to permit releases from either multiple intakes or from outlets near the base of the dam.

(9) Dredging of sand and gravel from stream beds be subject to approval of the State with appropriate consultation with the State fish and wildlife agency.

(10) Augmentation flows be passed through successive downstream dams without restriction or diversion.

(11) Specific provisions for access to permit the harvest of fish and wildlife resources at location as part of the Connecticut River National Recreation Area.

(12) Other programs for acquisition or designation of recreational areas provide for access for fish and wildlife pursuits.

(13) Rehabilitation of Moore Reservoir be studied to develop potential fishery resources.

(14) A Federal program be established to assist the States in developing those reservoir sites which do not satisfy requirements for construction under existing U.S. Army Corps of Engineers' or Soil Conservation Service authorizations.

(15) The Fish and Wildlife Service be notified in sufficient time to allow detailed investigations, in cooperation with the appropriate State Fish and Wildlife agencies, of the impact of reservoir development and formulation of necessary recommendations concerning construction and operation of developments and required mitigation measures during final detailed planning stages.

The Bureau of Outdoor Recreation recommends that:

(1) A three-unit National Recreation Area be established in the Connecticut River Valley. Further, that State and local governments and individuals participate actively in effective programs that foster wise land-use and water management within the Connecticut River Valley.

(2) The basin states individually create statewide scenic river programs together with preservation and protection programs in cooperation with other levels of governments, to enhance all rivers, reaches of rivers, or portions thereon, identified in this report as Wild, Scenic or Recreational.

(3) The basin states provide guidance through their statewide Comprehensive Outdoor Recreation Plans and, in cooperation with other levels of government, continue to establish management guidelines and master plans for the provision of additional access and recreation facilities to the impounded water of the Connecticut River Basin.

(4) The basin states act to utilize the underdeveloped recreation resources of the basin's water supply reservoirs. Such action should review existing state statutes and policy with respect to the recreation use of water supply reservoirs, formulate new policy and programs, as required, and establish administrative responsibilities.

(5) The basin states continue to investigate the feasibility of increased recreation development at existing hydroelectric projects. Such investigation should be conducted in cooperation with the utility industry and the Federal Power Commission, and reported through the Statewide Comprehensive Outdoor Recreation Plan.

(6) Reservoir sites at Victory, Bethlehem Junction, Gaysville, Claremont, Honey Hill, Meadow, Cold Brook, and Blackledge as well as existing reservoirs at Union Village, Tully, and Knightville, continue to be considered for development through Corps of Engineers and Statewide Comprehensive Outdoor Recreation Planning Programs.

(7) The potential Soil Conservation Service upstream watershed projects and individual sites retained for early action consideration continue to be considered in State and local planning programs.

(8) Studies conducted in water resources project investigations continue to identify the primary potential downstream area uses and, accordingly, give full consideration to those flows necessary for their enhancement.

(9) Releases during the summer season for existing dams along the Connecticut River be representative of natural and unregulated flows.

(10) The White and Green Mountain National Forests, the Connecticut River Basin State and local government agencies, in cooperation with one another, continue to plan, acquire, and develop land and facilities for outdoor recreation.

As part of the Long Range 2020 Plan an implementation program be established to facilitate the development of early action recommendations to include monitoring of basin resources, its socio-economic characteristics, and to update priorities as required.

National Park Service recommends that:

(1) Areas of significant natural historic and archeological importance be identified, designated and protected by local and State government. Cost of such preservation to be shared by State, local and private sectors, with limited Federal assistance.

(2) Historic sites selected for preservation should consider the setting and surrounding land which contributes to their effectiveness.

(3) The National Park Service encourages the appropriate State agencies to evaluate all historical and archeological resources described in this report as well as additional sites of State or local significance for possible inclusion in the Registry of National Historic Landmarks.

(4) It be authorized to evaluate the natural and scientific resources described in this report, to determine sites of national geologic, ecologic or scientific importance, if any, for possible inclusion in the Registry of Natural or Environmental Landmarks.

(5) Prior to start of construction on the projects recommended in the Basin Plan, investigations be undertaken to determine if any site of natural, historic or archeological importance will be disturbed with appropriate action to prevent or mitigate losses. Where archeological sites are affected, they should be scientifically excavated to the extent necessary to recover all significant data.

The Federal Water Quality Administration recommends that:

(1) Municipal and industrial water supplies be included at potential reservoir sites where possible and found to be more economical than alternate sources, with appropriate reimbursement by the user.

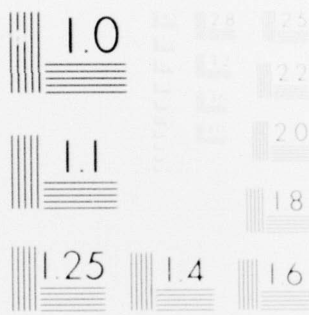
(2) Water quality standards be adopted as soon as practicable for intrastate waters which are presently unclassified, and approved standards on interstate waters be met.

AD-A043 894 ARMY ENGINEER DIV NEW ENGLAND WALTHAM MASS F/G 8/6
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION. C--ETC(U)
JUN 70

UNCLASSIFIED NL

5 OF 5
AD
A043894

END
DATE
FILMED
10-77
DDC



1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

(3) Improvement to water quality be contined. Waters below standard be improved, and high quality waters be maintained.

(4) A minimum of secondary wastewater treatment measures be in operation for all wastewater sources before 1980.

(5) Flow augmentation, advanced wastewater treatment or a combination of the two be provided where appropriate to assure desirable basin development by 1980.

(6) There be continued research to improve and reduce costs of known wastewater conveyance and treatment processes.

(7) Federal, State, and local funds be made available to implement pollution abatement measures to include increased levels of treatment, flow augmentation, modification of industrial plant processes, or a combination of these.

(8) Incentive and regulations be adapted to encourage, redesign of present treatment plant processes, recovery processes, pretreatment measures and land use practices to substantially reduce the volume and the effect of discharged wastes.

(9) Regional sewer and water feasibility studies be made to determine the best configuration, location and design of waste treatment facilities together with desirable water and land measures.

(10) Federal, State, regional and local agencies foster growth patterns and land uses consistent with water quality objectives. Future zoning, subdivision controls, scenic easements, water quality standards and other water and land use policies should support water quality and related environmental objectives.

(11) Additional and continuing assessments be made in areas of combined sewer overflows; stormwater; eutrophication; sludge deposits; pesticides; land drainage and erosion.

CHAPTER XI

Section 2 - Approval of Pre-Authorization Studies

Implementation of the comprehensive plan will require the active participation and cooperation of all Federal, State and local governmental and private interests in sharing the legal and financial responsibilities and obligations for construction, operation and maintenance of the projects and programs included in the Basin Plan.

The States of New Hampshire, Vermont, Massachusetts and Connecticut, other legal entities and local interests have the responsibility for initiating many of the projects and programs included in the plan. Even in those fields where a Federal agency normally performs the detailed planning and construction, the impetus for these activities should originate with those benefited by the programs and facilities.

Data for projects and programs included in the 1980 Early Action Plan are considered to be of the scope required by the applicable agencies for making decisions concerning project selections and engineering and economic feasibility. However, the data must be refined by detailed planning and design studies necessary to establish final design features of the projects, and form a basis for final construction plans and specifications. In many cases, studies for projects and programs included in the long-range plan have not been carried beyond the reconnaissance level. Therefore, additional planning would be necessary before these measures could be considered for inclusion in an early action program. Those projects in the 10- to 15-year plan for which the Corps of Engineers has primary responsibility for planning and constructing will be presented in a separate report through regular channels to the Congress for authorization consideration. Preauthorization studies are in compliance with the resolution authorizing the study. Upon authorization by the Congress and appropriation of funds, the projects would be planned in detail and then constructed. However, their construction would be contingent upon responsible interests providing local cooperation required by appropriate laws and regulations.

It is recommended that four authorization reports be prepared, one for each basin State which will include those major reservoirs noted in the Basin Plan, as well as navigational improvements for commercial and recreational programs.

Those projects and programs in the 10- to 15-year plan for which the Soil Conservation Service has primary responsibility in planning and assisting will also be presented in an agency report for appropriate implementation. These improvements would be constructed when funds are available and the required local cooperation is fulfilled. The United States Forest Service will be primarily responsible for obtaining necessary funds for the acquisition of lands and for the installation of improvements, including stream preservation in national forest land.

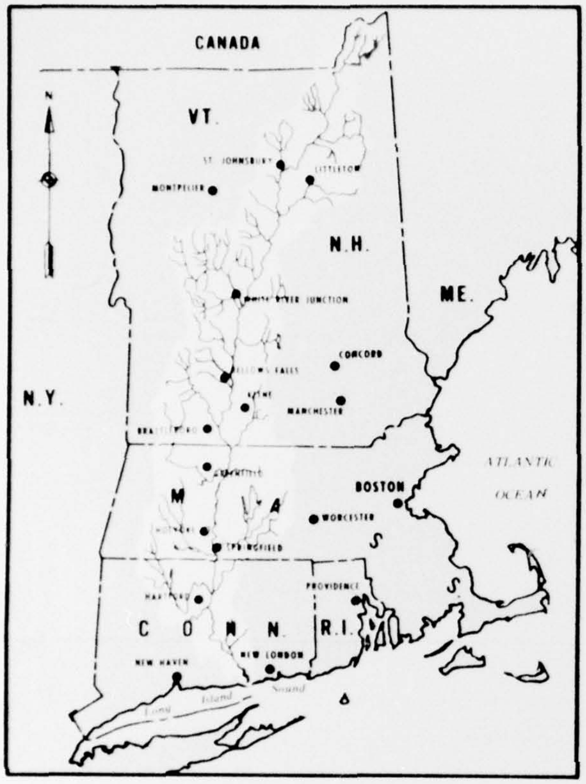
CHAPTER XI

Section 3 - Other Requirements

An important item of flood management concerns the establishment of a uniform drainage code among tributary basins and, if necessary, larger areas. Such a program should be established between local municipalities and State water resource commissions. It would require that permits for new construction on land areas having flood retention capability be approved only if the builder assures that changes in run-off patterns can be safely conducted through existing drainage systems. Developers would be responsible for improvements, if required, on the basis that changes to the water shed by way of urbanization, would result in increased runoff causing what were previously adequate outlets to become inadequate.

Such a program may be tied closely to existing wetlands legislations currently available in some of the basin States. It is evident that as urbanization increases unless a drainage code is established, there is certain to result a mounting frequency of nuisance type flooding. Such flooding although not of major proportions would cause hardships and burdens to the local municipality as well as burden the homeowner and other tenants of areas that heretofore were not flood prone. In the older communities, the cost of replacing major drainage outlets is prohibitive. New upstream developments should be undertaken with realization of the consequences downstream. The more frequent nuisance type flood drainage problems generally fall outside of the purview of existing Federal authorities and limited assistance can be given to a municipality in the way of Federal participation.

The Coordinating Committee recommends that the basin States develop legislation to permit the establishment of a drainage code with Federal incentives given to accelerate this program in the form of planning assistance or outright grants whereby local municipalities may do their own planning.



LOCATION MAP

LEGEND

PROJECT OR PROGRAM	EXISTING OR UNDER WAY	EARLY ACTION PLAN	LONG RANGE PLAN
UPSTREAM WATERSHED PROGRAMS			
MAIN STEM OR MAJOR TRIBUTARY RESERVOIR			
POWER [1] NUCLEAR			
POWER PUMPED STORAGE			
RECREATIONAL NAVIGATION			
COMMERCIAL NAVIGATION & CHANNEL IMPROVEMENT			
LOCAL PROTECTION			
ANADROMOUS FISH PASSAGE [2]			
NATIONAL RECREATIONAL AREA - FEDERAL			
NATIONAL RECREATIONAL AREA - STATE			

LEGEND

PROJECT OR PROGRAM	EXISTING OR UNDER WAY	EARLY ACTION PLAN	LONG RANGE PLAN
UPSTREAM WATERSHED PROGRAMS			
MAIN STEM OR MAJOR TRIBUTARY RESERVOIR			
POWER [1] NUCLEAR	N	N	N
POWER PUMPED STORAGE	P		P
RECREATIONAL NAVIGATION			
COMMERCIAL NAVIGATION & CHANNEL IMPROVEMENT	◁ ◁ ◁	◀ ◀ ◀	
LOCAL PROTECTION			
ANADROMOUS FISH PASSAGE [2]			
NATIONAL RECREATIONAL AREA FEDERAL			
NATIONAL RECREATIONAL AREA STATE			
NATIONAL FORESTS			

NOTES 1 EXISTING CONVENTIONAL HYDRO DAMS NOT SHOWN

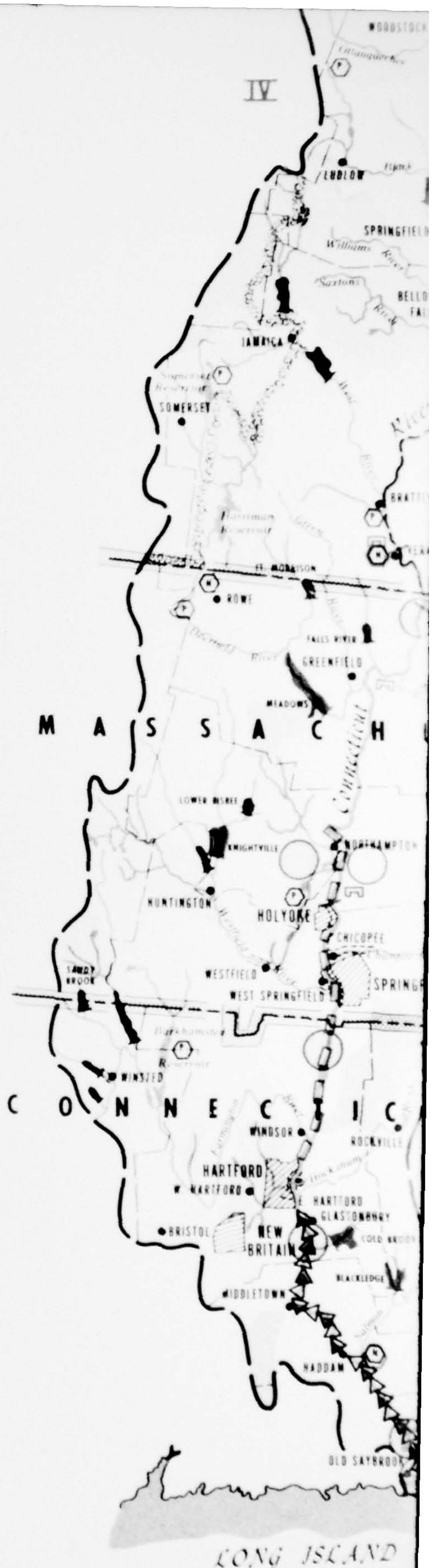
2 EXISTING POWER DAMS MODIFIED FOR FISH PASSAGE

PROJECTS AND PROGRAMS NOT SHOWN ON MAP

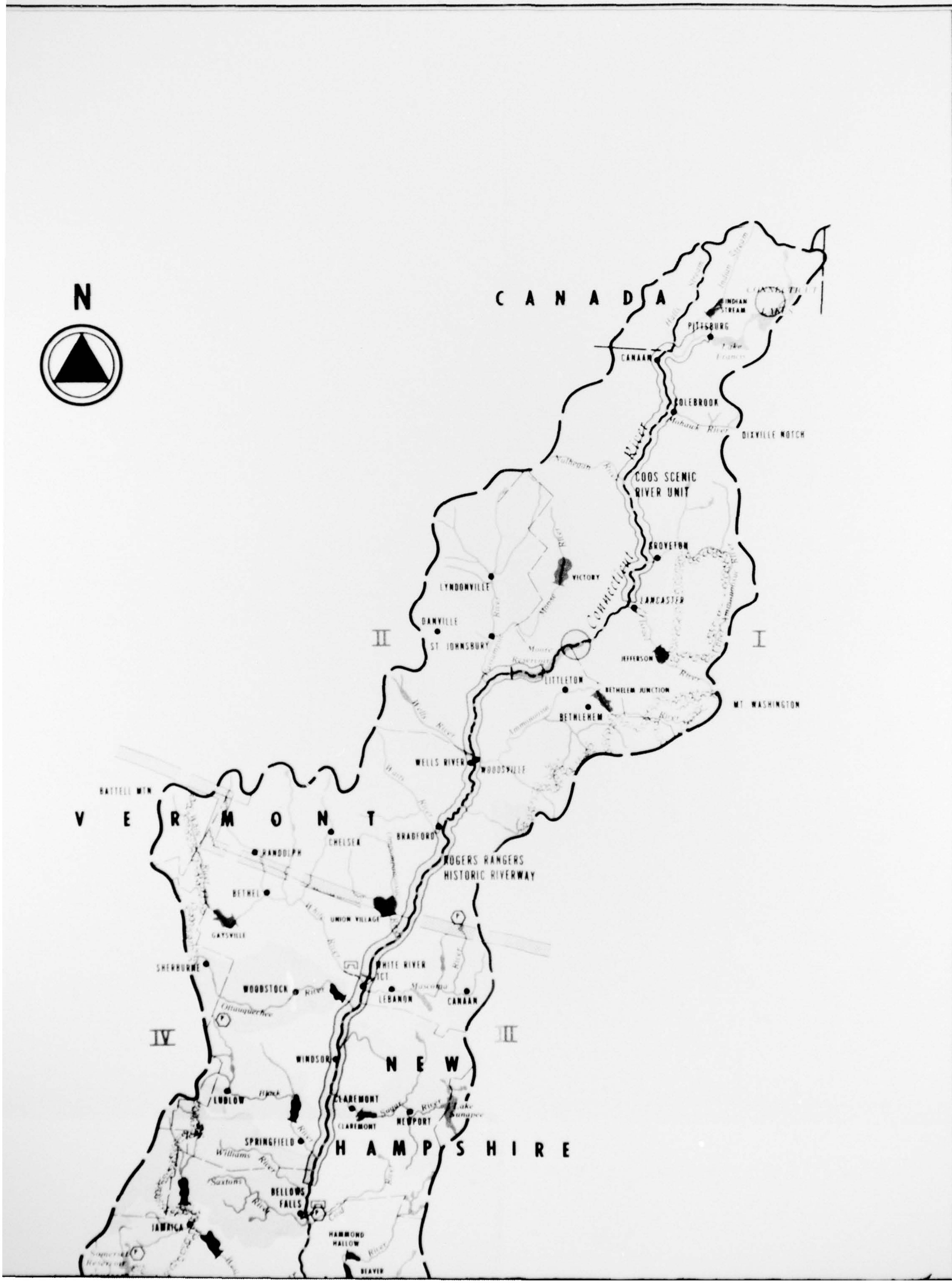
	EXISTING OR UNDER WAY	EARLY ACTION PLAN	LONG RANGE PLAN
FLOOD PLAIN ZONING	x	X	X
WATER QUALITY	X	X	X
POWER CONVENTIONAL HYDRO	X	X	X
NATURAL LANDSCAPE RIVER AREA	–	X	X
MAN INFLUENCED LANDSCAPE RIVER AREA	–	X	X
NATURAL, ARCHEOLOGICAL & HISTORIC POINTS OF INTEREST	X	X	X
FISH HATCHERIES [1]	X	X	X
WILDLIFE PROGRAMS	X	X	X
NATIONAL FORESTS [2]	–	X	X
STATE FORESTS & PARKS	X	X	X
WATER SUPPLY	X	X	X
SMALL UPSTREAM IMPOUNDMENTS	X	X	X
LAND TREATMENT MEASURES	X	X	X

NOTES 1 RESIDENT FISH HATCHERIES NOW EXIST IN BASIN
ADDITIONAL RESIDENT FISH HATCHERIES AS WELL AS ANADROMOUS
FISH HATCHERIES ARE RECOMMENDED IN EARLY ACTION
AND LONG RANGE PLAN

2 ADDITIONAL NATIONAL FORESTS LANDTAKINGS WITHIN
THE PROCLAMATION BOUNDARY



3



N
CANADA
INDIAN STREAM
PITTSBURG
Lake Francis
CANAAN
COLEBROOK
Mohawk River
DIXVILLE NOTCH
Connecticut River
Nulhegan River
COOS SCENIC RIVER UNIT
GROVETON
VICTORY
LYNDONVILLE
Moose River
LANCASTER
DANVILLE
ST JOHNSBURY
II
I
Moore Reservoir
JEFFERSON
LITTLETON
BETHLEHEM JUNCTION
MT. WASHINGTON
BETHLEHEM
Wells River
Ammonoosuc
WELLS RIVER
WOODSVILLE
BATTELL MTN
VERMONT
RANDOLPH
CHELSEA
BRADFORD
ROGERS RANGERS
HISTORIC RIVERWAY
BETHEL
UNION VILLAGE
GAYSVILLE
SHERBURNE
WHITE RIVER JCT
WOODSTOCK
LEBANON
Mascoma
CANAAN
Ottauquechee
IV
II
WINDSOR
NEW HAMPSHIRE
LUDLOW
Black River
CLAREMONT
Sugar River
NEWPORT
Lake Sunapee
SPRINGFIELD
Williams River
Saxtons River
BELLOWS FALLS
JAMAICA
HAMMOND HOLLOW
BEAVER

BASIN SUB-AREAS

LEGEND

I	UPPER BASIN	N.H.
II	UPPER BASIN	VT.
III	MIDDLE BASIN	N.H.
IV	MIDDLE BASIN	VT.
V	LOWER BASIN	MASS.
VI	LOWER BASIN	CONN.

COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION

CONNECTICUT RIVER BASIN

COMPREHENSIVE PLAN OF DEVELOPMENT

SCALE IN MILES

0 8 16 24 32 40

CONNECTICUT RIVER BASIN
COORDINATING COMMITTEE

JUNE 1970

PLATE NO. 1

4