MIDSTATE
regional planning agency

report 2

study of WATER RESOURCES

The preparation of this report was financed by an urban planning grant from the Housing and Home Finance Agency under the provisions of section 701 of the Housing Act of 1954, as amended; by a regional planning grant from the Connecticut Development Commission; and by contributions from member municipalities.

MIDSTATE regional planning agency

report 2

study of WATER RESOURCES

In August, 1964, the firm of Geraghty & Miller was retained by the Midstate Regional Planning Agency to conduct a study aimed at providing basic information needed for the orderly planning of water-supply facilities in the Planning Region. During the survey, geologic, topographic, and other resource features of the area were investigated in order to relate these to future planning programs and land-use alternatives. As an aid to surface mapping and water-well inventories, a limited amount of sub-surface exploration was undertaken by means of test borings in the various towns.

Grateful acknowledgement is made for the helpful assistance of Mr. Irwin Kaplan of the Midstate Regional Planning Agency and members of his staff. Much data on ground water and surface water were obtained from the United States Geological Survey, the Connecticut Water Resources Commission, the Connecticut Department of Health, and Dr. J. W. Peoples, State Geologist. In addition, we wish to gratefully acknowledge the co-operation of the various town and city agencies in the area.

David W. Miller — November, 1965

MIDSTATE REGIONAL PLANNING AGENCY

CROMWELL DURHAM EAST HAMPTON HADDAM MIDDLEFIELD MIDDLETOWN PORTLAND

P.O. BOX 139 MIDDLETOWN, CONNECTICUT 06458 203 347-6180

December 7, 1965

The Midstate Regional Planning Agency is pleased to submit to its member communities this Study of Water Resources for the Midstate Planning Region.

The need for the study was precipitated by an increasing urgency for sound, long range water resources planning. This is the result of a series of related major trends which have evolved over a period of years, and have in a relatively short time begun to interact with alarming consequences.

Connecticut's rapid urbanization, expanding industrialization, increased water utilizing technologies, casual water resources management and extended period of drought, have suddenly shifted our attitude from complacency to crisis.

It is now evident that there is the necessity for sound water resource planning not only to accommodate the regions future growth but to sustain our existing population as well.

It is the purpose of this report and the sincere wish of the Midstate Regional Planning Agency, that this study will accelerate the planning process by providing an initial step toward the water resource planning which is vital to the welfare and continued growth of the region.

Very truly yours,

John Lyman, Jr.
Chairman

IRWIN MOSS KAPLAN, DIRECTOR

AGENCY REPRESENTATIVES

NOVEMBER, 1965

CROMWELL	
George M. Byrnes	
Howard W. Paddock	
DURHAM	
Hugh Cox	
George M. Eames, III.,	Secretary-Treasurer
EAST HAMPTON	
Russel S. Dart	
Newton A. Clark	
HADDAM	
E. George Carlson	
John Martin	
MIDDLEFIELD	
John Lyman, Jr.,	Chairman
Sherman H. Perkins	
MIDDLETOWN	
Albert E. Carlson	
B. Ralph Gustafsson	
Howard B. Smith,	Vice-Chairman
PORTLAND	
E. Irving Bell	
James Weir	

AGENCY STAFF

Irwin M. Kaplan	Director
Harding Jones	Regional Planner (resigned 25 June 1965)
Cesar A. Garcia	Regional Planner
Geoffrey L. Colegrove	Junior Planner
Gerald M. Kagan	Summer Intern, 1965
Thomas R. Vischi	Summer Intern, 1965
Marra L. Casserino	Secretary

TABLE OF CONTENTS

TABLES

FIGURES

SUMMARY

The following paragraphs describe the basic factors that should be considered in the overall planning of water-supply development in the area. This section of the report has been broken down into two categories, surface water and ground water, and contains conclusions regarding the availability of each source and the role it may play in satisfying future domestic, industrial, commercial, and rural demands for water.

Surface Water

To date, only limited quantities of surface water have been developed in the Midstate Planning Region. Portland, Cromwell, and Middletown obtain some of their public supply from reservoirs fed by relatively small streams. In addition, some industries divert surface water for use in manufacturing. Recreation still remains one of the two major uses for streams, lakes, and ponds. This, of course, does not reduce the actual quantity of water available for domestic, industrial, or agricultural use. The other major use of surface waters in the region is the dilution of wastes from municipal and industrial sources. In some cases, this represents a consumptive use in that the water receiving effluent may be degraded in quality to a point whereby

its further use for another purpose must be ruled out. For the most part, streams in the region are of good quality, but the ability of certain rivers or stretches of rivers such as the Mattabesset to accept wastes and still maintain a reasonably high level of water quality has already been reached or surpassed.

The factors limiting the exploitation of surface waters are primarily dependent upon natural, economic, and water quality considerations. Although the Connecticut River with its tremendous volume of fresh water flows through the heart of the region, it is still untapped, except for some industrial use where the water is almost immediately returned to the stream channel. Direct pumpage from this river could alone supply many times the present and future population of the area. However, the degradation of water quality by pollution together with the high cost for treatment of surface waters from a river such as the Connecticut make it unfeasible to develop this stream to help solve public water-supply deficiencies at the present time. In addition, traditional surface-water sources have been located so that the water flows by gravity to the point of use as in the case of Middletown's Mt. Higby Reservoir. A major water-supply development from the Connecticut River would require pumpage from the source to all points of use.

The factors govering the availability of the Mattabesset River for water supply are quite similar to those for the Connecticut River. Industrial and sewage wastes have greatly affected the quality of water in this stream. However, with the proposed construction of sewer lines and a pollution control plant, which would treat much of the waste now entering the river, quality should improve markedly and the stream may offer a potential for future development.

Unfortunately, although the total runoff in streams in the region is vast when compared to water use, this resource is not evenly distributed throughout the area. The transportation of water is usually the major cost in its development and can rule out the use of a water source whose natural characteristics are quite attractive. The Salmon River, for example is a large stream of relatively good quality. It flows through the Town of East Hampton, which has long considered the development of a public water-supply system. However, the cost of transporting water from this stream to the center of population quite some distance away, together with the expense of treatment and pumping, has eliminated the Salmon River from consideration as a potential water-supply source.

On the other hand, a river such as the Coginchaug offers an almost immediate potential for direct development for either municipal or industrial water supplies. Its flow, even during extended periods of below normal precipitation, is large. Its chemical and physical quality is good although treatment by filtration would be required before direct use as a permanent public water supply. The Coginchaug has already served as an emergency water source for the City of Middletown, and its proximity to population centers in Durham and Middlefield places it within reach for consideration as a future source of supply.

The smaller streams in the Midstate Region would require construction of supplemental storage facilities before they could be depended upon for any significant quantity of water. Some of these streams have already been dammed, creating ponds or reservoirs for power purposes or direct diversion. Many are free of sources of contamination and their basins have not yet been occupied by any significant numbers of homes or highways. However, topography places certain limitations on the acceptability of a particular valley for dam and reservoir sites, and many streams in the area do not offer any potential for the construction of artificial storage. Furthermore, the rising cost of land, increasing density of buildings, and construction of major highways have, for the most part, ruled out the construction of dams and the flooding of large acreage.

In summary, the Midstate Planning Region has available abundant surface waters which offer a great potential for future development. Small diversions from less than one to two million gallons per day will probably continue to be obtained from small upland drainage basins whose streams have been dammed to store water during periods of little runoff. As the need for and the value of water rise, larger streams such as the Coginchaug and Salmon Rivers may be tapped directly not only by industry but also by public water-supply systems. Eventually, as the pressure for more water increases and urbanization takes place over a broader area, the Connecticut River itself may be tapped.

Ground Water

As shown by existing wells tapping the unconsolidated glacial deposits and the results of test drilling the Midstate Planning Region, a tremendous potential exists within the area for future ground-water development. As in the case of surface-water resources, there has been little exploitation of available ground-water sources. However, many of the limiting factors that must be considered in the latter's development are quite similar to those that must be considered for surface water.

Certain types of aquifers yield small quantities of water to individual wells. The crystalline rocks, for example, although they are of great areal extent, are only suitable for meeting limited needs such as those required for homes and farms. Large capacity municipal and industrial wells must be located in areas where permeable sands and gravels will produce substantial and dependable quantities of water for sustained periods of time. These deposits are found only in a relatively few areas and not always within economic reach of existing public water-supply distribution systems or places zoned for heavy industry. Water is only one of the many factors governing the attractiveness of a particular site for industrial development. However, for some types fo manufacturing, such as chemicals and paper, it can be a dominant one, especially for those companies which traditionally have developed their own supplies rather than purchased water from a nearby municipality.

The exploration for and development of large ground-water supplies is often a complex matter, especially in glaciated regions where the most prolific aquifers are confined to relatively small areas. The location of the most promising sites for test drilling requires geologic and hydrologic knowledge of the region and familiarity with the various techniques used in the interpretation of the topography and geography of the area.

Sub-surface investigations, using geophysical and test drilling and pumping methods, are expensive when compared to the costs of measuring surface-water resources. In addition, the ability of an area to yield ground water cannot be determined simply from the tests of the capacity of one or two wells but is dependent upon many factors not widely understood. A careful analysis must be made of the relationship of ground water to surface water, sources of recharge and discharge of individual formations, and long-term interference and water-level effects.

Water quality considerations are also important in the adaptability of a particular source of various water-supply purposes. For the most part, ground water is more highly mineralized than surface water, but the former is almost always free of suspended matter and bacteria. Also, ground water is of a uniform temperature year round, about equal to the mean annual temperature of the region. This makes it an ideal source for cooling and air-conditioning purposes. It is less likely to change in chemical and bacteriological composition than surface water because it is more protected from pollution and contamination although, in some circumstances, such chemical constituents as iron and manganese have been found to change in concentration with continued pumpage.

It is in the comparative costs of development that ground water becomes most attractive when compared to surface water. Evaluating a potential ground-water source may be expensive, but once the availability of the supply has been established and it is proven to be of satisfactory quality and quantity, only a few acres of land are required for the well development as compared with the broad area that would have to be flooded on a reservoir site. The cost of a production well tapping sand and gravel deposits at a rate of one to two million gallons per day may be as little as $25,000, a mere fraction of the cost of dam construction on a surface stream. Whereas some reservoir sites will yield water under gravity, wells must be pumped, and this is a long-term factor that must be considered in comparing the two types of water source. However, water must be pumped from some existing and proposed reservoir sites in the Midstate Region, and if rivers and streams are developed directly, here too, water would require lifting to the elevation of the area served.

The volume of ground water at any given moment exceeds the storage of water in all the rivers, streams, lakes, and ponds in the region. Computations of the amount of water stored in the unconsolidated glacial deposits alone reveal that they hold more than 65 billion gallons. Billions of gallons more are contained in the sedimentary and cryatalline rocks of the region. The aquifers are continually being replenished by precipitation as water is discharged to surface-water bodies or is withdrawn by man. However, not all of the stored water is available for use because much of it is contained in relatively impermeable formations. Although the amount of water available from the ground does not compare in quantity with the flow of the various streams in the region, individual aquifers can yield many tens of millions of gallons per day. The water requirements of the entire Midstate Region for many decades to come could be satisfied from wells tapping the unconsolidated glacial deposits of the area.

The sandstones and shales could withstand considerable more development before their safe yield is approached. Because of their widespread availability to homes and commercial establishments in Durham and Middlefield, and the relative absence of quantity and quality problems even under severe drought conditions, these formations will probably continue to bear the brunt of water development in the two towns. The dependability of the Triassic sediments as a water-supply source will in all likelihood retard any plans to construct public water-supply systems serving broad areas in this section of the region at least until the density of homes becomes great enough to overtax the ability of the formations to absorb waste and yield water.

The crystalline rocks, on the other hand, have always presented some problems as a source of water supply. The number of well failures in this relatively poor aquifer is quite large. Although much of the present population is supplied by wells tapping these formations, the safe yield of the aquifer as a whole has not been exceeded on a regional basis. However, many individual wells are overpumped especially during long dry periods. In addition, the fractures which transmit water are susceptible to pollution and contamination from septic tanks and industrial waste disposal. Thus, as population becomes more dense and these problems become more widespread, pressure for central water-supply systems increases.

An examply of this has already occurred in the Town of East Hampton where domestic water-well problems are widespread. This condition has led to action by public officials in the direction of establishing a municipal water-supply facility to serve broad areas of the Town. The population and the density of wells in the Town of Haddam, on the other hand, have not reached the point where use of the crystalline rock aquifer has created a large number of problems.

CONCLUSIONS AND RECOMMENDATIONS

In the following section are listed recommendations regarding the orderly development and utilization of water resources in the region. These recommendations are presented as a guide for the Regional Planning Agency and its member municipalities so that consideration can be given to steps which ought to be taken now to insure the dependability of adequate water supplies for the future.

General

1.) The Regional Planning Agency should set up a continuous program of monitoring water resources. Personnel of the Agency should contact public officials in each of the seven towns twice a year to obtain information on trends in public and self-supplied industrial water use, especially on new diversions, from either surface water or ground water, which amount to more than 100,000 gallons per day. It would be valuable to centralize records of such data in the Midstate Planning Region office, and any important new diversions for industrial, commercial, and public water-supply use should be located on suitable base maps. In addition, the Regional Planning Agency should maintain continued contact with federal and state agencies whose activities involve the study and control of water resources in the area. Such agencies include the Water Resources Division of the U. S. Geological Survey, the U. S. Corps of Engineers, the Connecticut Water Resources Commission, and the Connecticut Department of Health. Because these governmental bodies are continually collecting information on water resources, periodic contacts would provide Midstate with up-to-the-minute information affecting water resources.

2.) Because new water legislation, on both the state and federal levels, could have an important bearing on future planning, the Agency should continue to collect and distribute information concerning all existing and proposed programs involving pollution control and water-resource development. This should include up-to-date information on federal and state grant and loan assistance programs, eligibility requirements, and liaison where appropriate. Where proposed legislation would apparently help solve water problems in the region, support should be sought from the member towns.

3.) As the use and competition for surface-water and ground-water supplies increase within the region, it may become necessary for individual towns to pass ordinances to protect existing water users against overdevelopment of water resources. The Regional Planning Agency and the town and city governments should begin to investigate existing legislation in other areas, so that these can be used as guides for preparing similar regulations for use within the Planning Region.

4.) The water resource potential of sites which lay in regionally significant areas, such as those zoned for heavy industry or proposed for regional facilities, should be evaluated in great detail.

Town of Cromwell

1.) The Town of Cromwell is presently in need of developing a new source of water supply of at least one million gallons per day.

2.) In order to deliver this water source efficiently, a considerable amount of work is required for expansion of the existing distribution system.

3.) The most logical area for development of a groundwater supply for the town is located along the Connecticut River north of Dead Man's Swamp.

4.) If further testing north of Dead Man's Swamp reveals that ground water can not be economically developed at this site, serious consideration should be given to the purchase of water from neighboring communities.

Town of Durham

1.) The existing private water systems play a minor role in the overall distribution of public water supplies in Durham. Because of their relatively small size, the age of existing mains, and financial considerations, it is doubtful that the areas served will be expanded to supply any significant percentage of the total population in the future.

2.) Because of the availability of ground water for domestic and small commercial wells, there appears to be no immediate justification for the construction of a central water-supply system for the town. However, as population increases substantially and more pressure is placed on the development of ground water from the sandstone and shale deposits, the town will require a public water supply system.

3.) Several potential sources of supply for major water development exist in the town. One is direct diversion and treatment of surface water from the Coginchaug River. The second is ground water from the glacial sands and gravels underlying the Durham Meadows and contained in isolated ice-contact deposits in various parts of the town. These potential sources of water should be protected from contamination and pollution. Where feasible, ground-water areas should be further tested and set aside for future development.

Town of East Hampton

1.) The Town of East Hampton is presently in need of a municipal water supply system.

2.) Several sources of ground water that could be developed to serve such a system have already been pinpointed in the Town. These areas should be set aside for future development.

Town of Haddam

1.) At present, conditions in the Town of Haddam do not warrant the construction of a municipal water-supply system. However, a large potential for ground-water development for future municipal and industrial supplies exists in the glacial sand and gravel deposits along the Connecticut River. Additional ground-water exploration should be undertaken, and those areas with the most promise should be set aside for future development.

Town of Middlefield

1.) Because of the availability of ground water for domestic and small commercial wells in the sandstone and shale deposits underlying the Town of Middlefield, there appears to be no immediate justification for the construction of a central water-supply system. However, as the need for water increases, a community supply may become necessary.

2.) Large ground-water supplies have not been located in the town but more exploration in the valley of the Coginchaug River should be considered.

3.) The feasibility of using water from the Coginchaug River or purchasing water from neighboring municipal water supply systems should be investigated as an integral part of overall planning for the town.

City of Middletown

1.) The City of Middletown's existing reservoirs and River Road well field should satisfy water requirements for many years.

2.) Long-term demands for industrial, commercial, and domestic water supply could be met by wells in Sumner Brook Valley and the CANEL site. These sources should be protected for future development.

Town of Portland

1.) Although present needs for the Town of Portland can be met adequately by its reservoir and ground-water supply, a new heavy water demand for industrial use could overtax the existing system.

2.) The sand and gravel deposits contained in the buried pre-glacial rock valley which lies east of the center of Portland offer a great potential for ground-water development. This area should be explored in greater detail and sites for future wells set aside.

Topography

The Midstate Planning Region is located in two physiographic provinces of Connecticut, namely the Connecticut Valley Lowland and the Eastern Highlands. The Connecticut Valley Lowland occupies a belt through the center of the state, as much as 20 miles wide in places. It is underlain by eastward dipping sedimentary rocks which contain several interbedded basalt flows. These rocks terminate on the east against the crystalline upland area, which forms the Eastern Highlands physiographic province.

The topography of the Lowland area in which Cromwell, Middlefield, and parts of Middletown, Portland, and Durham are located is dominated by several mountain ridges having a northward trend. Higby, Lamentation, and Beseck mountains stand out in sharp relief of 400 to 500 feet above the land surface. The highest elevation, 895 feet, is found on Higby Mountain. These ridges are basalt flows and display precipitous west-facing scarps of 400 feet and gentler eastern slopes corresponding to the 15-degree regional dip of the sedimentary rocks which make up the Connecticut Valley Lowland.

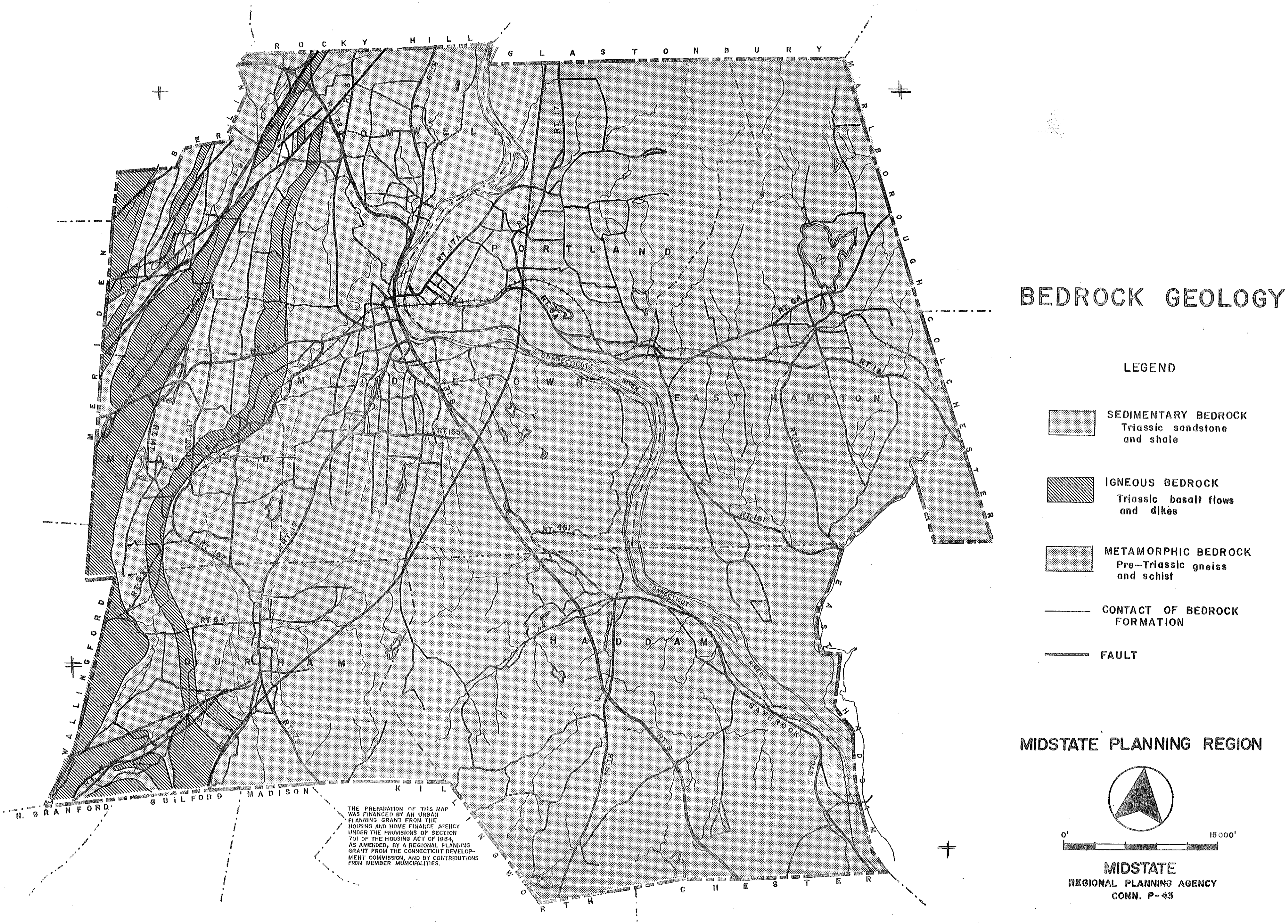
The Eastern Highlands in which the Towns of Haddam, East Hampton, and parts of Middletown and Durham are located exhibits a more maturely dissected and rugged topography. This hilly area, underlain by crystalline rock, has a relief of approximately 400 feet and reaches a maximum altitude of 894 feet above mean sea level in the Bald Hill area of East Hampton. Very steep slopes are found along the Salmon River Valley which is deeply incised in the bedrock floor.

Geology

The planning region is underlain at relatively shallow depths by several varieties of dense rocks which are referred to collectively as bedrock. The bedrock is overlain in most places by loose unconsolidated sediments and soils. Figure I is a generalized geologic map showing the major bedrock formations.

The three major rock groups which make up the crust of the earth, and which are known as igneous, sedimentary, and metamorphic rocks, are all present in the survey area. Igneous rocks are formed by cooling of molten silicate materials. They are found in the Midstate Region in the form of lava flows, sills, and dikes, the latter two having been injected into pre-existing rocks.

Sedimentary rocks, consisting of pebbles, sand grains, and smaller particles, which have been compacted and



BEDROCK GEOLOGY
LEGEND
SEDIMENTARY BEDROCK
Triassic sandstone and shale
IGNEOUS BEDROCK
Triassic basalt flows and dikes
METAMORPHIC BEDROCK
Pre-Triassic gneiss and schist
CONTACT OF BEDROCK FORMATION
FAULT
MIDSTATE PLANNING REGION
0'
15000'
MIDSTATE
REGIONAL PLANNING AGENCY
CONN. P-43
ROCKY HILL
GLASTONBURY
BERLIN
MERIDEN
WALLINGFORD
N. BRANFORD
GUILFORD
MADISON
KILLINGWORTH
CHESTER
HADDAM
EAST HADDAM
COLCHESTER
MARLBOROUGH
CROMWELL
PORTLAND
MIDDLETOWN
EAST HAMPTON
MIDDLEFIELD
DURHAM
CONNECTICUT RIVER
SAYBROOK ROAD
RT. 17A
RT. 17
RT. 66
RT. 66A
RT. 16
RT. 196
RT. 151
RT. 155
RT. 9
RT. 81
RT. 157
RT. 147
RT. 217
RT. 68
RT. 79
RT. 3
RT. 72
THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION, AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

cemented into firm rock, appear as conglomerates, sandstones, and shales. Metamorphic rocks, formed by transformation of pre-existing sedimentary or igneous rock masses by heat, stress, and deformation in the earth's crust, are present as gneisses and schists of various types.

During the Pleistocene epoch, when the great continental glaciers moved southward across the entire northeastern United States, the original topography was greatly altered by advancing and retreating ice sheets. The glaciers abraded, smoothed, polished, and scoured the bedrock outcrops and deposited rock debris known as till over the entire area. Although the glacial age can be divided into at least four stages during which unconsolidated material was laid down, the deposits in the New England area are chiefly related to those of the last and uppermost Wisconsin stage. Ice moving southward toward the Atlantic Ocean deepened the Connecticut River channel, and the present bedrock floor of the channel at Middletown is approximately 100 feet below sea level.

Retreat of the ice mass by melting resulted in deposition of sorted rock debris. Coarser material in the form of gravel and sand was deposited in stream deltas and in ice-contact features such as kame terraces. The finer sediments such as silts and clays were deposited in temporary lakes, which occupied many of the region's valleys. Large ice blocks left behind by the retreating glaciers created small depressions in the land surface upon melting. In some places, lakes and ponds now occupy these depressions.

Few geological changes have taken place since the end of the glacial period. Continued weathering and erosion have contributed to the gradual filling up of small lakes and ponds, creating swamps in the area. Rivers and streams have cut and eroded glacial deposits and formed new terraces along their banks. Small streams have modified the landscape by carving out channels in till and outwash deposits.

Climate

Precipitation records in the Midstate Planning Region are available for Mt. Higby reservoir in Middletown and the Cockaponsett Ranger Station in Haddam. Excellent records of over 100 years' duration have been made in the Middletown area. The average annual precipitation at the Mt. Higby reservoir station over the past 30 years has been 50.29 inches, with a high of 56.73 inches in 1955 and a low of 39.20 inches in 1964. Precipitation at Cockaponsett has averaged 48.98 inches, with a high of 59.05 inches in 1955 and a low of 45.26 inches in 1964.

Thus, the average for the region as a whole is roughly 50 inches per year.

Analysis of long-term precipitation data in Middletown reveals that the average rainfall is very evenly distributed throughout the year and averages 4.21 inches per month (see Figure 2). It ranges from an average low of 3.29 inches in the month of February to a high of 4.93 inches in the month of November. The minimum monthly rainfall ever recorded was 0.22 inches in September 1914 and the maximum was 15.84 inches in September 1938. A graph of the annual precipitation for the 100-year period from 1863 to 1963 is shown in Figure 3.

Snowfall in Middletown averages 37.2 inches per season and is highest (an average of 10.0 inches) in the month of January. The maximum snowfall ever recorded was 92.7 inches in the 1898-99 season. During warm weather in the spring, the accumulated snow melts rapidly, resulting in runoff similar to that produced by a heavy rainfall.

Temperatures in the Midstate region vary widely throughout the year. Records collected in Middletown show a range from a mean monthly low of 15.4°F in January to a mean monthly high of 77.7°F in July. The normal mean annual temperature is 50.2°F.

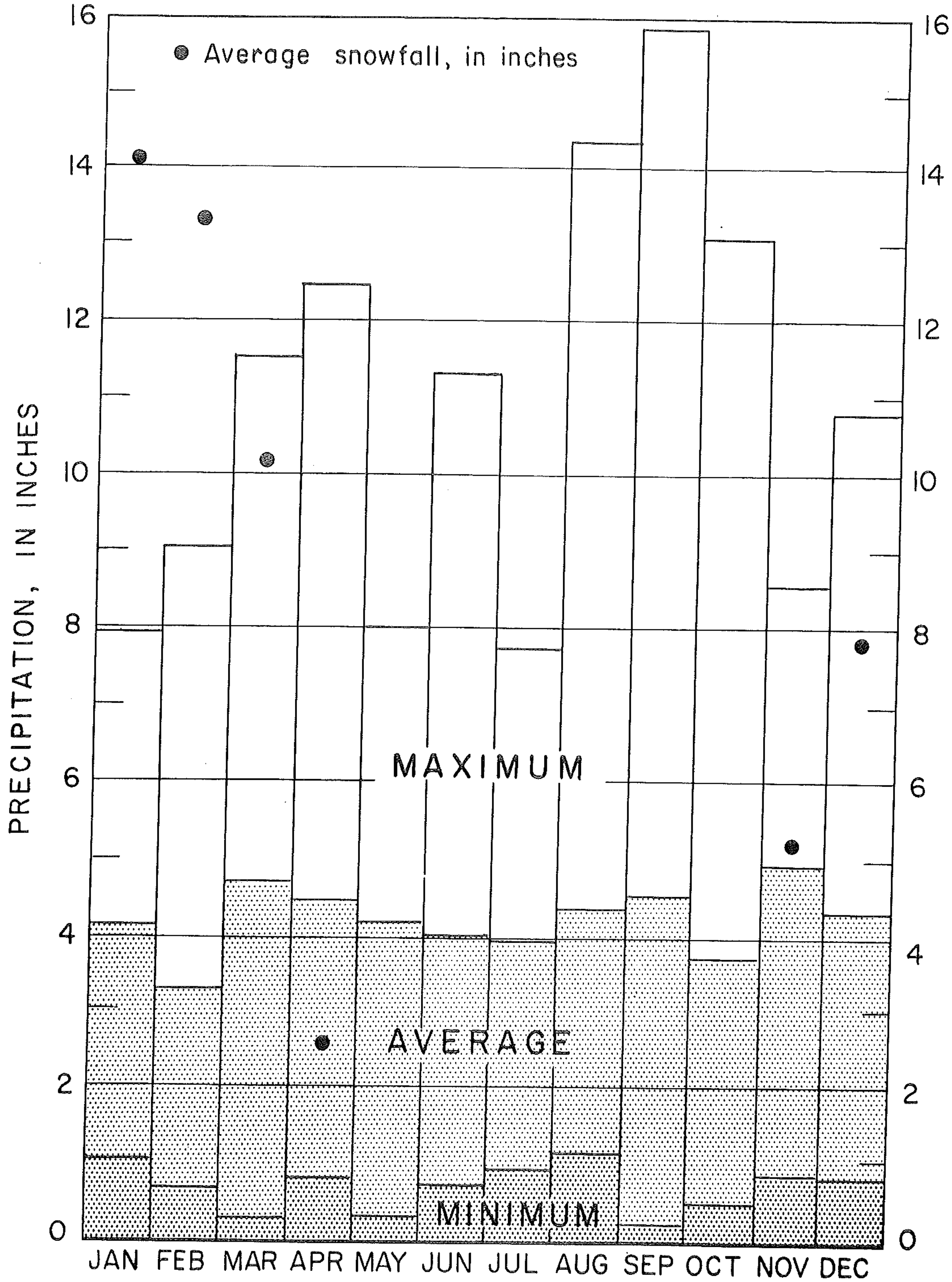


Figure 2. - Monthly maximum, average, and minimum precipitation (including snowfall) at Middletown, Conn. Period of record: 1899-1962.

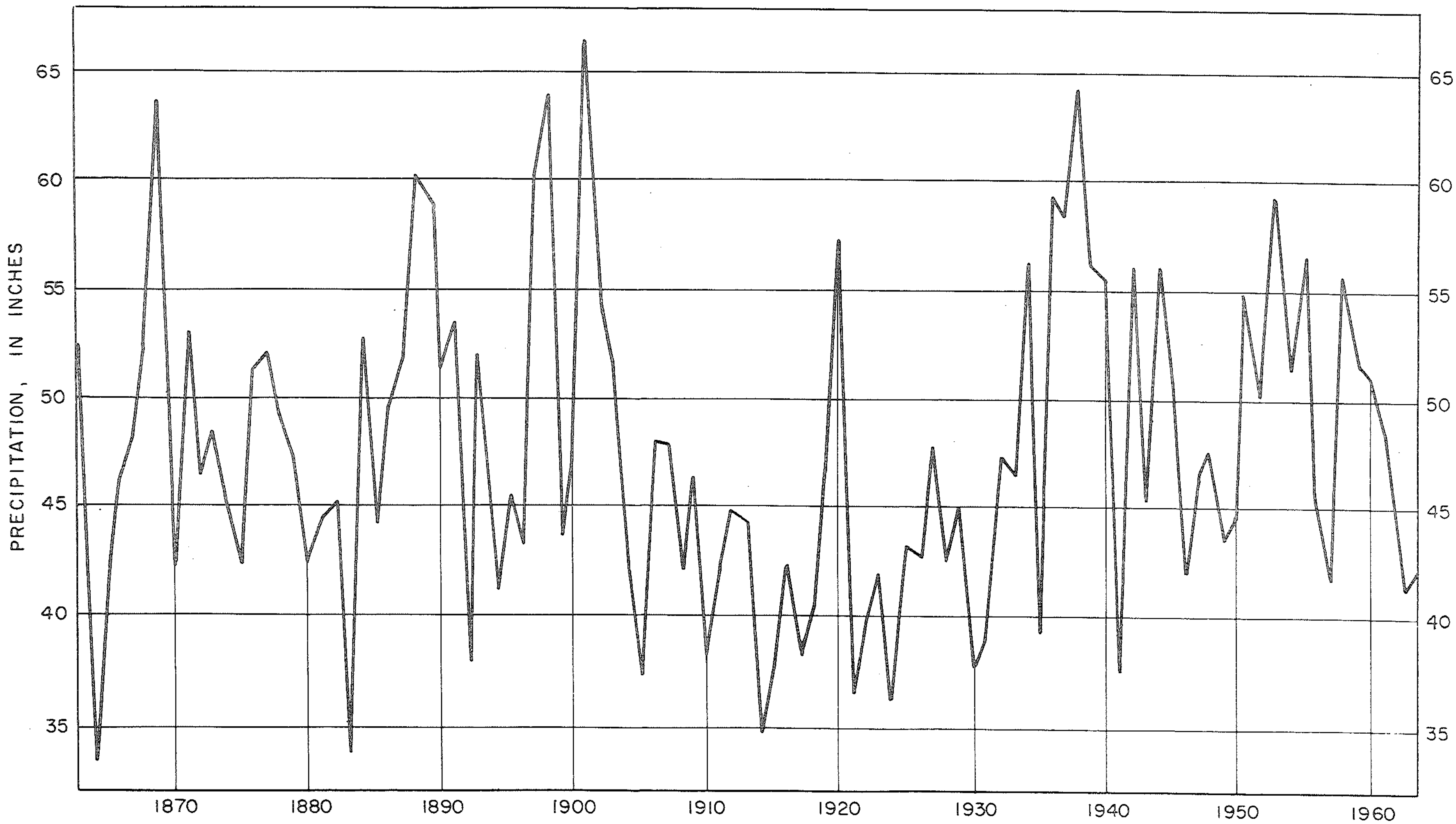


Figure 3. - Annual precipitation at Middletown, Conn. Period of record: 1863-1963.

Only a part of the total precipitation can be considered as replenishing the natural water resources of the area. According to the best estimates, at least half of the total precipitation is lost immediately to the atmosphere through evaporation and transpiration, and only the remainder is available for utilization in the form of surface runoff or replenishment of ground-water storage.

Few measurements of evaporation rates have been made in Connecticut, and none are available for the Midstate Planning Region. However, seasonal observations have been made by the Water Bureau of the Hartford Metropolitan District at its reservoir in West Hartford approximately 15 miles north of Middletown. These records show that potential evaporation from large open water bodies averages about 5.0 inches in the warm months of May, June, July, August, and September and reaches a maximum of 6.11 inches in the month of July.

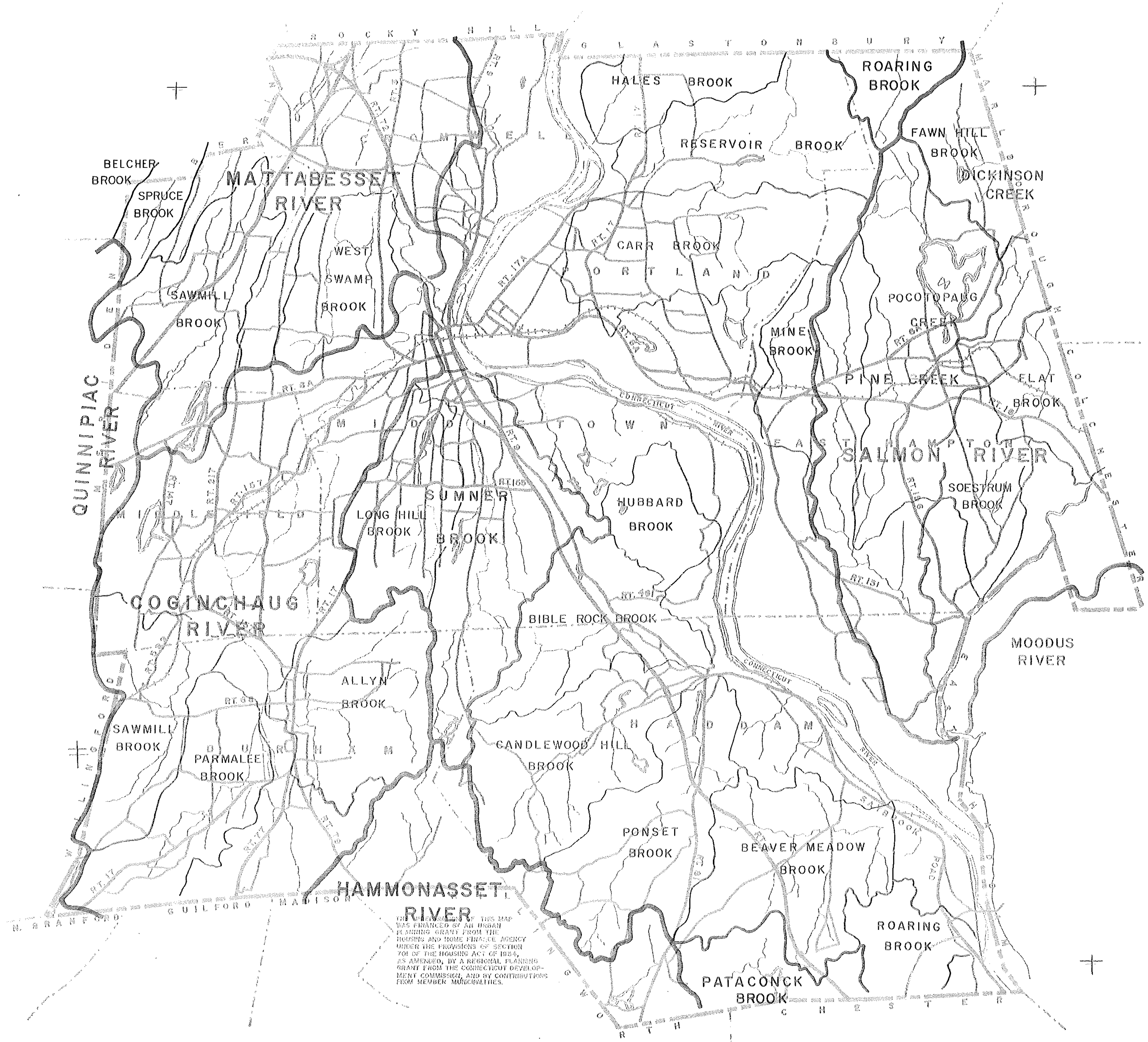
Although the rate of evaporation in the Hartford area is probably slightly different from that in the Midstate region, it gives a fair picture of conditions in the survey area. Thus, during the months of May, June, July, and August, the potential amount of evaporation from lakes and reservoirs is probably greater than the total precipitation, whereas the opposite is true during the rest of the year.

In addition to losses from open water bodies, evaporation causes losses from ground-water storage where the water table is close to the land surface in low lying or swampy areas. Water losses due to transpiration are also highest during the summer months or growing season. Thus, a large amount of water is removed from surface-water and ground-water storage during the warm season whereas most recharge takes place during the fall and winter.

SURFACE-WATER RESOURCES

Two basic sources of water are available for development in the Midstate Planning Region. One is ground water contained everywhere in the rocks and sediments beneath the land surface. The other consists of visible surface waters in the brooks, streams, rivers, lakes, ponds, and reservoirs that occur in abundance throughout the area. These surface-water bodies are contained within basins whose individual areal extent is controlled by topography. Figure 4 shows the topographic divides that delineate the various basins in the Midstate Planning Region. The dominant surface-water feature is, of course, the Connecticut River, and 92% of the region is contained within its basin. Other stream basins illustrated in Figure 4 are designated as Class 1, 2, or 3.

The Salmon, Mattabesset, and Coginchaug Rivers fall within the Class 1 category. These streams are major tributaries of the Connecticut River and each discharges its entire flow within the boundaries of the Midstate Planning Region. The Quinnipiac and Hammonasset are also shown in Figure 4 as Class 1 basins. However, only a small portion of these two basins is contained within the Midstate Planning Region area, and the rivers discharge directly into Long Island Sound. They are completely separate from the Connecticut River basin.



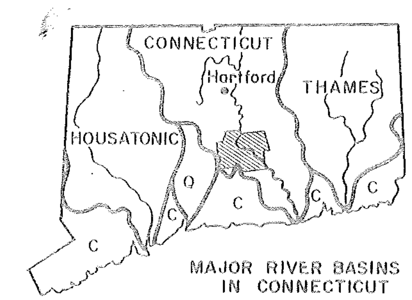
THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED, BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION, AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

DRAINAGE BASINS

LEGEND

SALMON	CLASS I BASIN
SUMNER	CLASS II BASIN
CARR	CLASS III BASIN

(BASINS SMALLER THAN TWO SQUARE MILES NOT SHOWN)



MAJOR RIVER BASINS IN CONNECTICUT

Q QUINNIPIAC
C COASTAL BASINS

MIDSTATE PLANNING REGION

0' 15,000'

MIDSTATE
REGIONAL PLANNING AGENCY
CONN. P-43

The Class 2 basins include Sumner Brook and Roaring Brook, which are minor tributaries to the Connecticut River; and Pine Creek and Dickinson Creek, which flow into the Salmon River. The remaining basins shown as Class 3 contain small tributary streams which discharge into the Connecticut or into the rivers in the Class I and Class 2 basins. The majority of the smaller basins, such as Hubbard Brook and Allyn Brook, are completely contained within the planning region.

Although stream-flow records for the region are limited, some data are available on the discharge of major streams. The largest single water source in the region is, of course, the Connecticut River, which flows by the City of Middletown carrying an average of 18,300 cubic feet per second. As measured at the stream gaging station located in East Berlin, the Mattabesset River has a mean discharge rate of 55.3 cubic feet per second, and the Coginchaug River, which is gaged at Rockfall, has a mean discharge rate of 48.5 cubic feet per second. Finally, the Salmon River, which is gaged at Old Comstock Bridge on the East Hampton-Colchester border, has a mean discharge rate of 177 cubic feet per second. Table I lists the sizes of the drainage basins shown on Figure 4 and Table 2 gives available information on stream flow.

Table 1. - Drainage basins in the Midstate Planning Region.

Basin name 1)	Total Basin Area (square miles)	Area within Midstate Planning Region square miles	% of basin
Connecticut River Basin (West Bank)			
Mattabesset River	67.7	21.3	32
Belcher Brook	5.4	0.1	1
Sawmill Brook	6.8	6.5	96
Spruce Brook	3.3	1.0	31
West Swamp Brook	3.3	3.3	100
Coginchaug River	38.7	35.0	91
Allyn Brook	5.6	5.6	100
Parmalee Brook	5.2	4.7	91
Sawmill Brook	5.1	4.8	94
Sumner Brook	12.8	12.8	100
Long Hill Brook	4.8	4.8	100
Hubbard Brook	2.5	2.5	100
Bible Rock Brook	5.3	5.3	100
Candlewood Hill Brook	6.8	6.8	100
Ponset Brook	5.4	5.4	100
Beaver Meadow Brook	6.9	6.9	100
Roaring Brook	2.8	2.4	86
Pataconck Brook	14.7	2.7	18
Connecticut River Bank	17.6	17.6	100

1) Sub-basins indented

Table 1. - (continued)

Basin name 1)	Total Basin Area (square miles)	Area within Midstate Planning Region square miles	% of basin
Connecticut River Basin (East Bank)			
Salmon River	128.7	29.9	23
Dickinson Creek	15.0	4.2	28
Fawn Hill Brook	3.9	2.7	69
Flat Brook	2.5	2.3	92
Pine Creek	15.8	15.8	100
Pocotopaug Creek	8.9	8.9	100
Soestrum Brook	2.9	2.9	100
Moodus River	16.2	0.5	3
Roaring Brook	25.7	1.6	100
Hales Brook	3.9	2.9	74
Reservoir Brook	6.3	6.2	98
Carr Brook	6.8	6.8	100
Mine Brook	2.2	2.2	100
Connecticut River Bank	14.6	14.6	100
Connecticut Coastal Basins			
Hammonasset River	-	5.5	-
Quinnipiac River	-	0.7	-

1) Sub-basins indented

Table 2. - Summary of stream flow data in the Midstate Planning Region

Stream Gaging Station	Period of Record	Drainage area above gage	Maximum Flow Quantity (cfs)	Maximum Flow Date	Minimum Flow Quantity (cfs)	Minimum Flow Date
Connecticut River near Middletown	Aug. 1928 - Sept. 1958	10,870	267,800	3-21-36	2,860 1)	-
Salmon River near East Hampton	July 1928 - Sept. 1964	105	12,400	9-21-38	1.0	10-31-35
Mattabesset River at East Berlin	Oct. 1961 - Sept. 1964	42	2,220	3-13-62	18	8-27-62
Coginchaug River at Rockfall	Oct. 1961 - Sept. 1964	34.8	1,100	3-13-62	0.6	8- 5-62
Partial Records 2)						
Parmalee Brook near Durham	1960 - 1964	2.8	400	3-12-62	.27	9-4-63
Candlewood Hill Brook near Higganum	1960 - 1964	3.79	-	-	.07	9-12-63
Ponsett Brook near Higganum	1962 - 1964	5.70	180	3-12-62	.26	9-12-63
Flat Brook near East Hampton	1960 - 1964	2.43	-	-	.05	9-11-63

1) Minimum weekly average Aug. 30 - Sept. 5, 1953.

Source: U. S. Geol. Survey, Hartford, Conn.

2) Only spot measurements available.

The most significant hydrologic data for a particular stream are those relating to fluctuations in stream flow. If an industry or municipality plans to take water directly from a river, the safe yield that can be relied upon is determined by the low-flow characteristics of the stream. Figure 5 illustrates the variation in stream flow in the Coginchaug River from season to season. The uppermost curve is a plot of the average rate of discharge per month, expressed in millions of gallons per day. The middle curve shows fluctuations of the water level in an observation well in Middlefield which is discussed in the groundwater section of this report. The bottom graph depicts monthly precipitation in inches at the Mt. Higby weather station.

It can be seen from the graphs that flow in the river is highest during the early spring months, when it amounts to as much as a hundred million gallons per day, due to heavy runoff and melting snow. It is lowest during the summer when rates of evaporation and transpiration are high. It should be noted that the low flows occur even in months of above-average precipitation. For example, June 1962 was a month of relatively high rainfall and yet the downward trend of the Coginchaug River discharge curve continued during that period. Thus, although rainfall in a normal

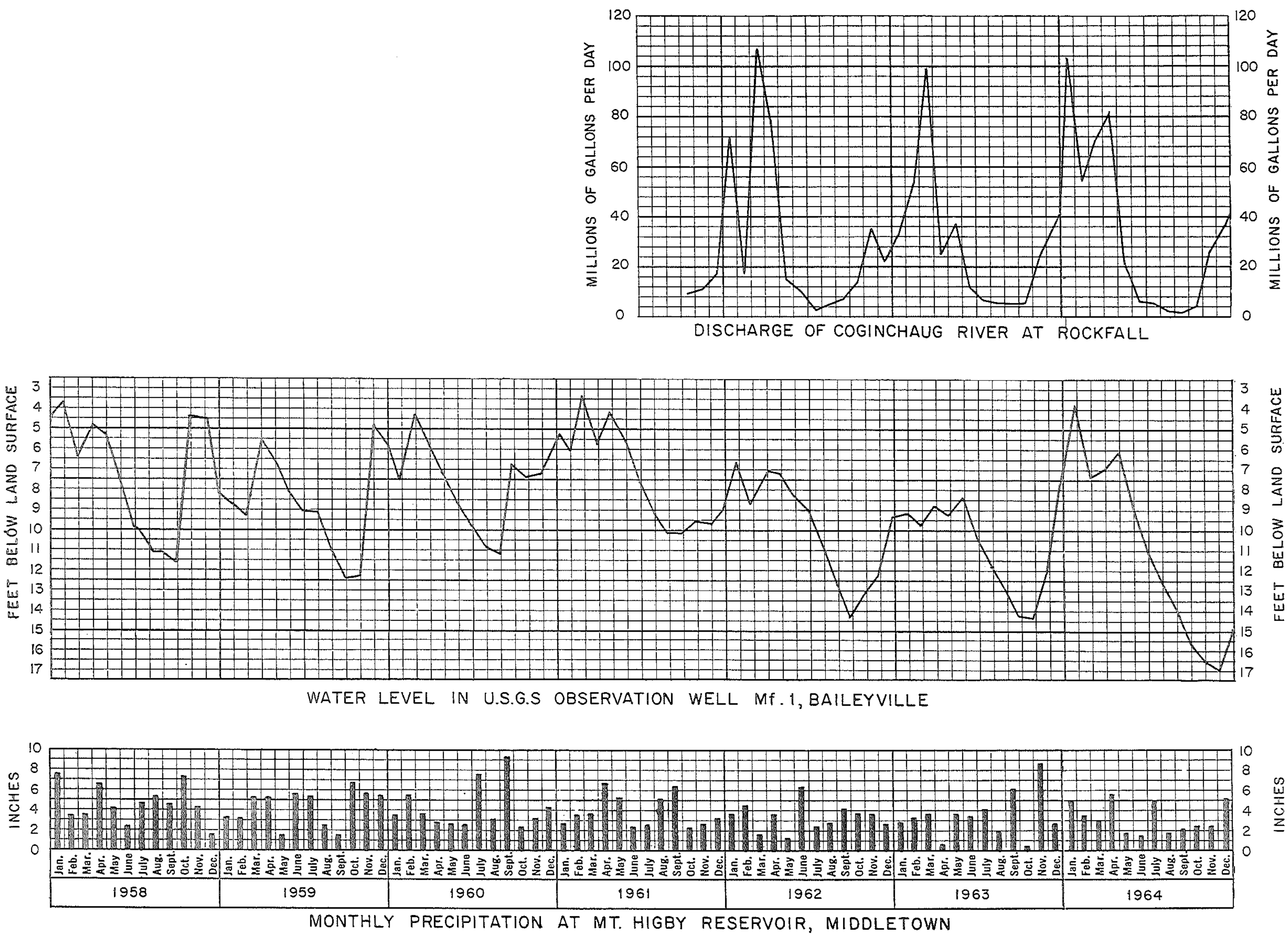


Figure 5. - Comparison of monthly precipitation at Mt. Higby Reservoir with water level in observation well Mf 1 at Baileyville, Conn., and discharge of Coginchaug River at Rockfall, Conn.

year in the Midstate Region is more or less evenly distributed, the flow of streams varies considerably. As mentioned previously, seasonal runoff characteristics are also influenced by such factors as the geology of the drainage basin and even the duration of a particular storm.

Ponds, lakes, and reservoirs store surface water, and releases from such storage can supplement stream flow during periods of little runoff. Numerous natural and artificial impoundments are located within the Midstate Planning Region. The majority of these water bodies are artificial impoundments, but a few water bodies, especially in the area underlain by crystalline rocks, were formed naturally by post-glacial conditions. The occurrence of surface-water bodies in Connecticut as well as in the other New England states is related to pre-glacial bedrock geology, modified by glacial erosion and deposition.

There are over one hundred ponds, reservoirs, and lakes in the project area. Twenty major water bodies, 20 acres or larger, have a total surface area of 2.2 square miles and occupy approximately 1.1 percent of the 194.3 square miles in the Midstate Region.

The 20 major water bodies range in size from 20.5 acres (Pameacha Pond) to 511.7 acres (Pocotopaug Lake), with an average depth of from 2.8 feet (Babcock Pond) to 59 feet (Portland Quarry). The total storage volume for the 20 major surface-water bodies is approximately 4,334 million gallons. Pocotopaug Lake has the largest storage volume (approximately 1,884 million gallons).

Surface-water bodies in the Midstate project area are used for municipal and industrial purposes and for a variety of recreational activities. The City of Middletown, the largest single municipal water user, drew 2.7 million gallons per day from Mt. Higby Reservoir (including Roaring Brook Reservoir) and Laurel Brook Reservoir during a period of peak water demand in 1963. A few lakes and reservoirs, like Turkey Hill Reservoir, experience severe fluctuations in water level due to industrial usage. Thirteen of the water bodies larger than 20 acres are stocked with game fish by the State Board of Fisheries and Game.

Closely related to the origin and present status of ponds and lakes in the Midstate Region is the occurrence of wetlands in the form of inland swamps and bogs. Wetlands are defined as those areas where the ground-water level approaches or covers the surface of the land. These surface features, such as Durham Meadows, have poorly developed drainage patterns owing to rapid deposition of unsorted deposits by a retreating continental ice mass. In the Midstate Region, 4.5 square miles exist as swamps and bogs. This is 2.3% of the entire project area and 2.1 times as much surface area as is covered by lakes, ponds, and reservoirs that are larger than 20 acres.

The most important uses which the wetlands in the Midstate project area serve are those of flood protection (by ponding large volumes of surface runoff), water table recharge, and wildlife conservation. Several areas in the Midstate project area are particularly important for this latter use. The U.S. Dept. of the Interior lists Round Meadow, Boggy Meadow located north of Middletown, and Wangunk Meadow in Portland as being of high value to waterfowl conservation. Dead Man's Swamp, north of Middletown, and Durham Meadows in the southwest portion of the project area are of moderate value as waterfowl conservation areas.

One important factor in the consideration of a stream or lake as a potential source of water supply is the physical, chemical, and bacteriological quality of the water. Streams, lakes, and reservoirs in the Midstate area contain water which generally has less than 100 ppm (parts per million) of total hardness and relatively low total dissolved solids. At times, however, iron and manganese concentrations are somewhat high and the water can be corrosive.

During periods of low flow or after heavy rainstorms, color and turbidity become high in many streams and lakes in the region. Filtration would be required before such sources could be used for a public water supply. Although the degree of bacteriological contamination of the streams varies considerably from season to season and place to place, the raw water in all of the major streams would require chlorination and, in many cases, filtration before it would be acceptable for municipal use.

GROUND-WATER RESOURCES

The source of recharge to the water-bearing formations in the Midstate Region is precipitation. The average annual precipitation, which amounts to about 50 inches, is equivalent to more than two million gallons of water falling on each square mile of land surface each day of the year. However, more than one-half of this quantity is lost to the atmosphere by evaporation and transpiration. The remainder is available in the form of overland runoff or accretions to ground-water storage.

Water levels in wells, whether they tap water-table or artesian aquifers, fluctuate more or less continuously in response to changes in rates of natural recharge or discharge. In much the same way that stream flow is greatest in early spring, ground-water levels are also highest during this period. They then decline during the summer because very little ground-water recharge takes place during the growing season. After prolonged periods of above-normal precipitation, ground-water levels will usually be at a higher elevation than after a severe drought. In the Midstate Region, for example, long-term records of ground-water levels in selected wells show a seasonal fluctuation of several feet. Water-level measurements in an observation well tapping shallow glacial till in the Beseck Lake area have shown a high of 256.88 feet MSL in April 1951 and a low of 243.08 feet MSL in November 1964. In addition, this well has a seasonal fluctuation which averages 7.9 feet. A graph of water-level changes in this well, referred to as Mf 1 in U.S. Geological Survey records, is presented in Figure 5 along with the precipitation records obtained at Mt. Higby Reservoir and stream-flow records from the Coginchaug River.

Basically, there are three types of water-bearing aquifers in the Midstate Planning Region. One consists of hard metamorphic and crystalline rocks which make up the highlands. These formations, because of their dense character, yield only small quantities of water to wells. They have virtually no intergranular porosity, except where altered by weathering, and ground water is contained only in fractures of relatively limited areal extent. Their storage capacity is small, and the success of well drilling is dependent upon the number and character of fractures encountered by the bore hole. Because of the irregularity in the occurrence of fractured zones in the crystalline rocks, two wells with similar construction and located within a few tens of feet of each other can have entirely different yields. For the most part, most large openings in the crystalline rocks are confined to the first few hundred feet of depth, and few large water-bearing fractures are encountered more than 300 feet below land surface.

As mentioned previously, recharge to all the ground-water aquifers in the region is primarily derived from precipitation. Overland runoff in the crystalline rock areas is considerably greater than that found in basins mostly underlain by glacial sands, gravels, and clays. The primary reason for this is the limited capacity of the crystalline rocks to store and transmit water. This factor has a definite effect on the safe yield of wells tapping the crystalline rocks. Although individual wells can be pumped at rates of up to 50 gpm (gallons per minute) for short periods of time, the long-term capacity averages about 5 gpm or about 5,000 gallons per day. An inventory of 89 wells constructed in the crystalline formations in the Midstate Region reveals that the yield of individual wells ranges from 1 gpm to 100 gpm. However, reported yields of more than 10 gpm for most crystalline rock wells are based on short pumping tests of several hours' duration conducted by the driller upon completion of the well. They do not represent the long-term capability of the individual well to produce water. Actually, it is doubtful whether the majority of wells in the region tapping the crystalline rocks can be pumped continuously at rates of more than a few gallons per minute from year to year.

Because the water-bearing zones in the crystalline rocks are relatively shallow, these formations are affected by extended periods of below normal rainfall. Natural fluctuations in the water table or piezometric surface may be large, and heavy pumping during dry periods may lower pumping water levels below the water-bearing zones. When this occurs, the crystalline rock formations are actually being drained, well yields decline, and in many cases, the ability of the bore hole to produce water even for short periods of time is much less than the capacity of the pump set in the well. Under such conditions, it is of little value to lower the intake of the pump because the safe yield of the well already has been exceeded. In addition, the chances of encountering more water-bearing zones by deepening wells are remote. A study of records in the Midstate Region indicates that existing wells drilled into the crystalline rocks range in depth from 65 feet to 500 feet, with an average depth of 168 feet.

The second major type of aquifer in the Midstate Planning Region consists of sandstone and shale formations of Triassic Age. All of these rocks were deposited originally as unconsolidated sediments. Water in these formations is contained in bedding planes and fractures. However, some sandstones contain a small amount of water in intergranular pores where the cementing material has been dissolved or was never deposited. Because of their greater storage capacity and ability to transmit water, the Triassic rocks represent a much more important aquifer in the region than the crystalline rocks. Although an inventory of 98 wells in the area shows that the average reported for the crystalline rocks, studies of the long-term dependability of Triassic wells indicate that few of them go dry even during extended drought periods. The reported yield of sandstone and shale wells averages about 5 gpm. However, this figure, derived from existing well records, more likely reflects the average capacity of domestic well pumps in the area rather than the ability of the sedimentary rocks to furnish water.

During the course of this investigation, a long-term controlled pumping test was conducted at the site of a test well located in the Town of Cromwell's well field adjacent to Route 9. This well taps the sandstone and shale beds underlying the site. The test revealed that the well, which is 300 feet deep, can produce water continuously for several months at a time at a rate of 75 gpm. Data obtained from pumping tests conducted in Middlefield and Middletown indicate that several other sandstone and shale wells in the region have long-term safe yields of as much as 70 to 100 gpm, or about 100,000 to 150,000 gallons per day.

The third and most important aquifer in the Midstate Planning Region is represented by the unconsolidated sands and gravels laid down in bedrock valleys during the glacial epoch thousands of years ago. Some sands, gravels, and clays are of relatively recent age, having been deposited by existing streams in temporary channels. Where the beds of sand and gravel are well sorted and relatively free of fine silt and clay, they tend to be extremely permeable. In the unconsolidated formations, water is contained in the interstices between the individual grains of sediment. Depending upon the thickness and depth of the aquifer, yields of more than several hundred gallons per minute can be obtained from individual wells.

Because the unconsolidated glacial deposits offer the most promise for development of large municipal and industrial water supplies, major emphasis in this study was placed on the mapping and testing of this type of aquifer. The results of the test drilling undertaken for the Midstate Planning Agency are described in the next section of the report. Data on other test borings and wells in the region reveal that the thickness of the unconsolidated materials overlying bedrock varies from a few feet in areas underlain by till to as much as 200 feet in places adjacent to and underlying the Connecticut River. The municipal wells drilled for the City of Middletown along River Road are an example of the ability of the glacial deposits to yield large quantities of water to single wells.

During February 1965, a long-term pumping test was conducted at Middletown's Production Well 1, which is located about 150 feet north of the bank of the Connecticut River. The well is 57 feet deep and 18 inches in diameter. It can produce water at a rate of two million gallons per day. Similar examples of high capacity wells tapping glacial sands and gravels are to be found at the Hartford Research Center (CANEL) site, where individual well yields are reported to be as much as 1,570 gpm, and in Portland, where the municipal well has a reported yield of 400 gpm with a pumping water level of only 10 feet below land surface.

In summary, the crystalline rock aquifers have a limited potential for ground-water development. Yields of individual wells in these formations are small, but are usually sufficient to satisfy domestic requirements except in long periods of below normal rainfall.

The Triassic sandstones and shales are a more dependable source of water for individual homes, and in many places these formations will yield enough water to supply small commercial and industrial wells. The sand and gravel aquifers are greatly limited to their areal extent, but where they are sufficiently permeable and where depth and thickness are adequate, they offer the greatest potential for large municipal and industrial ground-water developments.

In general, ground water in the region is of good quality. However, the mineral concentrations in ground-water in the region are greater than those found in surface waters. The total hardness of wells tapping the glacial sands and gravels is usually more than 100 ppm (parts per million). Relatively high concentrations of iron and manganese have been encountered in water from some sand and gravel wells. For example, the City of Middletown is obliged to reduce the iron and manganese content of the River Road wells before the water is put into the City's system. Water from the Triassic rocks is relatively hard and often contains objectionable amounts of hydrogen sulfide, which imparts a disagreeable odor to the water. The crystalline rock areas yield water somewhat softer than that obtained from other major aquifers in the region, but locally these rocks yield water which is high in iron and manganese.

Few cases of bacterial contamination have been found in the sand and gravel and Triassic aquifers. However, in some locations where wells in the crystalline rocks are in close proximity to septic tanks or polluted surface streams, abnormally high bacteria concentrations have been encountered.

GROUND-WATER POTENTIAL OF GLACIAL DEPOSITS

Because it is the most important aquifer in the region and yet is relatively unexplored, special consideration was given to the glacial sand and gravel deposits that occur within each town or city in the Midstate Planning Region. To help in this analysis, some of the funds for the project were used to carry out subsurface exploration by means of small-diameter test borings. This work, which was carried out by Water Exploration and Development Corp. of Hartford, Conn., consisted of drilling 2-1/2-inch diameter, cable tool, cased holes to establish the lithology of the unconsolidated sediments and their saturated thickness. In some cases, drilling reached the bedrock floor of the valley in which the well was located, but in others, refusal was encountered because of boulders or hard till layers. The result of this drilling is given in Table 3. Well locations are given on the maps accompanying the text which also show the occurrence of the various types of glacial deposits.

Locations for the various borings were chosen on the basis of existing information available in each town or city and on geologic and hydrologic considerations. Before any sites were picked for testing, a field survey was conducted in each community in order to

Table 3. - Logs of test borings, Midstate Planning Region.

1. Cromwell, December 1964.

Depth (ft.)	Thickness (ft.)	Description
0 - 6	6	Sand, fine, brown with silt
6 - 26	20	Sand, fine, brown to grey
26 - 36	10	Sand, coarse, brown, and small gravel, little silt
36		Refusal

2. Portland, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 6	6	Silt, reddish-brown and fine sand
6 - 15	9	Sand, fine, and silt, grey
15 - 43	28	Sand, fine grey
43 - 57	14	Sand, coarse, and small to medium gravel, reddish-brown
57		Refusal

3. Middlefield, December 1964.

Depth (ft.)	Thickness (ft.)	Description
0 - 11	11	Sand, coarse, brown and fine gravel
11 - 25	14	Sand, silt, and small gravel
25 - 27	2	Sandstone

4. Haddam, December 1964.

Depth (ft.)	Thickness (ft.)	Description
0 - 6	6	Gravel, medium
6 - 16	10	Sand, medium to coarse, and gravel
16 - 26	10	Gravel, medium, and some coarse sand
26 - 42	16	Sand, coarse, and some gravel
42 - 65	23	Sand, medium to coarse, and little gravel
65		Refusal

5. East Hampton, December 1964.

Depth (ft.)	Thickness (ft.)	Description
0 - 10	10	Sand, medium to coarse, brown
10 - 21	11	Sand, medium to very coarse, brown, and small to medium gravel
21		Refusal

6. Durham, December 1964.

Depth (ft.)	Thickness (ft.)	Description
0 - 32	32	Sand, fine to medium, with silt and clay and trace of gravel
32 - 45	13	Silt and clay with some fine sand and trace of gravel
45 - 50	5	Sand, fine, with some silt and clay
50 - 60	10	Sand, fine to coarse, and gravel with trace of silt
60 - 66	6	Sand, fine to coarse
66		Refusal

7. Cromwell, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 8	8	Sand, fine to medium, brown, and gravel
8 - 33	25	Sand, fine to medium, and silt and clay (till)
33 - 89	56	Sand, as above, some gravel and silt (till)
89		Refusal

8. Portland, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 11	11	Topsoil, silt and clay
11 - 21	10	Sand, fine, light brown to grey
21 - 26	5	Silt and clay, dark grey, trace of fine sand
26 - 80	54	Sand, fine grey
80 - 81	1	Sand, fine to medium, and fine to coarse gravel (till)
81		Refusal

9. East Hampton, January 1965

Depth (ft.)	Thickness (ft.)	Description
0 - 14	14	Sand, medium, and organic material, trace of fine and coarse sand
14 - 18	4	Sand, fine to medium, some silt and organic material
18 - 24	4	Clay, silty, grey
24 - 28	4	Sand, coarse to very coarse, with silt and small gravel
28 - 37	9	Sand, coarse to very coarse, and small gravel
37 - 40	3	Same as above with fine sand and silt
40 - 54	14	Sand, very coarse, and small gravel, little fine and medium sand
54		Refusal

10. Middlefield, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 11	11	Red sand, silt and clay

11. Durham, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 8	8	Sand, fine to coarse and small gravel
8 - 17	9	Sand, fine to coarse
17 - 42	25	Clay and trace of fine sand
42		Refusal

12. Durham, January 1965.

Depth (ft.)	Thickness (ft.)	Description
0 - 43	43	Silt and clay, red, trace of fine to medium sand
43 - 54	11	Sand, fine, and silt and red clay
54		Refusal

map the glacial deposits and to gather data on wells in the area. If a particular location looked promising and sufficient information was already available for assessment of the potential for ground-water development, the area was not chosen for testing. However, if it appeared that a small-diameter boring would add to the knowledge of the region, a site was selected for drilling.

Several types of glacial deposits are shown on the maps of surficial geology. The most widespread is till, which consists of materials ranging in size from clay to boulders. Till is characterized by its poor sorting, angular or sharp-edged fragments, and compact, partly indurated deposits. Till has a very low ground-water potential because of the relatively impermeable mixture of clay, sand, and boulders. Locally, however, it may contain enough permeable sand to supply shallow domestic dug wells.

Glacial outwash deposits were formed by streams flowing from the terminal area of stationary or receding ice masses. These streams transported silt, sand, and gravel and deposited these materials in valleys beyond the ice front. Glacial outwash materials are characterized by an abundance of sand and gravel, locally developed stratification and sorting, and wide distribution in the broad, low relief valleys of the Triassic lowlands. These deposits have a moderate to high ground-water potential.

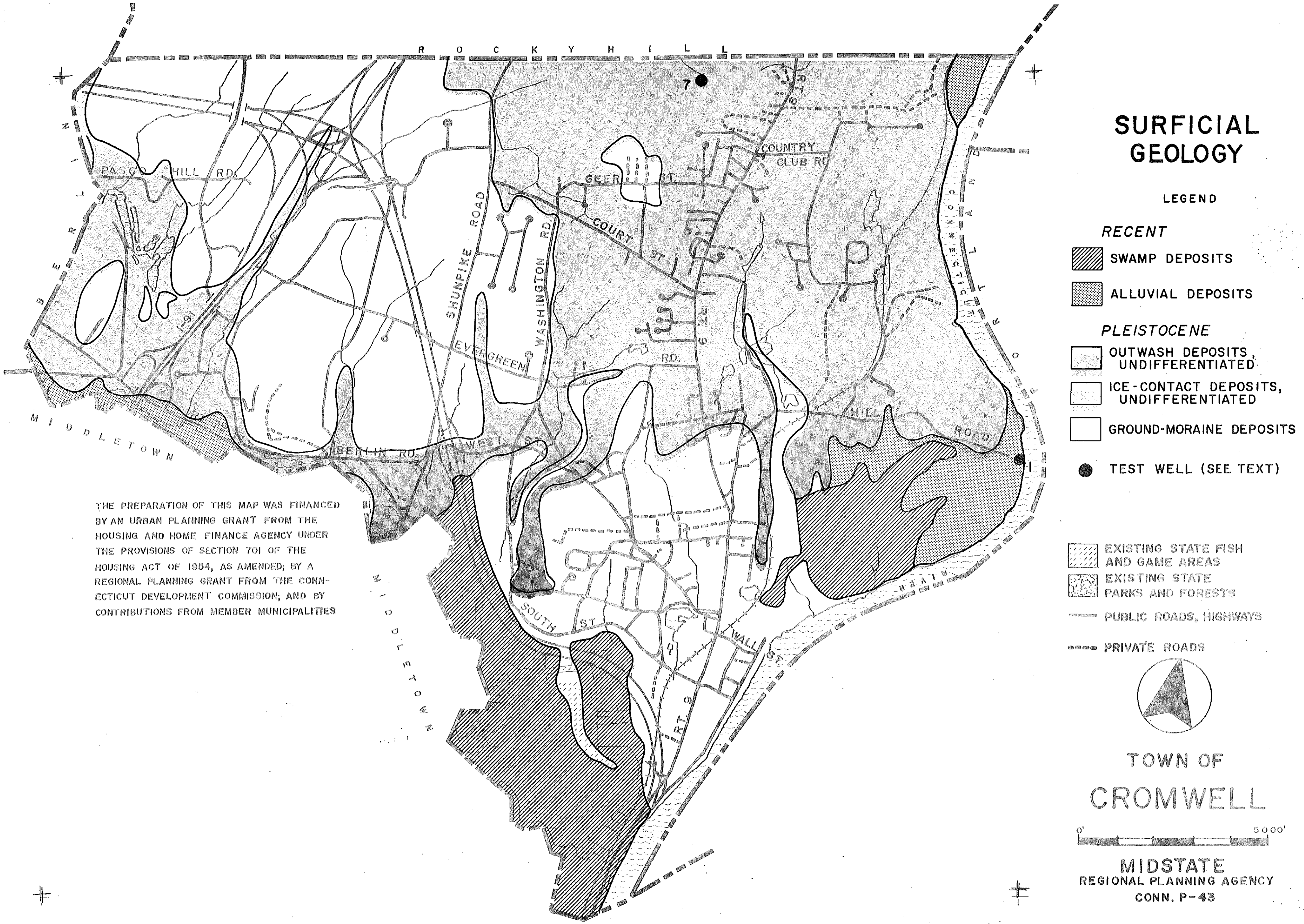
Ice contact deposits occur as kames in the Midstate Planning Region, and due to their high permeability and localized thickness, offer an excellent potential for ground-water development. Kame deposits were formed by marginal melt-water streams which flowed at or near the contact between the glaciers and the bedrock valley walls. These streams deposited their loads of sand and gravel in stratified terraces and deltas along the contact zones. As the ice masses occupying the valleys melted, kame deposits were formed at succeedingly lower levels along the valley sides. Some kame deposits, especially in the Triassic lowland valleys, merge with outwash and till deposits, and, in many areas, have been reworked by post-glacial stream action. Due to the large number of small, steep-walled valleys in the eastern crystalline highlands, there were many areas naturally adapted for ice contact deposition.

Alluvial deposits consist mainly of clay, silt, and sand laid down in the channels and flood plain areas of streams and rivers. Alluvial sands and gravels have a high potential for ground-water development. Since the retreat of glacial ice masses, the rivers and streams have been at work eroding and transporting the rock debris of the glacial period. Alluvial deposits occur within present or past flood plain limits, and the Connecticut River valley contains the largest area of alluvial deposits in the Midstate Planning Region.

Lake deposits consist predominantly of silts and varved clays deposited in standing bodies of water behind temporary natural dams of glacial debris and isolated ice blocks. They have a very poor ground-water potential because of their fine-grained character. Swamp deposits consist of peat and organic muck and occupy areas of poor drainage. In the Midstate Planning Region, swamp deposits occur behind natural levees on the flood plains of the major streams and rivers, in natural bedrock depressions, and in areas of glacially interrupted drainage. Swamp deposits are highly impermeable and are devoid of ground-water potential.

Town of Cromwell

The surficial deposits which cover the eastern portion of the Town of Cromwell are characterized by a relatively thin layer of outwash deposits. In only a few places are these deposits permeable or thick enough to use as



THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES a source for ground water. For example, municipal wells in the valley of Dividend Brook tap shallow outwash deposits with an average thickness of about 40 feet. Beneath these permeable beds lies a sequence of till, silt, and clay, the silt and clay having been deposited in temporary glacial lakes. Well records indicate that the total thickness of the unconsolidated materials is over 200 feet in places.

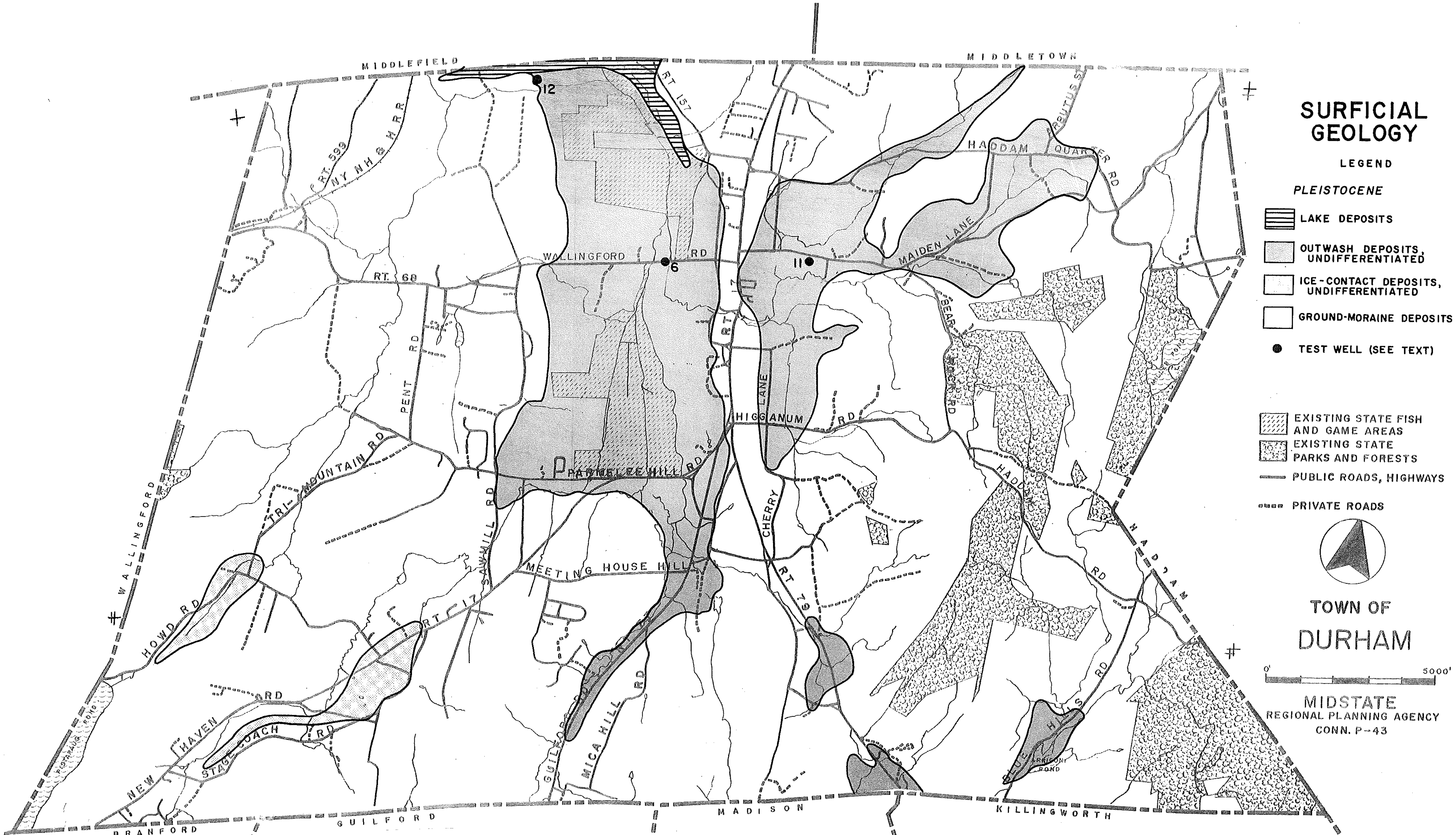
Two test borings were drilled in this locality for the Midstate Planning Agency. The first was located along the Connecticut River north of Dead Man's Swamp. This well penetrated 36 feet of unconsolidated sediment before encountering refusal. Subsequent drilling at the site revealed that the glacial deposits are 68 feet deep, but the lowermost sand and gravel beds were relatively tight and would yield only small quantities of water to individual wells. In March 1965, geophysical surveys and further test drilling about 1,000 feet south of the Cromwell boring revealed a thickness of glacial deposits of more than 100 feet and a prolific water-bearing sand and gravel zone at an average depth of 30 to 50 feet below land surface. It is quite probable that as much as several million gallons per day can be developed in this area adjacent to the Connecticut River. However, a chemical analysis of water obtained from pumping one of the test wells indicates that a ground-water supply from this site would very likely require treatment for iron and perhaps manganese.

The second Cromwell test boring was drilled west of the Dividend Brook well field in an attempt to locate permeable zones of sand and gravel at a greater depth than that encountered in the municipal wells. Eighty-nine feet of unconsolidated material was logged in this hole. However, it consists mostly of till and is relatively impermeable. There may be promising areas for ground-water development in the Dividend Brook valley, but to date, testing has not revealed their presence within Town limits.

Outwash deposits also occur in the southwestern section of the Town and may be relatively thick adjacent to the Mattabesset River. Very little is known of the permeability or ground-water potential of these sediments. Test boring was not attempted because this area is far removed from the present water-supply system.

Town of Durham

There are two major deposits of glacial outwash material



THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

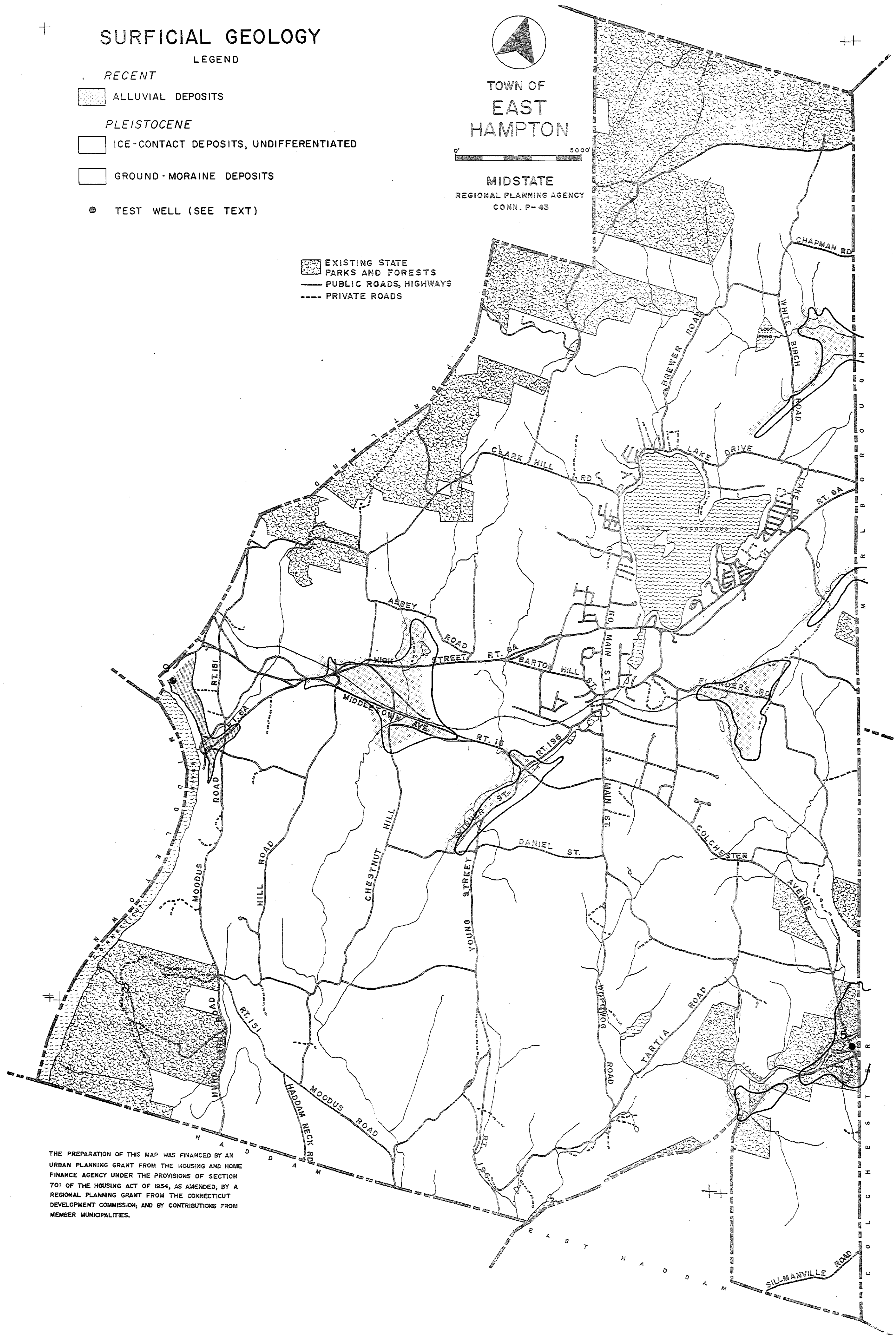
in the Town of Durham. The most important is located in the center of town in the Durham Meadows. In order to obtain geologic information in the area, the first boring for the Agency was drilled adjacent to Wallingford Road and Allyn Brook. It revealed that recent stream alluvium and outwash deposits overlay a zone of relatively permeable sand and gravel at a depth of 50 to 66 feet below land surface. This lower formation indicates that a potential for ground-water development exists in the area, but further exploration with larger diameter holes and pumping tests would be required to definitely establish the feasibility of developing significant quantities of ground water.

The second area designated as outwash lies to the west of the Coginchaug River. A test boring was drilled along Hersig Brook to determine the character of the glacial deposits. This well indicates that the area is underlain by a relatively thin bed of outwash from the land surface to a depth of about 17 feet, which in turn is underlain by finer sediments. Although some localities may contain thicker saturated zones of sand and gravel, it is quite probable that the area does not offer any great potential for ground-water development. Isolated outwash and ice contact deposits occur in other parts of the Town, and these may offer some potential for ground-water development, especially the area adjacent to the New Haven Road in the Southwestern part of town. Existing data on these sites is scanty, and test drilling would be required to establish the presence of thick permeable deposits.

Town of East Hampton

Two test borings were drilled in the Town of East Hampton. The first was located adjacent to the Salmon River in an attempt to encounter shallow permeable sands and gravels in direct hydraulic connection with the surface stream. If such a condition existed, it was felt that wells constructed along the river would receive recharge from the surface stream. The log obtained during drilling revealed that at least 21 feet of coarse sand and gravel underlies the site, and thus it may be feasible to construct shallow vertical wells or horizontal collectors to obtain a dependable ground-water supply from the ice contact deposits along the Salmon River. Before such a facility were designed, it would be necessary to drill additional test borings along the Salmon River in other ice contact deposits in order to locate the best site for developing a ground-water supply.

The second test boring was drilled in the Cobalt area adjacent to the Connecticut River. The location



THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

appeared to be underlain by a mixture of alluvium and outwash deposits along the river. This analysis was verified by the log of material encountered during drilling. The shallow zones consisted of fine alluvial materials underlain by very coarse sand and gravel beds which lay at a depth of 40 to 54 feet below land surface. Based on the results of test drilling, this site appears to be most promising from the standpoint of ground-water development. It is geologically similar to other areas along the Connecticut River where high capacity water wells have already been developed. However, before any plans for exploitation of ground-water supplies are undertaken, detailed information should be obtained on the safe yield of the aquifer and long-term water quality relationships.

Previous test drilling and pumping in the East Hampton area by Buck & Buck Engineers, Hartford, Connecticut, have shown that a potential for ground-water development exists in the outwash deposits south of Route 16 and west of Chestnut Hill Road. Their studies indicate that perhaps one million gallons per day can be obtained from a series of production wells tapping sand and gravel material which lies at a depth of 30 to 60 feet. Test drilling by Buck & Buck was also conducted in the outwash deposits south of the junctions of Route 16 and 196. The work revealed the presence of coarse sand and gravel beds which might yield significant quantities of ground water to properly constructed wells. It should be noted, however, that the site may be subject to contamination from Pocotopaug Creek. Other areas containing ice contact deposits in the town have not been adequately explored to establish their potential for ground-water development. However, for the most part, the beds appear to be relatively thin, and it may be difficult to locate high capacity wells in these locations.

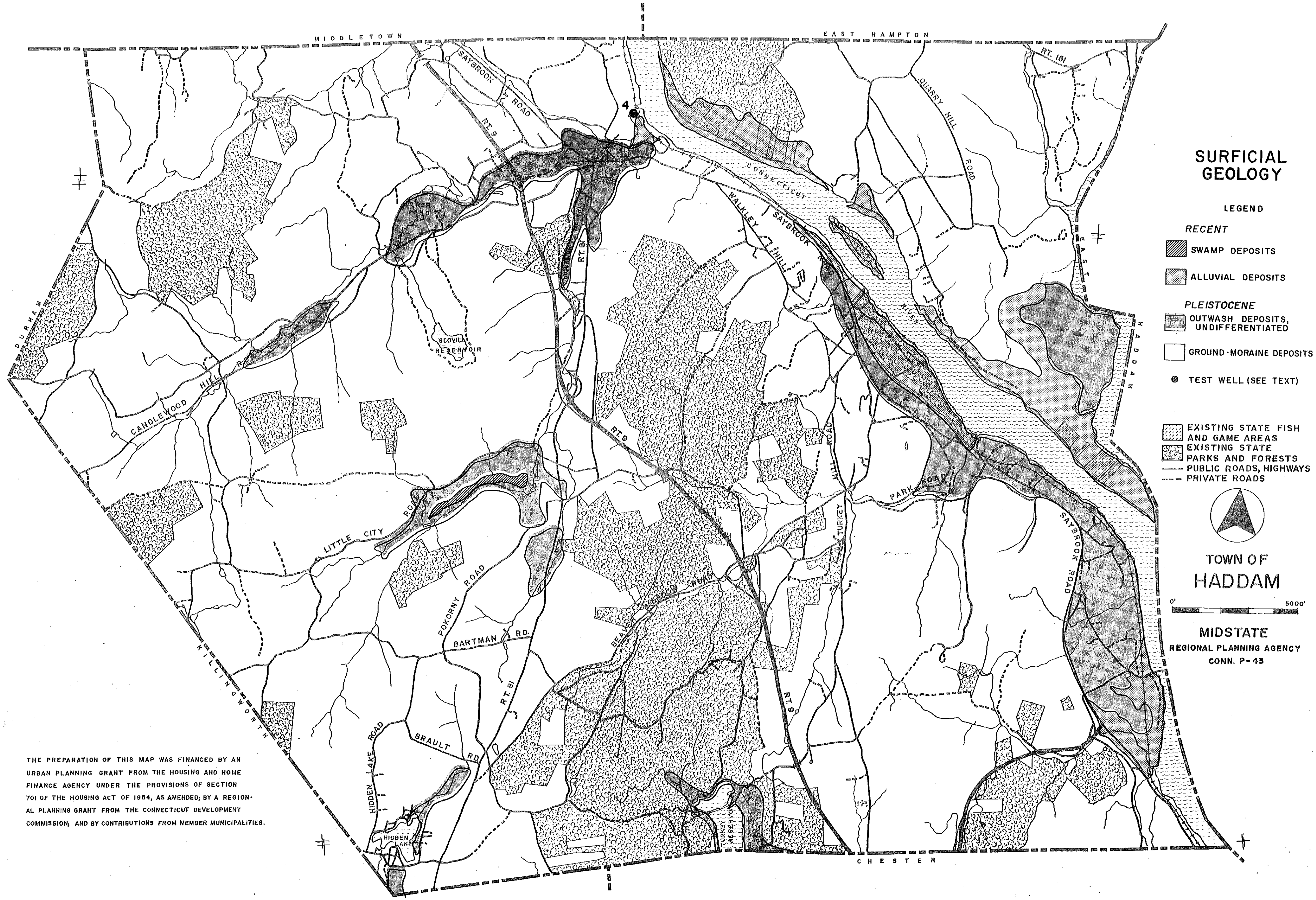
Town of Haddam

The Town of Haddam is underlain in many areas by a thick series of alluvial and outwash deposits. The most important of these, from the standpoint of groundwater development, are located adjacent to the Connecticut River. The test boring for the Planning Agency was located in one such area northeast of the Town of Higganum. Drilling revealed the presence of at least 65 feet of permeable sands and gravels. The area in which the boring is located offers a large potential for ground-water development.

Because of the thickness of the deposits and consequent high cost of drilling, no borings were attempted in the Haddam Meadows, Shailerville, and Tylerville areas. However, an inventory of existing wells indicated that enough information was available to arrive at certain conclusions regarding the geology of the glacial deposits and their saturated thickness. The data reveal that the entire area along the river, shown on the Town's surficial geology map, is underlain by alluvial and outwash deposits and offers a tremendous potential for ground-water development. However, the permeability and depth of important water-bearing sands and gravels vary considerably from place to place, and detailed test drilling and pumping would be required to determine safe yields of individual wells and ground-water quality. Wells inventoried between Haddam and Shailerville reveal a total thickness of unconsolidated material of as much as 122 feet.

Outwash and alluvial materials on the eastern shore of the Connecticut River along Cove Meadow were tested in detail in connection with the Yankee Power Project. Several wells on the Yankee property, screened opposite sand and gravel beds at depths of 45 to 60 feet, have been pumped at rates of 300 gpm. They serve as an excellent example of the potential for ground-water development in these and similar deposits along the river.

The outwash deposits along Ponset Brook and Saltpeter

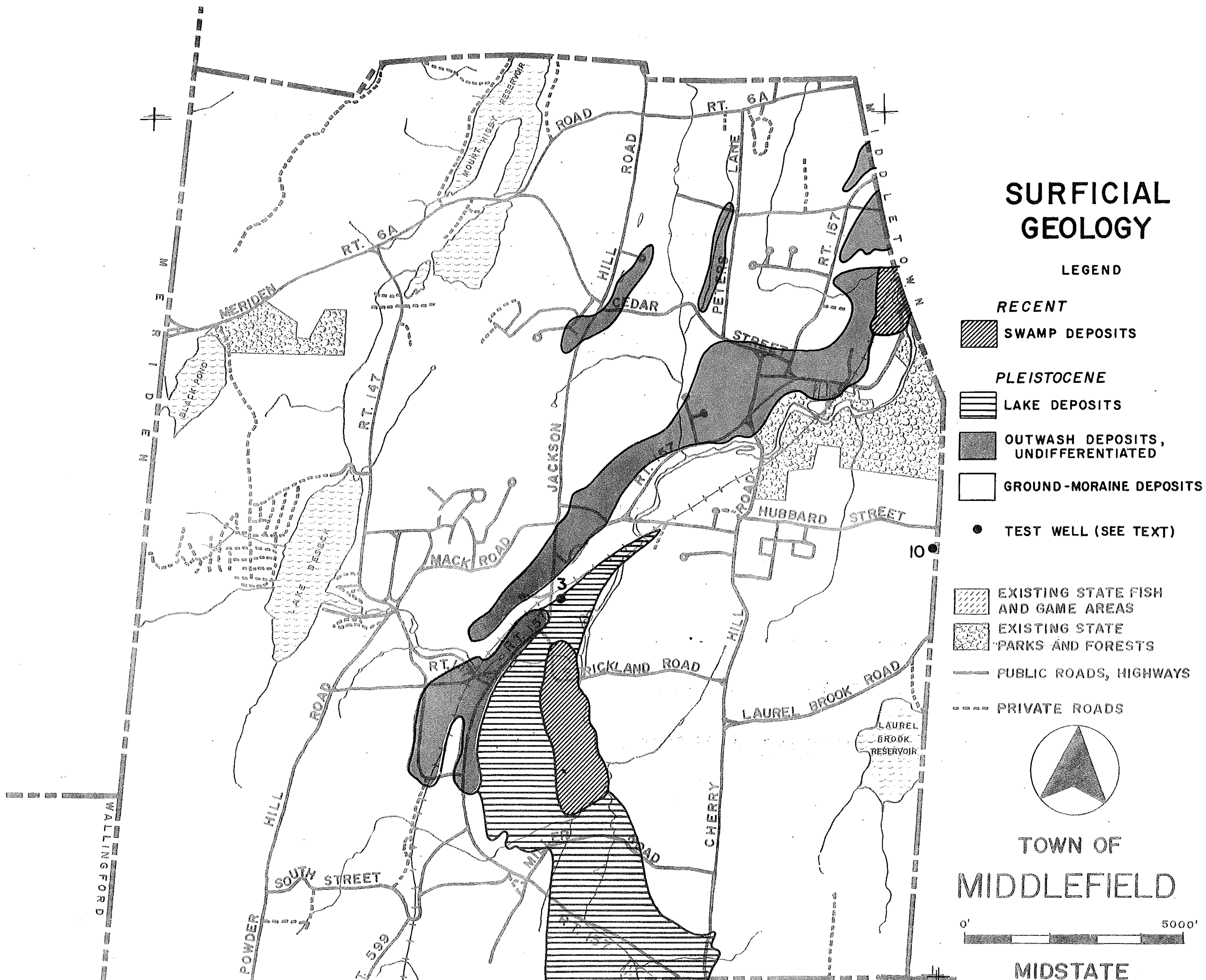


THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

Brook were not tested because existing information indicated that lands available for drilling were underlain by bedrock at a relatively shallow depth. However, they should not be ruled out completely in future studies of ground-water development and may, in certain places, contain permeable sands and gravels which might yield limited quantities of water to individual wells.

Town of Middlefield

Few potential areas for ground-water development appear to be present in the Town of Middlefield. Two sites were chosen for test drilling, one adjacent to Route 157 and the other in the valley of Laurel Brook. Both of these sites revealed that bedrock lay at shallow depths, and no potential for ground-water development from the glacial deposits exists. As shown by the surficial geology map, the only significant outwash deposits occur along the Coginchaug River. However, testing by the City of Middletown in this area indicates that the glacial materials are too thin to supply large quantities of water to individual wells. The only location in whcih thick glacial deposits were encountered lies along Strickland Road near the Coginchaug River. Here, over 100 feet of unconsolidated

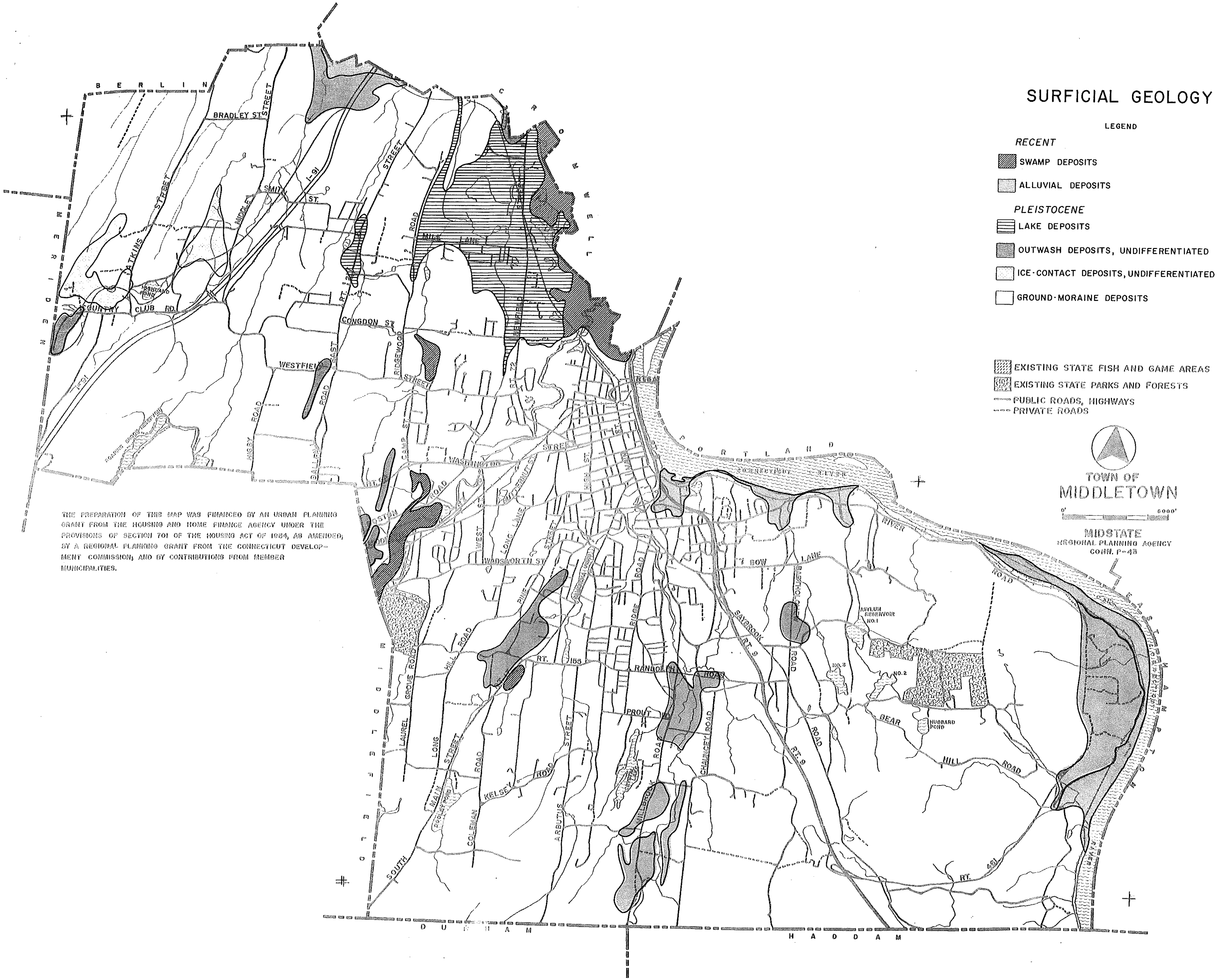


THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

material was encountered in additional testing for the City of Middletown. However, the deposits consisted of fine-grained lake sediments which would not yield water to wells. The character of the outwash materials in the smaller valleys has not been determined.

City of Middletown

Because of the extensive testing that had already been completed in the City of Middletown over the past fifteen years, no borings were drilled there for the Midstate Planning Region. Previous work has shown that prolific ground-water supplies can be developed in several areas, and many large wells tapping the glacial deposits already exist in the City. For example, pumping tests in wells completed in the alluvial and outwash deposits underlying the Hartford Electric Co. and CANEL properties along the Connecticut River have indicated that this area could support a pumpage of as much as 20 million gallons per day, and individual wells could yield more than 3,000 gpm. Production wells drilled in the alluvial deposits underlying the municipal well field along River Road have been pumped in excess of two million gallons per day, and it is estimated that as much as 6 to 8 mgd (million gallons per day) could be developed from a series of wells in this area. Pumping tests in wells



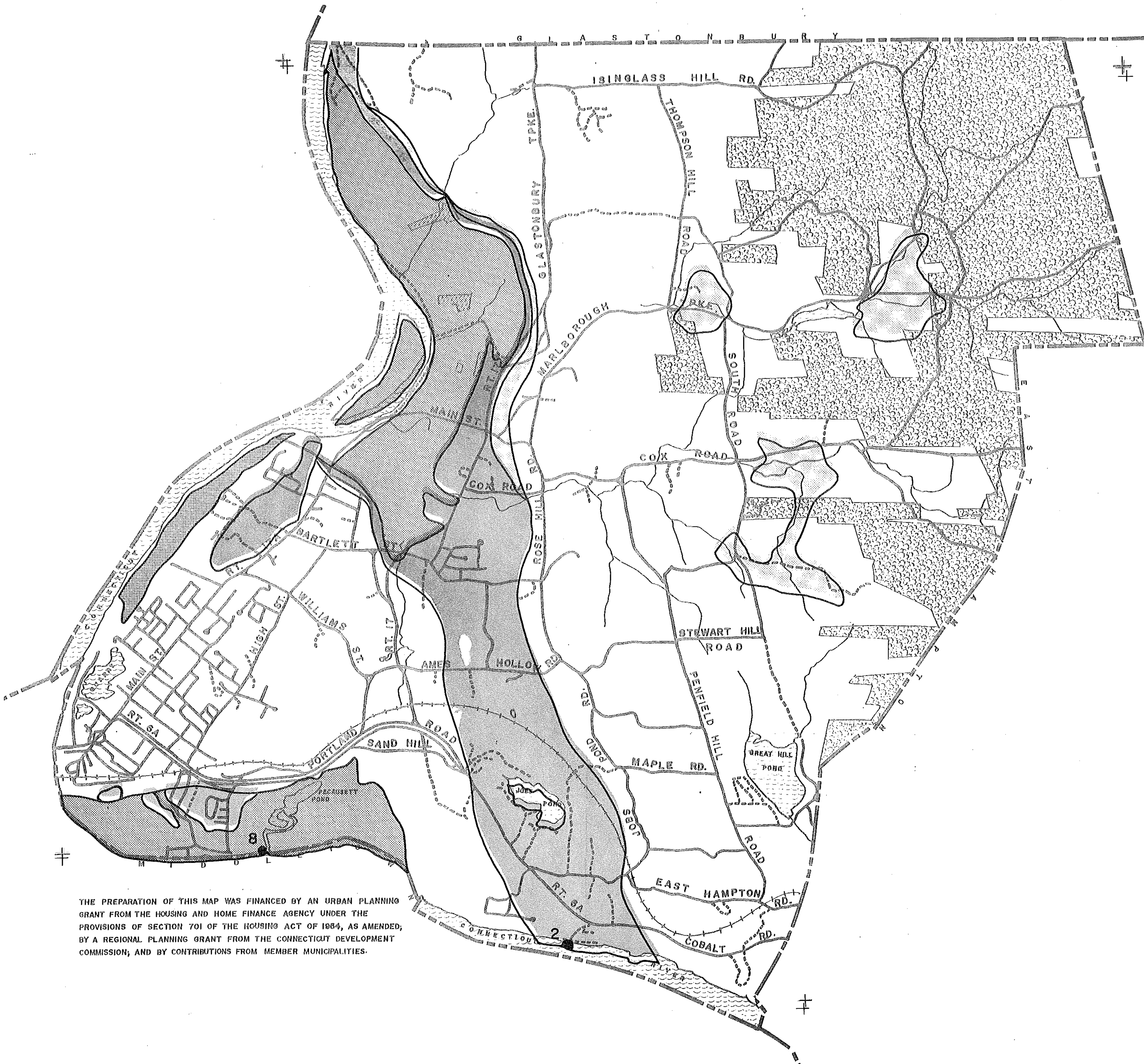
SURFICIAL GEOLOGY
LEGEND
RECENT
SWAMP DEPOSITS
ALLUVIAL DEPOSITS
PLEISTOCENE
LAKE DEPOSITS
OUTWASH DEPOSITS, UNDIFFERENTIATED
ICE-CONTACT DEPOSITS, UNDIFFERENTIATED
GROUND-MORAINE DEPOSITS
EXISTING STATE FISH AND GAME AREAS
EXISTING STATE PARKS AND FORESTS
PUBLIC ROADS, HIGHWAYS
PRIVATE ROADS
TOWN OF
MIDDLETOWN
0'
6000'
MIDSTATE
REGIONAL PLANNING AGENCY
CONN. P-48
THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.
BERLIN
CROMWELL
MERIDEN
PORTLAND
EAST HAMPTON
MIDDLEFIELD
DURHAM
HADDAM

drilled in the valley of Sumner Brook have shown that one million gallons per day could be developed from the outwash deposits contained in this buried valley.

The smaller valley areas in Middletown which contain ice contact, alluvial, and outwash deposits could probably support only limited pumpage because the unconsolidated materials are relatively thin. For example, a series of test wells drilled in the valley of West Swamp Brook showed that the outwash deposits were extremely permeable, but because of their limited extent, could support a pumpage of only about 1/2 million gallons per day. Although the depth to bedrock at the confluence of the Mattabesset and Coginchaug Rivers is great, drilling in this area has revealed that the glacial materials are too fine-grained and impermeable to yield water to wells.

Town of Portland

Two test borings were located in the Town of Portland. The first was drilled adjacent to the Connecticut River in alluvial, ice contact, and outwash deposits that now occupy a pre-glacial channel of the river. This boring encountered 14 feet of coarse sand and gravel at a depth of 43 to 57 feet below land surface. Although refusal was met at 57 feet, it is quite



SURFICIAL GEOLOGY

LEGEND

RECENT

ALLUVIAL DEPOSITS

PLEISTOCENE

OUTWASH DEPOSITS, UNDIFFERENTIATED

ICE-CONTACT DEPOSITS, UNDIFFERENTIATED

GROUND-MORAINE DEPOSITS

TEST WELL (SEE TEXT)

EXISTING STATE FISH AND GAME AREAS

EXISTING STATE PARKS AND FORESTS

PUBLIC ROADS, HIGHWAYS

PRIVATE ROADS

TOWN OF

PORTLAND

0' 5000'

MIDSTATE

REGIONAL PLANNING AGENCY

CONN. P-43

THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED; BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION; AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

probable that this was due to the presence of a boulder rather than bedrock. As a check on the configuration of the bedrock floor in the vicinity of the Midstate test boring, a geophysical survey was conducted in cooperation with the Geology Department of Wesleyan University. The results of this survey indicate that bedrock lies at a depth of more than 100 feet beneath the Riverdale area, and it is quite probable that large capacity wells could be developed at this location. In fact, the entire area of glacial deposits shown on the Town's surficial geology map as occupying the pre-glacial channel of the Connecticut River offers a great potential for developing prolific ground-water supplies. However, the thickness and permeability of the unconsolidated material varies considerably from place to place, and each potential site for ground-water development would require test drilling to establish the most feasible location for production wells.

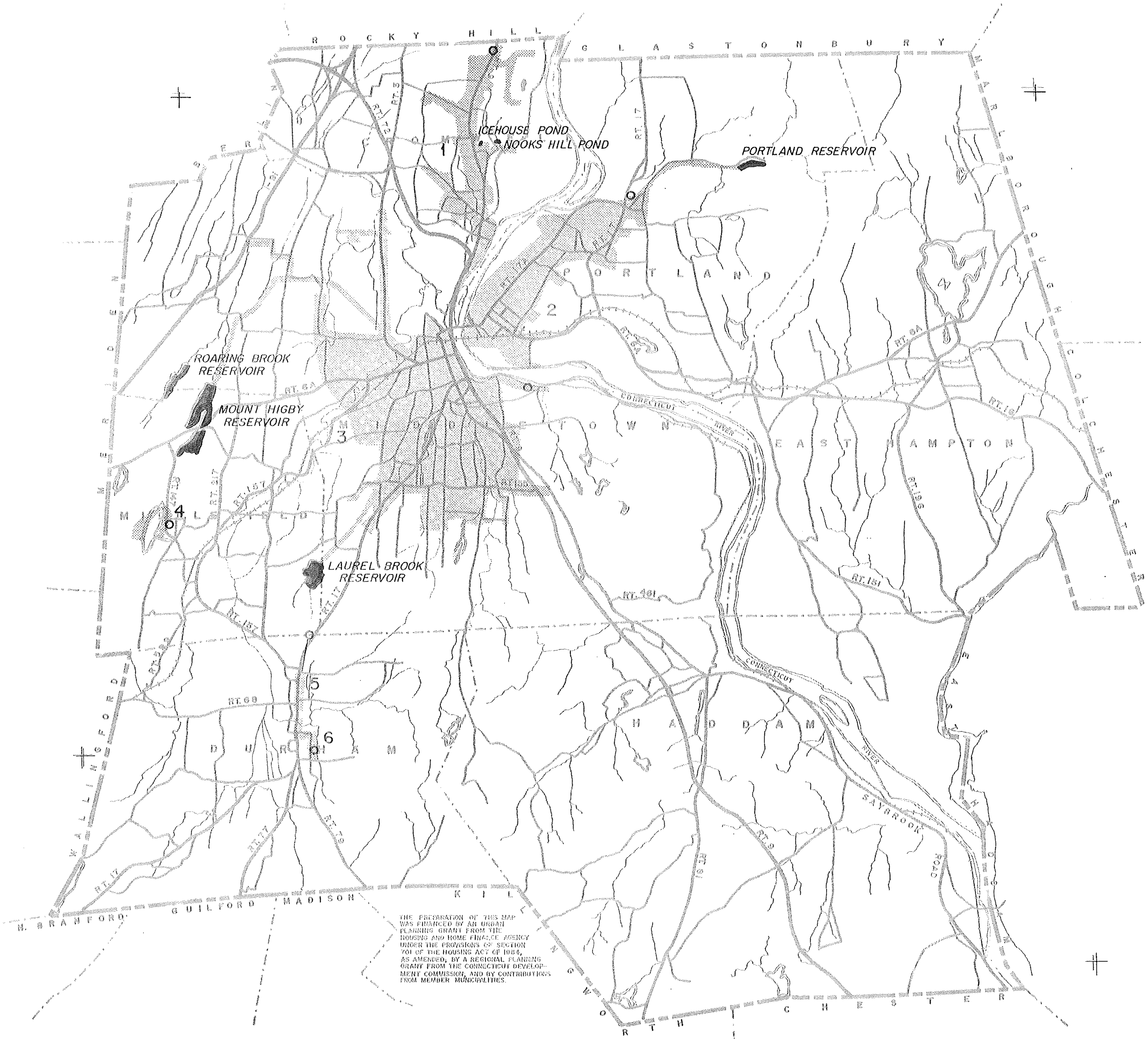
The second boring for the Midstate Planning Region was located in the alluvial deposits which lay along the Connecticut River south of Pecausett Pond. Drilling at this location indicated the presence of thick glacial materials, and bedrock lay at a depth of at least 81 feet below land surface. However, the deposits encountered were compact, and it is doubtful that this area offers as great a potential for ground-water development as the Riverdale area. In summary, the preglacial bedrock valley of the Connecticut River which occupies the area south of Gildersleeve Island through Job's Pond and Riverdale would support a large number of properly spaced and constructed wells whose capacities could average as much as a million gallons per day each. Ice contact deposits in other areas of the Town may also offer a limited potential for ground-water development, but they have not been explored.

EXISTING WATER SUPPLY SYSTEMS

Three of the seven towns which make up the Midstate Planning Region are now supplied by public water utilities. There are also present in the region several private water companies which serve small parts of Middlefield and Durham. These systems supply water for domestic, commercial and industrial purposes to the areas shown on Page 61. The location and type of source are also shown on the illustration. The Towns of East Hampton and Haddam do not presently have community water-supply systems.

Homes, stores, and manufacturing establishments outside of the areas served by public utilities are self supplied from local ground or surface water sources. Almost 100 percent of domestic supplies are derived from wells. In addition, most of the commercial and industrial facilities not served by city water use wells. However, some industries take water from streams and ponds.

Current total withdrawals in the Midstate Planning Region are listed in Table 4 by source and type of use. The information for this table was computed from municipal water use data and inventories by the State Water Resources Commission. The estimated



THE PREPARATION OF THIS MAP WAS FINANCED BY AN URBAN PLANNING GRANT FROM THE HOUSING AND HOME FINANCE AGENCY UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED, BY A REGIONAL PLANNING GRANT FROM THE CONNECTICUT DEVELOPMENT COMMISSION, AND BY CONTRIBUTIONS FROM MEMBER MUNICIPALITIES.

PUBLIC WATER SUPPLY AND DISTRIBUTION

LEGEND

- AREA SERVED
- RESERVOIR
- O WELL FIELD, WELL OR SPRING

WATER COMPANIES

1. CROMWELL FIRE DISTRICT - WATER DIV.
2. TOWN OF PORTLAND - WATER DEPT.
3. CITY OF MIDDLETOWN - WATER DEPT.
4. BESECK LAKE WATER CO., BESECK DIV.
5. DURHAM AQUEDUCT CO.
6. DURHAM CENTER WATER CO.

MIDSTATE PLANNING REGION

0' 16,000'

MIDSTATE
REGIONAL PLANNING AGENCY
CONN. P-43

figure for rural water use was determined by first calculating the population supplied by domestic wells and multiplying this figure by 60 gallons per day per capita. This figure is based on the average determined by the U.S. Geological Survey for an electrified or urban home with running water. It includes household purposes and the watering of lawns.

TABLE 4

ESTIMATED WATER USE, 1964, IN THE MIDSTATE PLANNING REGION IN MILLIONS OF GALLONS PER YEAR.

	Ground Water	Surface Water	Total
Public Water Supply	257	1,083	1,340
Industrial Water Supply	255	324	579
Rural Water Supply	628	-	628
Grand Total	1,140	1,407	2,547

Irrigation of farmland is of minor importance when compared to the overall use of water in the area. Due to the lack of specific quantitative data,an estimate for irrigation was not listed in the table. The figure for municipal use includes all water supplied by individual public water-supply systems to homes, commercial establishments, and industry. Industrial use includes only those manufacturing plants which are independent of public water distribution systems.

Almost all of the water used in the region is returned to surface or ground-water systems where it is available for reuse again and again before it ultimately discharges naturally to the sea. However, degradation of water quality due to the addition of domestic and industrial waste can render much of the discharged water unfit for many purposes. In addition, the discharge location affects the availability of water for reuse. For example, the City of Middletown discharges its sewage waste into the Connecticut River, which is presently not being used as a domestic source of water because of a heavy pollution load. If, on the other hand, Middletown discharged its waste into a stream whose flow was great enough to afford proper dilution, the diversion of water by Middletown could be considered a non-consumptive use.

Middletown

The Middletown Water Department obtained until recently all of its water supply from two surface reservoirs. The Laurel Brook , built in 1866, has a storage capacity of 223,000,000 gallons and receives water from a drainage area of 1.05 square miles. The Mt. Higby reservoir, including Roaring Brook reservoir, built in 1896, has a storage capacity of 374,000,000 gallons and receives its water from a drainage area of 2.06 square miles. An engineering survey conducted in 1958 estimated the dependable yield, or the amount of water which could be relied upon as being available under normal conditions of precipitation, at 1.44 million gallons daily from the Mt. Higby reservoir system. The yield of the Laurel Brook reservoir was estimated at 0.76 million gallons per day, giving a total safe yield of 2.20 million gallons daily.

During the summer of 1963 and again in 1964, water levels in the reservoirs fell to unusually low elevations, and in order to obtain additional supplies, the City turned to several emergency water sources. One of these was the Coginchaug River, from which water was pumped for a period of several months into the Laurel Brook reservoir. The average daily withdrawal from this source amounted to more than one million gallons. As a further step to augment supplies, an agreement was made with authorities of the Connecticut Valley Hospital at Middletown to transfer water from independent reservoirs owned by the hospital into the City's distribution system. An average of 500,000 gallons per day was obtained in this manner.

In December 1964, an 8-inch test well at the proposed River Road well field was equipped with a temporary deep well turbine and pumped at a rate of about 400 gallons per minute into the City system. This auxiliary water source has been used almost continuously up to the present time. Treatment of all municipal water supplies, including the reservoirs and the River Road well, is limited to chlorination.

The chemical quality of water from both reservoirs is typical of surface water in the area. It is soft, moderately corrosive, and low in total dissolved solids. Chemical analyses of water from the Mt. Higby reservoir reveal that, at brief periods during the year, the water may contain concentrations of iron and manganese that are slightly high for public water supplies. The River Road well contains a higher degree of hardness than the surface-water sources and also contains relatively high iron and manganese concentrations.

The Middletown Water Department now serves an estimated population of about 28,000, which represents about 78% of the City's total population. In the period from 1950 through 1963, the number of service connections rose from 4,040 to 6,081. The estimated population served rose from 23,700 to 27,400. During the same period, the total amount of water delivered to the mains per year showed an increase from 712,000,000 gallons to

923,000,000 gallons, or a rise of 30%.

The City of Middletown, in order to meet present and future water demands for domestic, industrial, and commercial purposes, retained the firm of Geraghty & Miller in 1963 to conduct a survey of ground-water conditions in the area. As a result of this survey, a report entitled "Investigation of Water Resources in the Middletown, Connecticut, Area" dated September 1964, was prepared by this firm. The report describes the drilling and testing conducted during the survey and provided the City with conclusions and recommendations for the development of additional water supplies. One of the recommendations was to construct production wells at the River Road site shown on map of public water supply and distribution, where it was determined that a ground-water source of from 6 to 8 million gallons per day could be exploited. It was also recommended that certain areas of the Sumner Brook valley be put aside for the future development of up to one million gallons per day from a series of wells.

The Henry Souther Engineering Corp. of Hartford, Conn., was then retained by the City to determine the engineering feasibility of developing the ground-water supply along River Road. Their recommendation was to develop a capacity of two million gallons per day with later expansion as the City's requirements increased. Consequently, the City has constructed two large diameter, high capacity wells, each capable of producing more than one million gallons per day at the River Road site. Because of the relatively high iron and manganese content of the water, a treatment plant is being constructed adjacent to the well field. Water from the production wells will be piped to the treatment plant where iron, manganese, and hardness concentrations will be reduced. The treated water will then be directed into the City's distribution system.

With the addition of the River Road well system and its capacity for expansion, the City's requirements for water should be satisfied for many decades of normal growth. However, it should be pointed out that the addition of a few industrial plants with heavy water demands could change this picture considerably.

Cromwell

The Town of Cromwell is served by independent domestic and industrial water supply systems administered by the Water Division of the Cromwell Fire District. The domestic system is supplied by a series of shallow wells tapping the glacial deposits in the valley of Dividend Brook.

A surface-water supply consisting of Nooks Hill and Ice House Ponds presently serves as the industrial source. About 65% of the total population of Cromwell is supplied by the Water Division. In the past ten years, the estimated population served has risen from about 2,500 to 4,500 people. Annual consumption of domestic water from the Dividend Brook well field averages about 0.3 million gallons per day, or a total of about 100,000,000 gallons per year. The industrial surface-water supply is purchased wholly by Pierson Nurseries. This consumption varies between approximately 75 and 100 million gallons per year.

The water contained in the Nooks Hill and Ice House Ponds is reportedly characterized by poor taste and high odor, color, and turbidity. It is unsuitable for domestic consumption without extensive treatment. At present, because of water quality considerations, there is no plan to use this system for domestic supply. The wells in Dividend Brook yield water of relatively low dissolved solids concentration. Total hardness is normal for ground-water supplies of the region, and no iron or manganese problems have been encountered. However, during extended periods of low precipitation and heavy pumpage, some taste and odor problems have been reported. A study of well records and pumpage data indicates that the Dividend Brook well field has been exploited to its maximum, and it is doubtful that the construction of new sand and gravel wells would produce significant quantities of additional water.

In 1965, Geraghty & Miller supervised the drilling of a rock well in the Dividend Brook field to ascertain whether the Triassic sandstones and shales could produce water for domestic supply without interfering with nearby existing sand and gravel wells. This well is 300 feet deep and the casing which seals off the unconsolidated material overlying bedrock is set at a depth of 108 feet. Testing at the site revealed that the well could be pumped on a continuous basis at a rate of 75 gpm or more than 100,000 gallons per day. However, excessive amounts of hydrogen sulfide, sulphate, and hardness are present in the well water, and it is doubtful that this source can be used without extensive treatment. The present Dividend Brook supply receives no treatment.

In addition to exploration in the present well field, test wells and seismic surveys were conducted along the Connecticut River in the area north of Dead Man's Swamp. This testing showed the presence of highly permeable deposits that might yield at least several million gallons per day to properly spaced and constructed wells.

Chemical analyses of the water obtained during testing showed a high concentration of iron, and treatment would be required before use of the water as a domestic supply. In addition, this source of water is not located near existing water mains, and the present Cromwell distribution system would have to be extended in order to tap this potential supply.

In 1961, the engineering firm of Anderson Nichols Associates conducted a study of the present Cromwell water system. In this study, the firm recommended that additional storage facilities be constructed and larger water mains be laid. Their analysis of water consumption indicated that by 1986, average daily demand would reach 1.2 million gallons, the percentage of the total population served by Town water would reach 85.5%, and per-capita water use would be as much as 77 gallons per day. Therefore, it appears that the Town of Cromwell is presently in need of developing a new source of water supply of at least one million gallons per day. In order to deliver this water source efficiently, however, a considerable amount of work would be required on the existing distribution system.

Portland

The municipal system of the Town of Portland is under the direction of the Portland Water Works. The Town is served both by surface and ground-water sources. The surface supply is obtained from the Portland reservoir which is situated in a watershed of approximately 3.56 square miles and which was recently expanded to a storage capacity of about 120 million gallons. The ground-water supply is obtained from a 10-inch-diameter well drilled in January 1950. This well is 66 feet deep, taps glacial sands and gravels, and has a reported capacity of 400 gpm.

The estimated population served by the public water-supply system in 1955 was less than 5,000, and the system now serves approximately 6,000 people, or 75% of Portland's total population. Annual consumption has increased from about 105,000,000 gallons per year to almost 150,000,000 gallons in 1964. In a report by Argraves Engineers, conducted for the Town in 1961, it was estimated that the population served in the year 2000 would be about 18,000, although estimates of total population ascertained in the recently completed comprehensive plan by Technical Planning Associates, Inc., are considerably higher.

The chemical analysis of water from the Portland reservoir indicates that the water is low in total hardness, averaging about 25 to 35 ppm. However, at times, the iron concentration rises to a level requiring the addition of Calgon for control. Water from the Portland well is higher in hardness (averaging about 80 ppm) than the surface supply, but is low in iron and manganese concentrations.

Because the potential for ground-water development near existing water mains is great, the Town of Portland could economically increase its diversion from wells. In addition, the recent enlargement of the Portland reservoir and subsequent additions to the distribution system have greatly increased the Town's ability to meet present and future water demands.

Private Water Companies

The Durham Aqueduct Company, founded in 1798, is reportedly the oldest municipal supply in the United States. The water source is obtained from wells and springs, the locations of which appear on map of public water supply and distribution. About 150 people are served by the system. The Durham Center Water Company, which was founded in 1911, serves about 100 people. The water is derived from two rock wells with reported yields of 14 gpm and 18 gpm. Some additional water is obtained from Fowler Brook, which is spring fed. Exact figures on water consumption from these two companies are not available. However, the Durham Center Water Company reportedly pumps 30 gpm to its two storage tanks for an average period of eight hours per day.

Water from the Durham Aqueduct Co. ranges in total hardness concentration from about 70 ppm to 120 ppm. The supply is low in iron and total dissolved solids. The Durham Center Water Company provides water of low total hardness, averaging about 40 ppm, but iron content at times reaches a level of 0.3 ppm.

The third private system in the Midstate Planning Region is the Beseck Lake Water Company. The system, which was inaugurated in 1932, is dependent upon two rock wells whose yields are unknown. The company serves a population of about 600 people. However, the majority of this population consists of summer residents, so that the system is only used at full capacity for about six months per year.

Chemical analyses of water obtained from the Beseck Lake wells revealed that this source is relatively hard, with 150 ppm total hardness. Other chemical constituents are low in concentration.

The three water systems mentioned above presently play a minor role in the over-all distribution of public water supplies in the area. Because of their relatively small size, the age of existing mains, and financial considerations, it is doubtful that the areas served will be expanded to supply any significant percentage of the total population of the region in the future.