US Army Corps of Engineers
New York District

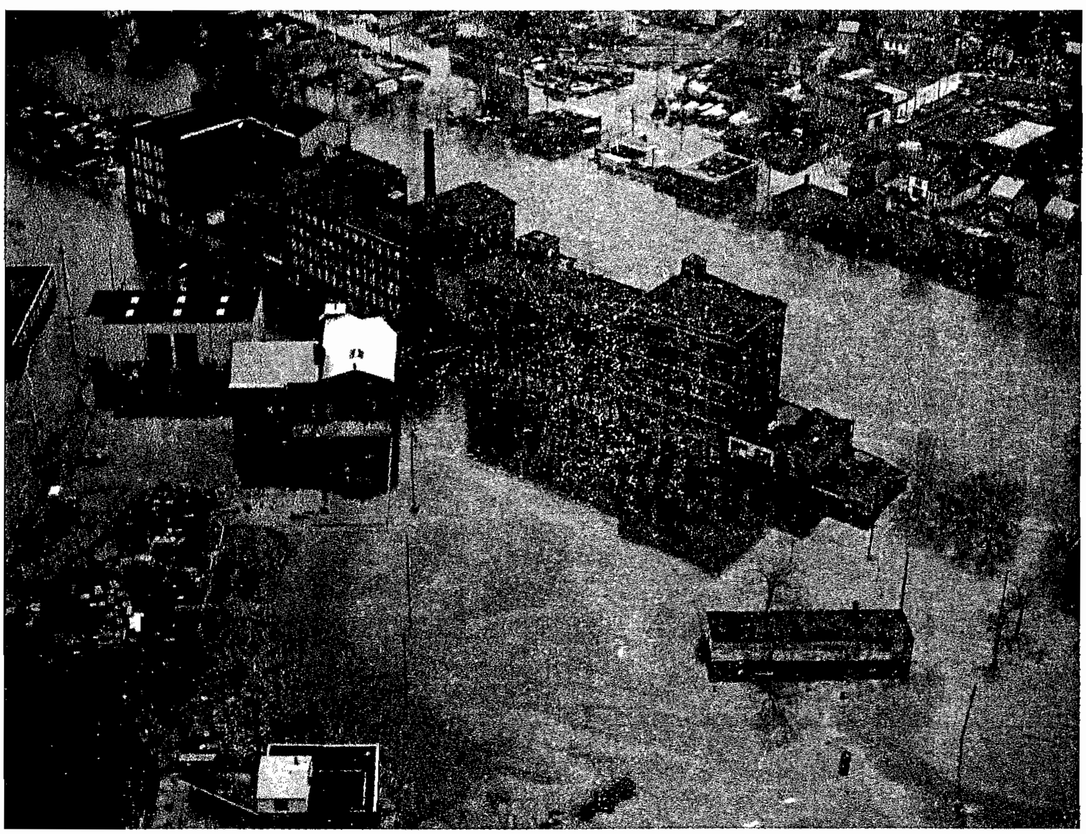
PASSAIC RIVER BASIN STUDY

Passaic River Basin, New Jersey and New York
Phase I - General Design Memorandum

Flood Protection Feasibility Main Stem Passaic River

Supporting Documentation

Economics



December 1987

Part V

PPMD

PASSAIC RIVER BASIN

STAGE 3 REPORT

PART V - ECONOMICS

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

LIST OF TABLES

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

LIST OF TABLES

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

LIST OF TABLES (CONT)

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

LIST OF TABLES (CONT)

PASSAIC RIVER BASIN
SUPPORTING DOCUMENTATION

PART V - ECONOMICS

TABLE OF CONTENTS (CONT)

LIST OF TABLES (CONT)

LIST OF FIGURES

LIST OF PHOTOS

PASSAIC RIVER BASIN STUDY SUPPORTING DOCUMENTATION

PART V - ECONOMICS

SECTION 1. INTRODUCTION

This supporting documentation is organized according to the format provided by NAD and is consistent with guidance provided in ER 1105-2-40 dated 9 July 1983. This appendix presents the results of the economic benefit analysis, the socio-economic assessments, and risk and uncertainty for flood control measures for the Passaic River Basin, New Jersey and New York. The description of the economic analysis details six subjects. These are: social and economic future existing conditions; historical flood data; basis for flood damage analysis, social and economic future without project condition; economic analysis of alternative plans and risk and uncertainty. A description of each subject is presented below.

This appendix is organized as follows:

Section 1. Introduction - Describes the Passaic River Basin service area counties.

Section 2. Social and Economic Existing Conditions - Information on the underlying socio-economic conditions of the Basin is presented.

Section 3. Historical Flood Data - Discusses historical flood damages as reported in previous U.S. Army Corps of Engineers Flood Control Reports as well as in newspaper articles.

Section 4. Basis for Flood Damage Analysis - Describes the methodology that was utilized to determine the stage-damage relationships. Describes the data handling and computer programs that were used in the analysis of damages for the Passaic River Basin Study. Discusses interpretation of Basin field data and calibration of economic computer programs. Provides detail on the reach numbering system, the number of structures in each floodplain, and the dollar value of damages in each floodplain and reach. This information provides a thorough summary as to the magnitude of flooding in each reach.

Section 5. Social and Economic Future Without Project Conditions - Develops the future socio-economic climate of the Basin with particular emphasis upon those facets (e.g. future land use) which will lead to increased future damages.

Section 6. Economic Analysis of Alternative Plans - Presents the benefit/cost comparisons for the alternative plans analyzed and the benefit categories applicable to potential plans of protection.

Section 7. Risk and Uncertainty - Evaluates various procedures to assess the level of sensitivity associated with potential flood control plans, benefit to cost ratios.

ANALYSIS OF SERVICE AREA COUNTIES

The "service area" includes the ten counties that are totally or partially in the Basin, as well as two other counties in New Jersey linked to the Basin by transportation and public utility networks, (Figure V-1).

The Passaic River Basin occupies portions of the following counties: Bergen, Essex, Hudson, Morris, Passaic, Somerset, Sussex and Union in New Jersey and Orange and Rockland in New York. The proportion of these counties actually lying within the Basin ranges from practically all, in the case of Passaic, to only a minor fragment, as in Sussex and Hudson counties. For the purpose of this study, the service area is defined as consisting of the counties listed above in their entirety plus the nearby New Jersey counties of Hunterdon and Middlesex.

This section provides a profile of existing land use for each of the service area counties. The county profiles that follow were derived (and excerpts taken) mainly from county master plans. Dissimilarity in depth and approach is in large part reflective of the differences in the source material.

Bergen County. Because of its immediate proximity to the N.Y.C.-Newark-Hudson County core area, Bergen County felt the impact of suburbanization and urbanization sooner and more intensely than most of the other New Jersey counties. The eastern and southern portions of the county had already been extensively suburbanized when the post-World War II boom occurred.

The years from 1945 to 1960 brought unprecedented development to Bergen County. Thousands of single family residential structures were developed in central and northern Bergen County. Towns such as Paramus, Fair Lawn, Ridgewood, Wyckoff, Oakland, Mahwah, Ramsey, Hillsdale, Park Ridge, Emerson, Oradell, Closter and Tenafly experienced large scale building booms. These single family units did not compare to the pre-World War II variety, being bigger and situated on much larger lots. Lot sizes of a half and full acre were not unusual.

While large tracts of land in the northern section of the county were being newly developed, areas closer to New York City were undergoing a change to higher densities. Fort Lee, just at the western end of the George Washington Bridge, became the location of luxury high rise apartment complexes that attracted many people out of New York City. Hackensack and other earlier centers of activity were also undergoing changes to higher densities.

Commercial activities underwent a drastic change in areas where major highways intersected. Paramus, in the central portion of the county, became the focus of Bergen's shopping center activity. Older downtown centers, such as Hackensack, found their commercial areas suffering from the new competition.

Industry was also developing in Bergen County. The marginal land fringing the meadowlands attracted light industry and distribution firms because of its good highway access to New York and urbanizing northern New Jersey.

The western portion of Bergen County is located in the Passaic River Basin. The three far northwestern municipalities of Mahwah, Oakland, and Franklin Lakes are in the Highland Area. These towns have the greatest reserves of vacant land left in the county but the terrain is rugged throughout much of the area. Low density residential use is the dominant form of development. The Lower Valley portion of Bergen extends from the north where availability of vacant land and low density use are similar to that in the Highland Area, to the central and south of the county, where residential, commercial and industrial use is intense, as reflected in municipalities such as North Arlington, Lyndhurst, Rutherford, East Rutherford, Garfield and Wallington.

Essex County. The county is densely populated and extensively developed. It forms the keystone for the industrial belt along the eastern portion of the State bordering Newark Bay and Arthur Kill. In this position, Essex County functions as the industrial and financial center for the northeastern portion of New Jersey. Newark, the largest city in the state is located in the south-eastern corner of the county. The county may be divided into three portions: Eastern, Central, and Western. The Eastern portion of the county, developed almost entirely before the Depression, is today undergoing some amount of redevelopment. Its character is primarily that of the older industrial heartland of the county augmented by the central business area of Newark, the Newark Airport, the Newark Seaport, and of course vast areas of older residences, (becoming progressively less dense toward the north).

The Central portion is characterized by large parks and recreation areas, combined with the rugged topography of the Watchung Mountains. This portion of the county also contains the older, more affluent suburbs, which presently are experiencing various stages of transitional change.

The Western portion of the county consists of the tier of communities between the Watchung Mountains and the Passaic River. This portion of the county, characterized by one-family homes and new subdivisions, is located in the Central Basin of the Passaic River. Most of the county is vacant land which is located in this section.

Hudson County. Hudson County is an old urban area characterized by the great density and age of its residential sector and the large proportion of heavy industry located in the county.

There is little vacant land remaining in the county and practically no growth in population has been projected for the county other than that entailed in development of the Hackensack Meadowlands. Secaucus and eastern Kearny contain most of the county's vacant land. Some high rise residential development has occurred in the northern Hudson communities. Three of Hudson County's municipalities, Harrison, Kearny, and East Newark are located within the Lower Valley of the Passaic River Basin.

Hunterdon County. Hunterdon County, which lies southwest of the Passaic River Basin, is still primarily rural in character. The pattern of development has been random and sporadic. Almost all developed land is devoted to residential use which is predominantly single family and low density (1-5 acre lot zoning).

Commercial and industrial use take up a very small portion of the county's land. Industry is located mostly along the Delaware River and in the Boroughs of Milford, Flemington and Highbridge, Raritan Township, and in the Lambertville and Frenchville areas.

Middlesex County. Middlesex which lies south of Union County is outside of the Passaic River Basin. During the past quarter of a century, Middlesex County has been one of the fastest growing areas in New Jersey. This growth has been the result of its location in the center of the New York-Philadelphia transportation corridor. With large amounts of vacant land still available, and an extensive public water and sewerage network, the county will remain attractive for future development.

In the recent past the predominant trend in land development in both housing and industry has been toward low density development in scattered rural sites away from major transportation corridors. By its very nature this residential development is almost exclusively upper income. Some low income housing is being developed along major highways but most is located in the older urban centers such as New Brunswick and Perth Amboy.

Morris County. The majority of Morris County's development is low density residential, though industrial and commercial uses have become increasingly important elements in the county's land use makeup. The intensity of this development is greater in the eastern section of the county (that area roughly contained in the Central Basin of the Passaic River Basin) which contains most of the county's older urban centers. In the central portion of the county (which lies in the Highland Area of the Passaic River Basin), and the western portions of the county (which is not part of the Basin) which have felt development pressure more recently, concentrations of housing are more sparse. Most of the county's industry is located in this western portion. The increasing spread of suburbanization from New York City and the recent and projected completion of a number of highways passing through the county are placing increased pressure for development on Morris County. The fact that Morris County is one of northeast New Jersey's less densely developed counties acts as a further inducement for such development. As of 1976 there were at least 174 square miles of developable land remaining in the county, almost as much as is currently developed.

Passaic County. Passaic County lies almost entirely within the Passaic River Basin; the southeastern portion lies in the Lower Valley, the central portion (Wayne) in the Central Basin, and the northwestern portion in the Highland Area. The Lower Valley section was developed first and contains the older urban areas of Paterson and Passaic and the dense older suburbs. Most of the county's industry is also located in this area. Wayne, in the Central Basin, is also extensively developed, but residential use is of a lower density with relatively little of the multi-family housing development that can be found in the Lower Valley. Much of the regional shopping and industrial activity is located in the southwestern corner of Wayne, along Routes 23, 46 and 80. Office development has sprung up at various locations throughout this township. The Highland Area contains most of the county's vacant land. The hilly terrain and limited transportation access have acted as growth constraints in the Upper Passaic County municipalities, limiting their development relative to the Central and Lower Passaic municipalities. So far development has been almost totally low density residential.

Somerset County. The most intensive development in Somerset County has occurred along the east-west transportation corridor (Routes 22, 28, 202 and the southern portion of 287) that crosses the middle of the county and to a lesser extent in the north, in the towns of Bernards and Bernardsville.

The major active land uses are residential 17%, and agricultural 23%. Vacant land comprises 21% of the county's area with wooded land comprising an additional 25%. Residential development is practically all low density single family with at least 1 acre zoning occurring in most towns. A substantial portion of residential development is scattered throughout the county centering around lakes.

During the 1960's and 70's there was a dramatic rise in both year round and seasonal residences. Many lakefront properties, previously seasonal, were converted to year round homes. Parts of the municipalities of Warren, Bernards, Bernardsville and Far Hills are located in the Central Basin of the Passaic River Basin.

Sussex County. Of the county's entire land mass, approximately 90 percent is either used for farming or recreational purposes or is unoccupied and undeveloped. Residential land use constitutes 7.4 percent of the total land area 67.9 percent of all developed areas. Lands in Sussex County developed for commercial, industrial, institutional, transportation and utility purposes constitute only 3.4 percent of the total land uses in the county.

Patterns that characterize the urban development in the county are: commercial, industrial and residential development occurring in linear or strip fashion along major thoroughfares such as U.S. Route 206 and State Routes 23 and 15; and low density residential dispersal ("sprawl"). Urban or dwelling unit concentration either provide nuclei for various farming areas or are in the form of metro resort developments centered around lakes or the vacation trade. The increase in the county's residential base has had a great impact on agriculture which often occupies land most suitable for development. The Sussex County Planning Board estimates that since 1972 land in active agricultural use has declined at a rate of 3 percent per year. Also the development of first and second homes around lakes has often put considerable strain on the environment.

The county has limited highway access and much of it has rugged terrain inhibiting large scale development, especially industrial. Only parts of three Sussex County towns lie within the Passaic River Basin (specifically, the Highland Area). These towns are Hardyston, Sparta, and Vernon.

Union County. Union County was among the first of the New Jersey counties to feel the impact of the suburban movement. Union County's 103 square miles are densely settled, with 85% of the land area currently developed.

The major portion of the County's development consists of residential neighborhoods. Multi-family housing is generally concentrated in Elizabeth and Plainfield with lesser concentrations in Linden and the Roselles. Moving out from Elizabeth, the residential character gradually changes. Few apartments are found adjacent to the railroad in Roselle, Roselle Park, and in Linden and Rahway. Single family houses on small lots are predominant but there are a considerable number of two, three, and four family units. Further west the number of two, three, and four family units is greatly reduced. The single family lots become larger and the neighborhoods are less densely developed.

Commercial development is generally concentrated in the central business districts, notably Elizabeth, Plainfield, Summit, Westfield, and along the major thoroughfares such as U.S. Route 22, St. George and Morris Avenues, in typical "strip" fashion.

Industrial usage is directly related to transportation facilities and is primarily concentrated in Elizabeth, Linden and Rahway, east of the Pennsylvania Railroad. Other sizable concentrations are found clustered around major railroad and highway connections.

There is very little vacant property remaining in the county. The largest concentrations are found in the low lying areas bordering Newark Bay and Arthur Kill or in the western portion of the county, notably in Berkeley Heights and Scotch Plains. The intensity of land use in the county follows three patterns. The first emanates from Elizabeth, the oldest settlement, port, county seat, and the center of county activity. It is characterized by high density residential areas, regional shopping facilities and extensive industrial complexes. The area adjacent to the core is composed of the older suburbs of Elizabeth, which have become almost completely urbanized, but at a somewhat less intense level than Elizabeth proper. The residential use is of medium to low density; commercial activity is fairly intense and some heavy industry exists in the waterfront areas. The next ring is best described as "new suburban." Once agricultural or rural, this area is rapidly filling in with low intensity development (single family residential, local shopping, "clean" industry, etc.).

The second pattern is also one of concentric rings, but the focal points are secondary urban centers or subcores. Two such complexes have grown up around the Westfield-Garwood-Cranford and Plainfield areas, all of which are older municipalities that have been extensively built up for some time.

The third pattern, completing the current picture of development in the county, is lineally oriented along the major transportation routes. These routes, both rail and highway, link the core, sub-core, suburban and fringe areas. Because transportation facilities are critical to most types of urban development, areas well serviced by road or rail are inevitably utilized to serve high intensity uses such as heavy industry, extensive commercial operations and multi-family dwellings.

Most of the linear development in the county has been "highway" or "strip" commercial, and industrial, although the demand for apartments is steadily increasing and the availability of public transportation, as well as general accessibility have become important locational factors. For the most part, the linear development does not extend back very far from the right-of-way along which it is situated. Often bounded by low intensity uses, strip development is shown only as high intensity without the moderate intensity rings characteristics of the other developmental patterns.

Three townships in the northwestern section of Union County are included in the Central Basin of the Passaic River Basin. Of these, Berkeley Heights and New Providence are similar to much of western Union County in their low density single family residential nature. The town of Summit may be classified as a secondary urban center having the physical characteristics and low intensity development more common to the older suburbs than a core area. Berkeley Heights contains 1,482 acres of vacant land, 14% of the county's total, and the three townships combined total of 2,447 acres represents 24% of the county's vacant land. These townships will probably come under heavy development pressure in the near future.

Orange County. Construction of the N.Y. State Thruway made Orange County reasonably accessible to New York City and helped spur suburbanization in the county, particularly in Monroe. Similarly suburbanization spread along N.Y. Route 17.

Growth was dynamic during the 1960's and 70's. The pattern of development has been such that the older cities have lost population and the older villages have barely been holding their own. The rural towns have been the county growth areas. Virtually all of the new growth, over 90%, has taken place in unincorporated towns. New residential development as well as numerous research facilities and corporate headquarters have been attracted to rural areas by the cheap cost of rural land and the relatively low cost for site preparation and development particularly for cleared farm land.

This trend has serious implications for agriculture, which has been an important element in Orange County's economy. Between 1950 and 1969 total farm acreage dropped from 274,000 to 157,000 and the total number of farms from 2,958 to 1,124.

Though zoning has been instituted in 10 municipalities allowing only recreation, parking, and agriculture; the majority of Orange County's farmland remains vulnerable to the pressure of suburban development.

Parts of the towns of Tuxedo, Warwick, and Monroe lie in the Highland Area of the Passaic River Basin. This area's proximity (relative to the rest of the county) to N.Y.C. and access to the N.Y. State Thruway make it a focus of development pressure.

Rockland County. Located on the west bank of the Hudson River, approximately 30 miles (at its center) from N.Y.C., Rockland County has been the recipient of dynamic urbanization and suburbanization pressures in recent years. In 1953, 60% of all land in Rockland County was undeveloped. In 1968, only 30% was vacant. Land capacity and saturation are likely to be reached in the near future.

The completion of the N.Y. State Thruway and Tappan Zee Bridge, the Palisades Interstate Parkway and the extension of the Garden State Parkway, in the 1950's facilitated and encouraged the development boom of the 60's.

The surge of subdivision development spurred by these highway routes followed the patterns of decreasing densities radiating outward from villages and from southern to northern Rockland locales. The initial impact was in the construction of new homes in the closed-in portions of established hamlets such as New City, Nanuet and Pearl River, as well as certain villages such as Spring Valley and Suffern. The southern outlying areas, Orangetown, portions of Ramapo and Clarkstown, were then developed rapidly. The central areas and later the northern areas of Rockland were similarly intensely developed.

By 1970, with the small amount of vacant land remaining, the main thrust of development had passed over Rockland and was moving towards counties further upstate such as Putnam, Orange and Dutchess. In Rockland, scattered vacant properties in the five-town areas were being developed, but at a slower rate than in the previous expansion years.

In recent years, as the number of new single-family homes constructed has declined somewhat and prices have drastically risen, construction of apartment houses has assumed a more important role. Apartment units which comprised slightly over 1% of the total housing stock in 1960, comprised almost 7% in 1970. The predominant type of apartment has been the garden apartment (2 stories) with a limited number of high-rise (6 stories or more) apartment buildings.

Because of established zoning and density patterns, the predominant location of apartments has been in the villages of Nyack, Spring Valley and Suffern. Some projects have also been located in New City, Pearl River, Nanuet and Mt. Ivy. Although located in higher density areas, the newer apartments often have not been situated on "main streets" but on roadways leading to "main streets." The old concept of constructing apartments within a few-minutes-walk of shops and services has been changed to a few-minutes-drive of shops and services. Thus, in many cases, new apartment houses have ceased to be a main support of village or core area business and activities. In response to this trend, villages with extensive business areas, such as Nyack, Spring Valley and Suffern, are contemplating constructing new apartment structures within core business sections.

Commercial activity is abundant in Rockland County. Significant central business and or shopping districts exist in Haverstraw, Nyack, Pearl River, Spring Valley, Suffern, New City, and Hillcrest. For the past two decades the rapid development of outlying residential areas has spurred the proliferation of commercial development along highways. Significant highway districts exist at Nyack, Central Nyack, Nanuet, Spring Valley, Monsey, Tallman and Airmont. The Nanuet district is by far the largest commercial area in the county drawing heavily from the entirety of Rockland and much of the surrounding area.

EXISTING LAND USE AND DEVELOPMENT: GENERAL TRENDS IN THE PASSAIC RIVER BASIN

The pattern of development and land use distribution in the Passaic River Basin is a product of the post-World War II trend of suburbanization in interaction with the natural physical characteristics of the area. From the urban City of Newark in the Lower Valley to the rural western perimeter of the Highland Area, the Passaic River Basin displays all the degrees and stages of development caused by the suburban trend.

Patterns of suburban development radiate from the core central city. In the case of the Passaic River Basin, the urban cores are New York City, which lies east of the study area; and to a lesser extent, Hudson County and the City of Newark, which border the Basin. Smaller urban cores in the Lower Valley, such as the cities of Paterson and Passaic, generate their own smaller patterns of development, as do, to a lesser extent Central Basin towns such as Morristown.

Prior to World War II, the great majority of the northeast's population was contained within the cities. Industry and commerce, hence jobs, were located within the cities. Large scale commutation from suburbs was limited by the lack of an extensive highway system. Suburbanization was confined to a few commuter rail corridors and most of this development was located fairly close to urban cores.

After World War II, the baby boom and the limited housing supply within the cities provided the impetus for suburban residential expansion. The growing importance of the automobile and the continuing expansion of the highway system provided the means for making formerly inaccessible outlying areas practical for suburban development.

The impact of this suburban trend on areas such as northeastern New Jersey was dramatic. Development moved progressively away from the urban centers. Cities, such as Newark, lost not only population, but part of their economic and social vitality as well. Many of the older suburbs in close proximity to the core areas underwent extensive redevelopment and were transformed into essentially high density urban areas. Further out, development occurred along major highways, with greater density development occurring closer to the N.Y.C. - Hudson - Newark core, and, to a lesser extent, the secondary urban centers.

Suburban development in the Passaic River Basin is characterized by low density residential, commercial and industrial land use, with residential land use representing the major portion of developed land in the suburbs.

Development has been almost exclusively in the form of single family homes ranging from 1/8 acre subdivisions in the older eastern suburbs to one and two acre (or larger) lot zoning in many towns in the Central Basin and Highland Area.

Commercial activity is automobile-oriented, occurring in strip development along major highways and clustered around the intersection of major routes. Shopping centers such as those in Paramus (in Bergen County) or Nanuet (in Rockland County) have taken over much of the role of commercial-cum-social centers formerly contained in the central business and shopping districts of the older cities.

Industry has also been attracted to the suburbs by the availability of cheaper land and the subsequent feasibility of modern low-rise facilities with immediate access to major highways. Another trend has been the growing acceptance and prestige of suburban locations as sites for corporate offices and research facilities. These operations can often be found located on land unsuitable for other types of suburban development. The extensive relocation of commerce and industry, and the jobs they provide to the suburbs has made commutation feasible from new residential suburbs, from which the original central core would have been completely out of reach.

Lower Valley. The Lower Valley is the oldest and most densely developed portion of the Basin, containing and receiving the primary influence of its older urban areas, the core City of Newark and the secondary centers of Passaic and Paterson. High density multi-family housing predominates with low income and, minority groups comprising a large proportion of these cities populations.

The southern portion of the Lower Valley between Newark and Paterson is almost completely developed. This area contains many of the older suburbs which, because of their proximity to the cities, were redeveloped at higher densities. Bloomfield, East Orange and the Lower Bergen municipalities have densities of 10-20 dwelling units per residential acre (d.u./res. acre), contain significant proportions of multi-family housing, and can be classified as urban communities. Other southern Lower Valley towns, such as Montclair, are characterized by suburban single family homes at medium densities of 5-10 d.u./res.acres. Generally, between the larger cities of Newark and Paterson, houses are primarily single family or 2 family. Near the Passaic River and along the major thoroughfares are pockets of high and low rise apartments and scatterings of urban renewal projects. Most of the housing in this area, except for Clifton, is more than 40 years old.

North of Paterson, the residential patterns range from a mixture of dense older suburban and newer subdivisions near the City of Paterson, to almost exclusively newer subdivisions and larger lot private homes in the far north near Suffern. Here only a handful of apartment complexes are found and these are near the major highways. Throughout this northern portion of the Valley, the centers of the older villages are apparent by their rectangular streets and small commercial areas. The northern Bergen municipalities within the Lower Valley may be characterized as outer suburban with densities of 2-4 d.u./res. acre. This northern area contains most of the vacant land in the Lower Valley.

Both Paterson and Newark have large central business districts. Scattered throughout both cities are smaller neighborhood business districts at the intersections of major streets. Commerce outside of Paterson and Newark is in the form of small central business districts in each of the smaller cities and strip development along the major roads. Within the Newark-Paterson axis there are few shopping centers. Along the radiating arteries to the north of Paterson, several large shopping centers have been built.

Two other notable commercial patterns are found in specific parts of the Lower Valley. Near the mouth of the Passaic in Newark, Kearny, and Harrison there are large areas devoted to the transfer of goods and materials. These enterprises are in the form of petroleum off-loading facilities (tank farms) and large truck terminals.

Mixed with the port facilities and truck terminals of the Newark-Kearny area is a band of heavy industry up to a mile wide on both sides of the Passaic. To the north, there are pockets of heavy and light industry along the Passaic River in the cities of Belleville, Nutley, Clifton, Passaic, Garfield, Fair Lawn, Hawthorne and Paterson. North of Hawthorne and Fair Lawn, industry is widely scattered, generally light, often in newer buildings, and usually oriented to highways for the movement of raw materials and finished products. Further north, in the Ramsey-Wyckoff area there are several large corporate headquarters.

In the south, the only open areas are those associated with school playgrounds, a few city parks and some large cemeteries. In the north these open areas are augmented by golf courses, larger schoolyards, some large community colleges, a few wood lots on the fringes of the watershed, and orchards.

Agriculture to the south of Franklin Lakes and Waldwick is nonexistent and, to the north, there are a few truck farms and small orchards.

Transportation in the Valley is oriented to the moving of people and goods to and from the few gateways into Manhattan. Many limited access and multiple lane highways radiate to the north, west, and south. These multiple lane highways, combined with an intricate network of secondary highways and local streets, exemplify the dependence of the area on automobiles and trucks.

Rail transportation is centered on the Newark-Kearny area where several lines converge from all directions on two large railyards. From here only a few tracks leave for the tunnels to New York City. The major function of the rail lines are freight, although commuter and long distance passenger service is also provided. Almost all of the industrial areas from Newark to Paterson are serviced by rail lines or spurs.

Newark Airport, just to the south of the watershed, is the major center for commercial aviation. General aviation needs are serviced by Newark and Teterboro airports outside of the watershed, and Caldwell and Morristown Airports in the Central Basin.

Land use in the floodplain of the lower mainstem Passaic River and much of the smaller tributaries is dominated by high density commercial, industrial and residential development.

Central Basin. The Central Basin may be characterized as almost completely suburban. Densities range from 2-4 d.u./res. acre, in the outer suburban eastern rim and older towns, such as Morristown and Boonton, to less than 2 d.u./res. acre in the rural-suburban western section, where zoning ranges from one-half acre to ten acres. The predominant housing type is the single family house. However, garden apartments have increasingly appeared along major automobile routes and the eastern towns of Wayne, Livingston, and others have several large apartment complexes.

Many of the region's residents commute into the Newark-Paterson core and many into New York City. The trend of business and industry to move to the suburbs, however, is reflected in the Central Basin. The major highways linking the region to the urban complex are lined with strip development of individual businesses and shopping centers. The largest shopping center in the Passaic watershed, Willowbrook Mall, is located adjacent to I-80 and U.S. 46 in Wayne. Other smaller centers are found along I-80 and N.J. 10 in Livingston.

In addition to the shopping centers, each of the communities has its own local business district and industrial park or parks containing predominantly light industries and service industries. These businesses are for the most part dependent on highway transportation for the movement of raw materials and finished products. Also found in the region, especially in the vicinity of Whippany and Morristown area, are the headquarters of several large corporations and or their research facilities. Large industrial complexes, often in industrial parks, lie along many of the major thoroughfares.

In the Watchung Mountains, on the rim of the Basin, to the east and south, the basaltic ridges are being quarried for construction materials. This extremely hard rock can be used for riprap, railroad ballast, and concrete aggregate. North of the glacial terminal moraine and in the moraine itself are many sand and gravel pits that are mined. The clays found in the Pompton River Valley are good sources of materials for brick and clay tile. Several large clay pits can be found along the river.

Other large land holdings in the Central Basin belong to institutional users, including hospitals, state and county facilities, large consolidated secondary schools with attendant athletic facilities, and public and private residential and commuter colleges. These institutions are dispersed throughout the region. Several are found along the peaks of the Watchung Mountains.

Besides the major highways through the region, transportation is provided by primary and secondary highways connecting the highways with the well-developed local street networks, a few rail lines through the larger suburbs, two large general aviation airports in Morristown and Caldwell, and several small airports in Hanover, Basking Ridge, Totowa, and Lincoln Park. Several large pipeline and powerline rights-of-way also cross the area.

Open land in the Central Basin is dominated by the wetlands, though, large areas of other types of open land may be found throughout the region. Scattered liberally over the region and concentrated on the flanking hills are stands of dense hardwoods of similar composition to the forests of the Highlands. These forested areas occur mostly on the tops and sides of the hills and throughout the local, state and federal parks. Softwoods are limited to small, scattered plantations, and, because most housing tracts were once fields, tree cover in the residential area tends to be of the ornamental variety.

Recreational land uses include over twenty golf courses, numerous local, county and state parks, horseback riding areas, a small ski area at Campgaw Mountain, and some water activities. Standing water in the region is limited to a few small natural lakes and several large and small water supply reservoirs. Most of the water bodies are found in the Wayne-Franklin Lakes area.

Towns and villages throughout the region and especially along the eastern edge have experienced rapid growth, and development pressure will continue. A great deal of vacant developable land exists in the Central Basin, even in the established towns. Development has in the past been confined to transportation corridors, leaving many areas not directly contiguous to highways, vacant and available for infill development.

Another supply of vacant land in the Central Basin consists of wetlands. More than 15 per cent of the Central Basin is wetland. This area includes the Troy Meadows in East Hanover, Hanover and Parsippany-Troy Hills; Black Meadows in Hanover, East Hanover and Florham Park; Bog and Vly Meadows in Montville, and Lincoln Park; Great Piece Meadows in Lincoln Park, Fairfield, and Montville; Hatfield Swamp in West Caldwell, East Hanover, Fairfield, Roseland, Montville, and Parsippany-Troy Hills; and Great Swamp in Harding, Chatham, and Passaic Townships. These large wetlands are valuable habitat for various flora and fauna and provide large natural storage areas for flood waters, lessening the amount of flooding downstream. The large open areas that these wetlands represent, provide great temptations for development. Along the Passaic River from Little Falls to Livingston, and along the Pompton River to Pompton Plains, some wetlands have been filled for housing developments, shopping centers, and industry. Great Swamp is protected by governmental ownership. However, except for parts of Troy Meadows which is protected by Green Acres acquisition these areas such as Hatfield Swamp, Black Meadows, Bog and Vly Meadows, parts of Great Piece Meadows and some smaller wetlands will remain under intense pressure because they are the only large expanses of level land still undeveloped.

Floodplain land use in the Central Basin is characterized by two distinct patterns. The first is a suburban area upstream of Little Falls, composed largely of residential developments in the northerly portion of the Central Basin along the Passaic River from Little Falls to Two Bridges and along the lower reaches of the Pompton and Ramapo Rivers. The second is the wetland area, with a continuing influx of industry and residential homes in the southern portion of the Central Basin along the Passaic River from Two Bridges to Chatham and along the lower reaches of the Rockaway and Whippany Rivers.

Highland Area. Due to its distance from the urban center, its often rugged topography, and poor highway access, most of the Highland Area has so far been spared from any significant impact of suburbanization.

All but a few towns within this area have densities of less than 2 d.u./res. acre. Residential development is sparse and scattered, one acre (and more) zoning predominates. Much of the land is given over to parks and reservations as well as to agriculture.

While large lot single family homes are the norm throughout the Highlands, a few multi-family dwellings are seen in the Dover-Wharton complex. In the southern Highlands housing is generally first homes located in tract developments. To the north, residences are divided among rural residential strips, older homes in the small, older villages and second home developments near some of the many lakes.

Commercial activities are primarily local retail and service establishments located in or near the centers of the area's communities. In addition, there is a strip of highway-oriented commercial development along each of the major highways through the Highlands. In the north, there are many businesses oriented toward the second home and tourist activity. Included in this latter category are marinas on several of the lakes, a few ski areas, ornamental gardens, motels, and restaurants.

Light industries, dependent upon the highways for the movement of raw materials and finished products, are located in many of the communities along the I-80 corridor. The only major heavy industry in the region is the Picatinny Arsenal, north of Dover. With the exception of rail service to the Picatinny Arsenal, most rail transportation passes through the Highlands with little local service.

Outside of the built-up areas, the Highlands are dominated by forests and lakes. At least 75 percent of the region is forested. Nearly all of the Passaic Basin's surface water occurs in the Highlands in the form of natural or augmented man-made lakes and reservoirs. These water bodies, varying in size from the very large Greenwood Lake and Wanaque Reservoir to small Beaver Ponds, generally trend northeast-southwest following the bedrock trends. The larger water bodies are attractive for second home development, although many are protected from development because of their use as water supply sources.

North of the Dover-Wharton area, where the Highlands were glaciated, there are numerous small wetlands, both on the ridge tops and in the long, narrow valleys. Most of these are forested. Often there are wetlands adjacent to the valley lakes (e.g. the north shore of Echo Lake). These unforested wetlands support growth of reeds, sedges and grasses. Few, if any, unvegetated wetlands occur in the Highlands.

The sparseness of development and the relatively inexpensive land in the Highlands have made the region attractive as a location for gas and petroleum pipeline and electric transmission line corridors. These corridors, connecting the utilities to the north and west with the urban complex to the east and south, transect the region. Together with the aqueducts connecting the urban area with the reservoirs, they mark the woodlands with long ribbons of cleared rights-of-way.

To the north of the moraine, gravel deposits on the sides of mountains are economically valuable and iron deposits occur throughout the region. The extraction of these materials through shaft mines and pits has left marks dotting the landscape.

Only a very small portion of the mainstem floodplain lies in the Highland Area. Parts of the townships of Pequannock and Pompton Lakes near the junction of the Wanaque and Pequannock Rivers and part of the town of Oakland along the lower reach of the Ramapo River constitute the main part of the Highland Area floodplain.

ANALYSIS OF DATA FOR PASSAIC BASIN COMMUNITIES

Introduction

This is a descriptive analysis of major demographic and social characteristics for the Passaic River Basin. The Passaic River Basin consists of 132 communities whose geographical area encompasses portions of Bergen, Essex, Hudson, Morris, Passaic, Somerset, Sussex and Union Counties in New Jersey, and Rockland and Orange Counties in New York State (Figures V-2 and V-3). Passaic River Basin counties and communities are displayed on Table V-1.

The data is divided into two sections: demographic and social characteristics (total population, density, type of community and age): Personal and family economic characteristics (employment, unemployment, median family income, per capita income, changes in residence, source of water and method of sewage disposal). The data has been derived from the U.S. Census of Population and Housing for the years 1950, 1960 1970 and 1980.

Due to the large number of communities which comprise the Passaic River Basin (see Figure V-4), it is cost appropriate to present the major findings for each variable in the Basin, as well as the relevant "high and low" communities.

Because of the manner in which census information is reported, as well as other factors, such as changes in municipal boundaries, the data is not complete for all the communities in the Basin for each of the four census years.

The outstanding changes in the Basin between 1950 and 1980 were its overall growth, the dramatic population and employment increases in the newer suburbs and outlying areas and the decline of the older urban settlements, especially the central cities.

Demographic and Social Characteristics

a. Total Population

In 1950, approximately 1.8 million persons resided in the Passaic River Basin 1/ (see Table V-2). Nearly one quarter of these people (439,000) lived in the City of Newark. In comparison only 600 persons resided in Far Hills, a community of some five square miles in Somerset County, New Jersey. The average community in the Basin had over 14,000 persons in 1950.

Between 1950 and 1960, the Basin's population increased by nearly 20% to over 2.1 million persons. Although Newark remained the largest municipality, its population decreased by 7.7% to 405,000. Meanwhile, Far Hills' populace increased slightly to 702.

1/ Table 2 details Population Characteristics for the Passaic River Study Area.

Between 1960 and 1970, population in the Basin grew by nearly 16%. This rate of increase exceeded the national growth rate of 11.7% and New York State's growth of 8.7%. However, it was less than New Jersey's overall growth rate of more than 18%.

Between 1970 and 1980, the population in the Basin had declined by nearly .5%. By 1980, the Basin's total population reached approximately 2.5 million. The gain of more than 672,000 people in the three decades between 1950 and 1980 represents a growth of about 38%. During the same 30 year period, population in the typical Basin community also rose by 28% to over 18,546.

The largest absolute and percentage gains in population between 1950 and 1980 were posted by the rapidly developing communities in Morris and Rockland Counties as well as in the northern and western sections of Bergen and Passaic Counties. The Rockland County community of Ramapo registered the largest absolute gain, increasing from 20,584 persons in 1950 to 89,060 in 1980, a 333% increase. Other communities on the fringe of the Basin, particularly those in Somerset and Sussex Counties, exhibited high rates of population growth between 1950 and 1980, (see Table V-2).

While suburban areas experienced significant growth during the three decades, most of the older central cities and built-up suburbs either lost population or remained relatively stable. Four of the five largest central cities in the Basin experienced population loss and one gained during this period. Newark, the most populous central city, showed the largest absolute decline; going from 439,000 people in 1950 to 329,000 in 1980 (a 25% decrease). This precipitous decline of Newark's population in relation to the Basin's growing population can be seen from the fact that it had 25% of the Basin's population in 1950 but only 14% in 1980. The City of East Orange also experienced population decline, from approximately 78,000 in 1950 to 77,000 in 1980 (a 1% decrease), as did the City of Passaic, whose population decreased from 57,700 to 52,500 over the three decades (9% decrease).

Paterson, the second largest central city in the Basin, showed a slight decrease in its 1950 population of 139,000 to 138,000 in 1980 (a 1% decrease) while Clifton's population grew by more than 15% going from 64,500 in 1950 to 74,400 in 1980.

b. Density

As the typical Basin community's population grew between 1950 and 1980, its average density also rose. Although figures for 1950 are unavailable, population density in the mean community was over 3,745 persons per square mile in 1960. In 1960 among all communities, density ranged from a minimum of 32 persons per square mile in Vernon Township, New Jersey, a 67 square mile municipality at the fringe of the Basin, to a maximum of 19,315 persons per square mile in the City of East Orange. Between 1960 and 1970, the population density of the mean community in the Basin increased by 11%, from 3,745 to 4,158 persons per square mile. The minimum density reported in 1970, 61 persons per square mile in lightly settled Tuxedo in Orange County, was about double the minimum figure for 1960, and similar to the nation-wide density of 57.5 persons per square mile. In contrast, New York State's density for 1970 was 381 persons per square mile, while New Jersey reflected a much greater overall density of 950 persons per square mile. Between 1970 and 1980 the population density of the mean community in the Basin decreased by 4% from 4,158 to approximately 4,000 persons per square mile. The minimum density reported in 1980, 57 persons per square mile, was found in Tuxedo. In 1980, the density figure for New York was 371 persons per square mile, and for New Jersey as a whole 986 persons per square mile. These figures strongly contrast with the density figure for the Basin.

At the other extreme, East Newark, which embraces only 0.1 square miles, reported the second highest population density for 1980, 1,923 persons per square mile, the maximum density of 19,750 persons per square mile being reported in East Orange.

The greatest absolute and percentage increases in population density within the Basin between 1960 and 1980 occurred in the rapidly developing communities in Morris, Rockland, Bergen and Passaic Counties. Generally speaking, in 1960, 1970 and 1980 the communities on the fringe of the Basin in Somerset, Sussex and Orange Counties exhibited the lowest population densities.

c. Type of Community

Each of the communities within the Basin were grouped according to the following density classification developed by the Regional Plan Association:

Rural - fewer than 150 persons per square mile
Suburban - 150 to 2,500 persons per square mile
Suburban/Urban - 2,500 to 10,000 persons per square mile
Urban - more than 10,000 persons per square mile

Based on 1980 population densities, the Basin's communities are primarily "suburban" or "suburban/urban" in character. Some 70 municipalities, or approximately 53% of the total, are classified as "suburban". The mean population density among this group is about 1,000 persons per square mile. More than half of the "suburban" communities were found in Morris and Bergen Counties, including Denville and Riverdale in Morris and Woodcliff Lake and Upper Saddle River in Bergen County. A total of 47, or approximately 36% of all the Basin's municipalities fall within the "suburban/urban" category, exhibiting a mean density of 5,000 persons per square mile. Bergen County contained nearly 37% of all such communities, including Rochelle Park, Saddle Brook and Waldwick. A number of communities in Essex and Passaic counties achieved this density level.

An additional 13, or approximately 10% of the Basin's communities are "urban" and have a mean density of 14,000 persons per square mile. These "urban" municipalities are generally older declining communities such as Newark, Paterson and Garfield. Lastly, just two municipalities, or 2% of all communities in the Basin are considered to be "rural" in character: Tuxedo Town, and Hardyston. The average density among this group is nearly 100 persons per square mile.

d. Age

The age structure of the Passaic River Basin's population, as measured by median age and the share belonging to two key age groups those under 18 years of age and those over 65 years of age also underwent significant change between 1950 and 1980. Among 77 communities in the Basin for which data was available, median age in 1950 (Represents 85.9% of the Basin's 1950 population), ranged from 27.2 years (Ringwood) to 40.2 years (Glen Ridge). Based on 123 of 132 communities for which data is available (represent 99.6% of the Basin's 1960 population), the median age for the average community was 33.6 years.

For the typical community in 1950, the "under 18" cohort (or group) averaged 27.5% of the total population and the "over 65" cohort averaged 8.4% of the population. In 1950, the proportion of the population under 18 years of age was as low as 20.4% in East Orange and as high as 30.6% in Ringwood. Meanwhile the relative share of the population over 65 years of age ranged from a low of 3.7% in Elmwood Park to a high of 13.5% in both Washington Township and West Caldwell.

By 1960 the median age in the typical community in the Basin had declined to 32.3 years. Among all communities the median age in 1960 ranged from 23.3 years (Victory Gardens) to 41.8 years (Haledon). For the typical community in 1960, the "under 18" cohort averaged 34.5% of the total population and the "over 65" cohort averaged 8.3% of the population. Haledon had the smallest proportion under 18 years of age in 1960 (17.1%) and Waldwick had the largest share under 18 years of age (44.0%). Meanwhile the relative share of the population over 65 years of age in 1960 ranged from a low of only 1.8% in Victory Gardens to a high of 15.7% in Haledon.

As births continued at a high level in the 1960's, the median age of the typical Basin community declined, reaching 31.0 years in 1970. This figure is comparable to 1970 median age figures for both New Jersey and New York State, 30.1 years and 30.3 years respectively. The national median age in 1970 was slightly younger at 28.1 years.

In the Basin the range in median age remained unchanged from 1960 to 1970. The mean share of the "under 18" population in 1970, 34.7%, was also virtually unchanged since 1960 and was slightly higher than both New York State (32.0%) and New Jersey (33.3%) figures. Meanwhile, the proportion of population "under 18" years of age nationwide was as high as 38.0%.

The "over 65" population in the Basin increased only slightly to 8.7% during the 1960 to 1970 period. The relative proportion of population aged 65 and over in the Basin in 1970 was less than both the New York State (10.8%), New Jersey (9.7%) and nationwide (9.9%) percentages.

The median age of the typical Basin community in 1980 increased over the 1970 figure of 31.0 years to 33.5 years. This is higher than both the New York State figure of 31.9 years and the New Jersey State figure of 32.2 years. In fact, the median age for the Basin in 1980 (33.5 years) is higher than the national figure of 30.0 years for that same year. In 1980, the mean share of the "under 18" population in the Basin was 26.4% of the total population, and the mean share of the"over 65" group was 10.6% of the total population in the Basin.

For the entire Basin, Wallington Borough had the smallest share of its population under 18 years of age in 1980, its relative share being 18.6% of total population. Monroe Town in Orange County reported the largest share of the population less than 18 years of age in 1980 (37.7%). Although the minimum share of the population over 65 years of age has remained relatively stable in all communities since 1950, the maximum share has steadily increased to the high of 21.2% reported in Haledon in 1980.

The median age of the population residing in the typical Passaic River Basin community steadily increased between 1970 and 1980. This phenomenon is far more evident in those communities which have undergone significant population decline over the period, such as North Arlington and Fair Lawn Borough. The percentage of the population over 65 years of age has also risen in the older cities but has declined in the rapidly growing areas of Morris, Somerset, Rockland and Orange Counties. At the same time the percentage of the population under 18 years of age has steadily increased since 1960 in the rapidly growing areas, while in most of the older cities and suburbs the share of population under 18 years of age has remained stable since 1960.

Personal and Family Economic Characteristics

a. Employment

Employment data for 1950 is available for 57 of the 132 Basin's communities, or just 43.2% of all communities, which represent 71.6% of the Basin's 1950 population. Because of the small share of the population covered, it was decided that 1950 employment data would not provide a useful basis for comparative analysis.

In 1960, employment data was available for 110 of the Basin's communities, representing 94.8% of the Basin's population.

Over 6,200 of the 16,600 residents in the typical Passaic River Basin community in 1960, or close to 38%, were employed. Although the City of Newark had the largest number of employed residents in 1960, some 162,000, this represented only 40% of its population. Far Hills had 310 residents employed, representing 43% of its population in 1960.

In 1970 the number of employed residents in the average Basin community had grown by nearly 26% to 7,800, but because population growth during the same period averaged 35%, the share of employed residents increased to only about 40%. While Newark's population declined by 23,000 persons, or some 6% between 1960 and 1970, the number of employed residents decreased by 25,000, or about 15%, reflecting marked changes in its demographic structure and the exodus of industrial jobs from the city. Only a handful of other communities reported a significant decline in resident employment from 1960 to 1970, including Orange and East Orange in Essex County, both older central areas.

On the other hand, rapidly growing communities in Morris County, for example, recorded the largest gains in resident employment during the 1960 to 1970 period as employment opportunities shifted from the central cities and new jobs were created in the outlying areas. Between 1960 and 1970, the largest absolute gain in resident employment occurred in Parsippany-Troy Hills, where the number of employed residents grew from 7,929 to 23,277, an approximatly 194% increase. A gain of such magnitude outpaced the rate of the community's population growth, 118%, as the share of employed residents in the municipality rose from 31% in 1960 to 42% in 1970. The largest relative increase in resident employment between 1960 and 1970 was recorded in Roxbury Township, also in Morris County, where the number of employed residents increased by 261%, from 1,662 to 5,997 while population increased 58% from 9,983 to 15,753. The share of employed residents more than doubled from a low of 17% of the total population in 1960, reflecting a large proportion of younger people, to an average of 38% in 1970.

By 1980, the number of employed residents in the average Basin community was around 11,200, a growth of about 44% over the 1970 figures. The growth trends of the 1960 to 1970 period continued in Morris County and in the other communities, during the 1970 to 1980 period. For the entire Basin, total resident employment was nearly 1.5 million persons in 1980, representing about 60% of its population. The increase in absolute employment in the Basin during the 1970 to 1980 period seems contradictory to other trends such as declining population in the Basin area. This is explained by the fact that during this period the median age of the population increased with a sharp decline in the share of the population under 18 years old. The "over 65" group also showed a very similar change. The result of the group trends was an absolute increase in the labor force during the 1970 to 1980 period even though the population in the Basin area declined.

b. Unemployment

Another important economic indicator for the Passaic River Basin is the rate of unemployment. Based on data available for 110 communities in 1960, or nearly 95% of the Basin's 1960 population, approximately 3.2% of the labor force in the average community in the Basin was unemployed. The economically troubled City of Newark exhibited the highest unemployment rate among all communities, with over 8.2% of its labor force unemployed in 1960. At the other extreme, less than 4% of Rochelle Park's labor force was unemployed in 1960.

In addition to Newark, older, developed communities such as Garfield (7.1%), Lodi (6.3%) and Wallington (7.6%) in southern Bergen County and the central cities of Paterson (7.6%) and Passaic (7.2%) in Passaic County all reported high unemployment rates in 1960, as did developing communities in Passaic County, including Ringwood (6.8%), Wanaque (6.8%) and West Paterson (6.5%). At the other extreme, the lowest rates of unemployment in 1960 were posted in widely separated communities including Rochelle Park-Allendale (0.5%) and Ridgewood (1.1%) in Bergen County; Jefferson (0.4%) and Morris Plains (0.9%) in Morris County and Livingston (1.1%) in Essex County.

In 1970, the unemployment rate in the average community in the Basin was about 3.0%, compared to 3.2% in 1960. This was less than the New York State (4.0%), New Jersey (3.65%) and nationwide (4.45%) unemployment rates for that year.

The declining cities of Paterson and Passaic had the highest unemployment rates in the Basin, with identical percentages of 6.6% in 1970. The rate of unemployment in Newark was slightly below this figure at 6.5%. Other communities with high unemployment rates in 1970 included Haledon (5.8%), Fairfield (5.1%) and Mine Hill Township (5.1%). Meanwhile, the lowest unemployment rate in 1970, (0.4%), was registered in three communities: Essex Fells, Wharton and Tuxedo.

In 1980, the unemployment rate in the average community in the Basin was about 4.8%. Again this was less than New York State (8.6%), New Jersey (9.0%), and the nation as a whole (9.7%). In 1980, Newark, Passaic City, Paterson, and East Newark had unemployment rates of approximately 10.0%, with the highest unemployment rate being found in Newark (13.4%). Throughout the Basin, the lowest unemployment percentage was found in Harding Township (1.8%) in 1980. Unemployment rates followed no geographical patterns, with high and low rates randomly dispersed throughout the Basin.

c. Median Family Income

In 1980, the median family income in the average of 132 municipalities was $28,892. This figure was well above the median family income in New York State ($16,647), New Jersey ($19,800) and the U.S. as a whole ($16,841).

Among all communities in the Basin, the maximum 1980 median family income of $49,484 was registered in the affluent community of Mountain Lakes, a hamlet of about 4,153 people. Excluding Mountain Lakes, eight other communities in the Basin had median family incomes greater than $40,000 in 1980. Of the total of nine communities, four communities were located in Bergen County (Franklin Lakes, Saddle River Borough, Upper Saddle River Borough and Woodcliff Lake). Of the remaining five communities two were in Essex County (Essex Fells and North Caldwell) and three were in Morris County (Chatham Township, Mendham Township and Mountain Lakes).

Newark reported the lowest median family income among Passaic River Basin communities in 1980. As a result of substantial losses in population and jobs during the 1960's and 1970's the 1980 median family income in Newark City was only $10,118, or just 39% of the average for the Basin. A number of other communities in the Basin had median family incomes under $15,000 in 1980, including such older declining central areas as Paterson, Passaic, East Orange, and Orange City.

d. Per Capita Income

Per capita income is another major indicator of economic conditions within the Basin. Based on data available for the communities in the Basin in 1980, per capita income for the mean community was approximately $9,735, higher than New York State ($7,498), New Jersey ($8,127) and the U.S. as a whole ($7,298). Per capita income for the Passaic River Basin counties is displayed on Table V-3.

Newark had the lowest 1970 per capita income (under $5,225) among communities in the Basin. Two other older areas Paterson ($6,253) and West Orange ($5,931), were the only other municipalities with per capita income of less than $6,300 in 1970 (1979 price levels).

Among communities in the Basin, the highest 1980 per capita income of $24,270 was recorded in the Morris County municipality of Harding. Mountain Lakes, which reported the highest 1980 median family income, had the tenth highest per capita income in 1980 ($14,470) mainly, due to the large percentage of its population which was under 18 years of age (35.7%). Per capita income in both Saddle River Borough in Bergen County and Far Hills in Somerset County exceeded $19,000 in 1980. Communities at the edge of the Basin in northern Bergen and Morris Counties accounted for the largest share of municipalities with 1980 per capita incomes of between $10,000 and $15,000.

Newark had the lowest 1980 per capita income, (under $5,000) among communities in the Basin. Two other older areas, Paterson ($5,060) and Passaic City ($5,813), were the only other municipalities with per capita incomes of less than $6,000 in 1980.

e. Changes in Residence

Data regarding changes in residence was available for 63 municipalities in 1960, representing 81.4% of the population in the Passaic River Basin in that year. Nearly 43% of the people who resided in the average Basin community in 1960 had changed their place of residence in the previous five years. Such changes in residence included moves within the municipality as well as moves from other areas. Among the communities for which 1960 data was available, the percent of residents who had changed residence since 1955 ranged from a high of 70% in Oakland to a low of 6% in Rochelle Park.

Approximately 40% of the people who resided in the average Passaic River Basin community in 1970 had changed their place of residence since 1965. The same percentage of persons residing in New York State in 1970 had changed their residence in the previous five years. Meanwhile, some 42.9% of the national population changed residence between 1965 and 1970, while as many as 47.3% of New Jersey residents had changed their residence in the five years prior to 1970.

Among 118 communities in the Basin for which data is available, (representing over 97% of the basin's 1970 population growth), the percent of 1970 residents who had changed residence in the previous five years ranged from a high of over 61% in Mount Arlington to a low of 23% in Woodridge. Not surprisingly, high rates of residential change are associated with high rates of population growth. Thus, the large share of Mount Arlington's population that changed residence from 1965 to 1970 can be largely explained by its explosive population growth, as it went from 1,246 people in 1960 to 3,590 in 1970 (a 188% increase). Similarly, in Parsippany-Troy Hills and Ramapo, both of which more than doubled their population between 1960 and 1970, the percentages of the population changing residence since 1965 were 61% and 58%, respectively, before 1980.

At the other end of the spectrum, a number of older, southern Bergen County communities showed remarkable stability during the late 1960's. Among them were Woodridge, Hasbrouck Heights, Lyndhurst, Rochelle Park and Saddle Brook, all of which experienced population growth of less than 5% between 1960 and 1970.

For the year 1980, among the same 118 Basin communities for which data was available in 1970, the percent of 1980 residents who had changed residence in the previous five years was about 44%. Areas where residential changes were high, over 50%, included Vernon, Sparta, Paterson, and Passaic City. Areas where residential changes were low, less than 30%, included Riverdale, Maywood, and Woodridge.

Areas of greatest residential changes included the older, declining communities of Passaic City, Paterson and Newark, where the unemployment rates were more than 10% and the decline in total population being equal to or more than 5%. Areas of greatest residential change also included communities which experienced relatively large population growth in 1980. Vernon Township whose population grew by about 169% between 1970 and 1980 had about 60% residential change in the previous 5 years.

Monroe Town experienced about 63% population growth between 1970 and 1980, and about 52% residential change. Woodbury's population grew by some 39%, and this community experienced 50% residential changes. Sparta, whose population grew by 23% between 1970 and 1980 had 55% change of residency in the previous 5 years before 1980.

Areas in which residential changes were least had relatively low rates of unemployment. Maywood, Riverdale and Woodridge, had unemployment rates of 2.7%, 4.8% and 5.4%, respectively in 1980. Rochelle Park which experienced the lowest percent of residential change throughout the Basin had 3.8% unemployment in 1980.

f. Source of Water

Data on utilities (i. e. source of water, type of sewage disposal) is also indicative of settlement patterns and levels of urbanization within the Basin's communities. Because such data is not available on a comprehensive basis for 1960 and 1970, it is difficult to compare the changes in the provision of utilities with corresponding changes in population and density. Nevertheless, certain valid generalizations can still be made on the interrelationships between these variables.

Based on the 76 communities for which 1960 data is available, encompassing just 47.1% of the Basin's population, over 91% of the housing units in the average community in the Basin were served by public water. An additional 8% of the dwelling units had private wells and less than one-half of one percent received their water from other services. In 1960, 33 of the 76 communities relied entirely on public water and the rest had mixed sources. Most of the communities that depended exclusively on public water were in the built-up areas of Bergen, Essex and Hudson Counties. The extreme dependence on private water in 1960 was in Upper Saddle River, where some 96% of all units tapped private wells while only 2% used public water systems. Other localities where over half of the dwelling units were served by private wells included low density areas such as Franklin Lakes, Kinnelon and North Haledon.

Of the 70 communities for which data is available in 1970, comprising nearly 60% of the Basin's population, 23 or nearly one-third relied solely on public water systems and the rest depended on mixed supply systems.

New York State and New Jersey both had higher percentages of housing units relying on public water systems in 1970, 90.2% and 89.7% respectively. The nationwide figure was 81.7%.

For the typical community in the Basin in 1970 nearly 82% of all housing units were served by public water; nearly 18% more drew water from private wells and less than one-half of one percent use other sources 4/. In 1970, the maximum dependence on private wells was attained in Warren Township in Somerset County, where 76% of the units relied upon this source. Other communities which were largely dependent on private wells (more than 65% of all units) in 1970, including Franklin Lakes, West Milford, Hardyston and Vernon, are similarly situated at the fringe of the Basin and are characterized by extremely low densities. For example, of the five communities cited, the densest in 1970 was Franklin Lakes, with about 770 persons per square mile, compared to a density of 5,160 persons per square mile in the average Basin community. Most of the other communities with over half of the dwellings served by private wells in 1970 are located in rapidly developing Morris County and typically had population densities of less than 1,000 persons per square mile.

g. Method of Sewage Disposal

As with source of water, comprehensive data on sewage disposal methods in the Passaic River Basin is unavailable for 1960 and 1970. Such data was reported for the same 76 communities in 1960 and the same 70 communities in 1970.

The smaller share of units served by public water in 1970, compared to 1960, is partly explained by the fact that data on "source of water" was unavailable for a number of rural and semi-rural communities in 1969, communities which presumably depended on wells, as well as for a number of developed communities in 1970, communities which presumably relied on public water system.

WATER SUPPLY

This section will describe the existing water supply situation in the Passaic River Basin and present the results of our analysis of future needs. This includes the analysis of existing data, its adequacy for water supply studies as mandated in recent guidance and projected future demands.

a. Existing System

The existing water supply systems in the Passaic River Basin are operating at or above safe yield. (Safe yield is the amount of water which could be supplied under repetition of the drought of record.) This is the case, in spite of the fact that the average annual rainfall is 47 inches. Approximately 50% of the precipitation runs off, either through overland runoff or groundwater discharge to streams. The remaining percentage is lost to evaporation, transpiration, and consumptive use. Of the 750 mgd (1,159 cfs) average discharge at Little Falls, approximately 300 mgd are diverted for water supply use. This represents a relatively high level of development. During the 1960's drought, rainfall fell to 30.54 inches during one year, (about 2/3 of the average). There were several consecutive years of below normal rainfall as well. This caused a deficit in groundwater recharge. This drought, the most severe on record, caused the reevaluation of water supply source yields which had been based on the previous drought of record that occurred in the 1930's. This reevaluation has placed some of these systems in deficit, should a drought of this magnitude recur.

b. Study Area

The water supply study area extends beyond basin lines because of the seven large water purveyors that service the Northeastern New Jersey area. The northeast portion of the state includes the Passaic, Hackensack and Raritan River Basins which are heavily developed to provide water for the cities and communities in the area. The Hackensack Water Company, while draining most of its water from the Hackensack River, draws water from Saddle River and has a service area that includes 560 communities in Bergen and Hudson Counties. Jersey City, located outside of the Basin, draws its supply from the Rockaway River and serves other communities in the Basin. Newark draws on the Pequannock in a similar manner.

The purveyors are interrelated directly through many interconnections with each other and with several smaller companies. These interconnections are one-way, many have never been used and others have an undetermined capacity or size. The probable number is well over one hundred and, in effect, extends the study area to include several additional communities.

c. Base Conditions

The Basin has already been developed extensively for water supply. Development began in the 1800's when cities experienced groundwater contamination and heavy surface water contamination; large quantities of pure water were required and even greater quantities were anticipated in the future. As a result upstream tributaries were developed for the municipal water systems far removed from their sources. These systems were developed and have grown to their large, present day sizes. Typically, this water is impounded in the headwaters of rivers that are tributary to the Passaic and transmitted via pipeline, rather than stream channel, to the center of demand. The Passaic Valley Water Commission (P.V.W.C.) is the exception to this trend as it withdraws water from the Passaic River at Little Falls; therefore, much of its water has been previously used.

d. Groundwater Resource Development

Groundwater is a major source in the Highland Area and Central Basin for potable water supply. As was previously mentioned, the surface water supplies have been largely developed for export from these areas and as development has occurred there, groundwater has become the major source. It provides 75% of the potable water used above Little Falls and represents 16% of the total developed water supply upstream of Little Falls. The publicly supplied potable water demand of the area is estimated at 61 mgd. Approximately 45 mgd of this amount is taken from public wells, the remainder from surface supplies. The largest diversions of groundwater are:

1) The Commonwealth Water Company which withdraws 12.5 mgd.

2) The City of East Orange diverting up to 8.8 mgd from its well fields in Millburn.

3) Morristown has developed wells which are producing almost 5 mgd.

4) The Parsippany-Troy Hills Water Department is producing nearly 5 mgd.

5) Municipalities whose wells are producing between two and three mgd are Mahwah, Livingston, Dover and Essex Falls. The water departments of Madison, Oakland, Rockaway Borough and Pequannock are supplying from one to two mgd to their service area.

6) The remaining 18 purveyors of potable groundwater downstream of Little Falls produce less than one mgd each. Of these, only 11 supply over one-half mgd each. Additionally, approximately 50,000 private wells are used for domestic water needs.

e. Range of Deficits

The State of New Jersey's Water Supply Master Plan has projected significant needs for water for its Region 1, an area which encompasses the Passaic Basin. However, these needs are substantially less than what was projected as part of the Corps' Northeastern U.S. Water Supply Study (NEWS). Both, however, indicate a significant water supply problem through the year 2020.

The reported deficits have been reduced by the inclusions of the Wanaque South Project which will go into operation in 1987 to provide an incremental yield of 79 mgd to the region in Northern New Jersey.

	2020	2030
Water Supply Master Plan	72 mgd	124 mgd
NEWS	241 mgd	671 mgd

The differences can be accounted for in the underlying assumptions about population growth, industrial development, proportion of future increments served by public systems, and the mix of technologies used to produce products which, in the past, utilized water intensive technologies.

The State of New Jersey's Master Plan has developed alternative solutions for the projected water supply deficits only through the year 2020. Beyond that date, long run concepts are discussed, but the focus is clearly on the immediate future. If the projects identified for implementation are built, and this is not certain, deficits beyond the year 2020 will still be significant.

The plans most frequently discussed can be separated into three categories: 1) emergency type actions undertaken during periodic drought events; 2) those plans being considered currently; and 3) plans previously identified which are not being actively considered.

1. Emergency Actions: Additional proposed potential sources of water supply in New Jersey include Greenwood Lake and Hopatcong Lake.

2. One plan being considered currently is the Morris County Municipal Utility Authority proposal for a reservoir on the Whippany River. Washington Valley Reservoir would be a 1.2 billion gallon capacity reservoir with an estimated 7 mgd sustained delivery. It would be located on the Whippany River in Morris Township and be used to satisfy local demand.

3. Inactive Plans include.

a. The City of Newark requested approval of Dunker's Pond Reservoir in 1967. The Water Policy and Supply Council of the State of New Jersey granted the request in May 1971. The proposed reservoir would be located in the Pequannock Basin, have an 11 billion gallon capacity and provide an additional 20 mgd to Newark's system. The reservoir would store excess Pequannock flows and could also be used to store water diverted from the Delaware Basin.

b. Longwood Valley Reservoir has been proposed by Jersey City for development as an additional source of water to supplement its existing supplies. This was proposed as a joint project with New Jersey Power and Light Company and would involve two reservoirs for a combination of water supply and pumped storage for electric generation. Longwood Valley would have a capacity of 2.5 billion gallons and would be constructed along with a 5.5 billion gallon reservoir in the Musconetcong Basin. A pumped storage electric power generation system would be arranged between the two. An estimated 10.5 mgd in additional safe yield would be realized from the project. Recent announcements from Jersey City have indicated that the City is abandoning the original plan and investigating alternative concepts. The fate of Longwood Valley Reservoir is uncertain at this time. It is however, a plan under consideration as part of the Upper Rockaway River Basin Feasibility Study with the inclusion of flood control as a project purpose.

Project Under Construction

Approval for the North Jersey District Water Supply Commission and Hackensack Water Company was granted by the Water Supply and Policy Council for: (a) Diversions of a maximum of 250 mgd from Pompton and Passaic Rivers at the Two Bridges location; (b) Diversions of a maximum of 150 mgd from the Ramapo River at Pompton Lakes; (c) Storage of 7 billion gallons in Monksville Reservoir located on the Wanaque River immediately upstream of Wanaque Reservoir. This overall project is known as the Wanaque South and Monksville Reservoir Project which will provide an additional estimated safe yield of 79 mgd to the two water supply systems. Construction of the project was begun in 1985 and will be completed and in full operation later this year.

RECREATION

a. Existing Conditions

The Passaic River Basin has numerous physical characteristics which lend themselves to recreational development. The Highland Region is characterized by extensive timbered terrain, steep narrow valleys, and fast, high-gradient, good quality streams which contain many natural and man-made lakes. The Central Basin is a relatively flat, broad, oval shaped valley which includes floodplain, fresh water marshes and meadowlands along flat gradient water-courses. The Lower Valley is a densely populated and highly industrialized region. The river in this area has a generally flat gradient except where broken by falls. Opportunities for fishing, wildlife study and recreation in the basin are plentiful. The potential of the Passaic River Basin as a recreation area arises from its physical characteristics and from its proximity to the large population of the New York and New Jersey Metropolitan Region. The demand for outdoor recreation facilities is increasingly due to the rise in population, greater per capita income, and increase in leisure time. The annual visitor attendance of New Jersey State recreation areas approximately quadrupled between 1950 and 1970, indicating rapidly increasing use patterns and demand.

b. Service Area Counties

The area most likely to benefit from any planned facilities would consist of the counties of Bergen, Essex, Hudson, Hunterdon, Middlesex, Morris, Passaic, Somerset, Sussex, Union, Orange, and Rockland. Although the Passaic River Basin residents will enjoy the close proximity to any new recreational development, the comprehensive transportation network will extend the influence of such development to the larger areas.

There are public parks, forest areas and historic sites in and adjacent to the Passaic Basin zone of recreation influence. The only Federal facilities in the area are the 958 acre Morristown National Historical Park, which is administered by the National Park Service, the approximately 6,700 acre Great Swamp National Wildlife Refuge, administered by the United States Fish and Wildlife Service, and the Delaware Water Gap National Recreation Area.

The Morristown National Historical Park located in Morris County, New Jersey, is dedicated to the preservation of historical grounds and artifacts associated with winter encampments of the American Army during the Revolutionary War. The primary use of the Great Swamp National Wildlife Refuge is conservation education with some water fowl management in the northwest section. There are also picnic areas and nature trails. For the most part, the state forests are relatively undeveloped, except for Stokes State Forest, which has facilities for picnicking, camping, and swimming. It is contiguous to High Point State Park in Sussex County, and together they comprise the largest single recreation facility in the area. The activities most commonly found in the State parks are boating and canoeing. Also located in the Basin are a number of county parks. These are usually smaller in area than the state parks and have a more limited range of activities. In addition to the Federal, State, and County facilities, there are numerous municipal parks and recreational facilities which are generally only available to serve the needs of residents of those municipalities.

The Passaic River Basin contains numerous meadows, woodlands and streams that provide a natural habitat for propagation of wildlife and opportunities for hunting, sport fishing, and nature study. Some Federal, State and local organizations are actively supporting measures for conservation and development of these resources, while other organizations and communities prefer land filling or clearing and development of these areas to meet the needs of an expanding population and economy.

Access to all Federal, State and county recreation sites is very good. Major highways leading into the region are U.S. Routes 202 and 46 and New Jersey Routes 17, 23, and 3. In addition, the Garden State Parkway and the New Jersey Turnpike also assist in providing easy access. Locally, there are numerous hard-surfaced roads providing an all weather network in the immediate vicinity of the sites. The New York Thruway bisects the New York portion of the Basin. Interstate Highways 80, 78, 287 and 280 cross the Passaic River Basin, making it more accessible to a greater number of people. Travel studies indicate that about 20 percent of the people passing through also use outdoor recreation facilities in the area. Access roads connect with the major highways at points of intersection.

The Service Area, which comprises the aforementioned counties in New Jersey and New York, had a total population of about five million people in 1975. The growing population, growth of per capita income, increased leisure time and changing attitudes toward outdoor recreation point to a definite need for a corresponding increase in recreational facilities. The area is more developed than the nation as a whole, as indicated by the higher per capita income generated by the local economy. In 1980 the Service Area's per capita income of $11,266 expressed in 1983 dollars, was 19 percent greater than that in the nation as a whole.

c. Summary of New Jersey SCORP Findings

A number of problem areas surfaced repeatedly during the planning process for the New Jersey Statewide Comprehensive Outdoor Recreation Plan (SCORP). Foremost among them were the lack of recreational opportunities for large segments of the State's population and the need to preserve more open space. Much more open space is necessary to adequately serve the recreational requirements of New Jersey. This open space should be located where the people live now, and where they will live in the near future. Recreation sites need to be provided which are readily accessible to most of the State's residents, especially those in crowded urban areas, on a daily basis. This might be accomplished by providing adequate, inexpensive transportation to existing sites or by locating new facilities where they are most in demand. There is a lack of water-related recreation facilities throughout the State, especially in urban areas. Also, the need for a greater variety of recreational opportunities is acute in urban centers.

The recreation needs of some groups of people in New Jersey are not being met satisfactorily. The Green Acres staff has recently completed planning studies dealing with urban needs and the needs of the recreationally disadvantaged. In the past, urban areas have been underfunded as available money was spent on rural and suburban open space. The prevailing negative attitudes toward crowded, older cities and a misunderstanding of the nature of recreation have been prime causes of underfunding. However, the State is now working to correct past inequities. One of the most pressing needs identified by the Urban Needs Study is the desire for more choice, for a wider variety of activities, especially those centered around water.

RECREATION IN THE COUNTY AREAS

Bergen County. Bergen County has experienced a tremendous outward expansion of population growth over the past three decades. It is the most populous county in New Jersey. The rapid population growth has in turn created a surge in the demand for recreational facilities. The County Park Commission, attempting to operate in accordance with this expanding demand and decreasing availability of vacant land due to ongoing development, has recommended that an additional 5,300 acres be acquired in the county by the year 2000. Present parkland locations are not evenly distributed within the county. The southern portion of Bergen County still retains major salt water marshes, commonly known as the Hackensack Meadowlands. Portions of the Hackensack Meadowlands have been recently developed for a racetrack, an open air sports arena, and lastly, an enclosed arena for sports and entertainment affairs. A recent state acquisition, the Ramapo Mountain State Forest, covers an area of 2,300 acres. The scenic Palisades, in northeast Bergen County under the authority of the Palisades Interstate Park Commission, provide good hiking along with dramatic views of the Hudson River and Manhattan Island. The Hackensack Water Company still retains considerable watershed land which has recreation potential.

The most popular outdoor recreational activity in Bergen County as well as all of New Jersey is bicycling (1984 New Jersey SCORP Survey). The bicycling demand in Bergen is 260,000 activity days annually. An activity day represents one person participating in an activity, for any length of time during a day. Swimming is the second most popular activity based on an annual demand of 149,000 activity days. Ice skating and tennis are the third and fourth most popular sources of recreation. The remaining popular activities include picnicking, skiing, open field activities, and passive recreational activities such as walking, jogging, and driving for pleasure. Demand for the two most popular activities in each of the New Jersey Counties is shown in Table V-4. The top activities are similar throughout most of the counties. Bergen County is not alone in experiencing a large expansion of recreation demand. Throughout the state, increasing demands are being made on recreational facilities by increasing numbers of both in state and out of state residents. The trend will continue with increasing family income, leisure time, and daily pressures of urban and suburban living. In the instances where recreational demand has surpassed the capacity of existing facilities, the result has been overcrowding and or people being turned away at recreation sites. This occurs in many of the New Jersey Counties.

Presently in Bergen County, peak day demand deficits exist for all facilities except playground areas and basketball courts. A deficit indicates lack of sufficient facilities to meet recreational demand. By 1990, major peak day demand deficits are expected for freshwater swimming (70,600 activity days), ice skating (97,900 activity days), bicycling (265,500 activity days), tennis (66,300 activity days), and both baseball and softball fields (27,700 activity days). Playground areas and basketball courts are expected to continue to show a surplus in peak day facilities.

To aid in alleviating expected increases in recreational facility deficits, Bergen County has received ten percent of New Jersey's Land and Water Conservation Fund, 1965-1977, (a program developed to assist state and local governments in providing recreational facilities) including $1.9 million for the State acquisition of the MacEvoy Estate and $175,000 for a County acquisition on the Ramapo Mountains. All of the development funds ($581,867) were spent on the local level, including projects such as Fort Lee Historic Park and five miles of bike trails in Saddle River County Park. In addition, Bergen County received approximately 6 percent of the total funds of the Green Acres Program (1974-1977) for the acquisition and development of recreational facilities. Approximately $4 million was received from the Green Acres local development fund and $1 million from the State program.

Essex County. Essex County residents are fortunate that over a quarter of the county is forested and its location provides easy access to the Passaic River and Newark Bay. The Essex County Park Commission operates an extensive park system totaling 2,704 acres. South Mountain Reservation, the largest unit of the county park system, provides a near wilderness area for hiking, fishing and horseback riding. Branchwood Park and Weequahic Park in Newark provide large open spaces in otherwise crowded areas. The State Park in Great Piece Meadows, consisting of approximately 120 acres is also in Essex County. Open space deficits are the most extreme in the southern part of the county. In this densely populated area, it has become increasingly difficult to purchase or preserve land for open space and recreational county parks. In Essex County, peak day recreational demand deficits exist for all facilities except playground areas, camping and basketball courts. However, present facilities are expected to become increasingly inadequate in meeting recreation demand. In 1990, the County's major peak day demand deficits will occur in playground areas and basketball courts (16,938 and 9,311 activity days respectively). Bicycling (266,400 activity days), freshwater swimming (72,400 activity days), tennis courts (62,500 activity days), ice skating (56,400 activity days), picnicking (45,300 activity days), and baseball and softball fields (39,400 activity days) show a surplus in peak day facilities. To meet present and future recreational demands, Essex County was accorded seven percent of the total Land and Water Conservation Fund in New Jersey (1965-1977). All of the approximately $3 million dollars were spent on local development projects. These included projects such as the County Park Commission's total reconstruction of Westside Park in Newark, renovation of an overgrown cemetery into a park in South Orange and several other municipal developments. Essex County also received 9% of local funds from the 1974 Green Acres Program. Seven development projects were approved as well as one acquisition project.

Hudson County. Hudson County is the most densely populated county in New Jersey and its natural resource recreation opportunities are severely limited. Those that exist are mostly associated with water access to the Hudson River and New York Bay. The Hudson County Parks System totals 90 acres made up of Kearny Park (40 acres) and West Hudson Park (50 acres). The high recreation demand has been relieved to some extent by the relatively recent development of Liberty State Park. The Hudson County Planning Board utilizes the Regional Plan Association's standard of 3.6 acres per 1,000 population with regard to county open space needs and 2 acres per 1,000 population for municipal needs. Land values in Hudson are at a premium. The western part of the county is less densely populated and has more available open space but acquisition costs are still extremely high. Currently, there is a deficit of 1,168 acres of land on the entire county level and 134 acres on the municipal level. By 1990, there will exist a need for 3,729 acres of open space to meet the population growth countywide. The Hudson County "Open-space Acquisition Plan" recommends that by 1990, the county should have 2,659 acres reserved for open spaces and recreation purposes. If these acquisition plans are met there will still be a deficit of 1,070 acres.

Hudson County's recreation facilities are presently unable to meet the peak day demand for the majority of activities analyzed. By 1990, severe peak day facility deficits are expected to occur in many activities: bicycling (175,600 activity days), ice skating (74,400 activity days), freshwater swimming (47,600 activity days), tennis (40,300 activity days), football/soccer fields (31,300 activity days), softball and baseball (33,200 activity days), and regulation golf (8,500 activity days).

Hudson County received seven percent ($1,416,521) of New Jersey's Land and Water Conservation Fund (1965-1977). This apportionment went toward the development of local recreation facilities and nearly half went to the County Park Commission for an upgrading of parks in Jersey City, Bayonne and North Bergen. Hudson County also received the largest share of funds from the 1974 Green Acres Program. Fifteen million dollars were authorized for state projects as well as over two million for local efforts. Liberty State Park, the important recreational site in Jersey City, was built to attract both in state and out of state recreationalists.

Morris County. The population of Morris County is distributed in dense urban areas in the southern and eastern sections of the county, expanding suburban development in the central section and rural areas in the highland hills and valleys to the north and west. Population growth projections for Morris show a rapid increase in new residents, making outdoor recreation and public open space competitors for available land areas. The conservation of open space has become a primary concern of planning agencies.

A chain of fresh water marshes runs along the Passaic River in Morris County. These marshes include the Great Swamp National Wildlife Refuge, Troy Meadows and Hatfield Swamp (in part), where there exists many wildlife habitats, especially those of migrating water fowl. These areas, the county's extensive park system, and numerous lakes and ponds offer recreational opportunities for good fishing, hunting, canoeing, and boating. The County's northern watershed lands have great potential for future recreation development. Overall population growth in Morris County is expected to double by 1990 and increase the demands on the already stressed recreational facilities. At present, peak day recreational demand deficits exist for all activities except freshwater swimming, basketball and playground activities. By 1990 major activity deficits are expected for bicycling (121,300 activity days), tennis (28,120 activity days) horseback riding (25,100 activity days), picnicking (18,900 activity days), and freshwater boating and fishing (14,900 activity days). To keep up with increasing recreation demand, Morris County has acquired over 5,200 acres for outdoor recreation purposes. However, using park acreage standards, established by the State of New Jersey, the need for additional parkland is expected to increase to 9,600 acres. An addition of 2,200 acres to the park system is proposed to meet needs by 1990. This represents half of the county's requirements for additional park acreage.

Morris County received 3% ($1,434,478) of the Land and Water Conservation Fund in New Jersey (1965-1977) for aid in providing recreation facilities. This sum was committed completely to local projects. Three municipal acquisitions were completed including Patriots Path in Morristown. Major developments included Camp Washington on Sun Rise Lake by the County Park Commission and three separate grants to Pequannock for the development of Greenview Park. Morris also obtained 4% ($3,868,750) from the 1974 Green Acres Program for acquisition and development projects.

County park development plans emphasize linear parks connecting existing park systems. This park network would interlock various types of recreation activities such as riding, hiking, and fishing. Linear parks would also provide conservation of riparian lands. This is proposed for the Passaic River corridor, which would also tie in with adjacent county proposals. The county's watershed areas exhibit high recreation potential for controlled public access and use.

Passaic County. Passaic County's extremely diverse geographic make-up includes parkland and open space. Western Passaic County, with its lakes and forests offers a wide diversity of recreational opportunities. Some bodies of water in the county are Greenwood and Upper Greenwood Lakes and water supply reservoirs including Canistear and Echo Lake. Of Passaic County's 192 square miles, over 51% is forested, much of which is located in the northwestern portion of the county. Eastern Passaic County is heavily urbanized with few large tracts of open space other than the Garrett Mountain Reservation and Point View Reservoir. State investments have resulted in the assemblage of over 10,000 acres of parks and forests. Included in this acreage are the Greenwood Lake State Park, the Ringwood State Park, Hewitt State Forest and Norvin Green State Forest.

Within the heavily urbanized area of Passaic County, the Great Falls of the Passaic River in downtown Paterson is a well known tourist attraction. The Falls form a focal point of historic restoration. Except for one small northern county park, Sand Cap, the entire county park system is located in the populated southeastern part of the county. There is no federally owned parkland in the county.

Presently in Passaic County, deficits in facilities exist for all recreational activities except freshwater swimming and hunting based on peak day demand. (Peak day demand is equal to the annual demand for an activity multiplied by the estimated percentage of participants on a peak day; usually a weekend day.) By 1990, Passaic County is expected to experience significant deficits in peak demand day opportunities for bicyling (142,000 activity days), ice skating (116,130 activity days), football and soccer fields (21,700 activity days), tennis (32,600 activity days), and freshwater boating and fishing (9,600 activity days). On a peak demand day, surpluses are expected for freshwater swimming and hunting.

Passaic County has received aid to enhance its recreation opportunities from both New Jersey's Land and Water Conservation Fund, 1965-1977 and the 1974 Green Acres Program. Six percent ($2,926,568) of the Land and Water Conservation Fund went to Passaic County projects such as the State's development of Sheppard Lake, Rifle Camp Park, sponsored by the County Park Commission and Sandy Hill Recreation Area in Paterson. As part of the Green Acres Program, eight projects were authorized for Passaic County. The largest of these was the Ramapo acquisition. Approximately, $700,000 has been approved for a Paterson project in addition to $572,500 for the four local development projects. The county's total acquisition is $5,417,467.

Passaic County encourages the development of more passive recreation usage in the floodplain. At this time, the Passaic River itself is not a heavily utilized recreation resource due to the industrialization of the river corridor over the last century. However, the county recognizes the value of utilizing the existing river land in a manner compatible with floodplain management and in a manner which encourages the preservation of open space and recreation. The county emphasizes developing already existing county owned lands rather than acquiring new areas.

Somerset County. Somerset County has an open, rural character. A number of waterways flow through the county including the north branch of the Raritan River, the Millstone River, and the Delaware and Raritan Canal. Recreation sites situated in Somerset include Lord Sterling Park, Duke Island Park, the Delaware and Raritan Canal State Park, Colonial Park and Green Knoll; when acquisition and development is completed, the Six Mile Run Reservoir and Confluence Reservoir will also offer diversity for the recreationist.

As county growth trends continue, shortages will result in open space and areas for recreation purposes. Currently in Somerset County, demand deficits exist for all recreational facilities except those for swimming, motorboating, camping, basketball, and playground activities. By 1990, major demand deficits are expected for bicycling (55,600 activity days), ice skating (19,200 activity days), tennis (12,500 activity days) and football and soccer fields (7,500 activity days). Surpluses are expected to continue for swimming, basketball, and playground facility needs. According to Somerset County's master plan, increased emphasis is placed on expanding existing land holdings. Basin activities include the expansion of Lord Sterling Park along the Passaic River by an additional 834 acres. County plans also include increasing developed recreation facilities located on present holdings. Using the County recreation standard of 10 acres in local parks and 15 acres in county parks per 1,000 people, county recreation areas should total 2,800 acres.

Sussex County. Sussex County is largely characterized by mountainous terrain and farmland. The County contains 80 lakes and streams, including the Delaware River, Paulins Kill, Lake Hopatcong and Lake Mohawk and 74,000 acres of recreational land. Recreation land areas include: the Delaware Water Gap National Recreation Area, High Point State Park, Allamuchy State Park, Stokes State Forest, the Hamburg Mountain State Fish and Game tract and part of the Appalachian Trail. This collection of recreational areas offers trout streams, camping facilities and extensive hiking trails.

The least populous counties in New Jersey, including Sussex County, show the lowest demand for close-to-home activities. These same counties, however, have large tracts of land and generally show higher demands for activities such as camping, trail hiking, and hunting. Presently in Sussex County, deficits exist for all recreational facilities except those for swimming, ice skating, and playground activities. The highest projected facility deficits for 1990 are for bicycling (26,800 activity days), freshwater boating and fishing (16,600 activity days), picnicking (8,300 activity days), and tennis (4,400 activity days).

Sussex received 15% ($2,429,599) of New Jersey's Land and Water Conservation Fund (1967-1977) for enhancement of its recreation program. The vast majority of the money was spent on acquisitions at Wawagaronla, Appalachian Trail, Whittingham and Allamuchy. Sussex also received 2% of the 1974 Green Acres Program.

Union County. Union County is a heavily urbanized area, however, its extensive county park system provides large tracts of open space. The Passaic River Park, the Elizabeth River Park and Ash Brook Reservation form a linear greenbelt system through the county. The Watchung Reservation, on the heavily wooded First Mountain, offers fishing in Lake Surprise, hiking, picnicking, horseback riding, a nature museum and small zoo. Union County has three county golf courses: Galloping Hill, Ash Brook, and Oak Ridge and a skating rink at Waumanco Park in Elizabeth.

Union County is one of the most densely populated counties in New Jersey. Presently in Union, peak day demand deficits exist for all recreational facilities except playground areas, basketball courts, and shoreline for freshwater fishing. Based on the New Jersey SCORP, by 1990 Union County will be experiencing significant recreation deficits in bicycling (162,400 activity days), tennis (38,900 activity days), swimming (30,100 activity days), football/soccer (23,800 activity days), and baseball/- softball (22,300 activity days). Surpluses are expected to continue in freshwater shoreline fishing, basketball and playground activities.

The 1972 Open Space and Recreation Master Plan for Union County identified the purchase of the remaining available land along the Green Brook, Elizabeth, Passaic and Rahway Rivers as a top priority. Union County intends to secure land in narrow bands for flood control and recreation purposes through easements and flood control projects. The purchase of the Passaic River Park land in Union County has been largely completed. The Union County Department of Parks and Recreation indicated long-range goals to include a major county recreation complex, in addition to the purchase of as much undeveloped land for preservation of open space that is financially viable.

Rockland County. New York statewide planning efforts emphasize similar needs as those identified by the State of New Jersey. These include parks and open space close to urban areas, recreation services and facilities for the handicapped and disadvantaged groups, and conservation and preservation of natural areas. Rockland County, which is predominantly suburban, serves as an important recreation resource for the New York metropolitan and northern New Jersey areas. The strain on existing recreational facilities and services is expected to increase. County parkland in Rockland totals 353 acres. Part of this land, is Kakiat Park which provides long trails for hikers and sightseers. The majority of open land in the county is state owned. Harriman State Park consists of approximately 25,490 acres in Rockland County. The outdoor recreation activities the park provides include: swimming, fishing, picnicking, boating, hiking, biking, camping, winter court and field sports. A goal of the County is to continue to preserve this valuable resource and gradually encourage more active as well as passive recreation use. When evaluating the recreational facilities there is no shortage of existing open space in this portion of the Passaic River Basin.

Orange County. Predominantly suburban, the county's population of 259,500 in 1980 is expected to double by the year 2000 according to the New York SCORP. Deficiencies in almost all outdoor recreation activities can be anticipated with swimming and picnicking accounting for the majority of demand. Under recreation directed policies, the SCORP ascertains that programs and activities that can increase off-peak use of existing facilities with only modest additional capital expenditures will receive top priority. The major deficiencies projected by the year 2000 include swimming and picnicking. Biking and boating will also reach extremely high demand by the year 2000.

SECTION 3. HISTORICAL FLOOD DATA

Historical data on flood damages throughout the Passaic River Basin has been compiled beginning with the flood of 1903 and ending with the April 1984 flooding. (A map of the municipalities in the Basin is shown on Figure V-2).

The search for information regarding past floods was conducted in two phases:

1. Newspaper search

2. Federal post-flood reports

Because of the general nature of most newspaper reporting, the first search phase usually yield only the location of significant damage areas and broad figures of the losses involved.

During the second phase of the search, an examination of Federal post-flood reports often supplied more detailed information. Data obtained from these reports included an estimate of flood damages by type and specific location. In addition, a narrative description of the major floods in the Basin was obtained.

In certain cases damage estimates for a municipality based upon either newspaper searches or Federal post-flood reports did not distinguish the stream causing the flooding. Therefore, certain flood estimates could not be fully disaggregated based upon the source of the flooding.

MAJOR FLOODS

The 1903 flood is the flood of record for most of the Passaic River Basin, while the flood of July 1945 and more recent floods are the floods of record for several tributaries. The Basin experienced additional flooding in 1810, 1819, 1882, 1902, 1917, 1936, 1938, 1951, 1955 and 1960. More recently, flooding has occurred in 1968, 1971, 1972, 1973, July and September 1975 (for each of these six events portions of the Basin were declared Federal disaster areas), November 1977, January 1979, March 1983, and April 1984 (also declared a Federal disaster). A summary discussion of the major floods in the Basin follows below.

October 1903. The October 1903 flood resulted from an extratropical type storm centered over Paterson, N.J. where a total of 15.5 inches of rainfall were recorded. During the October 1903 flood, the greatest runoff from the headwater regions was contributed by the Ramapo, Wanaque and Pequannock Rivers at their confluence with the Pompton River. In this vicinity the destruction by floodwaters was far greater than along the Rockaway, Whippany and Upper Passaic Rivers. The major source of floodwaters in the entire watershed was the Ramapo River, which is the largest of the upland tributaries. On the Ramapo, destruction was virtually total along several stretches of the valley. With only one exception, every bridge across the river was washed away. Several small villages were entirely destroyed. Extensive portions of the town of Ramapo, N.Y. were "practically obliterated." The riverfront property of the Ludlum Steel and Iron Company was scoured out, the warehouse washed away, and the coal docks along the Morris Canal feeder were destroyed.

Along the Pequannock River, the principal damage consisted of road washouts and damaged bridges. Despite the storage afforded at Greenwood Lake, the damages along the Wanaque River were comparable to those on the Pequannock. Inundation over the floodplain along the Pompton River was also severe. All bridges but one were washed away and over 100 houses were flooded.

In the Great Piece Meadows area, all of the swamplands and some farmlands were under considerable depths of water. Heavy damage to crops was experienced and because of the long-continued presence of the water over the land, the growth of coarse meadow grasses was fostered at the expense of the desirable feed grasses which were destroyed. Upstream of Little Falls, the total area flooded exceeded 31,800 acres.

From Little Falls to Paterson, flooding was generally over the river's banks, and almost all the bridges over the Passaic River in Passaic, Essex and Bergen Counties were damaged or destroyed.

In Paterson, where the center of precipitation occurred, all bridges were severely damaged and 10 were completely destroyed. All low-level bridges were completely inundated, and extensive damages were caused by overbank flow which rose 10 feet over the lower streets of the city. A highly developed area of nearly 200 acres was flooded in Paterson, and over 10 miles of streets were rendered impassable. More than 1,200 persons were fed and housed in the armory.

In the City of Passaic, damage was also severe, especially to manufacturing plants. Additional damage was caused by high water on the main stream bursting the banks of the Morris Canal a few miles east of Passaic and overflowing into Weasel Brook, which washed out every culvert and bridge in its course. Downstream of Passaic, damage to bridges, roads, and industrial plants was extremely severe.

March 1936. The March 1936 flood was caused by a general transcontinental storm which occurred during March 10-12 and 17-19. In the Passaic River Basin, flood damages were most severe upstream of Dundee Dam. Downstream of the dam, the Federal navigation channel afforded sufficient channel capacity to permit passages of the flood crest with only minor losses.

Areas most severely damaged included the lower business and manufacturing districts on the right bank of the Passaic River in Paterson. The Manhattan Shirt Company, one of Paterson's oldest industrial establishments, was one of the heaviest flood sufferers. Other areas affected were the residential and business districts on the left bank of the river in Paterson, residential districts in Totowa, Little Falls, and Singac, and farmlands and bungalow colonies upstream of Little Falls. Many streets along the Passaic River were under several feet of water, and traffic across the river was halted everywhere except over a few high-level bridges. Trolley and bus services in and near Paterson were interrupted and normally heavy vehicular traffic was rerouted over lengthy detours. Several hundred automobiles were damaged by muddy flood waters. It is estimated that 25 industrial plants and 20 public utility plants were flooded wholly or in part, and about 250 families were evacuated from their homes.

Agricultural losses in the territory upstream from Little Falls consisted of the extra cost resulting from a delay in spring planting, losses to chicken hatcheries because of lack of access and interruption of incubator operation, and the cost of moving livestock to safer locations. No apparent permanent damage was inflicted upon agricultural lands as a result of silting or erosion.

July 1945. The July 1945 flood was caused by a storm which extended over northern New Jersey, southeastern New York and the New England States. Moderate precipitation started over the Passaic River Basin on July 15, continued with increasing intensity to July 20, then stopped almost completely for two days. On the night of July 22, torrential rainfall accompanied by thunderstorms reached such intensity that 30% of total storm rainfall fell within an 18-hour period.

Extensive flooding occurred throughout the watershed when the flood crests of July 23 were superimposed upon the lesser flood stages occasioned by the initial rainfall. Flood stages throughout most of the Basin were the highest since the 1903 flood. At the S.U.M. Dam at Paterson the peak flood stage was only 1.75 feet below that of the record 1903 flood.

Widespread disruption of traffic and communications occurred throughout the watershed as floodwaters inundated and seriously damaged the extensive rail and highway network which forms an integral part of the New York City Metropolitan area. General disruption of activities throughout the region occurred from interruptions to industry and commerce. Damages incurred along the smaller tributary streams in Bergen and Passaic Counties between Little Falls and Passaic were approximately equal to those inflicted in the highly developed areas along the main stream in this reach.

On the Passaic River, in the urban areas of the City of Passaic, Clifton and Paterson, about 1,000 persons were evacuated from their homes and numerous industrial plants incurred extensive damage to power and production equipment and supplies, with consequent cessation of operations. Some of the larger plants in the area were seriously affected including several plants of the Wright Aeronautical Corp., the Manhattan Shirt Co., Allied Textile Printing, Inc., Barbour Linen Thread Co., John Royal and Son Machine Co., Burton Carton Co., Dreyers Furniture Co., and the Lazarus Baking Corp. At Totowa, 300 residences were flooded.

Along the Passaic mainstem upstream from Little Falls, between Mountain View and Canoe Brook, several bridges were damaged but most of the damage was confined to crops. In Fairfield, about 200 residential cellars were flooded; and along the Pompton River and its tributaries in Lincoln Park and Pequannock, about 800 residences were affected.

Passaic River minor tributaries, along which extensive damages were inflicted, included Weasel Brook, the Saddle River, Hohokus Brook, Diamond Brook, Goffle Brook, Molly Ann's Brook, Slippery Rock Brook, the Peckman River and Singac Brook, all in the Lower Valley. In the principal damage reaches of these tributaries, it is estimated that approximately 1,700 dwellings, 250 business establishments, 40 industrial plants, and 30 utility plants and public institutions were inundated.

On Weasel Brook, nine bridges were damaged. Approximately 10 industrial plants and 230 residences and small business establishments were affected in the communities of Clifton and Passaic. Extensive damages were suffered by the Tobin Paper Box Co., the Mountain Ice and Coal Co., Clifton Swimming Pool, and the Eureka Press.

Flooding from this event exceeded the 1903 flood in the Saddle River Basin. On the Saddle River and Hohokus Brook, 6 bridges were damaged and 11 destroyed. Approximately 10 industrial plants, 80 small business establishments and 500 residences were affected. Major damages were suffered by the United Piece Dye Works and Fine Organics, Inc., in Lodi, when floodwaters inundated supplies and equipment. The New Jersey State Fish Hatchery at Saddle River suffered considerable loss when floodwaters washed out cages and stock and damaged operating equipment and the piping system. Considerable damage was inflicted on the residential areas of Waldwick and Hohokus when three small private dams on Hohokus Brook failed and the release of impounded waters flooded the communities.

On Diamond Brook, the greatest damage was sustained by the Wright Aeronautical Corporation plant near the stream's mouth. Damage upstream was restricted to 16 residences and one commercial establishment.

On Goffle Brook, two bridges and five dams were damaged. Six industrial plants and approximately 100 residences and small business establishments were affected. The Vitromar Piece Dye Works, Inc., Wright Aeronautical Co., Normandy Silk Co., American Coating Co., R & E Textile, Inc., and tenants of a group of buildings in Hawthorne near the mouth of the Brook suffered severe flood damage when about nine feet of water damaged equipment and stock on the first floor. In this same section, Goffle Brook Park along the lower reach of the Brook suffered damage from erosion, deposition of debris, and damage to rustic footbridges.

On Molly Ann's Brook, flooding caused extensive damages in several communities north and west of Paterson. Twelve bridges were damaged and two were completely destroyed. Part of a building, housing valuable machinery, of the Seyer Silk Dyeing Co. in Haledon was washed out. Other industrial, commercial and residential developments suffered severely from flood depths up to four feet. Approximately 500 homes were inundated, most of which were located in Paterson near the mouth of the Brook and in Haledon.

On Slippery Rock Brook, one bridge was washed out, service was disrupted on the DL&W Railroad, roads and utilities were seriously damaged, and scores of homes were inundated.

On the Peckman River, a culvert blocked by debris caused the temporary impounding action and final failure of a high embankment supporting the Erie Railroad's Greenwood Lake Branch. Traffic on this line, which services commuters of the suburban and large resort area west of Cedar Grove was completely destroyed. Approximately 150 residences and small business establishments were affected. Extensive losses occurred at the Little Falls Laundry Storage Plant near the mouth, where four feet of water washed away 1,500 tons of coal, flooded the power plant, damaged stored supplies and garments and disrupted operations for four weeks. One death occurred in Little Falls when a home was swept from its foundations.

On Singac Brook, four bridges were damaged and one was destroyed. Approximately 150 residences and small business establishments were affected when floodwaters reached lowland sections.

September 1960. On September 12, 1960, as a result of Hurricane Donna, there was tidal flooding along the Passaic River to Dundee Dam. Damage occurred principally to industrial and commercial property. Many low-lying streets were under several feet of water, resulting in long traffic delays.

May 1968. During the 1968 flood, all the major and most minor tributaries of the Passaic River overflowed. Towns along the river from the headwaters to the City of Passaic suffered the most damage, other communities sustained damage to a lesser extent. Damages to the entire Passaic River Basin were estimated at $19,323,000 in 1968 dollars. At 1985 price levels these damages total $71,700,000 and updated to both 1985 prices and 1985 levels of development, damages would be $139,000,000.

Flooding occurred on the Passaic River and all major and most minor tributaries, from the headwaters to the City of Passaic (about 12 miles upstream of the mouth). The Great Swamp area was flooded. Severe damage was caused by flooding from the two large tributaries, the Whippany and Rockaway Rivers. In Fairfield, 150 residents were evacuated. Flooding of the Whippany River caused severe damage at Hanover and Morristown and flooding of the Rockaway River brought extensive damage to Parsippany-Troy Hills. There was damage to the Boonton Dam of the Jersey City water supply system and silting of the water supply line. Other communities were affected by flooding of these rivers to a lesser extent.

The Pompton River and its tributaries, the Ramapo, Wanaque and Pequannock Rivers, caused severe damage in all the communities through which they flowed. In Totowa, 50 families were evacuated; in Wayne Township, 500 residents were evacuated. The Wanaque River caused damages to residential, recreational and public property in Ringwood, Wanaque and West Milford. Along the Ramapo River there was severe damage in Mahwah, Franklin Lakes, Oakland and Suffern, New York. At Oakland, some dwellings were so badly damaged that they could not be repaired. The Pequannock and Pompton Rivers caused severe damage in Pequannock, Riverdale, Bulter, Bloomingdale and Pompton Lakes, the latter community being flooded by all three rivers. Over 200 families were evacuated in Pompton Lakes and 100 persons were evacuated in Pequannock.

The Peckman River caused severe damages to residential, commercial and industrial property in Little Falls and West Paterson. Over 200 families in Little Falls were evacuated. Molly Ann's Brook caused severe damage in Hawthorne, Haledon and Paterson.

In Wayne and Totowa there was severe damage to all classes of property. About 50 families in Totowa and 500 residents of Wayne were evacuated. Several large industries had to close their plants for several weeks. Routes 23 and 202, important highways, were closed to vehicular traffic for 2 days.

In Paterson there was severe damage to industrial and commercial property as well as residential property and over 200 persons were evacuated. Two bridges over the Passaic River were closed for a week. Fleisher's Brook caused severe damage to dwellings in Garfield and East Paterson.

The Saddle River caused damages in every community from its headwaters in New York to the mouth of the river. Lodi suffered severe damage to all classes of property. Hohokus Brook, a tributary of the Saddle River, caused damages in Ridgewood and Waldwick.

August-September 1971. Extensive flooding took place throughout the Basin. Damages along the tributaries were estimated (1971 dollars) at:

Mainstem	$ 2,201,000
Rockaway and Whippany	1,560,000
Ramapo and Pompton	3,143,000
Saddle	1,281,000
Other Tributaries	2,216,000
Total	$10,401,000

August 1973. The most severe damage from this flood was a result of the local tributaries and drainage systems not being able to handle the intensity of the storm. Damages were estimated at $1,000,000 (1973 dollars) for the Basin.

November 1977. New Jersey suffered what was considered its worst storm since the August/September storms in 1971. Most communities along the Passaic River had substantial flooding. Traffic snarled, houses and basements flooded, many commercial and industrial structures were damaged considerably. The National Weather Service reported that the 8.25 inches of rain that fell in the area over the two day period was an all time high, surpassing the 7.8 inches that fell during the August/September 1971 storm. Police in many communities were planning to evacuate people in low-lying areas but large scale basin-wide evacuation generally proved unnecessary. However, more than 600 families were evacuated along the Saddle Brook in Lodi and the Pompton River in Wayne. Numerous bridges and roads, were closed, as power was out in many areas due to the flood. Felician College in Lodi experienced substantial damage when retaining walls and earthen banks along the Saddle River failed. Damage from this flood had been estimated to be over $179,000.000 (Oct. 1985 dollars).

January 1979. The flood of January 1979 was extensive throughout northeastern New Jersey. A continuous downpour of over 4 inches on frozen, saturated ground led to the worst flooding some areas experienced in over a decade. In the Rockaway River Basin the communities of Denville, Dover, Lake Hiawatha, Mine Hill, Montville, Parsippany-Troy Hills, Rockaway Borough and Rockaway Township were most seriously affected. Garfield on the Saddle and Passaic Rivers, Lodi on the Saddle River, Morristown on the Whippany River, Oakland on the Ramapo River, and Wayne on the Pompton and Passaic Rivers also suffered flood related damages. Five hundred families were evacuated in Dover and Denville, and 200 in Lake Hiawatha. Hundreds of people were evacuated in Morristown, Wayne and Lodi. One person drowned at Lodi and several were rescued from floodwaters. Numerous roads and bridges were flooded, isolating several areas and structures, including St. Clare's Hospital in Denville.

March-April 1983. Low pressure systems moving across the northeast brought heavy rainfall repeatedly to northern and western New Jersey. Though none of the storms' rainfall exceeded that of a 2 year flood event, each weeks' precipitation imposed higher water stages on prior weeks' rainfall. Precipitation generally ranged between 1 and 2 inches. Sustained high water elevations reached flood stages at several locations in the Basin.

In the Central Basin the municipality of Fairfield experienced significant street flooding. Families were evacuated in Lincoln Park in the vicinity of Two Bridges and along River Edge Road, Midwood Road and Beaver Brook Road. Fayette Avenue was under water. In Wayne Township, at the confluence of the Pompton and Passaic Rivers, families were evacuated and water stages reached heights of 4 to 5 feet above the streets.

Along the Ramapo River in Oakland, homes near the Doty Road Bridge and along Island Terrace were inundated. Along the Saddle River, Main Street in Lodi was closed for several hours at the Route 46 overpass. Floodwaters topped the banks of the Saddle River at the Lodi Boy's Club and at Felician College though no significant damage was incurred.

The numerous spring storms with considerable level of rainfall left much of the Basin's floodplain underwater for weeks.

April 1984. Flooding occurred when a two day storm which brought approximately 5 inches of rain to the basin combined with the runoff of the snowmelt from the previous week's one foot snowfall. The flooding was the worst to occur in forty-five years throughout the Passaic River Basin. Nineteen communities along the Pompton River, Pequannock River, Lower Ramapo River, Wanaque River and Passaic River from Elmwood Park upstream to the Borough of Chatham sustained substantial flood damages. In addition, communities along the Upper Ramapo River and Saddle River also experienced flooding. The worst flooding occurred in Pompton Lakes, Wayne, West Paterson, Paterson, and Little Falls in Passaic County; Riverdale, Pequannock, Lincoln Park, and Montville in Morris County; Oakland, Fair Lawn and Lodi in Bergen County; and Fairfield in Essex County. Areas inundated by the April 1984 flood are shown on Photos V-1 through V-6.

The April 1984 flood was declared a National Disaster on April 12, 1984. Evacuations totaled approximately 9,400 people. Flood relief involved many State of New Jersey agencies including the Departments of Health, Community Affairs, Human Services, Labor, and Transportation, as well as the State Police and the Bureau of Floodplain Management. Federal agencies such as the National Guard, U.S. Army Corps of Engineers, Environmental Protection Agency and Civil Defense also supplied aid along with national volunteer organizations, the Red Cross and the Salvation Army.

Evacuees took emergency shelter in schools, churches, fire stations, friends' and relations' homes, and hotels. Approximately 2,500 customers of Jersey Central Power and Light Company lost electricity and 1,200 customers of Public Service Electric and Gas Company went without power. Disruptions in electric service of up to 3 weeks prevented people from returning to their homes, caused damage to heating systems, and extensive losses in refrigerated food supplies. Electric and gas meters were completely destroyed by floodwaters. Water seepage into gas meters and broken seals caused explosions in several areas damaging both the exterior and interior of structures. A total of approximately 6,400 residential, commercial, utility, and industrial establishments were significantly damaged by floodwaters. Numerous street and bridge closings were reported, creating massive traffic delays throughout the Basin. Major highways were at a standstill for hours and impassible for days. Three lives were lost due to the April 1984 flood.

The April 1984 flood was not a significant flood event in the Lower Valley. Flooding was estimated at an approximate 25 year storm. Nonetheless more than 500 Paterson residents were taken by National Guard and Fire Division boats from low-lying areas around President Boulevard to River Street. About 100 residents stayed in an emergency shelter at John F. Kennedy High School until they could return to their homes. Flooding along the Passaic River in the Lower Valley forced the closing of the Monroe Street and Wall Street bridges between Garfield and Passaic County. Inundation also caused serious damages to driveways, lawns and garages. Water entering structures through garage doors, basement windows and foundations caused extremely severe damages to floors, walls, washers, dryers and heating systems.

In the Central Basin where flooding was much more severe, approximately 1,700 residential and 300 commercial and industrial structures were inundated during the April 1984 flood. Water heights reached an estimated 12' above many main floor elevations. Major highways including Routes 23 and 46 were closed to traffic for 3 days. Many inundated roads were closed in Morris County including: sections of Route 10 near Troy-Hills Road in Parsippany; a portion of Blackwall Street, Dover's main street; Salem Street in Randolph, Franklin Rock in Denville and the Hamburg Turnpike from Riverdale to Bloomingdale in Passaic County. Long vehicular traffic delays and detours resulted when roadway retaining walls, shoulders and walkways were washed-out by floodwaters. Ringwood Avenue bridge in Wanaque was weakened by floodwaters. The Willowbrook Mall, Willow Square and West Belt Plaza in Wayne were left inaccessible for approximately 3 days. Parking lots, inundated with 4'of water forced approximately 200 retail outlets and restaurants to close and lose sales. Businesses forced to close included major retail stores such as Sears Roebuck and Company, Ohrbachs, Bambergers, Stern Brothers, Fortunoff and J.C. Penney. Damages to roadways, parking lots, landscape and walk ways were extensive. Merchandise in Bambergers' furniture store was virtually destroyed. West Belt Plaza, which includes 13 stores, estimated damages due to loss of sales, clean-up cost and property damage alone, totaled over $1,000,000 (Oct 1985 price levels). Overall Basin damages for the April 1984 flood were approximately $335,967,000 in October 1985 price levels.

PHOTO V-1

April 1984 Flooding in Paterson City, N.J.

PHOTO V-2

April 1984 Residential Flooding.

PHOTO V-3

Garden Apartments on Park Ave., Borough of Lincoln Park, Flooding caused by the Beaver Brook.

PHOTO V-4

Looking south from Wayne Township across Passaic River into Little Falls, Flooding caused by Passaic River.

PHOTO V-5

Residential Community, Bank Lane, Midwood Road and Woodland Road, Borough of Lincoln Park and Wayne Township, N.J., Flooding caused by the Pompton River.

PHOTO V-6

Industry on Pompton Turnpike in Wayne Township, N.J., Flooding caused by the Pompton River

SECTION 4. BASIS FOR FLOOD DAMAGE ANALYSIS

DAMAGE INFORMATION

In evaluating both the need for flood control and specific solutions to meet this need, the Passaic River Study documented the level of existing development and the susceptibility of that development to flooding. As a first step in this process the structures within the Basin's floodplain were inventoried via a windshield survey. This survey inventoried in excess of 40,000 structures and their characteristics. Structure data inventoried included: structure type, first floor elevation, owner/operator and 20 other such characteristics. These characteristics were selected in order to help group structures so that sample sizes for the interview phase could be developed and for their potential explanatory power regarding damage variability. This information was placed onto a computer data base in order to facilitate analysis. Analysis of this data was carried out to determine the groupings necessary for defining the interview samples. Utilizing statistical techniques, specific structures were selected for interviews. The selected structures were then interviewed in order to determine both actual historic damages and potential damages at storms greater than those experienced. Initially a total of approximately 3,300 interviews were conducted, representing approximately 8.3% of the structure occupants in the floodplain. Based upon this information standardized stage damage curves by structure type were developed. These standardized curves were then utilized in HEC's Structure Inventory of Damage (SID) program along with selected inventory characteristics. In addition, actual stage-damage data relationships for interviewed non-residential structures were loaded into the SID program. Approximately 214 flood damage reaches were established based on hydrologic, hydraulic and plan formulation criteria, and analyzed in SID. Aggregate stage-damage curves were then generated for each reach using SID. The resulting stage-damage curves were examined to ensure their integrity and then integrated with stage-frequency data using HEC's Expected Annual Damage (EAD) program to compute expected annual damages. The resulting expected annual damages were then calibrated with historical storm data, field verified and cross-checked with hydrologic frequency data to ensure validity.

In determining the potential for flood damages, three main steps were taken: a determination of the development at risk was made, the potential dollar damage caused by certain flood heights at representative structures was determined; and the dollar damage to representative structures was applied to all the development at risk to determine the susceptibility of development to flooding.

In initiating this study of flood damages in the Passaic River Basin, different methodologic approaches were sought from other Corps of Engineering Districts. Based upon their input, as well as the existing methodologies in the New York District, three methodologies were examined in detail. These were the grid cell data bank approach, the traditional approach, and a 100% windshield survey/statistical approach.

Briefly, the grid cell data bank approach was developed for the Oconee study as part of the Expanded Flood Plain Information studies. This methodology involves the geographic subdivision of the Basin into land uses of similar types and densities. Representative grid cells are then analyzed to determine depth percent damage curves. A program developed by the Hydrologic Engineering Center titled DAMCAL then provides a mechanism for the integration and the determination of the susceptibility of development to flooding.

The traditional approach combines the determination of the development at risk and the potential dollar damage caused by certain flood heights at representative structures into one step. This approach involves analyzing a representative structure and then determining which other structures in the area exhibit similar characteristics with adjustments made for differing main floor elevations and structure value. Thus, every structure is either determined to be representative or assigned to a representative structure in the field.

The third approach examined in detail was based upon a 1976 Flood Damage Report for the Huntington-Ashland-Portsmouth study area by the Huntington District. This method involves a 100% windshield survey which identifies every structure at risk in the area. Statistical analysis of the information gathered during the windshield survey determines the needed number of representative structures to be analyzed for dollar damage relationships in order to have a given level of confidence in the results. This methodology allows the user to maximize the representative aspect of the determined dollar damage relationships.

An analysis of the three alternative methodologies determined that the 100% windshield/statistical methodology would be best for the Passaic River Basin Study. The grid cell data bank approach results in too much distortion in the Passaic River Basin area due to the nature of topographic changes and the pattern of development. Specifically, each grid cell has associated with it one elevation. Given the size of the grid cells being considered in the Passiac survey, 10.33 acres, this would result in an average elevation being applied to several structures in a reach. This could lead to gross distortion in cases where the cell has any type of gradient. In addition, the grid cell approach by its very nature results in averaging which would distort the analysis of specific reaches.

The traditional approach, while addressing, several of the concerns mentioned above, does not allow for the maximization of the basic data collected regarding the stratification for sampling and therefore, the explanatory power of the results. For a study of the size of the Passaic, it was necessary to be able to maximize all the data collected. Maximization refers to the process of getting the smallest coefficient of variation for a given set of interviews. Without the ability to fully utilize all the data collected, the best product for the cost could not be produced.

In order to implement the preferred methodology - the 100% windshield survey/statistical approach, it was necessary to develop a detailed step by step procedure. Additionally, because of the very large size and complexity of the study, a contract with a consultant having academic and nationwide practical expertise in the field of statistics was undertaken. The A/E worked with NAN economists in the application of the appropriate statistical techniques, the interpretation of study results, and the development of study conclusions.

The major steps taken in the determination of the susceptibility of development to flood were as follows:

pre-inventory
inventory
interview selection
interviews/damage assessment
pilot survey
full survey
statistics and damage functions

Each of these steps is discussed in detail below.

PRE-INVENTORY

Prior to performing an inventory of the structures in the Basin it was necessary to develop standard assumptions regarding the classifications of structure types and structure values (market value net of land value).

Structure types were determined for residential structures prior to the inventory; while for apartment, commercial, industrial, and utility structures no priority types were determined before the inventory due to the anticipated diversity of types.

The residential types were selected as follows:

Bi-level	-	Entry is through front door into a foyer. Upstairs to the bedrooms or downstairs to living room/dining room/kitchen areas. (Foyer is between floors when entering from the front door).
Bungalow	-	Very small square building with about 4 rooms.
Cape	-	Two levels with living room, dining room, kitchen and one or two bedrooms on the first level and bedrooms on the second level. This type may be recognized by rooms protruding from the upper roof (second floor).
Colonial	-	Full two-story house with bedrooms on the second floor and possibly a third floor.
Raised Ranch	-	Enter through the front door onto the main floor. Walk down to basement/garage area.
Ranch	-	All rooms are on one main level.
Split level	-	Tri-level house where entry is through the front door into the living room and a kitchen area (second level), down a short staircase to the den and laundry area (first level) and upstairs to the bedrooms (third level).
Tudor	-	High pitched rooflines at various levels w/dormers and extensive paneling.

Additional structure types added during the inventory process included: Custom, Duplex, Frame, Mobile, Multi-family, Shack, and Two-family categories.

Residential structure values were determined by first preparing a catalog of structures including photographs depicting different types and sizes (small, medium, and large) of these houses. These catalogs were then used in consultation with real estate agencies throughout the study area to determine structure values. For apartment, commercial, and industrial structures, values were based upon dollar per square foot construction cost curves developed from McGraw-Hill's "Dodge Building Cost Calculator and Valuation Guide." Square footage for these structures was determined from the 1" = 200' topographic mapping of the Basin. Utility value was not determined, the damage functions were developed as a function of square footage.

(Structure value determination was also coordinated with the N.Y. District Real Estate Division.)

INVENTORY

To determine the extent of the development at risk in the Passaic River Basin a windshield survey was performed which included all establishments potentially subject to flooding. The area at risk was determined based upon topographic mapping and the level that floodwaters would reach during rare occurrences. A great deal of information was gathered on each individual establishment. This information, consisting only of data that could be determined from visual inspection, was needed in order to be able to: a) determine which structural characteristics are responsible for explaining the potential dollar damages at certain flood heights for given structures; and b) determine which structures possess similar characteristics.

This information provided a basis upon which the number of interviews, needed in order to achieve a targeted explanatory power, could be determined. Additionally, it was imperative that any characteristic important in the determination of the representative structure's dollar damage at a given stage be collected for all structures in the inventory. Otherwise, the representative structures' dollar damage relationship could not be accurately applied to non-representative structures.

The data gathered during the windshield survey is detailed in Table V-5 for all structures.

The windshield survey inventory aided in the selection of 48,752 establishments for inventory: 40,674 residential, 6,237 commercial, 1,099 industrial, 494 apartments, and 258 utilities. Certain of those establishments, particularly in the Lower Valley, are complexes of buildings consisting of many structures. These establishments are located in an area comprising 69 communities in seven counties in central and northern New Jersey and four communities in Rockland County, New York. Based upon interview information, stage-damage curves were developed. Stage damage curves were utilized in the determination of residential, commercial, industrial, apartment and utility damages.

As the inventory progressed, field data were processed for input into a Computer Data Base Management system. The data base was designed so structures could be indexed by any of the input variables for later statistical analyses.

INTERVIEW SELECTION

In order to evaluate the damage potential for a population of this magnitude it was necessary to utilize sampling techniques.

A stratified random sample was used to obtain the sample needed for the survey. By this method, the universe was divided into small homogeneous groups and a small sample as taken from each subgroup. A stratified random sample provides an accurate way of dealing with any parent group which possesses considerable internal variability, and is economical for this type of case because the sample size needed to give a specific degree of precision is very much smaller than would be the case with ordinary random sampling.

The number of in-person household interviews conducted in the survey needed to be large enough to provide sufficient data for a reliable statistical analysis and at the same time, small enough to be cost-effective (i.e., more interviews than necessary were not made).

The first step in designing such a survey was to group (or stratify) all structures in the areas to be studied (the universe) based on the data obtained from the windshield survey. By this method, the universe was divided into smaller groups with common characteristics, but with each group fundamentally different in respect to the average of the total.

A sample was then taken from each homogenous subgroup as if it were a separate universe, resulting in an overall sample that included a cross-section of all types of structures in the study area. This results in a greater accuracy for a fixed number of observations, since representation from each subgroup is guaranteed.

For the initial residential and commercial studies, the proxy utilized in the interview selection was structure value, while for the final survey for these types the coefficients of variation for damages developed during the initial study were utilized.

In order to define the sample size the following relationship was utilized:

$$\text{Sample size} = \frac{(\text{coefficient of variation } x Z)^2}{\text{accuracy}^2}$$

First, in order to express the degree of confidence for a specified accuracy, a standard score was used. This score, called the Z score, is a measure of the deviation of a sample value from the universe value expressed in terms of the standard deviation. The rationale used in the development of the concept of the Z score is that, if random samples of sufficient size are taken from a universe, the sample means are essentially normally distributed around the universe mean. Approximately 68 percent of the sample mean values will fall in the shaded area between the universe mean (n) and the universe mean plus or minus one standard deviation (n ± 1 u), corresponding to a Z score of 1. The range n ± 2 u includes 95.5 percent of the sample values. To achieve a 95 percent level of confidence, the appropriate Z score is equal to 1.96.

The next step in the determination of the sample size was the calculation of the number of interviews for each group based upon the variation of the structure values as measured by the coefficient of variation and the desired degree of confidence and accuracy for the results. The coefficient for variation is a standard measure used to describe the spread of the values for a group around the average value for that group. It is obtained by calculating the ratio of the standard deviation to the mean. The range of values for the coefficient of variation is between zero and infinity. The closer the value to zero, the less the dispersion relative to the mean; the larger the value, the greater the dispersion relative to the mean.

For this study, the sample size was designed with the goal of attaining a level of confidence of 95 percent and an accuracy of 5 percent for each structure type. This means that there would be a 95 percent probability that the value of the sample mean will be within 5 percent of the value of the universe mean.

INTERVIEWS/DAMAGE ASSESSMENT

Since actual damage data was not available for determining the required sample size for the pilot survey, structure value was selected as a surrogate statistic to be used in place of damages for the following reasons:

- a review of results of past studies such as the 1976 Flood Damage Report for Huntington-Ashland-Portsmouth Study area;
- the direct relationship among cost of structure, size of structure and potential for damages;
- the direct relationship between cost of structure and cost of furnishings; and
- experience with damage studies at similar areas.

Damage assessment was based upon the owner's estimate of the values of various items and their potential for damage. If the figures were not supplied an estimate was used to determine the damage. The estimate was based upon a survey of retail prices conducted early in the study, upon estimates of local contractors, and repair and remodeling costs published in standard estimating books.

Interviews were conducted on the sample population through a door-to-door canvassing of the randomly selected structures within each stratification category. The interview forms utilized for both the pilot and the full-scale survey were based upon OMB authorized flood damage survey forms and received NAD approval numbers as well. The form developed historical as well as potential damages in 3 basic groups: structural; contents; and other; at 9 specified flood (elevations) levels relative to the main floor: zero damage point +1', zero damage point +2', historical flood point, MF, MF+1', MF+2', MF+5', MF+9', MF+15'. The following general categories of damage were determined in the residential damage form:

Structure Damage
- Floors
- Walls
- Foundation
- Heating System
- Stove and Dishwasher

Content Damage
- Appliances
- Furnishings, Clothes & Supplies
- Other

Other Damage
- Lawn Damage
- Outbuildings
- Preparation & Flood Fight
- Evacuation & Reoccupation
- Extra Housing Cost
- Lost Income
- Cost of Cleanup

The following general categories of damage were determined on the nonresidential damage forms:

Structure Damage
- Foundation and Supports
- Floors, Exterior Walls,
- Insulation, Interior Walls, and Ceilings
- Water Systems, Heating, AC, Communication
- Electric Power Transformers and Other Elect.
- Engines/Generators/Alternators

Content Damage
- Foundry Furnaces and Welding Equipment
- Machine Tools and Patterns
- Other Equipment
- Furniture (Office)
- Merchandise

Other Damage
- Outbuildings
- Car, Trucks, etc.
- Flood Fight and Evacuation
- Loss of Wages
- Replacement of Records
- Loss of Net Income
- Removal of Debris and Damaged Items
- Disinfecting, Other Clearing, Rehabilitation

Additional questions dealt with land size, assessed values of structure and land, average sales, payroll, number of employees and questions designed to elicit information on potential intensification and location benefits.

PILOT SURVEY

The pilot survey included in-person household interviews of a sample of property owners in a specific area in order to gather flood data for these structures and also to obtain data to be used in designing the full survey.

The Rockaway River Subbasin of the Passaic River Basin was selected for the pilot survey because it was considered to be representative for the overall study area. This area encompasses 11 communities and includes approximately 2,100 establishments, of which approximately 1,500 are residential. Table V-6 details the number of residential structures by type.

Residential Stratification. Prior to stratifying the residential structures in order to determine sample sizes it was decided to limit the analysis to the ten largest groups in Table V-6. The other structure types were not included since they represented a small portion of the structures in the floodplain. The largest group not considered was Tudor with 11 structures, or 0.7 percent of the total number of structures.

The 10 structure groups were then stratified into smaller subgroups designed to provide subsets with similar characteristics, thus producing smaller variances in structure value (and therefore variances in damages). The more uniform the group, the smaller the sample size that needs to be taken. The following characteristics were selected based on past experience in order to create more uniform subgroups:

- value class
- basement
- low-opening
- garage (by size and type)
- exterior facing
- attic
- foundation

The total number of structures, the highest subgroup coefficient of variation (used for determining the required sample size as discussed above) and the estimated number of required interviews for each structure group are summarized in Table V-7.

For four of the structure groups representing less than 12 percent of the total structures in the Rockaway Basin, the required sample size for the desired level of accuracy was deemed to be excessive in comparison to the overall importance of these structures in the total group of structures; therefore, a less stringent level of desired accuracy was used: for Two-family and Multi-family structures, 7 percent; for Bungalow and Raised Ranch structures, 10 percent.

After the required number of interviews was estimated, the structures to be included in the survey were randomly selected from amongst all the structures in the Rockaway Subbasin.

Commercial Stratification. There are approximately 500 commercial establishments in the Rockaway River Subbasin floodplain. As noted previously no priority structure types were set. In excess of 100 different structure types were reported. Several groupings were made of these various structure types in order to determine a more appropriate number of subgroups and analyze the variation of their structure values. The initial groupings were made by aggregating like structures, but these groupings contained such high degrees of variability that most of the structures would have required interviews. It was then decided to group the structures conceptually based upon their potential for content damage. Content damage was focused upon since a high proportion of commercial damages are associated with contents. Structures were therefore broken into three groups: 1) high inventory value at risk; 2) median inventory value at risk; and 3) offices. Typical of those in the first category were the following structure types: stereo stores, bicycle shops, jewelers; while the second category typically included stationery stores, halls, and florists.

An analysis of the data with subgroupings for value classes (0-100k, 101-200k, 201-400k, 401-1000k, and 1000k+) produced the following sample sizes for commercial structures.

Type	Universe	Interviews Needed		%
Offices	94	28		29.8
Medium Contents	237	42		17.1
High Contents	176	28		15.9
Total	507	98	mean	19.3

Residential Analysis. In all, 265 residential interviews and 82 commercial interviews were conducted. The commercial number of interviews differed from the projected sample size due to difficulties in procuring interviews. As the first step in the analysis of the pilot survey interview data, three general types of computer printouts were prepared for analysis. Computer printout runs listed several variables such as structural damage information and statistical analysis data.

The initial results were not satisfactory. The analysis indicated that more detailed groupings would be required. The data was then grouped in four other ways. In all, the analysis was done on the data grouped by:

1. structure type;
2. value class;
3. basement type;
4. structure type and basement type; and
5. individual unit (i.e., ungrouped).

By observing the computer-prepared plots of the structure, content and other damages versus structure value, it was observed that, in general, the damage values did not fit a trend line as closely as had been anticipated. A review of the means, standard deviations and coefficients of variability for the damages and structure values indicates that the damages are more widely dispersed than structure values. Structure value variability was similar for the sample and the universe.

Correlation coefficients were then developed to determine the degree of relationship between structure values and structure, content and other damages at several elevations.

For this study a correlation coefficient greater than or equal to 0.6 was interpreted as indicating a relationship between the variables. It is expected that the sign of the correlation coefficients would be positive indicating that as structure values increased, damages increased.

The correlation coefficients for an aggregate group of structures are presented in Table V-8. As can be seen from the table, only two of the values, structural damages at main floor +9' and +15' are greater than 0.6. Some other observations can be made:

(1) As flood depths increase, the correlation coefficients increased indicating that at higher levels there tends to be a stronger relationship between values and damages.

(2) As had been anticipated, the signs of the correlation coefficients are positive indicating that higher value houses are associated with higher damage values.

Table V-9 presents the correlation coefficients for the houses grouped by structure type. In general, the correlation coefficients increase as flood depth increases, similar to the results for all structures combined. In addition, the data shown:

(1) Correlation coefficients for value and structural damage at a flood depth of main floor +15' are greater than 0.6 for six of the ten structure types -- Bi-level, Colonial, Duplex, Multi-dwelling, Raised Ranch and Ranch. These types represent 959 (or 63 percent) of the total 1,523 houses in the Rockaway Basin.

(2) Contrary to expectations, some of the values of the correlation coefficients are negative. This indicates that higher house values are associated with the lower damage values. In particular, these relationships showed up in the category of content damages, and could relate to the location of contents in higher valued (greater size) homes. For example, larger homes with a third floor or an attic may have less contents stored in the basement and first floor.

(3) On a whole, the correlation coefficients for content damages are on a lower level than those for structural and other damages.

Additional correlation matrixes were also developed relating damages with various structure characteristics, and general linear modeling was performed to determine stepwise regression and factor analysis.

These analyses did not yield the results desired. The purpose of the pilot survey was to obtain estimates of damages for each of the ten major structure types in The Rockaway Basin with a level of confidence of 95 percent and an accuracy of 5 percent. Since damage data was not available prior to the survey, the required sample size was estimated based on a surrogate statistic, structure value, which was assumed to be closely correlated with damages. As noted above, the relationship between structure value and dollar amount of damages was not as strong as have been assumed. The results of the survey indicated that, although the reliability of the mean structure values was close to what had been anticipated, the reliability of the mean damage values was not as high as had been anticipated. An example is shown in the following summary of mean structure values and structural, content and other damages at main floor level for Duplex houses.

At Main Floor Level	Mean	Standard Error	Range of Values for 95% Level Confidence	Accuracy
Structure Value	$63,524	1,470	$60,114 to $66,934	5.4%
Structural Damages	$ 3,424	320	$ 2,797 to $ 4,051	18.3%
Content Damages	$ 1,082	290	$ 514 to $ 1,650	52.5%
Other Damages	$ 3,644	601	$ 2,466 to $ 4,822	32.3%

Since the data obtained in the survey did not reach the level of reliability desired, stage-damage curves based on these values would not have the specified level of reliability.

It was decided to continue with the full survey with the expectation that the larger data set would provide better results.

Commercial Analysis. A total of 82 commercial interviews were obtained in the Rockaway Subbasin in order to prepare preliminary flood damage values and to estimate the required sample size for the full Passaic River Basin. For analysis purposes, the structures were divided into three groups characterized by similar usage: high inventory (22 interviews), medium inventory (39 interviews which included lower inventory units) and offices (27 interviews). These groups were further subdivided by structure value.

The first step in the analysis was to determine whether the structures were correctly categorized by usage. The measure used for this purpose was contents value as a percent of structure value; and high, medium or office designation for each structure. The range of values for these percents was 0.0 to 742.9, with a median value of 39.1 percent. It was determined that the grouping was reasonable since:

- only 4 of the 22 high inventory structures had percent values less than the median;

Mean + 1.96 (Standard Error)

1.96 (Standard Error) Mean

- 15 of the 39 medium inventory structures had percent values higher than the median; and

- the 21 office structures had percent values fairly evenly distributed over the full range of values.

The next step in the analysis was to calculate the mean, standard deviation and coefficient of variation for damage values for each of the three groups. This was done by weighing the means and standard deviations for the value subgroups by the total number of units for each subgroup in the subbasin. At this point, the analysis was limited to damages at three levels: main floor, main floor + 1' and main floor +15'. The analysis was done for structure, content and other damages for dollar value of damages and for damages as a percent of structure value. The mean for the structural, content and other damage categories as a dollar value of damages ranged from $0 to $201,100. As a percent of structure value the mean amongst the damage categories ranged from 0% to 76.5%. The standard deviation for each of these damage categories as a dollar value ranged from $0 to $51,500 and as a percent of structure value ranged from 0% to 19.9%.

Overall, the coefficients of variation indicated a very good relationship. However, given the small sample size such a conclusion was tentative. It was therefore decided that more data would be required prior to further analysis.

FULL SURVEY

Interviews for the survey were randomly distributed throughout the Basin. The number of interviews required for residential and commercial types were based upon the coefficient of variation analysis discussed earlier.

<u>Residential Structures</u>. In order to reduce the required sample size, an attempt was made to group the structures by similar structural characteristics, such as basement type, low opening, foundation type, garage size and type, etc. However, the results indicated that the groupings would not result in significantly lower coefficients of variation. For example, structure type ranged from 0.375 to 1.906:

Structure Type	Coefficients of Variation For Content Damages At Main Floor
Bi-Level	0.375
Bungalow	1.501
Cape Cod	0.917
Colonial	1.906
Duplex	1.443
Multi-Dwelling	1.506
Raised Ranch	1.021
Ranch	1.354
Split	0.861
Two-Family	0.840

When the houses are aggregated into one group, the coefficient of variation for all structures is 1.326 lower than five of the values shown, but higher than the other five.

Although the coefficients of variation were not computed for all the additional groupings included in the analysis, the data indicated the additional calculations would not result in significantly lower values.

The following table shows the estimated required sample size corresponding to selected other values for the coefficient of variations for one group.

Coefficient of Variation	Sample Size
0.10	15
0.25	96
0.50	384
0.75	864
1.25	2,401

As can be seen from the table, the coefficients of variation for the groups of structures would have to be significantly below 1.00 to result in a small sample size. Study cost constraints dictated that the target number of residential interviews total approximately 1,600.

For example, if the structures were divided into two groups, the coefficients of variation for each group would have to be reduced to 0.72 to get an estimated required sample size of 1,600. If the structures are divided into five groups, the values for each group would have to be reduced to 0.46. In the case of five groups, if the coefficient of variation for one group was reduced to 0.75, the values for the remaining four groups would have to be reduced to 0.35 to result in a total sample size of 1,600. As noted above, the analysis does not indicate that results of this type can be expected.

Thus, based on the high coefficients of variation developed from the groupings of the pilot data, it was concluded that further groupings would not yield results that would permit us to subdivide our overall population into more than one group at this time and still obtain the required accuracy while staying within the bounds of the number of interviews desired. Because of this it was determined that only one group would be utilized to stratify the data.

The estimated sample size for the expanded survey was determined by using a coefficient of variation of 1.00 in the formula for sample size:

$$\text{Sample Size} = \frac{(\text{coefficient of variation} \times Z)^2}{\text{accuracy}^2} = \frac{(1.00 \times 1.96)^2}{.05^2} = 1{,}537^*$$

*rounded to 1,600

The equation applies where Z = 1.96, and accuracy = 5%, to achieve 95% probability that the value of the sample mean will be within 5% of the value of the universe mean.

The value of 1.00 was selected as being representative of the values of the coefficients of variation for the ten structure types, three damage types and six flood levels included in the survey.

The conclusion drawn from this is that reliability estimated prior to the onset of the study can not be achieved. However, as discussed later, the reliability which is important for the purposes of this study is on a reach by reach basis, since this is how plans will be evaluated. Table V-10 details the interview schedules. Table V-11 details the number of structures in each group and the total number surveyed.

*For a level of confidence of 95% and accuracy of $\pm$10%.

Commercial Structures. The first step in estimating the required sample size for the full Passaic River Basin was to calculate the mean, standard deviation and coefficient of variation for damage values for each of the three groups. At this point, the analysis was again limited to damages at three levels: main floor, main floor +1' and main floor +15'. The analysis was done for the structure, content and other damage categories using two methods: 1) for dollar value of damages; and 2) for damages as a percent of structure value. As a result of the analysis from the pilot study, it was determined that to achieve an accuracy of +5% would require too many surveys. For a level of confidence of 95% and an accuracy of +10%, it was estimated in addition to those interviews in the pilot study, an additional 633 interviews would be required.

During the analysis of the Rockaway Basin, one of the structures was eliminated from the statistical analysis because it was unique. The structure value was $7.3 million, more than twice as great as the next highest value. As a result, all establishments with a large structure value were selected for an interview. Therefore, 9 additional structures in the Basin, each with a structure value equal to or greater than $10 million were also selected for an interview.

Commercial structure data was utilized for the stratification as well, with the following results:

Commercial Structure Type	Recommended Sample Size*
High	240
Medium	294
Office	99
Unique	9
Total	642

Industrial Structures. The Passaic River Basin floodplain includes approximately 1,100 industrial structures. The initial intent was to interview a 100% sample. However, as many of the establishments did not wish to participate in the study, it was only possible to initially obtain completed interview forms for 642 structures. Acknowledging the importance and possible uniqueness of industrial firms, an exhaustive and comprehensive secondary survey was made of industrial structures in the Basin. An additional 90 interviews were completed in the Lower Valley where concentrated industrialization exists and was determined to be potentially sensitive to damage. The survey

*For a level of confidence of 95% and accuracy of ±10%.

information in addition to the original interviews obtained resulted in interviews covering approximately 100% of the Lower Valley 100 year floodplain and over 90% of the 400 year floodplain. For these structures which interviews were not available a secondary windshield survey was performed to verify structure characteristics and usage. Damages were not computated separately for non-interviewed industries since damage accruing to the majority of the noninterviewed industries were accumulated at events greater than the 500 year storm, therefore, contributing slightly to total expected annual damages. Potential error due to major inaccuracies in the non-interviewed stage-damage data would not significantly affect total expected annual damages. No formal statistical analysis was performed due to the large degree of coverage of the overall population.

Utilities. A total of 35 interviews were performed for the utility entries. The interviews were grouped as shown in Table V-12 and represent a crosscut of the 258 entries obtained during the inventory stage. Again, no formal statistical analysis was performed since the overall population was so small.

Apartments. During the inventory phase of the project, a total of 494 apartment entries were recorded. A visual inspection of the data indicated that 494 entries represented a total of 150 actual complexes. Although a complex may be comprised of different buildings, the physical and economic character of each building is basically representative of the complex. Therefore, an attempt was made to interview each complex in order to develop a representative damage function for the overall population. However, due to some complexes being unwilling to participate, only 132 interviews were conducted, roughly 90% of the total number in the Basin. No formal statistical analysis was performed due to the large degree of coverage of the overall population.

Summary. Interviews for the full survey were distributed throughout the Basin. The number of interviews were based upon the coefficient of variation analysis discussed, earlier utilizing the variability of the damage information generated in the pilot survey for residential and commercial structure types. However, for each of these categories the actual number of interviews performed exceeded the targeted sample size. For utility and apartment structures, a sample based upon similarity of types was utilized. Meanwhile, for industrial structures an attempt was made to interview all structures. However, as discussed above, it was not possible to obtain the 100% sample desired for industrial structures. A total of 3263 interviews were actually conducted and broken down into the following groups:

	Target Sample	Actual Number
Interviews		
Residential	1600	1701
Commercial	642	753
Industrial	1099	732
Utilities	35	35
Apartments	150	132

STATISTICS AND DAMAGE FUNCTIONS

Two different approaches to the analysis were taken: for residential and commercial structures, statistical techniques were first utilized to group the data in order to minimize the variability of the information generated for the development of generalized curves were computed for each group. For utilities, industrial, and apartment generalized curves were computed by type.

Residential. For residential structures several different approaches were investigated. Based upon the size of the population, in excess of 40,000 structures, a first step taken was to restrict analysis to structure groups constituting at least 5% of the total population. This resulted in seven groups. One additional group, mobile homes, was considered even though it constituted less than 5% of the universe population due to the unique nature of the structure. See Table V-13 for details of the different types and the number of structures in each category.

As in the pilot the first step was to summarize the sample data and calculate the mean, standard deviation and coefficient of variation for structure, content and other damages associated with each structure type in order to measure the variability of the damage estimates within the structure groups. Based upon the analysis undertaken it became apparent that basement presence was not important in the determination of the residential damage functions. While this was not anticipated, it was found that the basement presence was subsumed under structure type. Due to the stratification of the eight residential structure types it was found that inherent in a given category was the existence or nonexistence and characteristics of basements. For example: in reviewing the ranch category, basements were not prevalent. Basements, as a variable analyzed separately were, therefore, not statistically significant.

The next step in the analysis was the development of a correlation matrix in order to test the possibility of grouping the structure types based on similarities of structural characteristics and damage values. The possibility of further combining the residential groups into other group combinations was considered, as follows:

- Raised Ranch and Bi-level;
- Bungalow and Ranch;
- Two-family and Multi-family;
- Two-family and Duplex;
- Cape and Colonial; and
- Two-family, Multi-family, and Duplex.

In order to see whether or not there was a significant difference between the mean values of damages for the structures within each grouping, "T" tests were developed for the groups with two structure types and "F" tests for the groups with three structure types. The tests were developed for six conditions: three damage types (structure, content and other) at two levels (main floor +1' and main floor +15'). If the "T" score was equal to or less than 1.96, the hypothesis that the two structure types have the same mean damage values could be accepted with a 5% level of confidence.

For the one group of three structure types - Two-family, Multi-family and Duplex - an analysis of variance was performed in order to obtain "F" scores for the six conditions mentioned above. For this case, if the "F" value was equal to or less than 3.04, the hypothesis that the three structural types have the same mean damage values could be accepted with a 95% level of confidence.

The results of the statistical tests are summarized in Table V-14. For each of the six groups of two structure types, the "T" score exceeds the acceptable value of 1.96 at least once and for the groupings of three structure types, the "F" score exceeds the acceptable value of 3.04 twice.

Based on the results of the statistical analyses, combined with the fact that the structural characteristics of the houses do differ, the possibility of further grouping of the structure types in the statistical analysis of the data was rejected and the eight groups originally proposed were further analyzed.

In order to assist in determining whether dollar value of damages, or damages as a percent of structure value, should be used in the development of generalized curves, regression equations were prepared with the dollar value of damages at main floor +1' as the dependent variable and structure value as the independent variable for each of the eight structure groups. A similar set of regression equations was then developed with damages as a percent of structure value as the dependent variable. Since damages in dollar values or percents were practically the same for each structure type the results of analyzing either statistic would be equally reliable.

Since the differences were slight, and the percent values were adaptable to further processing, the depth-damage value relationships were prepared in terms of damages as a percent of structure value.

Two possible methods of developing damage functions were considered: mean values and regression analysis. The mean value is the average value for the group. Regression analysis is a method by which an estimating equation is developed for use in relating damages to a set of structural characteristics. For this study, both stepwise regression and mean values were tested to determine the accuracy of predictions, ease and timeliness of development and appreciation.

A detailed analysis of the Colonial category was performed to assist in determining whether mean values or regression analysis would result in a better definition of damages as follows:

1. The first step consisted of obtaining the mean, standard deviation, coefficient of variation and standard error for the ratio of damages to structure value at each level below the main floor, at the main floor and at levels above the main floor for which damages were given. A summary of these results for damages at main floor +2' is shown in Table V-15.

2. Stepwise regression equations were then developed for selected representative floor levels spread over the range of possible levels. The equations showed the relationship between damages as a ratio of structure value and 10 structural characteristics. These characteristics included structural value, size, attic, foundation, age, number of stories, low opening, basement, garage size and garage type. Linear multiple regression equations were then developed with three structural

characteristics that appeared fairly consistently in the stepwise regression equation (value, age, low opening). Since the R values for these equations were low, two additional sets of equations without Y intercepts were developed, and the R values improved. Table V-16 shows the R values for the four sets of equations.

3. Damages were then calculated for three hypothetical structures. These structures represented typical Colonial structures in the Passaic River Basin and were identical except for structure value. Structure #1 had a low value of $25,000; Structure #2, the mean value of $64,414; and Structure #3, a high value of $110,000. The results of these calculations and a summary of damages at main floor for all three houses indicated that using either the mean values or the regression equations would result in similar damage values. The results for the house with the average value are shown in Table V-17.

Since the results of this analysis indicated that the damage values would be similar and the use of mean values would be more efficient in further calculations, damage functions were developed in terms of mean values. A test was also made to determine whether or not content damage was related more closely to content value or structure value. The results indicated that content value was more closely related.

Therefore, the final generalized residential depth-damage functions were developed for each of 8 structure types for 3 categories of damage: structure, contents and other. The curves were based on mean damage values as a percent of structure value, for the structure and other damage categories, and as a percent of content value for content damage.

Commercial. Commercial structure damage functions were developed in light of the analysis performed for residential structures. The three groups developed in order to stratify the damage interviews - high value inventory, medium value inventory, and offices - were analyzed to determine whether or not they were effectively grouped. The analysis yielded a greater degree of diversity in this case than in the pilot stage. A calculation of the damageability of contents as a percentage of content values was made.

The following relationships were found:

high value inventory	35.3%
medium value inventory	57.1%
offices	64.8%
Total	49.9%

Since these results did not fit as closely as those for the pilot study and since it was not clear that the best possible grouping had been developed, an alternative grouping was explored. Table V-18, which listed the ratio of commercial damages at +15' versus the value of the contents, was developed. Utilizing this information, ten equal sized groupings having similar ratios were developed.

Table V-19 shows, for each of the ten groups, the estimated total number of units in the Passaic River Basin, the sample size, the mean, the standard error, the standard error divided by the mean and this last value squared. The average of the last column of numbers of each of the sets of groupings is then presented and a factor of 0.3 is applied to the ten groupings to adjust for the smaller sample size. The average value for the 10 groupings is higher than the average for the three groupings indicating a smaller range of values within the 10 groups.

Those ten groupings were used in further analysis of the commercial contents, damage functions. However, for the structure and other damage categories, these ten groupings were not utilized. Since the ten groupings discussed above and the original high value inventory, medium value inventory, and office groupings all reflected consideration of content damage, it was decided that those were inappropriate for use in the structure and other analysis. For the structure and other damage categories all the interviews were initially analyzed as one group.

Further analysis was performed utilizing the above groupings. The first step in this analysis was to examine possible subgroupings to determine if more accurate results could be obtained. Tables V-20 and V-21 depict the results of this analysis for the variable number of stories.

This analysis did not yield any substantial improvement in the results, therefore, stepwise regression and factor analysis were examined to determine if more accurate results could be obtained. This analysis determined that for the commercial structures the presence of a basement is an important factor in the determination of damages. Therefore, the ten groups utilized for content damage, and the groups for structure and other damage, were further stratified into with-basement and without-basement groups.

All 20 functions, which were stratified based on the relationship between content damage as a percentage of content value, with and without basements, were developed for commercial content damage. Two functions were developed for each of the structure and other damage categories. The final commercial content damage function groupings are listed in Table V-22.

Industrial. Since 732 industrial structures out of a total of 1,099 agreed to be interviewed, it was necessary to generate damage functions in order to evaluate the remaining 367 structures. In order to assign damage functions to those structures not actually interviewed all the industrial structures were grouped according to similar usages. Thus if two auto manufacturers were interviewed and a third was not, they were grouped together. The net result of this grouping was thirty-five groups exhibiting similar usages. Damage functions for each of the thirty-five groups were then calculated as a percent of the structure value.

Utilities. Damage functions were based on interviews of similar usage. The 258 entries were distributed into twelve categories and damage functions based on damages as a function of size in square feet were employed to generate the stage-damage relationships for those structures not interviewed. Size was used rather than structural value due to the difficulties in appraising value accurately.

Apartments. Since 90% of the complexes were interviewed, the physical and economical makeup of the population was well represented. Mean damages as a percent of structure value were generated for 2 subgroups (garden apartments and high-rise) based on combining the apartment figures for each subgroup. These values were then used to generate damages for the rest of the population.

Municipal Damages. An analysis of the historical data on public damages, of the data gathered in compiling the historical search and of data found in previous Corps Post Flood and Survey Reports, was made to determine if, for the major damage areas (Pompton, Central and Lower Valley), a consistent relationship existed between the frequency of an event and the percent of total damage that was public for the event. It was expected that the share of total damages that are public would decrease as the flood frequency decreased. This was compiled based on historical events which had frequencies ranging from the 2 year through the 235 year storms. The analysis indicated that, in fact, the public share of damages did decrease for all areas as frequency decreased. These results were then utilized to develop estimates for municipal damages.

SUMMARY

The final product consists of damage functions for the Passaic River Basin and a population inventory upon which to apply these functions. The damage functions represent damages for one foot increments of height referred to main floor for each of the "Structure," "Contents" and "Other" damage categories for each structure group. This results in 24 residential, 24 commercial, 105 industrial and 6 apartment depth-damage functions. The 30 functions for the ten utility groups were generated as a function of size in square feet rather than value due to the difficulty in quantifying their value. In all, there are 189 functions within the groupings presented in Tables V-23 and V-24.

The coefficients of variation for the subgroupings did not reach the level that had been sought. This resulted from the greater variability of the damages rather than the structures' values. However, it should be noted that damage analysis is on a reach by reach basis. The aggregation of individual structures by structure damage functions and their variability, will lead to a greatly reduced level of variation, and therefore a higher level of confidence in the results on a per reach basis.

DATA MANAGEMENT SYSTEMS

To aid in the analysis of existing flood damages and the evaluation of alternative flood control measures, the Passaic River Study Group utilized the spatial data management and analytic programs available from the Hydrologic Engineering Center (HEC). The programs utilized are of two types: spatial and site specific. Each type has three distinct components: data management, data file processing interface, and analytical computer programs, as discussed below. Spatial data for the Passaic River Basin is contained in the data base file. The processing interface element of the data base file is comprised of computer programs that compile and reformat geographic and resource data retrieved from the data bank into a format processable by the analytical computer programs. These programs service the functional analysis area of flood hazard; (Figure V-5) HYDPAR links the data base file to the flood hazard hydrologic soil group and land use to generate the modeling parameters required to simulate storm runoff.

The analytic element of the spatial programs is comprised of the general simulation and analytical computer programs that perform the detailed technical assessments that compare the existing condition to the development condition of interest. All final-analysis computer programs are standard Corps of Engineers analytic tools that have been in use for a number of years. HEC-2 is used to perform the river hydraulic analysis, HEC-1 serves as the general hydrologic simulation to forecast the hydrologic effects of development measures. The Expected Annual Flood Damage Computation program (EAD) is used for expected annual damage computations.

The site specific data is contained in the structure file. The processing interface element is the Structure Inventory of Damages (SID) Program. The SID Program is designed to expeditiously collect and manage data related to structures subject to flooding. Its function is to process structure inventory data to develop aggregate elevation-damage functions by damage categories and by designated damage reaches. The resulting functions can then be subject to additional processing, via an automated linkage to EAD. Direct linkages from HEC-1 and HEC-2 to EAD as part of this network have been developed by HEC. Stage-frequency relationships were input into EAD via an interface program which was developed by the Passaic River Special Studies Branch automatically links HEC-2 to EAD.

The Passaic River Study data base file and the structure file were both created under contract by Environmental Systems Research Institute. The files were placed on magnetic tape and forwarded to Boeing Computer Services in Seattle, Washington, where it was placed on their MAINSTREAM computer system. The tapes and files have since been converted to the Cybernet Computer Service (CDC), the service currently under government contract. The HEC analysis programs are also stored on the CDC facility, and can be accessed through a remote terminal at the New York district office.

DATA BASE FILE

Conceptual Basis. Data base file development includes the collection and assessment of raw data through its transformation into an orderly arrangement of variables in a grid cell data file. This is done via a set of computer programs which process raw map or other spatial type data to the grid cell format which becomes the overall data bank. This includes a program that permits displaying data digitized in the polygon format and generates grid cell data from polygon format data, special purposes programs to create grid cell topographic data from digitized contour lines and programs to properly register polygon data to the base grid system and place the grid data into the general data bank. The purpose of spatial data management was to inventory the geographical area of the Passaic River Basin in a systematic way so that its co-occurring parameters can be retrieved, displayed and consistently and comprehensively analyzed with proven analysis programs and with a common data set.

The creation of a spatial data bank was accomplished by overlaying the geographical study area with a grid. The total Basin is represented by a uniform network of small grid cells. Each grid cell was then assigned numerical records that legend its location and its specific data value for each parameter of the landscape (Figure V-6). Alternately, if large geographical areas contained common values, these data were placed in the data bank by the polygon method. Using a polygon, mapped data has its spatial extent defined by delineating the area with a sufficient number of x,y coordinates. The bounded area and the area which it circumscribes all received the same value for that particular variable. An example would be a computer file of the x,y coordinates of the boundaries of land use types for the Passaic River Basin. All the area within the boundaries represents a specific land use and is subdivided into grid cells for use in further processing. Figure V-7 demon- strates the relationship between grid cells from different data maps and their correspondence to one another. The relationship between the grid cells of each variable was created as a continually overlaying process where data variable 1 was over- laid by data variable 2, which in turn was overlaid by data variable 3, etc. In other words, the data bank is constructed by stacking individual grid representations of the data vari- ables onto a computer storage device in a systematic fashion so that efficient access and data manipulation is possible. All data variables for a given cell were stored sequentially, cell by cell, in a manner so that, regardless of the number of variables in the data bank to be used in calculation, or their number of grid cells for each variable, only one search of the grid cells for each variable, and only computer storage capacity to process the collapsed number of variables involved are required.

The computerized grid cell data bank consists of economic, environmental and hydrologic variables. Special purpose programs properly registered grid cell data to the base grid system and placed the data into the general data bank. The data from the spatial data bank are made available for computation through a group of computer linkage programs.

The initial step in the creation of a spatial data file was the establishment of a basemap for the areas to be studied. Once the scale of the basemap was determined, various mapped documents and photos were enlarged or reduced, and optically adjusted to match the basemap scale. After all of the data types were rectified to the basemaps, the aerial information on each was encoded. Data encoding is the conversion of spatially related data to a digital form for subsequent processing into the grid cell data base file. This is done by using actual numbers (e.g., elevation in feet above mean sea level) or by assigning numeric codes to non-numeric data (e.g., land use types).

The advantages of the computerized data management system are:

a. It provides a central, coordinated data set for consistent analysis in each functional area.

b. It enables consistent and expedient assessments of the effects of alternative land use patterns.

c. It provides flexibility in scope and detail of analyses.

d. It provides a permanent data base that is documented or may be used as a foundation for future studies.

e. It enables management of large data sets.

Passaic River Data. Ten different data variables were entered into the data bank file. From this basic data, two types were derived and entered into the data bank. The data variables (the term variable is used here to indicate a data type which can be stored in a data bank) resulting from this process are.

Basic Data Variables

- Hydrologic Subbasins
- Topography (elevation)
- Soil Series
- Existing Land Use
- Municipal Boundaries
- 1990 Land Use
- 2040 Land Use
- Damage Reaches
- Index Flood Elevations
- Tributary

Derived Data Variables

- Land Surface Slope derived from elevation
- Hydrologic Soil Groups (derived from soil series)

<u>Creation of the Data Bank</u>. The final data bank produced for the Passaic River Basin includes the row/column location of each grid cell plus a record of all data variable codes encoded for that cell. Each grid cell represents 10.33 acres of the approximately 950 square mile Passaic River Basin. In excess of 50,000 grid cells were recorded. This sequence of data records is called a multi-variable file (MVF). It differs from a single variable file in that the string of numerals following the row and column numbers represents more than one data variable. The codes for specific variables are identified by their position in the sequence of numerals. The following illustrates the sequence of variables in the Passaic River Basin MVF.

PASSAIC RIVER BASIN

Sequence of Variables in Data Bank

1	Row
2	Column
3	Subbasin
4	Topo
5	SCS Soils
6	Hydrologic Soil Groups
7	Existing Land Use
8	Slope
9	Municipal Boundaries
10	1990 Land Use
11	2040 Land Use
12	Damage Reaches
13	Tributary
14	Index Flood Elevation

The multi-variable file is created by a software program which first reads in a single variable file and reserves enough space to store the subsequent variables. The second and subsequent variables are entered into the MVF by inserting their attribute codes into the correct specified positions in the record of the appropriate grid cell. This is done in sequential fashion, one cell record at a time. Once merged, each variable can be retrieved by specifying the position (or layer) of the desired variable in the data bank.

Applications. The utilization of data in the multi-variable file has been primarily via the HYDPAR program. HYDPAR is utilized to model changes in the hydrograph parameters and loss rates that are associated with future urbanization. This procedure lends itself to application in the Passaic River Study grid cell data bank and HEC's HYDPAR program. The grid cell data bank variables contain information on hydrologic subbasins, slope, hydrologic soil group, existing land use, and projected land uses for 1990 and 2040. The HYDPAR program accesses this grid cell data and computes, for subsequent use, hydrologic parameters that permit the determination of precipitation loss-rate functions and surface runoff responses. The parameters that can be generated are those required for the U.S. Soil Conservation Service (SCS) curve number technique and those needed for watershed modeling using subarea imperviousness and characteristics for the Snyder unit hydrograph procedure.

The urbanization effects can be derived using the HYDPAR program in conjunction with the grid cell data bank. Through HYDPAR, the SCS basin lag times can be obtained for each subarea for future land use scenarios (existing condition, 1990, and 2040). The urbanization effect on the loss rate can also be derived using HYDPAR in conjunction with the grid cell data bank. HYDPAR is instrumental in the evaluation of future condition hydraulic and hydrologic data of the Passaic River. The Resource Information and Analysis Program (RIA) also utilized the data bank variables. RIA is designed to perform selected geographic analysis by the use of a grid cell data bank.

The RIA program has capabilities for four major types of analysis and can generate computer printer graphic displays and tabulations of analysis results. The major options of the RIA program are: distance determination, impact assessment, locational attractiveness, coincident tabulation and mapping. The distance determination option enables the program to systematically search for and compute distances between grid cells of any designated variable type. The calculations are based on a distance evaluation which measures the linear distance between the centroids of the appropriate grid cell. One utilization of the distance determination option consists of determining the distance between existing development and a particular site in order to forecast future land uses.

Perhaps the most useful option available in the RIA program is for future land use forecasting; this is the locational attractiveness modeling option. This option develops a relative attractiveness value for each grid cell in the data bank based on combinations of data variables selected by the user. The data variable classifications, (for example: slope 0-15%, 15%-40%) are assigned a relative scale, the number 10 indicating most attractive, zero, least attractive. If more than one data variable (for example shape and soil) are to be used in the analysis, the variables may be given a relative weight to monitor their impact in the locational analysis. The location attractiveness model, used with careful detail and strong indicator variables can efficiently and effectively illustrate by mapping and tabular output the most attractive areas of land for particular future land use development. This option incorporates judgemental decisions made by the user.

Coincident Tabulation performs accounting operations of the coincidence of classes or categories between two data variables within the classes or categories of a third variable. This operation was not utilized.

The Mapping option produces line printer graphic output of analysis results from the data bank. Printer display can be generated for Distance Determination, Impact Assessment, and/or Attractiveness Modeling.

Of the variables available in the data bank, the ones considered to be most appropriate for land use projections were existing land use and slope. Hydrologic soil groups and soil series did not have a high correlation with specific future land uses. Also, within the Passaic River Basin hydrologic soil groups, there is not enough diversity to adequately use this variable as a determining factor or a locator variable in projecting future land use. Several runs of RIA were made to verify that hydrologic soil groups and soil series could not significantly aid in forecasting land use.

As a result, the variables existing land use and slope were the focus of analysis utilizing RIA. The option of RIA utilized was Locational Attractiveness. The existing land uses viewed for future development were undeveloped open space, barren land, woodland and cropland. The previous order was, the order of attractiveness input into the RIA program with open space undeveloped being the most attractive initially for development and cropland being the least attractive. Wetlands were eliminated from the potential grid cells considered for future land use development. The sensitivity of the impact of development occurring in the wetlands will be discussed later.

RIA runs first generated data on the relative ranking of land available for future development. Additional runs combined this output with ranked attractiveness qualities such as distance to existing development.

The other data variable also essential in land use forecasting is slope. By ranking slope classifications of 0-2% slope being highly attractive, and greater than 25% slope being highly unattractive an even finer definition of existing land's potential for future uses was obtained. RIA is able to eliminate certain slope classifications from the analysis, for example, slopes greater than 45% were omitted.

STRUCTURE INVENTORY OF DAMAGES PROGRAM

The Structure Inventory of Damages (SID) program is designed to aid in the expeditious collection and management of data related to structures subject to flooding. Its basic function is to process structure inventory data to develop aggregate elevation damage functions by damage categories and designated damage reaches. The resulting functions can then be subject to additional processing, such as provided by HEC's Expected Annual Flood Damage Program. SID has also been designed to enhance the study of a variety of nonstructural floodplain management measures, so that measures, such as selected floodproofing, relocation, and raising can be accommodated in the aggregation. The program has also been designed to be compatible with spatial data processing systems.

The concept of automating a structure inventory is not a new principle or practice. However, the careful construction of the data handling features, such that structure inventory files are compatible with spatial gridded data files and sensitive to policy analysis is quite unique. Figure V-8 details the process via which SID is incorporated into the data management system.

Basic structure information input includes identification codes, locational information and structure elevations (see the structure file discussed later in this section for more detail). Structure inventory data provides precise cataloging of each structure including:

1. Damage reach
2. Individual structure identification number
3. Geographic coordinates
4. Damage function
5. Elevation information
6. Monetary value

The Structure Inventory of Damages Edit Program (SIDEDIT) provides correction capabilities for structure inventory files. The orginal version of SIDEDIT, which was developed specifically for the Passaic River Basin Study, was designed to locate and revise data in the structure inventory file and to provide flexible data input, merging, selection, manipulation, modification and output capabilities. Data are input and output as files containing attributes descriptive of individual structures, such as main floor elevation, reference flood elevation, structure value, content value, etc. SIDEDIT provides the capability of selectively reading all or some of these attributes from the input file. New attributes may be added to each structure either by merging them from a separate input file or by deriving them from attributes within the file, such as adding structure value, contents value and other value to obtain a total value attribute. The new attributes may be retained and the output used to create a new structure data file.

Data files may be expanded by merging files of different geographic area together. SIDEDIT automatically inserts structures from the subordinate file into their correct position in the master file. If duplicate structures are found, the structure coming from the subordinate file replaces the structure in the master file. If files are to be merged, they must be sorted before SIDEDIT is executed.

Structures may be selected for manipulation or output by either their geographic location Universal Transverse Mercator, coordinates or by their attributes. Selection by attribute may be simple (e.g., all structures in a specified damage reach) or complex (e.g., all structures in a specified damage reach that have a certain elevation and a certain structure value). Selections based on attributes are performed by stating conditions in logical expressions. That is, combinations of "IF" and "AND" tests and logical operations such as "greater than," "less than," "equal," "not equal," etc. are combined to identify all structures conforming to the specified conditions.

Attributes may be manipulated by performing any arithmetic operation (i.e, add, subtract, multiply or divide) between two or more attributes or between attributes and constants. The results of such operations may be stored in a temporary file and then input to other applications within the program. Manipulations may incorporate the logical conditions discussed in the preceding paragraph.

SIDEDIT was instrumental in the calibration of stage damage relationships. Structure specific data, such as structure value, were modified in cases where the original inventory data required modification. Changes were implemented on a structure by structure basis. The effective utilization of SIDEDIT to facilitate the refining of structure file data was a critical element of the data management process. SIDEDIT was later expanded by HEC and provided with capabilities to edit and generate random access data files. This program expansion was instrumental in damage function testing and utilized by the PRSG to verify stage-damage derivation.

Structure File. The structure file, a necessary component input to the SID program (described in the previous section) was compiled by merging data from three sources, the structure inventory data, information generated by the Passaic River Study Group and data processed by ESRI (Environmental Systems Research Inc.). Data variables in the file which were obtained from the structure inventory were the structure main floor elevation, the structure damage category and the structure value. Information supplied by the Passaic River Study Group included the card identification, the structure, content and other damage functions codes, contents values and other value. The damage function codes in the structure file correspond to the actual depth-damage relationships which are applied to each structure. Data processed by ESRI include damage reach information, Universal Transverse Mercator coordinates UTM for structure geographic location and reference flood elevations for each structure.

The file consists of specific data for each structure evaluated in the economic analysis of flood control measures. The data contained in the file is in standard 80 column format and is detailed below.

Field Name	Card #	Card Location	Record Location	Data Type	Attribute
ICODE1	1	1-2	1-2	CHAR	Card Identification
IDRCHI	1	3-8	3-8	INTEGER	Damage Reach
IBLDG1	1	9-16	9-16	INTEGER	Structure Identification
ROWN	1	17-24	17-24	REAL	UTM Northing
COLE	1	25-32	25-32	REAL	UTM Easting
ADJ	1	33-40	33-40	REAL	Reference Flood Elevation
STOPO	1	41-48	41-48	REAL	Main Floor Elevation
ICODE2	2	1-2	81-82	CHAR	Card Identification
IDRCH2	2	3-8	83-88	INTEGER	Damage Reach
IBLDG2	2	9-16	89-96	INTEGER	Structure Identification
LUSE	2	17-24	97-104	CHAR	Structure Damage Category
IDIFS	2	25-27	105-107	CHAR	Structure Damage Function Code
VIFS	2	28-32	108-112	INTEGER	Structure Value
IDIFC	2	33-35	113-115	CHAR	Contents Damage Function Code
VIFC	2	36-40	116-120	INTEGER	Content Value
IDIFO	2	41-43	121-123	CHAR	Other Damage Function Code
VIFO	2	44-48	124-128	INTEGER	Other Value

EXPECTED ANNUAL DAMAGE PROGRAM

The Expected Annual Damage EAD Program has as its purpose the computation of expected average annual flood damages. The program facilitates the comparison of floodplain management plans, different analysis years, and the utilization of updating factors.

Damage may be computed in three different modes: (1) the damage associated with a specific flood event; for example, the estimated damage should the Standard Project Flood occur, (2) the expected annual damage associated with a particular discount rate and period of analysis; for example, expected annual flood damage for year 1985, 1990, and 2000 hydrologic, hydraulic, and economic conditions, and (3) the equivalent annual flood damage associated with a particular discount rate and period of analysis. The computation of damages for specific flood events or for expected annual flood damages is made for each floodplain management plan based on the hydrologic, hydraulic and economic data for a damage reach. Several damage categories - urban, agricultural, industrial, residential, etc. - may be analyzed simultaneously and are summarized for each plan and reach. Expected annual damages may also be computed for conditions existing during some previous year (historic conditions). Equivalent annual flood damages are computed when the discount rate and period of analysis are specified.

Analysis is conducted on a reach-by-reach basis. Data is input by reach and up to 200 reaches may be processed and summarized in one run. The input data may be referenced to past or future years. The magnitude of the relationships for a particular year are then determined by linear interpolation between the input data years for that relationship. Up to nine different input data years may be utilized.

To compute expected annual flood damages different combinations of stage, flow, damage and frequency data can be organized and input in the EAD program to develop damage frequency relationships. The program then integrates the area under the damage frequency curve to produce expected annual damages in addition to stage damages. Corresponding flows and stages for particular plans are input with the corresponding stage damages.

Passaic River Basin stage damage relationships generated as output utilizing the SID program were transferred by computer as input to the EAD Program. Hydraulic and hydrologic data were also input by computer to run EAD. The damages output is identified by damage category number and by specific damage reach.

Each floodplain management plan which was analyzed is described by the effect that it has on the input hydrologic, hydraulic and or economic relations. If inundation reduction benefits are to be computed, the first plan must be for the "without" condition. Up to nine plans may be specified, summary is presently designed for a seven plan display. Additional floodplain management plans may be manually subtracted from each other for comparison purposes.

The various types of flood damages (urban, agricultural, industrial services, residential, etc.) are computed separately and then totaled in the summary table. Up to 18 damage categories may be specified. The study year, base year, five decade years and the end-of-analyses years, if utilized, are added to the input data years as points in time to compute expected annual damages. Then expected annual damages EAD are found for each year by linear interpolation, the present worth of EAD for each year is computed at the base year, and then amortized over the period of analysis. EAD analyses and runs generated for this report include 1985, 1990, base year 2000 and 2040 evaluation.

Data Storage System. The Data Storage System (DSS) enables the automatic interface of analytical programs. DSS was designed to minimize the effort of the user in manipulating and processing information, provide enhanced data management capabilities in an orderly manner, and expedite the evaluation process. This common data storage system offers the potential for greatly simplifying data management.

Present and Future Program Development. HEC began the development of DSS during its work on the Kissimmee River investigation. During this development, HEC-1, DAMCAL, EAD, and other programs were linked via data storage files. At this time, however, the program does not have full documentation but may be utilized with assistance from HEC. HEC plans to implement the DSS system and complete the documentation of linkages between the HEC-1, HEC-2, SID and EAD programs in the near future. It provides a direct mechanism for the transfer of data between these programs. General purpose tabulation, report generation, statistical analysis and computer graphics routines will be appended to the HEC-DSS. Eventually, special tabular plot, and other routines that were written and implemented specifically for each HEC program will be discarded and the standard general appendages to the HEC-DSS used in their place.

HEC has completed the following to date:

1. Freq-Q array to DSS
2. Elev-Q to DSS
3. HEC-1 parameters from DSS
4. Freq-Q from DSS to EAD
5. Elev-Q from DSS to EAD
6. Distributable HEC code version four for all 11 HEC-DSS links

EXISTING WITHOUT PROJECT CONDITIONS

The number and type of structures in the 100 year and 500 year floodplain by major tributaries are detailed in Table V-25. The number of structures presented in each floodplain differs from structure counts utilized in plan formulation nonstructural and evacuation plans of protection because these plans did not treat structures affected only slightly by overland flooding. This procedure was effected to achieve maximum feasibility of the nonstructural measures. Maps designating the 100 year and 500 year floodplain for the planning area are presented in Figures V-9 - V-41.

Table V-26 details the levels of damage expected to occur during a 10 year, 100 year and 500 year flood event, and includes a comparison of the calibration of the 10 year damages versus the 1968 flood, an approximate 10 year event.

This section focuses on the development and calibration of the model for flood damage estimation for the Passaic River Basin. A description of the reach definition and the reach numbering system is provided, followed by a description of the methodology and procedures utilized for the economic calibration of the EAD model from 1981-1985. Articulated in the summary reach areas, is a general description of the aggregate Lower Valley, Central Basin, Upper Passaic and Pompton Valley subbasins damage reach designations and damagability. Reaches containing significant damage areas were selected to exemplify the critical damage areas of the Passaic River Basin. An explanation is provided, concerning expected annual damages and at stage damages due to 10 (May 1968), 50, 100 and 500 year floods. All damages are in October 1985 price level dollars.

REACH ANALYSIS: Reach Definition.

The Passaic River mainstem has been divided into 214 damage reaches. These reaches were determined by analyzing the relationship between hydraulic parameters and economic considerations, including, number and type of structures, damage potential, and sensitivity of damage potential.

Reach Numbering System

A six digit reach numbering system has been utilized for damage reach designation. In order to have consistent numbering of damage reaches within the Passaic River Basin Study the following nomenclature has been adopted:

a. The first two digits designate a river or portion thereof as detailed below. Backwater areas of the rivers listed below are being treated as part of the river from which the backwater originates. E.g., the backwater area of the Passaic on the lower Rockaway River below the Boonton Reservoir would be coded 02. Occasionally the reach designation was made prior to the availability of final hydraulic information; therefore, a few backwater reaches are not so designated. An example of the latter case is the Passaic River backwater reaches along the lower Peckman River which were coded 50 rather than 01.

b. The next three digits designate a reach within a particular river or portion thereof. Numbering starts with 01 and proceeds upstream.

c. The last digit designates bank, a 1 in this column indicates left bank (looking downstream), a 2 right bank, a 0 indicates that no subdivision is made. In certain areas where left or right bank is not a sufficient break down - i.e., there are more than one subreach on a bank within a reach - odd numbers (1, 3, 5, ...) are used for the left bank and even numbers (2, 4, 6, ...) are used for the right bank.

The numbering systems for the first two digits are as follows:

01 Lower Passaic
02 Central Passaic
03 Upper Passaic
30 Saddle River
40 Molly Ann's Brook
50 Peckman River
60 Pompton River and Preakness Brook
66 Lower Ramapo
67 Wanaque
68 Pequannock
70 Rockaway River
80 Whippany River

An example of this system is as follows:

Reach 030010 would be the Upper Passaic River (03), first reach (001), and no bank differentiation (0). Municipalities and damage reaches are displayed on Table V-27. Figures 9 through 41 detail the damage reaches utilized.

Economic Calibration 1981-1985

Economic calibration builds on the collection and interpretation of Basin field data. As previously detailed Basin data was collected in two formats; first, the 100% windshield survey and inventory of the Basin floodplain and second, the interviewing of owners of floodplain structures. Economic calibration was begun with the review and inspection of flood damage surveys conducted during 1979 through 1980. The surveys totaled 1701 residential, 132 apartment, 35 utilities, 753 commercial and 732 industrial interviews. The interviews were used for the definition of historical flooding and the development of depth-damage relationships specific to the Passaic River Basin. The interview and inventoried data were placed on computer data files for use in the development of stage-damages and later in the calculation of expected annual damages. This information is the foundation of the economic model. The New York District's review, acceptance, and utility of the above information are detailed below.

The field damage surveys, which were extensive in length, were reviewed by in-house economists, engineers, environmentalists, and cost estimators in the Passaic River Basin and Special Studies Branch. Approximately 50% of the 3353 damage surveys were examined in detail. Because of the difficulty in obtaining good non-residential data, and its critical level of importance, close to 100% of industrial, utility and apartment complexes were included in the review. Approximately 10% of the residential and 30% of the non-residential surveys were returned to the contractor for improvement and verification. The importance of obtaining accurate, complete and up-to-date information at the onset of the study was recognized. All damage estimation work which was to follow was a product of the field survey base data.

Thorough review of the field damage surveys sometimes identified changes to be made to the files containing inventory data files to improve the depth and detail of information. These changes included main floor elevations, structure types, contents and land values, and other collected variables. These modifications to basic data were necessary to assure accurate and comprehensive economic evaluations. The majority of this work was accomplished by the A/E who performed the surveys. Remaining editing and verification were done by the Corps.

A "structure file" was developed from the collected inventory data. This file was specifically formatted for use with HEC's Structure Inventory of Damage Program (SID). During the formation of the structure file (the compiling of the collected data, Corps developed data and additional contractor* developed data) necessary additions and modifications became evident. Again the accuracy of structure contents and other values were improved, and absent values were corrected. Modifications were made to main floor elevations when there were inaccuracies evident from a structure's geographic location, tributary location or mainstem location. Main floor elevation, an extremely critical variable, was reviewed many times during the calibration process. As improved and additional information became available, such as, field data, interview data, and historic event floodmarks, this information was incorporated into calibration decisions and actual economic modeling.

The generation of stage-damages by reach using the SID program created an opportunity to further improve the structure file. Any areas of data subject to doubt were then extensively researched. At this time thalweg elevations and SPF elevations were known, so that general decisions on appropriate damage-ability for each damage reach could be correctly made. These elevations served as benchmarks for assessment of the stage damages by reach generated in the very early SID runs. Each reach along the entire Passaic Main Stem, Pompton River and Upper Tributaries was examined in this fashion.

Initial SID runs were generated to provide 35 depth-damage one foot increments in all reaches to assure that start of damage elevations, through and beyond SPF water surface elevations, were captured in the array. Because the EAD (Expected Annual Damage) program can only receive a maximum of 18 increments (using increments greater than one foot was not considered) each SID run had to be edited to appropriately span the necessary elevation range between the start of damage and the SPF event.

A systematic checking of the SID output resulted in the careful review of certain elevations specific to the Lower Valley. Final (ADR) 1"=200' topographic mapping had not been available for use in this area during preliminary data collection. Older (GEOD) mapping was used as the next best source. This mapping, however, was developed with 5 foot contours and not as well suited for the development of structure specific main floor elevations as the ADR mapping. Once the ADR mapping was available main floor elevations for all structures in the reaches using GEOD mapping were verified to assure accurate mean sea level elevations.

*A firm was contracted to provide certain essential data such as geographic coordinates and reference flood elevations.

Continual review of SID output focused on reaches with significant stage-damages. For these reaches and/or damage categories (residential, apartment, commercial, industrial, utility) the trace option of the program was utilized. The trace option allows the user to output and display the specific structure depth-damage relationships that are aggregated to compose reach totals. This option allows the user to examine structure specific depth-damages at one foot increments. This allowed the inspection of inappropriate jumps in damageability and identification of inappropriate absences of increasing damageability. Structures that fell into either category were carefully examined to assure that all the structure variables were accurate. Data was field verified or confirmed by interview or telephone research whenever necessary.

The trace option was extensively utilized throughout significant damage centers in the Lower Valley, Central Basin, Upper Passaic, Pompton River and Upper Tributaries. Basic data was systematically examined to guarantee a high degree of confidence for all input data utilized in the analysis and development of stage-damage figures.

During this time, other work indirectly related to economic calibration was also ongoing to improve the methodology used by the study. It included the:

A. Modification and expansion of the SID program to incorporate the calculation and display of residential contents or the contents damage in any of the damage categories.

B. Access of damage functions through the SID program to assure that the depth-damage relationships were being utilized and read correctly. Spot check of the approximately 5,000 damage functions on computer file to verify both percent damages versus stage, and dollar damages versus stage relationships.

C. Conversion of any mis-associated damage function codes.

After SID output was thoroughly reviewed, the SID results (stage-damages) were run into the EAD program using preliminary hydrologic and hydraulic data. The integration of each reach's stage-damage data with stage frequency allowed and encouraged further evaluation of the economic variables. Damage thresholds in specific damage reaches were crosschecked with hydrologic predictions of annual flooding and documented historic flooding. Economists and hydrologists worked together to assure that the lower end of the frequency-discharge relationships were representative of actual field events.

Many calibration steps were taken, beginning with the comparison of current model results to the damage data documented in the 1972 Passaic River Basin Survey report. The current reach designations were grouped to parallel the geographic reach definitions in the 1972 report. This assessment enabled a comparison of current model results with respect to the damage estimates contained in the 1972 report.

Reaches that differed (whether high or low) with the 1972 data were researched. Since the 1972 report was based on fairly old data, changes in development, land use, and damage reoccurrence were investigated in light of the past decade in which changes have taken place. Discrepancies were reconciled. This included for example, the recognition of such factors as industrial use changes, increased development in the floodplain, and changes in damage frequencies due to updated hydrologic data. The comparison also highlighted areas for which more extensive historical flood data should be collected wherever available.

Historical flood event damage figures were collected for all areas of the basin for recorded flood events. Data from Corps' Post Flood Reports, municipal records, newspaper accounts and personal accounts were compiled whenever available. Historical floods were identified with their expected return interval and then compared with dollar damages generated at the same frequency in the EAD model. The model was calibrated accordingly, to replicate historical damages where appropriate, and also to differ from historical damages where floodplain characteristics have significantly changed overtime. For example, the May 1968 flood which approximated a 10 year flood event was compared to the EAD model. The EAD model was calibrated consistent with historic May 1968 flood damages.

To obtain a first hand accounting of historical flooding, district employees performed a substantial number of interviews in the areas where data could be strengthened. Interview teams were used to assure thorough collection and complete documentation of field information. The teams were given specific objectives to make optimum use of the time spent in the field. Because of the size of the Basin, routes were carefully laid out for maximum floodplain coverage. These surveys were in addition to the 3353 interviews performed by a contractor. All areas of the Basin were canvassed during the study, however, approximately 60 reaches were specifically visited. This work provided the opportunity for genuine field observations regarding the type of homes, home sizes, market quality, and location to the river. Discussions with floodplain residents confirmed and supplemented previously collected flood damage data, and served to provide district employees with actual evidence of the flooding hazard in the Basin.

Flood damages were analyzed on a municipal basis also. Flood damages by damage reach were aggregated by municipality for specific flood frequencies and then crosschecked with municipal records on past flooding. It was acknowledged that historic damages are often uncertain due to minimal record keeping and/or understatement of actual costs incurred by municipal officials. Comparisons were made nonetheless. Several inconsistencies between historical records and predicted damages initiated an exhaustive topographic review using current Basin mapping to ultimately reconcile the differences identified.

Damages generated by the EAD program were carefully reviewed on a reach by reach basis for all 214 reaches. Using topographic mapping, the review focused on start of damage elevations, main floor elevations, source of flooding and the character of development in the floodplain.

Start of damage elevations were determined by examining top of bank elevations, low openings, and utilizing structure interviews in the specific area to verify when structures began to incur flood damage. Main floors were reviewed in light of surrounding ground elevation spot marks and checked for reasonableness. The source and direction of potential flood water were identified to determine the viability of flood waters reaching structures. All gullies, culverts, and natural levees were considered in the occurrence or absence of predicted flood damages.

Damage interviews were repeatedly used in each damage reach to obtain information on damages incurred by residents of residential homes, commercial firms and industrial establishments. Data including the frequency of historic flooding, the type of flooding, the height of floodwaters and the most severe dollar damages experienced, were often noted on the topographic mapping for easy reference. This information was critical for reach calibration. It was used as a guide for judging the reasonableness of expected annual damages per structure and various damages at stage figures. It also aided in the verification of potential seepage due to high river stages.

Modification and calibration of the hydrologic and hydraulic models generated several iterations of discharge, frequency and stage relationships. The altering of hydrologic and hydraulic input data for the expected annual damage program created the need to continually fine tune and re-examine specific economic decisions made during preliminary calibration work. Even a minor change in the lower end of the discharge-frequency relationships could affect damage thresholds and decision criteria established during calibration.

After implementation of the final hydrologic and hydraulic data available in 1983, attention was directed at specific damage reaches with significant amounts of flood damage. This was the final effort prior to documentation of the Stage 2 Report Passaic River Basin Study, June 1983.

Over 40 reaches were included in this level of evaluation. The reaches were investigated by in-house engineers and economists of the Passaic River Basin and Special Studies Branch. This interdisciplinary approach was deemed advantageous for four reasons.

a) The review was most comprehensive focusing on both the economic damageability of sites and the engineering variables affecting damageability.

b) The structural integrity and building construction elements were examined in light of damageability.

c) The hydrologic and hydraulic characteristics of the Basin (tidal, riverine, and backwater flow) were incorporated into decisions on damageability.

d) The economic parameters such as content and structure values, per capita income, reoccurring damage, and the economic vitality of the area were examined in light of calibration.

Reviewers of the 40 selected reaches recompiled all the base data for each reach. Complete listings of all structures in the reach were utilized for a complete scanning and verification of structure variables. Calibration work sheets were developed which allowed the systematic detailing of expected annual damage by structure for each structure category. The categories included residential, commercial, industrial and apartment components. At stage damage estimates were also detailed and scrutinized at various flood frequencies.

An extraordinary amount of effort was spent looking into the very detailed data which was collected, compiled and evaluated for the Passaic River Basin Study. Despite the scope of the study, encompassing approximately 214 damage reaches, the economic calibration and review were thorough and extensive. The repetitive nature of the review served to assure that any weakness in the information was supplemented with additional research, additional field work and additional improved data. Though repetitive in nature, the review as conducted over several years by teams of economists, engineers and cost estimators, brought insights and information to all iterations of the calibration process.

Standard evaluation rules were applied, such as the determination of expected annual damage per structure. Residential damages were reviewed in this light to judge the reasonableness of the results. Expected annual damage figures as a percent of total structure value in the floodplain were also calculated and utilized as an evaluation tool. New York District and Corps wide standards of acceptability were applied during the levels of review.

The economic model, as developed prior to the Stage 2 documentation, was considered final with respect to current without project conditions and stringent levels of accuracy. Only minor changes were anticipated prior to Stage 3 documentation. These changes would reflect any known structure additions, demolitions, and other existing development changes. An example of one of these changes, was the occurrence of a severe fire in the City of Passaic. Approximately 22 buildings were destroyed. The structure file was adjusted in Stage 3 to reflect that all reconstruction at the site would take place at an elevation at least equal to the 100 year water surface elevation. Another example of an appropriate structure file change was the deletion of structures bought out by FEMA after the devastating damages of the April 1984 flood.

An unanticipated change that was required for appropriate Stage 3 analysis, was the incorporation of the April 1984 flood event. As previously discussed, the April 1984 flood was the most severe flood to occur in the Basin in approximately forty-five years, and therefore, initiated two changes in the economic modeling. Prior to any economic model changes, Stage 2 EAD model residential damage figures showed accurate results when compared to Post April 1984 residential damage figures. Comparison indicated that Stage 2 EAD model figures were slightly higher (8%) than Post 1984 flood damage figures. The first change was in the use of revised hydrologic and hydraulic data. These engineering models were expanded to include the April 1984 flood in addition to updated hydrologic data reflecting seven recent years of continuing data collection. As a result of the supplemental data and the occurrence of a severe flood event there were some changes in the Basin's stage-frequency relationships. This updated information was utilized in the expected annual damage program and did change the original economic damage frequency relationships. Thresholds for damages were reviewed across damage reaches in addition to at stage damage totals. Damage figures on the average increased approximately 7% due to the upward shift in the basin discharge-frequency relationships.

The second change that took place resulted from calibration changes to the model, made by careful examination of an actual flood occurrence. To determine the potential need for these additional changes an evaluation of the expected annual damage model's predictability was conducted. Because of the occurrence of the very severe flood event, there existed the opportunity to verify the predictability of the economic model and its measure of hypothetical events. It was determined that the frequency of the April 1984 flood ranged from a 25 year event in the Lower Valley above Paterson, to a 50 year event in various areas along the Pompton River.

Flood stages and floodmarks collected in the field were recorded throughout the Basin. These stages were referenced to the expected annual damage model to define the corresponding damages at stage generated by the model. These dollar figures were then compared to documented damage figures obtained in the field. This type of cross-comparison was performed throughout the Basin. Table V-28 shows the results of this comparison. The above procedure was conducted exactly as detailed for the residential sector.

It was extremely difficult to perform pure comparisons between industrial and commercial damages generated by the expected annual damage model and damages recorded in the field. Approximately 900 industrial and commercial structures were flooded, therefore, it was not possible to perform a 100% field damage survey. As a result, actual industrial and commercial field damages collected during the post flood report were not total figures and could not be compared to total industrial and commercial damages generated by the EAD model. Industrial and commercial damages could be compared, however, on a structure specific basis. This was accomplished with very compatible results when field damages were compared to model figures. The structure specific stage-damage comparisons were conducted utilizing the trace option in the SID program.

Total industrial and commercial damages were estimated for the April 1984 flood. These estimates were compiled from several sources. Field data consisted of flood delineations, floodmarks, recorded discharges and damage surveys. These figures were all corroborated to provide the best information on the storm's damages to the non-residential sectors. The expected annual damage model also contributed information for specific stages and respective damages.

Overall the assessment of the EAD model's predictability was very positive. Because of the successful replication of an actual field occurrence, the existing conditions model was confidently accepted. Utilizing calibrated EAD model figures to predict April 1968 flood damages indicated insignificant differences between EAD figures and Post April 1968 flood damage figures, (see Table V-26). Not only has the model been extensively calibrated but it has functioned extremely well in predicting the flood damages due to a severe basin storm. The existing conditions model represents without plan conditions. It was therefore utilized in the evaluation of potential plans of protection and the determination of project benefits.

Aggregate Reach Areas

Expected Annual Damages

Stage damage relationships were developed as detailed previously from SID for use in the EAD program. Existing expected annual damages were developed from the EAD program described earlier.

A general description of the areas of interest to the Main Stem Passaic River including the aggregate Lower Passaic (01), Central Passaic (02), Upper Passaic (03), Pompton (60), and Lower Ramapo, Wanaque, Pequannock (66-68) damage areas is provided below. This is followed by a description of 10 selected reaches within these areas. These reaches were selected because they either were significant damage areas in terms of total EAD, or they were typical of a number of reaches for that portion of the mainstem. Table V-29 provides a summary of the Expected Annual Damage information. The Expected Annual Damage Tables V-30 through V-36 presented were adjusted to reflect municipal damages within the displayed damage categories.

Reaches 01 - Lower Passaic. The Passaic River Main Stem reaches, 010011 thru 010272, plus backwater areas on Molly Ann's Brook (400011 and 400012), backwater areas on the Peckman River (500011, 500012, 500014, and 500016) and backwater area on the Saddle River (010106, 010107, 010108, 010109, 010113, 010115, 010117, 010118, 010119, 300011 and 300012) are grouped together to form the Lower Passaic damage reaches. The area extends from Beatties Dam, downstream to the mouth of the Passaic River (see Figures V-9 thorugh V-16). The Lower Passaic reaches contain 6103 residential structures and 1881 commercial, utility and industrial establishments in the 500 year floodplain, see Table V-25. Commercial structures include retail shopping malls and extensive strip highway development. The industrial establishments in the Lower Passaic are primarily large complexes containing more than one structure per establishment. Damages in this area due to a 100 year flood event would be approximately $404 million while damages for a 500 year event would be approximately $1.2 billion, see Table V-26.

Major damage areas extend through the industrialized cities of Newark, Kearny, and Harrison near the mouth, Clifton, Passaic and Wallington downstream of Dundee Dam, Paterson in the vicinity of S.U.M. Dam, and Little Falls, West Paterson and Totowa below Beatties Dam. For further details on significant damage reaches see the discussion of selected damage reaches.

Reaches 02 - Central Passaic. The Passaic River Main Stem reaches, 020011 through 020230 plus backwater areas on the Preakness Brook (600013, 600015 and 600017) are grouped together to form the Central Passaic damage reaches. The area extends from above Beatties Dam, upstream to the U.S.G.S. Passaic River gage at Chatham Borough, (see Figures V-16 through V-24, V-29 through V-31 and V-35 through V-39). Central Passaic reaches contain 5683 residential structures and 1593 non-residential establishments in the 500 year floodplain, as displayed on Tables V-25. Non-residential establishments include retail commercial centers, large indoor shopping malls, industrial structures and complexes and utility structures. Damages in these reaches due to a 100 year flood event and a 500 year flood event are approximately $313 million and $906 million, respectively, (see Table V-26). Major damage centers exist in the municipalities of Wayne and Little Falls near the Willowbrook Mall Shopping Center, Fairfield and West Caldwell along Deepavaal Brook and along the lower Rockaway River in Parsippany-Troy Hills, East Hanover and Lake Hiawatha. Further details of significant damage reaches can be found in the discussion of selected reaches.

Reaches 03 - Upper Passaic. The Passaic River Main Stem reaches 030010 through 030110 are grouped together to form the Upper Passaic damage reaches. The area extends from upstream of the U.S.G.S. Passaic River gage at Chatham Borough to the Dead River confluence in Passaic Township (see Figures V-24 through V-28). As shown in Table V-25, the Upper Passaic damage reaches contain 1089 residential structures and 297 non-residential establishments and include commercial, industrial and utility structures. Damages in these reaches due to a 100 year flood event would be approximately $6 million while damages for a 500 year event would be approximately $16 million, (see Table V-26). Major damage reaches are located in the communities of New Providence Township, Berkeley Heights Township and in Passaic Township.

Reaches 60 - Pompton; Reaches 66 - Lower Ramapo; Reaches 67-Wanaque; Reaches 68 - Pequannock. Reaches along the Pompton, Lower Ramapo, Wanaque and Pequannock Rivers (see Figures V-16 and V-17, V-31 through V-34, V-41 and V-42) were analyzed with the main stem Passaic due to the interdependence of their flow. The number of residential structures and non-residential establishments in the 100 year floodplain and the 500 year floodplain in each of the tributary areas can be found on Table V-25. Damages for these areas for a 100 year flood event and a 500 year flood event are found on Table V-26. The Pompton River reaches contain critical damage areas. For a description of several significant damage areas see the discussion of selected damage reaches.

Selected Damage Reaches

Selected damage reaches Expected Annual Damages are displayed on Tables V-37 through V-46. Total expected annual damages figures exclude municipal damages.

As shown on Figure V-13, reach 010102 is located in the City of Passaic and is bordered by the lower Passaic River in the east and south and by Passaic Street in the north. There are over 100 residential structures and over 30 commercial and industrial establishments in the 500 year floodplain. Several of the industrial establishments incorporate more than one structure. Total expected annual damages in the reach are approximately $842,700, (see Table V-37). Damages incurred by a 100 year flood event would be approximately $21.3 million. These figures include municipal damages, whereas the figures presented on Table V-37 do not include municipal damages. Damages estimated for a 500 year flood event are over $59.5 million. Over 90% of these damages are incurred by commercial and industrial structures. Residential structures incur an average of $500 expected annual damages per structure. Flooding due to 500 year flood event would produce stages of 5 to 10 feet above the main floor levels.

Reach 010171 is located in the Town of Fair Lawn and is bordered on the south and west by the lower Passaic River and in the north by Fairlawn Avenue, (see Figure V-14). There are over 450 residential structures and several industrial and commercial establisments in the 500 year floodplain. The reach includes a public school and an athletic field. During the 1968 storm approximately 30 residential structures had damages to their cellars and grounds. During August and September of 1971 overflowing of the river caused flooding of grounds and basements along River Road. As displayed on Table V-38, total expected annual damages in the reach, including municipal damages, are approximately $445,800. Damages incurred by a 100 year flood event and a 500 year flood event would be approximately $6.9 million and $19.5 million, respectively. Approximately one third of all residential structures are located in the 50 year floodplain. Expected annual damages per residential structure would approximate $700. Flooding due to a 500 year flood event would produce possible stages of 7 to 9 feet of water at the main floor of residential structures.

Reach 010203 is located in the City of Paterson bordered by the lower Passaic River on the east, Goffle Brook on the North and Christopher Columbus Drive on the southwest (see Figure V-15). There are approximately 400 residential structures, 5 apartment complexes and 90 commercial and industrial establishments within the 500 year floodplain in this reach. Flooding during the May 1968 flood caused large amounts of damage to the residential, commercial and industrial areas located in this reach on the left bank of the river. Two bridges sustained damage to their abutments and had to be closed for a week. As displayed on Table V-39 total expected annual damages in this reach are estimated at $1.7 million. Damages incurred during a 100 year flood event would be in excess of $23.3 million. Damages due to a 500 year flood would approximate $59.4 million. Approximately 63% of these damages would be incurred by non-residential structures. Expected annual damages per residential structure are approximately $1,300.

Reach 020021, as shown on Figures V-16 and V-17, is located in the municipality of Wayne and lies within a major bend of the Passaic River. Historically, Wayne has experienced significant flood damage due to the overflowing of the Passaic River. The reach contains approximately 129 residential structures and 29 non-residential strutures within the 10 year floodplain. Residential structures most impacted by flooding are located along Riverlawn Drive only, which runs parallel to the Passaic River. The most significant non-residential establishment is the Willowbrook Shopping Mall, which with its total areas and parking lots comprises a majority of the reach. The Willowbrook Shopping Mall is one of the largest retail centers in the State of New Jersey. Currently there are over 175 establishments in the mall which include 3 major department stores, many specialty shops and restaurants. Total expected annual damage in the reach is approximately $6.0 million (see Table V-40). Total damages for the 100 year flood event and the 500 year flood event are $56.1 million and $121.9 million, respectively. Commercial damages incurred account for approximately 78% of the total expected annual damages.

Reach 020052 is located in the Borough of Fairfield bordered on the southwest by the Passaic River, on the north by Interstate Route 80 and on the southeast by Deepavaal Brook, see Figures V-17 through V-19 and V-35. The reach contains over 300 commercial and industrial structures which are flooded from the Passaic River and Deepavaal Brook. Industrial complexes along Gardener Road and Commerce Road have experienced frequent flooding of roadways and parking lots.

The reach contains over 1300 residential structures. Fairfield, which spans several reaches of the Central Passaic, has experienced significant historical flooding. The May 1968 flood caused over $1.6 million in damages (1968 dollars) to residential and commercial structures. During the May storm in 1968, about 250 dwellings were damaged by flooding. Many homes had water up to the first floor level where there was between 1 and 7 feet of water. About 35 commercial establishments were damaged when the Passaic River overflowed. Roads in some areas were impassable and an estimated 150 people were evacuated from their homes. Expected annual damages per residential structure are approximately $1,300 in reach 020052. Damages that would be incurred at the 100 year flood event are approximately $115.4 million. Over 70% of these damages are incurred by industrial and commercial establishments. Damages experienced at a 500 year flood event would approximate over $382.8 million. Total expected annual damages are $7.6 million for reach 020052. Expected annual damage figures are displayed on Table V-41.

Reach 020102 is located in Parsippany-Troy Hills and Montville Township, southeast of Lake Hiawatha, (see Figures V-29 and V-30). The reach is bordered by the Rockaway River on the east, Shore Road on the north and a drive-in movie area on the south. The reach is flooded by the Rockaway River due to backwater stages on the Central Passaic Main Stem. During the May 1968 flood the local police department evacuated 30 homes along River Drive, Rockaway Avenue and Lakeshore Drive. Many parked cars were damaged when streets were inundated. Sewer backup in poorly drained areas caused extensive damages in many residential structures. Approximately 150 homes are located within the 500 year floodplain. Expected annual damages are estimated at approximately $271,000 (see Table V-42). All of these damages are residential in nature. Expected annual damages per residential structure in the reach are estimated at $1,600,. Total damages for the 100 year event approximate $1.7 million. Damages incurred during a 500 year flood event are over $4.2 million. Water would reach stages of 1' to 7' above the main floor during a flood of this magnitude.

Reach 030050 is located in Berkeley Heights Township and is bordered by the Upper Passaic River on the northwest and located above the Berkeley Heights - Warren Township boundary on the southwest. Designated reach delineation for reach 030050 is displayed on Figure V-26. Developments in the Upper Passaic most susceptible to flooding from frequent storms are concentrated in the Townships of New Providence, Berkeley Heights and Passaic Township. The flood event of August 1971 inundated large areas to depths of up to 4 feet. There are approximately 252 residential structures in the 500 year floodplain and several commercial structures. Expected annual damages, 500 year and 100 year flood damages are displayed on Table V-43. Total expected annual damages in the reach are estimated at $69,800. Damages due to a 100 year flood event would be approximately $677,200. Over 99% of the damages is incurred by residential structures. Flooding due to a 500 year flood event would produce damages estimated at $1.5 million.

Reach 600025 is located on the left bank of the Pompton River in the Township of Wayne between the Erie-Lackawanna Railroad and Packanack Lake. The southern border extends along Packanaock Brook. Reach delineations are shown on Figures V-31 and V-32. Within the 500 year floodplain, there are approximately 129 residential structures, 45 commercial structures, 3 industrial structures and 1 utility building. Damages during a 10 year, 100 year and 500 year flood event would be over 2.6 million, 26.4 million and 42.1 million, respectively. Total expected annual damages would be approximately 1.5 million (see Table V-44). Damages for this reach will start at the 5 year flood event. Water stages due to a 25 year flood event would reach elevations of 2 feet to 3 feet above ground level and approximately 6 feet above main floor level for a 500 year event. Expected annual damages per residential structure are approximately $2,900. Almost 61% of total expected annual damages is incurred by commercial structures. Commercial structures in this reach which concentrated in the vicinity of the intersection of the Newark and Pompton turnpike and Routes 23 and 202, include businesses such as Bremen Mazda (new cars), Brickete Co. (landscaping), GBC Sales and Services (binding). Commercial expected annual damages would approximate $887,400.

Reach 600034, (see Figure V-32 and V-33), is located on the right bank of the Pompton River in the Borough of Lincoln Park and the Township of Pequannock. This reach is bounded by Ackerson and Franklin Avenues to the north, Beaver Dam Brook to the south, West Ditch to the west and the Pompton River to the east. The reach contains 1170 residential and 84 commercial structures within the 500 year floodplain. A 10 year flood would cause over $7.3 million in damages while damages for a 100 year flood would be approximately $36.6 million. Damages for a 500 year flood would approximate $87.3 million. Over 75% of the damages incurred at each of the noted flood events is due to residential structures. Total expected annual damages for reach 600034 are approximately $2.6 million, (see Table V-45). Expected annual damages per residential structure are approximately $1,700.

Reach 600042 is located on the right bank of the Pompton River in the Borough of Lincoln Park and the Township of Pequannock. As shown on Figure V-32 and V-33, this reach is bounded on the north by Nicholas Road and Tillet and Alexander Avenues, on the south by Ackerson and Franklin Avenue, on the west by the West Ditch, and on the east by the Pompton River. There are 1,404 residential and 128 commercial structures within the 500 year floodplain. As displayed on Table V-46, damages in this reach would be approximately $13.7 million for a 10 year flood, $48.3 million for a 100 year flood, and $109.5 million for a 500 year flood. Total expected annual damages for reach 600042 are approximately $4 million. Residential structures average approximately $1,700 in expected annual damages.

SECTION 5. SOCIAL AND ECONOMIC FUTURE WITHOUT PROJECT CONDITIONS

SOCIO-ECONOMIC FUTURE CHARACTERISTICS

The following portrays the character of the Passaic River Basin over the next several decades. Based upon the projections of selected key indicators, such as total population, population density, and employment, the character of the Basin's people, economy and housing supply is depicted for the period 1990-2040.

Socio-Economic Future Characteristics: Methodology. Initially, existing projections used by regional, state and county agencies were collected and reviewed. For the most part, population and employment projections for the ten counties in the Passaic River Basin were available at five year intervals, up to the year 2000, from the following sources: county planning and economic development boards, the Regional Planning Association, the Port Authority of New York and New Jersey, the New Jersey Department of Labor and Industry, and the New York State Economic Development Board. The factors that influenced the choice of methodologies and the resulting projections vary greatly. Predetermined ideas on regional growth affect such factors as the variables chosen for consideration and the weight given to past trends in establishing projections.

The variation is particularly noticeable for projections done by county agencies. Often the line between a projection, a "target" figure and a ceiling is obscured. Consequently, the existing population and employment projections differ considerably from one agency to another.

The existing projections of population that are available for the ten counties that comprise the Passaic River Basin Study area have been examined with regard to the basic methodologies used to develop them.

Population projections are usually developed using either a component or non-component model. Models which consider the separate effects of each determinant (i.e., births, deaths, and migration) of population change are component models. Models which use the net effects of the three components are non-component models. Each type of model has specific advantages and disadvantages.

Non-component models may be based on historical patterns of population growth or relate net population growth to external trends (i.e., voter registration). One specific non-component method is trend extrapolation which simply projects population based on past population trends. This approach will usually yield accurate short-term projections. However, long-term projections must be questioned if changes have occurred within a region.

Component models are based on the analysis of the individual components associated with population growth. The components are fertility, mortality and migration. There are two types of component models: 1) Cohort-Survival Models which analyze the first two components; and 2) Cohort-Component Models which analyze all three.

In conclusion, it is believed that a cohort-component approach, where migration is considered linked to economic factors, would yield the most accurate long-term projection of population.

A review was made of specific population projections developed by various agencies and sources. Each projection series is reviewed based on the following:

o Objective: Specific purpose for which the projection series was developed.

o Assumptions: Major assumptions which were made to develop the projection.

o Methodology: Analytical procedure and base data used to develop the projections.

o Results: Time period used as a base for extrapolation and the interval over which the series project into the future.

The population projections evaluated were:

1. Linear Regression Projections (1990-2000)

2. 1965 to 1970 Crude Component Projections (1990-2000)

3. 1970 to 1977 Crude Component Projections (1990-2000)

4. Demographic-Economic Linked Projections (ODEA) (1990-2000)

5. Northeast New Jersey Water Quality Management Plan (1980-2000)

6. Office of Business Economics and Economic Research Service (OBERS) 1977 (1980-2000)

7. New Jersey Statewide Water Supply Master Plan

   a. Slow Growth (1980-2000)
   b. Current Trends (1980-2000)
   c. Long Term Trends (1980-2000)
   d. Adjusted Averages (1980-2000)

8. New York State Economic Development Board (1980-2000).

It was necessary to evaluate employment projections as well. A review was also made of the existing employment projections for the Passaic River Basin study area. The employment projections have been examined with regard to the basic methodologies and assumptions used to develop them. They have also been assessed in terms of the results produced in order to assist in identifying those projections that can be of greatest utility in conducting impact analyses of proposed water resource projects.

Employment projection methodologies are usually divided into sectoral or nonsectoral methods. This is similar to the component and non-component models used for population projections in that the sectoral models are concerned with specific factors (i.e., demand for export goods, investment activities) which affect employment while nonsectoral methods examine the net effect of employment change rather than specific factors. The level of disaggregation associated with a region of this size effectively precluded the use of sectoral modeling. The nonsectoral models considered are outlined below.

Market share models are based on the premise that growth within a sub-region (i.e., county) is based upon growth of the larger region (i.e., state) in which it is located. Projections of employment for the larger region can be distributed to the smaller region using several different methods. These are:

- <u>Constant Share</u>: This approach assumes that employment by county will grow at the same rate as employment in the larger region. In other words, each county's current share of regional employment will remain constant.

- o <u>Population/Employment</u>: This approach is simply a modification of the constant share method in that population growth within the sub-region is used to adjust the current distribution of regional employment.

- o <u>Shift-Share</u>: This methodology utilizes the constant share approach of apportioning regional employment to sub-regions but adjusts the resulting distribution based on an analysis of historical trends which reflect differences between sub-regional (i.e., county) and regional (i.e., state) employment changes.

Trend extrapolation simply extrapolates selected trends in employment to derive future estimates. One common approach is to perform a regression analysis of employment over time. The obvious disadvantage of this approach is that future changes within the region may not mirror past trends.

In conclusion, Shift-Share analysis yields the most reliable estimates of future employment.

The employment projections evaluated included:

1. New Jersey Department of Labor and Industry 1978 Employment Projections (1980-2000).

2. Statewide Water Supply Master Plan (OBERS Shift-Share 1980-2020).

3. OBERS 1977 (1980-2020).

Based upon this review, the selected population and employment projections for New Jersey for this study were obtained from population projections made by the New Jersey Department of Labor and Industry, Office of Demographic and Economic Analysis (ODEA), and employment projections from the New Jersey Water Supply Master Plan. (See Tables V-47 and V-48.)

They were selected for several reasons:

1. They reflect more detailed local trends.

2. They are consistent with projections being made for other infrastructure development.

3. They tend to be more conservative and more reflective of the local variations of national trends than the OBERS themselves.

4. They are consistent with OBERS control totals developed for the State of New Jersey.

5. They reflect the public policy decision of the State of New Jersey regarding infrastructure development.

The ODEA population projections assume constant fertility rates, survival and migration rates based on employment projections for the population under 65 and past trends for the elderly population. Population changes reflect natural increases (births and deaths) and migration for each cohort. The series present projections for five-year intervals for the period 1980-2000.

The employment projections in the New Jersey Water Supply Master Plan rest on the assumption that sub-regional shares of regional employment will continue into the future. These projections use the 1972 OBERS Series E national employment projections as a base, with the 1970 base year adjusted to reflect actual economic activity in 1975. State projections were computed using a shift-share method while county projections were computed in relation to the state. The model was adjusted to limit growth or decline in each industrial sector. The projections are presented in 10-year intervals for the period 1980 to 2020 for both states and counties by industrial sector.

The population projections for New York State were obtained from the New York State Economic Development Board. The baseline figures for the projections were derived from the 1980 Census. The projections relied upon a cohort-component model which incrementally projects population for five-year intervals based upon specific rates for age-sex fertility, mortality and migration. The projections are presented in five-year intervals for the years 1980-2000.

New York State employment projections were developed via Passaic River Study Group's extrapolation based on historical trends. Population and employment projections were extrapolated to obtain data for additional decennial years up to the year 2040.

Per capita income projections for areas in the Passaic River Basin were obtained from 1980 OBERS projections for standard metropolitan statistical areas (SMSA). Geographic divisions that overlap the Basin are: 1) New York, New York-New Jersey SMSA, which includes Bergen County, New Jersey, and Orange and Rockland Counties, New York; 2) the Newark, New Jersey SMSA, which covers Essex, Morris, Somerset and Union Counties; 3) the

Paterson-Clifton-Passaic SMSA, which includes Passaic County, New Jersey; and 4) the Jersey City, New Jersey SMSA, which covers Hudson County, New Jersey. Remaining small portions of the Basin in Sussex County, New Jersey are similar to the chosen representative area and the projections are, therefore, applicable.

Base per capita income was determined from 1980 data. Projections for the years 1985, 1990, 2000 and 2030 were calculated for no-change-in-share, low-change-in-share and moderate-change-in-share analyses. All of the SMSA's reviewed showed comparative increases in per capita income from 1980 to 1990. The Jersey City, Paterson-Clifton-Passaic, and New York, New York - New Jersey SMSA were slightly higher with projected increases of 15%, 5% and 3%, respectively, while the New York-New Jersey SMSA projected a 1% decrease in per capita income. Figures for the year 2030 indicate that the Jersey City, New Jersey SMSA will have the largest increase in per capita income from 1990 to 2030, an increase of 110%. The remaining areas are as follows: Newark, New Jersey (109%), Paterson-Clifton-Passaic, New Jersey (108%), and New York, New York-New Jersey (110%), (Table V-49).

Three methodologies were used to project other characteristics such as population density, employment rates, number of dwelling units, median number of school years completed, employment and municipal debt for the Passaic River Basin for the years 1990-2040. The methodologies were chosen so that a wide range of variables could be projected, allowing for differences in the baseline information supporting the projections. In the case of significant data gaps, a relatively simple projection methodology related to population was used. When more complete data was available, more refined approaches, such as multiple regression, were utilized. In order to yield the most reliable projections, the methodologies sought to balance precision and data limitations.

The first and simplest of the methodologies was an extrapolation based upon the direct share of the population. Although the advantage of this method is that it keeps projections within acceptable limits, its disadvantage is that it is totally linked to population and does not allow for variations over time.

The second methodology is a multiple regression solution using 1950, 1960, 1970 and 1980 county data. The various data items, or dependent variables, were projected based upon the independent, or predictor variables - population, density and employment - for each county. For the second methodology, county projections were disaggregated to municipal levels, using the 1980 share of county totals (the ratio of 1980 municipal/ 1980 county data). The advantage of this method is its simplicity and applicability to situations where the data is limited, however, it does not allow for intra-county variations over time.

The third methodology is a variation of the second. County data were projected in the same manner as in the second approach, but the method of disaggregating the county data to municipal levels differed. The ratio of municipal data to county data for 1950, 1960, 1970, and 1980 were statistically regressed for future time periods to yield changing shares of county data projections. These ratios were then used to disaggregate county data to municipal levels to obtain the municipal projections. This method, which is only applicable when the ratio of municipal data to county data falls within acceptable limits, has the distinct advantage of accounting for intra-county variations.

Each methodology was used for specific variables. The results were checked for consistency among variables and with the variables previously described. The first method was used to project such characteristics as the total number of economic establishments, where 1950, 1960, 1970, and 1980 data were unavailable. It was also used where the variable was statistically unrelated to the predictor variables. The second method was used where county data were available and the relation between 1950, 1960, 1970, and 1980 municipal data and the county data was unmeasurable, such as for median family income. It was also used where there was insufficient municipal data to use the last method. Method three was used where county data was available and the limits of the ratio of municipal data to county data were reasonable.

Socio-Economic Future Characteristics: Results. Due to the methodologies used, there are limitations in presenting certain variables at the individual community level. This is especially true whenever projections made at the county level were disaggregated to municipal levels using the 1980 share of county totals. Because such a methodology does not allow for intra-county variations over time, in many cases it is more appropriate to present findings at the county-wide level.

The most important conclusion that can be drawn from the projections of future conditions in the Passaic River Basin is that the future will essentially be an extension of the last three decades. With some variations, the major trends that have been formative since the end of World War II and were first measured in 1950 are expected to continue.

As in the past, the single most important indicator of the changes that can be expected in the Basin over the coming decades is total population. Between 1950 and 1980, the population of the Passaic River Basin grew from 1.78 million to 2.5 million people, a gain of slightly over six hundred thousand people in just three decades and equal to an annual growth rate of 1.1%. Between 1980 and the year 2040, the Basin is expected to add over seven hundred thousand people, but this time the augmentation will take 60 years rather than 30 years. The rapid deceleration in population growth over the next six decades was heralded in the 1970's, where the trend shows slower growth (13,000 people) over the decade.

To a large degree, the central conclusion that the future of the Basin will be a continuation of the previous thirty years is a result of the projected scale of change. By the year 2000, nearly 2.8 million people are expected to reside in the Passaic River Basin. By 2040, the Basin's population will reach approximately 3.2 million. The growth of over seven hundred thousand people between 1980 and 2040 translates into an annual growth rate of over 0.5%, only one-half of the annual rate that was sustained in the preceding thirty years. Not only will net growth slow down enormously, but the combination of large and concentrated net growths in people and jobs and the decline of the older centers which produced massive changes during the 1950's and 1960's will abate, and in some cases be reversed, as the older centers regain some of their strength. Population declines in the cities of Newark and East Orange, for example, are expected to reverse themselves by the year 2000.

The projected striking deceleration in the Basin's rate of population growth after 1980, to a point below that of natural increase, will be the product of several factors. The most important will be the declining rate of economic growth, indicated by a slowdown in the rate at which new jobs will be added to the Basin's employmnent base, compared to the preceding 30 years. Another restraint on population growth will be the continued high cost of new housing and the decline in the construction of rental housing in response to the rising cost of home sites, high interest rates and market factors.

Between 1980 and 2040, population growth in the Basin will occur in the same counties that experienced high rates of growth in the preceding three decades. Thus, the older more populous and built-up counties that are all or partly in the Basin - Union, Essex, Hudson and the central and southern portions of Bergen will either remain fairly stable, or grow moderately by between ten and twenty percent. On the other hand, the less developed counties that exhibited high growth rates in the

1950's - 1960's, such as Morris, Somerset and Sussex in New Jersey and Orange in New York, will continue their strong growth, increasing by at least two-thirds in population, and in the case of the last three counties, by over 100% through the year 2040.

New people will settle towards the margins of the Basin on land accessible from the regional highway network and near the new jobs that will have been created in these areas. The Basin's older central cities and suburbs, many of which lost population between 1950 and 1980, will either stabilize, as in the case of Newark and East Orange, or gain slightly by the year 2000, and record modest increases in the following four decades.

Population density in the Basin measured by the number of people per square mile will, of course, rise in direct proportion to the changes in total population, with both indicators rising by about 33% in the sixty years between 1980 and 2040. The overall density in the Basin will grow from 4,000 persons per square mile in 1980 to approximately 4,202 in the year 2000 and to over 5,300 in 2040. Changes in density will directly mirror changes in the distribution of the population. Population density in the older, more built-up counties - Union, Essex, Hudson and the southern and central portions of Bergen County - will either stabilize, as in the case of Union and Essex County, or grow modestly. For example, the density in Essex County, the only county in the Basin that is projected to lose population between 1980 and 2040, shrinking by 3%, will decline by a similar proportion. Hudson and Bergen Counties will sustain relatively modest increases in density over the six decades, about 12% and 23%, respectively.

On the other hand, the largest increases in density will be sustained in the same counties that experienced major population growth between 1950 and 1980 and where there are large supplies of vacant land. Since the older counties of Essex, Hudson and lower Bergen have already developed at densities above the 1980 mean for the entire Basin (4,202 persons per square mile), growth will occur primarily in other counties with lower densities and developable land within the orbit of the recently expanded highway network, such as in Morris, Somerset, Passaic and Rockland Counties.

The densities at which new housing is built may be higher than the densities that prevailed in the 1950's and 1960's. As a result of rapidly rising land and construction costs and recent state court decisions that have required communities to increase densities in some residential zones, much of the new single-family housing will be on smaller sites and take the form of townhouses.

A useful indication of the future character of the Passaic River Basin is the types of communities that will be found within it. Each of the communities within the Basin was grouped according to the following density classifications developed by the Regional Plan Association:

Rural - less than 150 persons per square mile
Suburban - 150 to 2,500 persons per square mile
Suburban/Urban - 2,500 to 10,000 persons per square mile
Urban - more than 10,000 persons per square mile

Based on a distinction of communities by density, the Basin should remain predominantly 'suburban' and 'suburban-urban' in character through the year 2000. As in 1980, approximately one-half of all communities will retain a 'suburban' character. As towns in northwestern Bergen and Morris Counties continue to develop, the number of 'suburban-urban' municipalities is expected to increase slightly by the year 2000, accounting for some 40% of all communities. As in 1980, the number of 'urban' communities will remain unchanged, accounting for about 10% of all the Basin's communities in the year 2000.

As the population continues its outward expansion, the number of 'suburban-urban' and 'urban' communities will increase at the expense of 'rural' and 'suburban' municipalities to the point where approximately 45% of all communities will be 'suburban-urban' in character by 2040. Communities joining the urban ranks by 2040 will include Morristown, Belleville, Harrison, Maywood, Hackensack, Hasbrouck Heights and Elmwood Park. For the most part, communities whose densities are expected to surpass 2,500 persons per square mile sometime between 2000 and 2040 are concentrated in Rockland and Orange Counties. By the year 2040, there will be no more 'rural' communities in the Basin.

Another important indicator of the future status of the Basin is the anticipated number of jobs, especially the ratio of jobs to total population. In 1980, about 60% of the population in the Basin was employed. Reflecting the anticipated increase in the labor participation rate over time, particularly among women, this percentage is projected to decrease to about 44% in the year 2000 and then to climb slightly, reaching 48% in the year 2040.

The projected share of the residents who are employed varies considerably by county and its relative maturity, as roughly revealed for example, by the median age of its population. Thus, in built-up and established Essex County, with its mature population, a median age in 1980 of 36.6 years, 46% of the residents was projected to be employed in 1980; by 2040, over

50% of the county population will be employed. At the other extreme, in Rockland (a projected median age of 27.6 years in 1980), only about 29% of the resident population was expected to be working in 1980, and by 2040, the employment participation ratio among communities in the County will remain in the 30% range.

In both 1960 and 1970, about three percent of the Basin's labor force was unemployed, whereas in 1980 4.8% was unemployed. Although this rate grew during the 1970's, it is projected to fall back to about three percent over the long term. Through 2040, the highest unemployment rates, around seven percent, will occur in the older cities with weaker economies, such as Newark, Paterson and Passaic, continuing the experience of the preceding decades. Localities that experienced strong gains in population and economic activity during the 1950's and 1960's, such as Morris and Somerset Counties, are expected to have relatively low rates of unemployment. As noted, even though the total population from which the labor force is drawn will be expanding at a much slower rate, the share of the resident population that is employed will grow between 1980 and 2040, meaning that a relatively larger proportion of people living in the Basin will be of working age.

Reflecting the fact that the Basin will be absorbing new households at a much slower rate in the future than it did between 1950 and 1970, the average number of people per housing unit will not change measurably. In 1980, the average number of people per housing unit among communities in the Basin was about 3.2. Responding to slight demographic shifts, the figure is projected to rise to approximately 3.3 persons by 1980 and stabilize, with some slight fluctuations, by the year 2040. Average household size in 2040 will range from a low of 2.8 persons within Hudson County communities to a high of about 3.5 persons within the developing counties of Morris, Somerset, Sussex, Rockland and Orange.

Between 1970 and 2040, the number of dwelling units will remain fairly stable or expand moderately in the older and more populous counties in the Basin, such as Hudson, Essex and Union and the central and southern sections of Bergen County, and expand at a high rate in those burgeoning counties mentioned above that are projected to add large numbers of new households.

The years between 1950 and 1980 saw a relative decline in the share of single-family structures and an increase in multi-dwellings. As buildable land becomes more expensive, housing costs climb and commuting becomes more costly, this trend can be expected to continue. Higher density single-family housing on small lots, clusters of single-family housing, townhouses and apartment units will be the common housing types in the older suburbs and those that grew quickly in the 1950's and 1960's. Single-family housing on larger lots will be confined mainly to the newer suburban localities in Somerset and Sussex Counties in New Jersey and Orange and Rockland Counties in New York.

By 1990, the median years of school completed for the average floodplain community is projected to increase slightly to 12.3 years from the 1970 figure of 12.1 years. The central cities within the floodplain, including Paterson, Prospect Park, Passaic and Newark, characterized by aging populations and few new development opportunities, will continue recording the lowest median years of schooling in 1990 (under 10 years), registering slight declines relative to 1970. Meanwhile, youthful, but affluent communities such as Mountain Lakes, Chatham Township, Morris Township, Chatham Borough, Kinnelon, Ramapo and Florham Park, all of which will experience significant population gains between 1970 and 1990, are expected to be the leaders among floodplain communities in median years of schooling in 1990 (over 14 years).

Only very slight changes in the median years of school completed are projected for the decennial years after 1990, with the average rising to 12.4 in the year 2000 and 12.8 by 2040. The same communities that are expected to register the lowest and highest median years of schooling in 1990 will retain these positions throughout the projection period. The largest percentage increases in median years of schooling will occur in rapidly developing communities on the periphery of the Basin in Rockland, Somerset and Morris Counties.

All derived projections of local fiscal characteristics are based on total population. In the absence of suitable variables for projecting individual characteristics, total population was adopted as the most reliable single predictable variable for all these characteristics.

Projections for municipal debt are based on available data for 78 of 81 municipalities, representing over 93% of the total population in floodplain communities in 1979. For the floodplain communities as a whole, gross municipal debt will total more than $625 million in 1990 (projections are in 1979 dollars). In the average community, the municipal debt will be over $8 million. The city of Newark will report the greatest debt, approximately $70 million, followed by Paterson, $34 million and Wayne, $25 million. Less populous, residential communities such as East Newark, Victory Gardens, Hawthorne and Boonton Township will have the smallest municipal debts, under $652,000 by 1990.

By 2040, the municipal debt within the floodplain communities is expected to rise to over $740 million or about 18.5% over the 1990 figure. Municipal debt in the mean community will increase to nearly $9.5 million by 2040. While the communities with the largest municipal debt will remain the same as in 1990, their rate of increase will be significantly less relative to most other floodplain communities with the largest percentage increases (50% or more) occurring in the rapidly growing municipalities of Rockland, Somerset and Morris Counties.

FUTURE LAND USE IN THE PASSAIC RIVER BASIN

Forecasting future land use in the Passaic River Basin is an important element of the planning process. The determination of possible development on currently vacant land is necessary for the assessment of future potential flood damage. The type of development, whether it be residential, industrial, commercial or the expansion of parkland, has impact on the level of flood protection required in the study area.

The impact of development on future flooding in turn affects the design considerations of possible projects, costs and planned levels of protection. Future land use is an essential factor in the calculation of future hydraulic and hydrologic data and its significance is readily apparent in the analysis of future project site conditions, both with and without project implementation.

Future Land Use: Methodology. In assessing the socio-economic variables which are determinants of future land use, several variables were considered. Factors such as public sewage systems, public water supply, existing highway mileage, the number and frequency of highway interchanges and governmental regulations affect the attractiveness of future land in both positive and negative directions. However, the results of a study of these variables indicated a lack of significant historical correlation between the previously stated variables and land use.

The existing literature on land use describes the many motives behind land development. It concludes that the rate of land development is related to the favorable treatment of developers by Federal and State governments and the potential income from increases in the value of land, taken as capital gains. This action on the part of governments stimulates land speculation and dispersed land development.

This factor, additionally, is related to population growth, for as people increasingly compete for given quantities of land, it is economically advantageous for new development to occur. This is complemented by the widely held opinion that there exists a preference to live in rural areas, yet adjacent to urban areas. As a site becomes more urbanized, there is a tendency for people to expand land use outward.

In addition to further residential development, population increases and in turn employment parameters facilitate industrial and commercial development. As municipalities grow in population, it is common for local government to compete for commercial development and clean industry. Because municipalities rely on property taxation to finance local public services, future land development has favorable fiscal impacts.

Population and employment growth are so intrinsic to expansive land use that they are often unmentioned in expansive land use location theories. Land use theories answer the "where" question of land development, and bypass the initial question of "why" further development will occur. Natural population and employment growth are the underlying motivators of land expansion.

Based on the available literature which addresses the causality of future land use and the unique dynamics of the Passaic River Basin in this projection of land use, the two fundamental socioeconomic variables, population and employment, were used to project future land use.

Beginning with the premise that future residential development is directly related to future population, existing population per residential acre ratios were calculated to establish the status quo. Specifically, this ratio or conversion factor (CF) was the 1978 population in a municipality divided by the amount of residentially developed acreage in 1978 in that municipality. At the time this land use projection was formulated, 1978 was the most recent year for which complete population data could be collected.

The next steps involved in the projection of future land use, utilized the population growth projected for the Basin municipalities. Using the projected populations, a determination of the residential acres needed to accommodate the population growth, using the established 1978 residential densities, was made as follows:

1. Population projections for the years 1990, 2000, 2020 and 2040 were utilized to calculate the incremental changes in each municipality's population for the years 1978 to 1990; 1990 to 2000; 2000 to 2020; 2020 to 2040; and 1978 to 2040.

2. To calculate the residential acres needed in any year, in each municipality, to accommodate projected population growth for that year, the following equation was used:

$$\frac{\text{population in year X} - \text{population in 1978}}{\text{1978 Res. density}} = \text{Residential acres needed in Year X}$$

3. To account for anticipated redevelopment of existing land to higher intensity utilization in each municipality, the calculated residential acres needed in year X were reduced by 5%. A factor of 5% was used because of its general acceptability. It was based on a figure determined by Louis Berger and Associates in their land use study and was representative of the trend in land redevelopment.

Industrial, commercial and other land use (other land use being defined as urban uses, i.e., public and institutional uses and developed open space; i.e., parks, cemeteries, athletic fields and recreational facilities) were projected based on the growth of the respective employment in a municipality. Working from the premise that future industrial development is directly related to future industrial employment, existing industrial employment per industrial acre ratios was calculated to quantify the existing conditions. This premise and the following procedures were identical for industrial, commercial and other land use categories. To avoid redundancy, only future industrial acres will be discussed, however, the steps were applied in the same manner to establish projected future commercial and future other acres needed.

The publication "1978 County Employment Trends in New Jersey" was used as the source of employment information in the municipality. Once employment in the municipality was determined, however, the amount of industrial employment had to be extracted.

County employment data for 1978 was available from the same source and by Standard Industrial Code (SIC), therefore industrial employment data was available at the county level. A decision was made that types of employment were distributed equally among communities within any given county. County ratios were applied to the municipalities within the respective county. The SIC Codes were grouped as follows to form the three employment categories needed for this analysis:

2 Digit SIC Code	Employment Category
Manufacturing Industries................	Industrial
Wholesale Trade........................	Commercial
Retail Trade	
Small Services and Amusements	
Financial, Insurance and Real Estate	
Transportation.........................	Other
Communication & Utilities	
Construction Contract	
Mining, Agriculture,	
Government and other	

The previously mentioned equations were also used to calculate the conversion factors for commercial and other use acres, based on the above categories, for every municipality in the Basin, with a small number of exceptions. Difficulties arose in situations, where for example, a municipality had no industrial acreage according to the 1978 data accessed from the data bank, however, industrial employment was present in the municipality. In this case, absence of information in the data bank was explained by the rounding of land use categories that took place in order to form 10.33 acre blocks of land use within the grid cell data bank system. For these municipalities, an alternate method of establishing a conversion factor was used. County conversion factors previously developed by Louis Berger and Associates for the study area were utilized.

The next steps in the projection of future land use were to utilize the employment growth projected within the Basin's municipalities. Using the projected industrial employment figures, a determination of the industrial acres needed to accommodate the employment growth, using the established 1978 industrial densities, was made as follows:

1. Industrial employment projections for the year 1990, 2000, 2020, and 2040 were utilized to calculate the incremental changes in each municipality's employment for the years 1978 to 1990; 1990 to 2000; 2000 to 2020; 2020 to 2040, and 1978 to 2040.

2. To calculate the industrial acres needed in the year X in each municipality, to accommodate projected employment growth for that year, the following equation was used:

$$\frac{\text{Employment in Year X} - \text{Employment in 1978}}{\text{1978 Industrial Density}} = \text{Industrial acres needed in year X}$$

This equation was also used to calculate the acres needed in year X for both commercial and other land use categories with the appropriate variables.

3. To account for varying degrees of redevelopment in a municipality, the calculated industrial acres needed in Year X were also reduced by 5% as in the residential methodology.

Municipal employment projections were disaggregated from county employment projections developed by the New Jersey Water Supply Master Plan. Before the disaggregation was performed, however, the appropriate codes were grouped to form industrial, commercial and other employment figures since the county employment projections were available by SIC Code. County data were then disaggregated to a municipal level based on the ratio of the municipalities' 1978 employment to the 1978 county employment.

Comparison of Acres Available for Development With Future Land Use Acres Needed. After the acres needed in year X were calculated for residential, industrial, commercial and other land use categories for each municipality, the amount of acres available for future development had to be assessed. Acres available for development included the open space undeveloped land, barren land, woodland and cropland categories of the data bank. The categories in "most likely for development order" are: 1. undeveloped open space; 2. barren land; 3. woodland, and 4. cropland. Of the total amount of available acres in each municipality, only 90% was considered for future development. The 10% reduction was incorporated to insure a retention of some open land in each municipality, if the municipality was not already completely developed. A worksheet then was prepared which included the amount of available acres and all the acreage required to accommodate future population and employment growth.

Because of the level and intensity of development already present in the Passaic River Basin, various problems arose in the attempt to project future development based on future population and employment figures. Based on these projections, the amount of acreage required for a given community at times surpassed the amount of available land in that municipality. The situations which existed among municipalities in the Basin and the adjustments utilized are as follows:

1. The land needed, using the 1978 conversion factors was available. Therefore, no adjustment was necessary.

2. No additional land was available in the municipality, therefore, the increase in density due to increases in population and employment figures was calculated.

3. There was some land available in the municipality but not enough to accommodate the acres needed based on 1978 density. Therefore, the percent of residential, industrial, commercial and other land needed, of the total amount needed, was calculated. These percentages were then applied to the amount of available acres to distribute the amount of available land among the four land use categories. After the available land was allocated to residential, industrial, commercial and other land use, the new 2040 densities were calculated.

4. The specific land use category needed did not previously exist in the municipality, therefore, the county conversion factor was used to calculate the amount of acres needed.

Future Land Use Allocation Theories. The forecasting of future land use incorporates two underlying assumptions. First that further expansion of existing development will take place due to various identified factors, and second that this new development will locate in predetermined patterns based on land use theories and in agreement with historical development.

To determine which acres in each municipality would be developed by various land uses, criteria were established as guidelines to the allocation of future development. The following premises were used:

1. Future development would occur nearby or adjacent to existing development of the same category.

2. Commercial and industrial development will occur along highways and major roadways.

3. Land surface slope, marshes and wetlands will place limitations on land development. Wetland areas are currently being lost to development and are expected to continue to be lost. The impact of the future development of wetlands was analyzed incrementally to the 1990 and 2040 land use allocations in order to evaluate the feasibility of preserving natural storage areas in the Passaic River Central Basin. This flood control alternative is discussed in the Plan Formulation Appendix under the heading of PLAN FORMULATION RESULTS.

4. Developed open areas, such as parkland, cemeteries, golf courses, etc., will not be developed more intensively.

5. Future development will not occur in existing floodplain lands. This is consistent with the projected zoning of local communities to maintain greenbelts along local riverbanks and consistent with Federal floodplain management.

Future Land Use Coordination With Local Interests. The selection of population and employment projections for the study was made with the coordination of state agencies. The overall assessment was that the existing projections were acceptable for use in the Passaic River Basin Study. The State of New Jersey, Department of Environmental Protection acknowledged that the New Jersey projections are based on the State's official 208 Water Quality Management Plans.

The PASSAIC RIVER BASIN STUDY transmitted the resulting population, employment and land use projections to municipalities in the Basin. Comments were requested in view of the fact that these projections would be utilized to assess the impacts that potential future economic and hydrologic changes would have on flood damage reduction and water supply alternatives. It was anticipated that the projections were consistent with those approved at the municipal level. Approximately 40% of the Basin municipalities responded to the letter regarding population and employment projections. The majority of responses were in support of the transmitted data. Responses which suggested modification of the data were reviewed and incorporated into the analysis, when appropriate, even those suggested changes which were not significant in magnitude. No additional revisions are anticipated, therefore, due to local input. The projections were reviewed in light of the 1980 Census data and no adjustment was necessary to reflect current census data during the detailed planning stage.

Future Land Use: Results. The results of the future land use analysis are consistent with the future characteristics of the Basin as a whole. Since the land use projections were an outgrowth of population and employment projections, areas of the Basin, specifically the Highland Area, currently consisting of lower levels of development, are those which are expected to see the greatest increases in land development. Though population and employment trends show increases in the years 1990 to 2040, the explosive growth of the years 1950 to 1970 will not reoccur and accordingly land use projections reflect this. Figures V-44 and V-45 illustrate the existing magnitude of development and land use projected in 1990 and 2040. Table V-50 shows the number of acres developed under existing conditions, 1990 and 2040 by county. Compared to historical growth in the Passaic River

Basin, the future acreage projected to develop is relatively small. It should be noted that though comparatively more acres were developed in the past than are projected for the 1990 to 2040 period, the incremental effect on frequent flooding and the extension of floodplain areas is relatively more significant. Increases in flood stages in 1990 and 2040 over those in existing conditions were analyzed and equivalent annual damages were calculated. See Section 6, Detailed Plans (Stage 3) Benefit Analysis - Flood Damage Reduction.

Future Land Use Service Area Counties. Land use projections were reviewed in the four categories of land development; residential, commercial, industrial and other (i.e., public developed areas) in all of the service area counties lying partly or wholly in the Passaic River Basin. The acreage reviewed includes only those acres which fall in the county areas within the Passaic River Basin drainage areas.

Bergen County. The county has approximately 16,500 acres available for future development, greater than 22% of the total acreage in the county. Large areas of land in the northern section of the county consist primarily of medium density residential development, while areas nearer to New York City are high density areas. The greatest amount of vacant land is located in the Highland Area, primarily the three northwestern municipalities of Mahwah, Oakland and Franklin Lakes, due to much of the terrain in this area being rugged. The central portion of the county contains most of the commercial activity, and residential, commercial and industrial use in the central and southern portions of the county is intense.

Based on population projections, it is estimated that approximately an additional 1,100 acres will be developed for residential use by the year 2040. Additional commercial and industrial acres (approximately 1,000 and 200, respectively) are projected to be developed by 2040 based on employment trends in the county. The greatest increase in development will be for urban and institutional usages consisting of approximately 1,500 acres; however, this is less than a 1% increase from total developed acres under existing conditions.

Essex County. Essex County is densely populated and extensively developed, functioning as the industrial and financial center for northeastern New Jersey. Based on employment projections, it is expected that approximately 1,500 additional acres will be developed for commercial use by 2040 representing an increase of less than one percent. No additional industrial development is projected for 2040. Based on population projections, an additional 350 residential acres are expected to be developed in Essex County by 2040. The total increase in residential development by the year 2040 is less than 1% of total existing development. This is consistent with the fact that Essex County is already highly developed.

Hudson County. Hudson County, characterized as an older high density urban area, has little vacant land available in the county. Eastern portions of Kearny, a community adjacent to the Passaic River, contain most of the existing open land areas. Since population growth is projected to be minimal in the county, less than 50 acres of residential development are expected by 2040. Approximately 200 acres in the county will be used for other urban and institutional purposes. Based on employment trends, no additional industrial acreage is projected and only an approximate 150 acres are forecasted for commercial use by 2040. A total of approximately 400 additional acres will be developed by 2040 which is less than 10% of the county's total basin acreage.

Morris County. Morris County is one of northeast New Jersey's least developed counties, with the majority of existing development consisting of low density residential use. Industrial and commercial development have also become increasingly important to Morris County. Using population and employment projections, it is anticipated that the county will develop approximately an additional 11,300 acres by 1990 and approximately 13,400 acres by 2040. The majority of the projected development will be residential in nature, over 75%, approximately 10,300 acres by 2040. Additional commercial development will total approximately 2,000 acres while industrial development will only increase by over 100 acres by 2040. Increases in land use for urban and institutional purposes will also occur in approximately 1,000 acres by 2040.

Passaic County. Passaic County can be divided into three general areas reflecting land use. The southeastern portion, which lies within the Lower Valley, is basically an urban and dense suburban area. Most of the county's industry is located in the Central Basin, in Wayne Township. The Township also contains residential and commercial development. The majority of the county's vacant land is in the Highlands Area in the northwestern portion of the county. This land has rough terrain, therefore, development in the Highlands Area has been almost totally low density residential. New development in Passaic County based on population and employment projections is expected to consist of approximately 6,300 additional acres by 2040. The developed acres constitute approximately 3% of the county's total Basin acreage. The majority of these acres will be developed for residential and commercial use. No industrial development is anticipated while it is projected that over 1,180 additional acres will be used for urban and institutional purposes.

Somerset County. The most intensive development in the county has been along the east-west transportation corridor that crosses the middle of the county and to a lesser extent in the northern areas. The primary land use in Somerset is residential development. Strong growth is anticipated in this county, indicated by the large areas of open land, approximately 9,500 available acres. Utilizing population trends, over 3,100 acres of residential development is forecasted by 2040. The development constitutes 10% of the county's total Basin acreage. Employment projections indicate that approximately 500 additional acres of commercial development will take place, however, no additional industrial land use is projected. Approximately 175 acres of the county will be developed for other urban and institutional uses by 2040. Total development by 2040 utilizes approximately 20% of the county's total acreage.

Sussex County. Of all the counties in the Basin, Sussex County currently has the highest proportion of undeveloped acres relative to total acreage, approximately 95%. The majority of existing land use consists of residential development. Future population projections indicate that by 2040 an approximate 2,100 acres of additional residential development will take place. The increase in residential land usage will most probably impact on agricultural development which currently encompasses the land areas most suitable for more intensive development. The county has limited highway access and most of its land area is rugged terrain which prohibits large scale development. Based on employment trends, no additional industrial development is forecasted by 2040 and approximately 500 acres will be developed for commercial use. Over 900 acres of the county will be developed for other urban and institutional uses by 2040. An approximate total of 3,500 acres will be developed by 2040 or approximately 20% of the county's total basin acreage.

Union County. This county is a densely settled area with approximately 65% of its total area currently developed. There are many residential neighborhoods and commercial development tends to be concentrated in central business districts. Industrial land use is directly related to transportation facilities. Union County has less than 400 acres available for future development. Based on population projections, approximately an additional 20 acres of residential land development will occur by 2040. Employment trends indicate that approximately 140 acres will be used for commercial purposes and no additional industrial development will take place. Future land use for other urban and institutional development will comprise approximately 160 acres by 2040.

Orange County. Growth has been dynamic in this county. The majority of new development has taken place in the unincorporated towns. New residential development as well as many research facilities and corporate headquarters have been lured to rural areas by the inexpensive cost of rural land and the low cost for site preparation and development. This is especially true for cleared farmland. Orange County has over 39,000 acres available for future development. Based on population trends, approximately 15,700 acres of additional land will be developed for residential usage. Employment trends indicate that over 400 acres will be developed for industrial usage and approximately an additional 1,900 acres will be commercially developed by 2040. Over 4,400 additional acres will be utilized for other urban and institutional uses. Total projected development constitutes over 35% of the county's total basin acreage.

Rockland County. Rockland County has felt the pressure of urbanization and suburbanization in recent years. The surge of development has been spurred by the proximity of the N.Y.S. Thruway and has followed development patterns of decreasing densities radiating outward from municipal centers. Projected population indicates that approximately 8,100 additional acres will be used for residential development by 2040. Based on employment trends, commercial and industrial land use will increase by approximately 900 and 800 acres respectively. Development for other urban and institutional usage will utilize approximately 3,900 acres by 2040. Total projected development utilizes approximately 38% of the county's total basin acreage.

WITHOUT PROJECT CONDITIONS SUMMARY

The existing conditions in the Passaic River Basin and the most probable future conditions are reflective of the historical socioeconomic characteristics of the area. The favorable climate for economic growth that historically existed in the Basin is still strong in the majority of the Basin's service area counties. Almost half the Basin's communities will be described as suburban-urban by 2040. The projected continual growth is important in light of future flood conditions which would increase current expected annual damages due to worsening flood conditions. Impacts of without project condition future economic growth upon expected annual damages can be viewed on Table V-51. Expected annual damages for 2050 reflect no growth in economic activity between the decade of 2040 and 2050.

Potential increases in expected annual damages are due to future land development in the Basin drainage area. Urbanization was projected to occur in the Highland Area and in the remaining undeveloped natural storage areas of the Central Basin. A discussion on these developmental facets can be viewed in Appendix C, Plan Formulation, Section 2.

Equivalent Annual Benefits have been computated in light of 1990 and 2040 hydrologic conditions and are described in Section 7, Economic Analysis of Alternative Plans.

SECTION 6. ECONOMIC ANALYSIS OF ALTERNATIVE PLANS

STAGE 2 ANALYSIS SUMMARY

The results of the economic analysis of the alternative plans formulated in Stage 2 are presented in Section 5, Appendix C - Plan Formulation, of the Main Report. The economic analyses of Stage 2 alternatives included the evaluation of 59 plans. Data presented in the Plan Formulation Appendix reflect the updating of benefits and costs to October 1985 price levels and the use of 8-5/8% interest rate. Benefits were also updated to reflect the current estimate of the project's base year. The benefit categories for Stage 2 alternative plans of protection consisted of equivalent annual benefits, benefits from flood damage prevention, benefits from affluence, residential intensification benefits, advance bridge replacement benefits, benefits from reduction in traffic delays, benefits from industrial content growth and reduction in the administrative cost of FEMA's Flood Insurance Program. Benefits categories were applied to each alternative plan where appropriate. These benefit categories were reviewed more closely during the Detailed (Stage 3) Planning Stage. The Plan Formulation Appendix details benefit to cost ratios and net benefits for each alternative plans.

DETAILED (STAGE 3) PLANNING SUMMARY

Several iterations of plan formulation screening were performed during and subsequent to Stage 2 planning. Plans were screened in Stage 2 to a manageable array of approximately 25 intermediate plans, and subsequently to seven "basic" intermediate alternatives which were the focus of substantial public involvement and served as the basis for deciding which plan would be carried into the Detailed Planning Stage. Three intermediate plans of protection were selected to be analyzed in greater detail subsequent to completion of Stage 2. The plans carried into the Detailed Stage were Plans 16A, 30A, and 30E. Plan 30E, the Pompton River-Passaic River Dual Inlet Tunnel Diversion Plan, is the recommended plan. A summary description of the detailed plans is presented in Table V-52. Intermediate Plans 16A, 30A, and 30E were further refined and detailed during detailed plan formulation based on economic and environmental considerations. For example, Plan 30E (Intermediate Plan) underwent design changes based on such considerations. The Intermediate Plan 30E differs from Detailed Plan 30E in that the former includes a 40-foot diameter tunnel in conjunction with channel modification between Beatties Dam and Two

Bridges, and the latter includes a 39-foot diameter main tunnel with a 22-foot diameter spur tunnel. Numerous other refinements were made in Plan 30E, including the inclusion of environmental design features, the screening and optimization of levee/floodwall systems, and the incorporation of the preservation of natural storage as a plan feature. See Appendix C, Plan Formulation, for a full discussion of these refinements. Thus, to this extent, costs of detailed Plan 16A, 30A, and 30E reflect the results of additional Stage 3 studies in addition to price level and interest rate updating. The results of the benefit analysis for the detailed plans are discussed below. All benefits are shown in October 1985 dollars at a 8-5/8 percent interest rate.

BENEFIT ANALYSIS

The benefit analyses have been performed in accordance with ER 1105-2-40 dated 9 July 1983. All applicable regulations are consistent with the ten step procedure outlined in the Planning Guidance Notebook for the computation of NED benefits. The benefits derived from the plans of protection along the Passaic River consist of the equivalent annual benefits from flood damage prevention including future urbanization impacts, benefits from affluence, benefits from residential intensification, benefits from reductions in PATH and traffic delays, benefits from industrial contents growth, and reduction in the administrative costs of FEMA's Flood Insurance Program. Benefits from advance bridge replacement, location benefits and NED employment benefits were not found in the study area. Benefits due to less frequent pavement maintenance, reduction in floodproofing costs and recreational benefits were measurable yet not significant at this time and, therefore, not utilized in the computation of benefit-to-cost ratios. Other potential benefits which have not been calculated include the following:

Protection of National Register Historic Properties and Districts - Many historic sites and districts remain above the surface throughout the potential project area. Near the mouth of the Passaic River, a National Historic District includes the Pulaski Skyway and contiguous areas. The riverside areas below the Pulaski Skyway to within 0.5 miles of Great Falls have as high probability for being nominated as additional historic districts. The area from 0.5 miles downstream of Great Falls to 0.4 miles upstream is a National Historic District. Much of the remainder of the potential project area has been predicted to have a high potential for historic districts that may be nominated to the National Register. This high probability exists because Passaic River-related uses of land in the potential project areas are well documented. In addition, the Morris Canal, a National Historic District, closely parallels the Passaic River in Little Falls and West Paterson. These sites, located in the potential project area are currently deteriorating because of continual flooding;

Reduction of Hazardous Waste Clean-up Costs - Significant cost savings would be realized by the prevention of potential contamination of entire floodplain areas and river channels from the flooding and dispersion of materials from hazardous waste sites located in the floodplain; and

Recreation Benefits from Floodplain Evacuation - Recreation benefits could result from the evacuation of floodplains. The physical removal of floodplain structures and the conversion of private land to public recreation areas would result in a quantifiable increase in the number of recreational activity days.

Detailed Plans (Stage 3) Benefit Analysis

Discussed below is the detailed plans economic analysis for the flood damage reduction (including future urbanization effects), affluence, residential intensification, traffic flow, PATH delay and industrial content growth benefit categories. Benefits for each benefit category were applied appropriately to detailed Plans 16A, 30A, and 30E.

o <u>Flood Damage Reduction</u>. Flood damage reduction benefits including the effects of future urbanization were developed for the detailed plans by evaluating damages with and without the proposed projects under both existing and future conditions. The detailed plans included considerations of diversion tunnels, channel modifications, levees and floodwalls, and the preservation of natural storage. Damage reaches affected by both tidal and fluvial flooding were analyzed using a combined frequency analysis. Prior to the base year (2000) flood damage reduction benefits would be generated from the levee/floodwall, tunnel and preservation elements of the detailed plan. Computation of flood damage reduction benefits in advance of the base year due to these elements are discussed in the Interest During Construction (IDC) section, page 161, of this appendix. Construction schedule for advance of base year elements can be viewed in Supporting Documentation, Part IV, Cost Estimates Section, Figure IV-1. The equivalent annual flood damage reduction benefits that accrue as a result of the flood control plans are shown on Table V-53.

Urbanization effects from flood damage reduction for the detailed planning alternatives were evaluated under 2000 and 2050 future conditions. This analysis of future damage reduction is reflective of 2000 and 2040 hydrologic conditions resulting from the future land use and development projected in the Passaic River Basin. Significant future development is not expected between the decade of 2040 and 2050 under most probable future condition. Future land usage was projected in concurrence with State and local guidelines and was fully coordinated at the State and municipal levels as was previously discussed in Section 5.

Freeboard Benefits for fluvial, integral, and tidal levees were designed with freeboard of three to five feet. In accordance with EP 1105-2-45, change 4, dated 6 August 1984, SUBJECT: Flood Damage Prevention Benefits in the Freeboard Range, one-half the area under the frequency-damage curve between the design level of protection and the largest flood to be carried within the freeboard has been determined and included in the benefit evaluation.

o <u>Affluence Factor For Residential Contents</u>. Affluence benefits are calculated to account for future growth of residential content value, and are characteristic of increases in reproducible wealth. Because the extent of future flood damage to residential contents is directly related to the accumulation of wealth, trends in future contents damage can be derived from future growth rates in per capita income. Components of the affluence calculation include the growth rate, the interest rate for the project, the ratio of existing contents value to residential structure value, and the project life. The New York District utilizes a computer program entitled "Fact-5A" to compute the average annual equivalent affluence factor as shown on Table V-54. These computations utilized an 8-5/8% interest rate and a project life of 100 years.

To account for different levels of development throughout the watershed, affluence factors were calculated separately for each major tributary in the Passaic River Basin, see summary Table V-55. Content value to structure value ratios specific to each tributary area were utilized. Residential structure counts used for affluence CV/SV calculations on Tables V-56 and Table V-57 are inclusive of floodplain counts presented on Table V-25. For example, in reaches 020052 and 020102 approximately 1,913 residential structures are included in the total inventory count presented on Table V-56, with an estimated 1,450 of these residential structures being in the 500 year floodplain delineation for these reaches. Content value to structure value ratios were obtained from a weighed average based on residential structure types in each specific tributary area. The computation of the affluence factor reflected a 75% limit for the content value to structure value ratio, in accordance with ER 1105-2-40.

The growth rate utilized for the Basin was a basin-wide growth rate of the per capita growth rates of the four SMSA's that overlay the Passaic River Basin. Portions of the Jersey City, the New York- New Jersey, the Newark and the Paterson-Clifton-Passaic SMSA overlay the Basin. OBERS SMSA projections were utilized because of the projected per capita income data which were readily available. Since per capita income is a function of population, in order to ensure consistency among the demographic variables utilized in this report, OBERS population projections were compared to those of the NJ 208 Water Supply Master Plan. These latter population projections were utilized for the Passaic River Basin projection of future land use. See Table V-58 for a comparison of the two projection series. The comparison shows that the growth rates based on the two sources of data are not significantly different. The OBERS SMSA data is higher for some counties, however, average growth rate figures for the four SMSA's overlying the Basin are relatively low compared to each of the county NJ 208 Water Supply Master Plan policy projections. The utilization of the OBERS population projection series, therefore, is considered to be a conservative estimate of the growth that will be experienced in the Passaic River Basin.

However, before the basin-wide growth rate was determined, a sensitivity analysis was performed. The analysis reviewed the impact of the specific SMSA data of each of the four SMSA's in on the calculation of the affluence factor. When the calculation was performed using the same content value to structure value ratio, yet utilizing different SMSA growth rate data there was an insignificant change in the resulting affluence factors. The content value to structure value component had a greater impact on the affluence factor derived. Therefore, in the derivation of affluence factors, detailed content value to structure value ratios for each tributary were utilized, as previously noted. Specific SMSA growth rates, in light of their insignificance, were replaced by a basin-wide growth rate. Affluence benefits for Plans 16A, 30A, and 30E were estimated at 3,900,000, 6,600,000, and 6,700,000 respectively (see Table V-67).

o <u>Residential Intensification</u>. Potential benefits due to residential intensification were investigated in reference to ER 1105-2-40 dated 9 July 1983. An intensification benefit results if a plan or project induces an activity in the floodplain to modify its operation in such a way as to result in increased efficiency. The intensification benefit created by a flood control project is the net value of activities which results from the more efficient use of the structure. This study found that there is a reduction in the use of residential basement space and an accompanying reduction in market value due to the flood hazard, thus indicating a potential for intensification if the flood hazard is reduced. Such benefits do not duplicate benefits already credited for flood damage reduction or affluence. Flood damage reduction benefits, which are based on the basement use reflected under existing conditions, can only reflect increases in market value consistent with current use. Likewise, affluence benefits reflect growth of reproducible wealth based on content values derived from existing use, and do not include changes of utility or expansions of use.

Restoration of residential market value associated with full utilization of basement areas due to reduction of the flood hazard represents a measure of intensification potential. This approach ensures that benefits computed for flood damage reduction and affluence are not duplicated.

Methodology. Residential intensification benefits were previously investigated as part of the Interim Feasibility Study for the Ramapo and Mahwah Rivers, Mahwah, N.J. and Suffern, N.Y., November 1983. That study considered residential intensification effects for structures lying in the 100 year floodplain in Suffern, N.Y., based on data gathered from flood damage survey interviews for that area.

The analysis used in the Ramapo and Mahwah Rivers Feasibility Study attempted to utilize a direct measure of the difference in flood damage potential for unmodified and modified (intensified) basements. This difference, then, would be equivalent to the benefit the homeowner would derive from intensified usage. This was based on the concept that the marginal cost of the flood losses the homeowner would incur, would be equivalent to the marginal utility (benefit) the homeowner would derive from the intensification. Reducing the flood hazard would reduce the expected value of the losses, therefore reduce the marginal cost, and induce more people to intensify their usage. The Board of Engineers for Rivers and Harbors (BERH) had several problems with the analysis. They included:

a. The homeowners decision to fully utilize the basement may be unrelated to the flood damage threat because of flood insurance subsidies.

b. While the District based its analysis on field data, the flood threat would not totally be eliminated. There is some statistical probability of the project's design level being exceeded.

c. The benefits were apportioned over the whole floodplain, thereby overstating the potential benefits.

d. When project design is exceeded there are additional losses which will occur due to intensified use which should be considered as negative benefits.

e. A direct measure of market value differences would be a better measure of potential intensification benefits.

These concerns were carefully considered in the development of the revised analysis. As described below, market value change was utilized as a direct measure of the value of intensified use for homes in flood hazard areas as compared to those in areas of less frequent flooding. The number of homes and the extent of the floodplain within which intensification would most likely occur was analyzed and substantially limited to those areas which had the highest likelihood of intensifying. This was based upon home size, frequency of flooding, severity of flooding and field data as to the potential number of structures which would intensify. Finally, the numbers presented were adjusted by the percent of residential content damages occurring above the design level of the project in order to subtract out any negative benefits. The analysis presented herein for the main stem Passaic River has been modified to address the BERH/OCE concerns on the Mahwah/Suffern study.

Residential structures analyzed for intensification benefits for this study were limited to those having unfinished basements within the 10 year floodplain in the Lower Valley, Central Basin and Pompton Basin. These structures are subject to frequent flooding and therefore, suffer the greatest extent of reduced basement use as a result of the flood hazard. In this sense the main stem analysis provides a conservative estimate of potential intensification with project.

Modified use was defined as the underutilization of basement areas due to flooding. An analysis was made of the increase in market value which would result when the modified use of the basement area would be altered (i.e., intensified) because of a reduction of the flood threat. Market value was analyzed for with and without project conditions (homes lying outside of flood hazard areas were used as a proxy for flood prone homes under with project conditions). This direct measurement identified changes in basement value which would be directly related to the elimination of the flood risk. Increases in basement values due to a reduction of the flood threat is a quantification of the intensification benefits.

The underlying assumption is that the basement utility for a home under with project conditions provides a measurable increased increment of value to the overall market value of a home compared to the without project conditions. Of course, the overall market value of the home is depressed by the flood hazard, and in order to quantify the basement intensification benefits the incremental contribution of basement use to the increase in market value was developed. The relationship between the market value of homes under with and without project conditions and the increment of value provided by basement utility were developed directly from data gathered from local realtors.

Application. Approximately fifty realtors in the communities of Wayne, Chatham, Fairlawn, Clifton, Montville, Parsippany, Pompton Plains, Denville, Dover, Little Falls, Paterson, Totowa and Garfield were randomly selected. These realtors were contacted and asked specific questions in regard to reduction in market values and basement values for residential structures located in a flood hazard area. Approximately forty realtors stated that the market values of existing structures in the floodplain were measurably lower due to the flood hazard and that part of this reduction was due to decreased basement utilization. Approximately seven realtors expressed no idea of the effect the flood hazard has upon market values. The remaining realtors stated that market values would not change with a reduction of the flood hazard.

To develop the potential increase in basement values due to the reduction of the flood hazard, realtors were then asked what percent of market value would equal basement value. Responses were listed and the basement value was found to average approximately 6% of the market value. Realtors stated that this percentage could be used for existing residential structures in and out of the flood hazard area.

Realtors were also asked to estimate the portion of potential increase in residential market values attributable to reduction of the flood hazard. Responses were listed and the potential increases in residential market values due to reduction of the flood hazard were tabulated. To properly quantify this increase in residential market values, percentages were tabulated separately for the Lower Valley, Central Basin and Pompton Basin. Increases in residential market values due to reduction of the flood hazard were 38%, 37%, and 32% for the Lower Valley, Central Basin and Pompton Basin, respectively.

Realtors were asked to quote average market values for residential structures located in a flood hazard area for the Lower Valley, Central Basin and Pompton Basin, respectively. These average market values were increased by the appropriate Lower Valley, Central Basin and Pompton Basin percentages to reflect the increase in market values due to the reduction of the flood hazard. Utilizing 6% of residential market values, the incremented basement values were tabulated. Differences in the basement values with and without a flood hazard were computed, varying from 1.9 to 2.3% for the Pompton at Lower Valley area, respectively. Increases in basement values were compounded and annualized. The annual increments for the Lower Valley, Central Basin and Pompton Basin were estimated at $208, $207 and $182, respectively, per 10 year floodplain home with an unfinished basement.

All reaches along the Lower Valley, Central Basin and Pompton Basin were reviewed to determine the magnitude of flooding due to a 10 year flood event. Reaches which would incur significant damages due to a 10 year flood event were selected for further analysis. All residential flood damage interviews conducted in the 10 year floodplain were reviewed in detail. Approximately 60% of the residential interview sample was found to have unfinished basements. This percentage was applied to the total number of residential structures within the 10 year floodplain in each reach to determine the number of structures with intensification potential.

Residential intensification benefits for the Lower Valley, Central Basin and Pompton Basin total approximately $142,300, $426,000, and $561,500, respectively. Residential intensification benefits would vary by plan depending upon the level of protection provided for each reach. Plans 30A and 30E provide 100 year protection to these reaches and accrue the total annual benefits computed. Plan 16A, which includes 10 year nonstructural flood protection to the Pompton Valley, was credited only with the Lower Valley and Central Basin portions of total benefits. The computation of residential intensification benefits is displayed on Table V-59. Total potential benefits for all three study subbasins are approximately $1,130,000. Table V-67 presents benefits for each detailed alternative.

o Federal Insurance Administration Costs Reduction. Other costs of using the floodplain have been identified in accordance with the NED Benefit Evaluation Procedures for Urban Flood Damage, Step 8(b) of these procedures which identifies National Flood Insurance Costs. A national cost of the flood insurance program is in its administration. This cost includes the cost of servicing flood insurance policies and adjusting claims, and can be expressed as an average cost per policy. Such costs are solely administrative in nature and do not include any floodplain occupant costs which are indirectly reimbursed or externalized as insurance claim payments or policy subsidies. Thus, these administrative costs are separate from floodplain activities and are not included in existing flood damage reduction benefits.

Information from the Federal Insurance Administration (FIA) indicates that the current cost to administer a flood insurance policy is $57 annually. Currently there are approximately 16,600 policy holders in the study area's existing 100 year floodplain.

Expressing savings of these administrative costs as project benefits is appropriate for properties within the 100 year floodplain in communities that participate in or are expected to participate in the Federal Flood Insurance program under the without project conditions. All floodplain communities in the Passaic River Basin are participating in the program.

With project conditions have the effect of shrinking the 100 year floodplain and removing structures from the hazard area thus eliminating these structures from the FIA program. Based on the number of structures in the 100 year floodplain and the cost of administering each policy to be eliminated arrives at an annual benefit for complete 100 year protection of $946,200. This benefit would vary for each of the detailed plans (see Table V-67), depending on the extent of 100 year protection provided.

o <u>Traffic Flow Benefits</u>. An assessment was made of the additional costs, i.e., damages incurred by vehicular traffic due to the inundation of major arteries in the Passaic River Basin. The evaluation of such costs required the identification of the major routes utilized by vehicles in the Basin under existing conditions without flooding, and the flood frequencies, depths, durations and impacts on these roads.

There are essentially two major categories of benefits that were considered. These are benefits resulting from loss of time, and benefits from additional cost of operating the vehicle through diversion of traffic. Traffic delay takes the form of using an alternate route. The alternative route pursued will be that which minimizes inconvenience and, therefore, costs.

In order to determine alternate routes for the traffic which would be detoured off any one of the major Basin highways, consideration was given to the purpose for using the original route. A distinction was made between major east-west routes and major north-south routes in order to determine the predominant origin and destination of the traffic flow on each route. Utilizing New Jersey Department of Transportation (NJDOT) traffic data, vehicular traffic counts were reviewed and associated with three patterns of travel: 1) through traffic; 2) feeder traffic; and 3) local on-off traffic. This procedure confirmed the observation made of major transportation routes passing through the Passaic River Basin; the north-south routes act predominantly as feeders into the east-west routes. The major east-west routes, specifically I-80, U.S.46 and I-280 provide uninterrupted flow between the western-most portion of New Jersey and the New York City area.

Traffic data for north-south routes such as NJ-23, U.S.202 and I-287 indicates that much traffic on these routes feeds into the major east-west routes. Traffic counts at access and egress points along the routes were utilized to determine how much traffic is through traffic and how much is local traffic. This resulted in a conservative count of vehicles passing through the alternative detours. Different detour routes were chosen for the diverging of detouring traffic. This influenced the selection of the least costly alternatives route for detouring traffic. These procedures resulted in a conservative count of vehicles and mileage, reflecting the traffic detoured to alternative routes.

Since this analysis focuses on significant flood events, inundated roadways would cause major disruptions of traffic flow. Blockages along highways due to flooding and the subsequent detours established would be coordinated by state and local officials, police departments and emergency units. The detour would start at the nearest interchange prior to the inundated roadway and divert traffic onto another passable major route. The end of the detour would be represented by reentry onto the original highway. This procedure applied directly to through traffic. Local traffic that enters or exits a highway by any number of local, medium or light duty roads between the nearest interchange and the area of inundation would take local roads to the closest alternate highway. Once on the alternate route, the local traffic traveled only far enough to access the original highway at a point beyond any flood hazard.

In some cases traffic counts vary along an original route that has more than one point of potential flood blockages. The peak through traffic statistics were used in a detour route beginning at the outermost impassable flood location, since traffic would not be able to access the original route between the inundated locations.

Using the methodology described, traffic detours were analyzed. Flood elevation and depths were examined for major highways which cross the Passaic River's floodplain, located in the Lower Valley, Central Basin and Pompton Basin, for the 5 year, 10 year, 50 year, 100 year and 500 year events. Highways which experience flooding during any or all of these flood frequencies include several portions of U.S.46, I-80, I-280, (east-west highways), several locations along NJ 23, and U.S.202 (north-south highways), see Figure V-46.

The water surface elevations at the 5 year, 10 year, 50 year, 100 year and 500 year flood events were determined. One foot of water above the ground elevation of the highway was used as the threshold of when a road becomes impassable. During a 1 year flood event water heights would be less than one foot above ground elevation and traffic would be passable. The corresponding stream discharge for the ground elevation plus one foot was obtained and the duration of flooding above the one foot elevation was derived from HEC-1 hydrograph data for each frequency of flooding.

The traffic data compiled by NJDOT was used to compute the total number of vehicles affected by each inundated, impassable highway location. The traffic data consisted of average annual daily traffic (A.A.D.T.) counts representing the total volume in both directions during a twenty-four hour period. The average annual daily traffic counts developed by the NJDOT reflect factor adjustments to account for seasonal changes, and because they are developed over a twenty-four hour period, they include factor adjustments due to time of day. The nature of this data precluded the need to perform any seasonal traffic count analysis. Traffic counts were available for data years 1980 through 1981. These figures were then increased to reflect 1985 traffic counts and, therefore, are conservative in number since recent increases in traffic counts are not included.

<u>Vehicular Operating Costs</u>. Upon selecting the least costly alternative route for detouring traffic during the 5 year, 10 year, 50 year, 100 year and 500 year flood events, the increase in mileage between the original route and alternate route was computed. The resulting increase in mileage due to the traffic detour for each frequency of flooding was multiplied by the government automobile estimate of $0.25 per mile for passenger vehicles and $0.40 per mile for trucks. These figures include total expenditures associated with vehicle use such as gasoline, oil, maintenance, insurance and registration costs. (Traffic

data for trucks was also available from NJDOT). A sample computation for the increased cost of vehicular operation for Route 46 in Wayne, N.J. is presented for the 100 year flood frequency on Table V-60.

Delay Costs. Other costs associated with traffic detours are traffic delay costs represented by the dollar value of a person's time spent in increased travel time due to road blockages, detours and increased traffic congestion. The following steps were used to compute these delay costs. The traffic delay data, including original and alternate route mileage and total vehicles affected (trucks and passenger vehicles), previously developed for vehicular operation costs were used in calculating the delay costs. At each frequency of flooding for which data was developed, the total additional time that vehicles would spend on the alternate (detour) route versus the original flooded route was determined. The additional time consists of the difference between the followings: (1) the original route mileage times the total number of vehicles affected by a flood blockage on that route (over the duration of the flood condition) divided by the average speed of traffic flow under a non-flood condition; and (2) the alternate route mileage times the number of vehicles detoured (same as in (1)), divided by the average speed of traffic flow under flooding conditions in the Passaic River Basin. The average traffic speed used for the non-flood condition was 45 miles per hour and that used under flooding conditions was 10 miles per hour. The reduced speed takes into consideration the much heavier traffic volumes along the detour route. These steps were taken for trucks and passenger vehicles separately for each affected roadway and totaled for each flood frequency data point.

The next step consisted of the application of the number of persons determined to be in each passenger vehicle under both commuter and non-work related travel conditions (this is the total number of persons affected) and the average dollar worth of those persons' time. For trucks, however, a flat average wage rate was applied to the total number of trucks affected by the flood event, since no distinction was made between work and non-work related activities, as had been done for passenger vehicles.

For automobiles the character of the population affected by traffic detours and delay is a mixture of public commuters to place of employment and public vehicular travel for private purposes i.e., shopping trips, travel to school, and leisure activities. Because of the nature of the inundated routes in the Passaic Basin (major commuter highways), a weighted value for a person's time was derived utilizing the average rate for commutation trips, one-third of the average wage rate for adult non-work related travel and one-fourth of the adult value (one-twelfth of the average wage rate) for children. This resulted in a weighted dollar value, totalling $6.67 per hour, and reflects the procedure suggested to determine time value in the Water Resource Council's Principles and Standards, Subpart K - NED Benefit Evaluation Procedure.

The rate of $6.67 incorporates the gross average earnings of production, professional, and managerial workers in the New York-northeastern New Jersey area. This average hourly rate is $11.03 according to the latest data available from the Bureau of Labor Statistics ("Employment and Earnings" 3rd Quarter 1985).

An average of two adult passengers were determined to ride in commuting vehicles, while one adult and one child per automobile was estimated for non-work related trips.

Trucks delayed during flood events and the cost to drivers was estimated at $12.18 per hour, the basic hourly wage rate for drivers of service trucks in Bergen, Hudson and Passaic Counties as listed in the Federal Register. One truck driver per truck was calculated in the total delay costs.

Once determined, these average hourly rates ($6.67 per person-hour for passenger vehicles and $12.18 per person-hour for trucks) were multiplied by the total additional time spent on all detours for each frequency event. This final step represents the total delay cost for all affected vehicles on major highways under flooding conditions.

Traffic delay costs were not calculated to address flood conditions of one foot or less on the roadways subject to inundation. Although it is reasonable to assume that traffic flow would continue under such conditions, traffic would continue at a reduced speed and, therefore, traffic delays would occur. Benefits for such delays have not been examined at the present time and are not included in the overall benefits to the alternative plans presented in the report.

Total average daily delays and benefits were assessed for travel under existing conditions. The AADT figures utilized were not modified to reflect travel which might not occur during flood conditions (trips avoided) since it is recognized that much of the Basin's through traffic is destined for employment centers outside of the watershed and lost wages incurred by employers located outside of the Basin are not accounted for in existing damage data.

The sum of the increased vehicular operation costs and the traffic delay costs is the total cost of the interrupted traffic flow during flood events. Sample calculations of the traffic detour costs and delay costs are shown on Tables V-60 and V-61. The total cost or damages due to each flood event was utilized to compute a damage frequency curve which was then integrated to compute expected annual damages. Expected annual traffic costs, at stage traffic costs for various flood events and total expected annual traffic costs are shown on Tables V-62 and V-63. Flood control plans of improvement, therefore, alleviating highway flooding, accrue traffic flow benefits. Plan 30E, which provides comprehensive 100 year protection would accrue expected annual benefits through the 100 year flood, with benefits totaling $2,415,000 annually (see Tables V-63 and V-67).

o Path Delay Benefit. The Port Authority Trans-Hudson (PATH) lines is a major commuter rail link between New Jersey and New York. Interruption in PATH service would cause massive time delays to commuter and additional costs to the Port Authority Trans-Hudson Corporation. PATH trains normally run between Penn Station in Newark, New Jersey and the World Trade Center, in New York City. Path lines would not be completely shutdown due to Passaic River flooding. Commuter rail link that would be affected by flooding would occur in the tidal reach area (reach 010011 and reach 010013) of the Lower Valley. Tidal flooding in this area would cause interruption of the portion of Path Service between the Journal Square Station and the Harrison Station in New Jersey. To evaluate the delay costs associated with the flooding of the Journal-Harrison portion of the PATH line frequencies, depths, durations, and impacts on the PATH line were evaluated.

Interruptions to PATH service result in the use of an alternate means of transportation. The alternate means of transportation is that which minimizes time delays and, therefore, cost. Two major categories of benefits were considered. These were benefits resulting from loss of time, and benefits from additional cost of operating the alternative transportation.

The Port Authority Trans-Hudson Corporation was contacted to determine the alternate means of transportation, total ridership per period, additional time of commuting during flooding, and additional time required for cleaning and drying switches. They stated that in the event of flooding, shuttle trains run from Penn Station, Newark to Harrison Station. Buses chartered from the New Jersey Transit Corporation then transport passengers between the Harrison and Journal Square Stations. At Journal Square Station passengers can board PATH trains to continue their journey to destinations in New York City. Should the PATH trains not be able to operate between Harrison and Newark, chartered buses are made available to transport commuters directly between Penn Station, Newark and Journal Square Station. In the development of the expected annual damages associated with this delay we presumed that only the rail link between Harrison and Journal Square in Jersey City would be closed.

The PATH lines were found to be inundated during floods equal to or more severe than a 10 year event. Based on input from the Port Authority Trans-Hudson Corporation, one half foot of water on the track was used as the lower level at which flooding would cause disruption of service. This occurs because the third rail, which supplies the power to the train and is only about one-half foot above the ground surface, would be shortcircuited, and therefore would become inoperable.

Shuttle Buses Operating Costs. Based on information provided by the PATH, during a flood event, 10 buses would be used continuously for the period of time that the PATH trains are inoperable. Estimates from the Port Authority Trans-Hudson Corporation, indicated that an hourly rate of $50 per bus should be used to calculate shuttle bus operating costs for the 10, 50, 100 and 500 year flood events. These buses are rented from New Jersey Transit Corporation and driver and bus come as a package. The shuttle bus operating cost per flood event is shown in Table V-64.

PATH Delay Costs. Other costs associated with PATH delay are represented by the dollar value of a person's time spent in increased travel time due to the journey by shuttle buses instead of Path trains, between Harrison and Journal Square Stations. The following were used to compute these delays: PATH train ridership, flood duration, additional time of travel, a weighted value for time delay reflecting the composition of the ridership were used in the calculation of delay costs.

It was necessary to determine an average dollar value for the ridership. The first step was to develop average hourly rates for workers in the professional and managerial sector and for production workers. This was obtained from the Bureau of Labor Statistics ("Employment and Earnings" Nov. 1985). This average hourly rate for both groups was $11.03. This was used for persons travelling to and from work. The hourly value was then weighted for those travelling for leisure purposes. The average weight for leisure trips was one-third the weight for commuter trips. Finally, to reflect the fact that children use the services of the PATH lines resulted in a further weighing of the average rate to account for children (one twelfth of the average wage rate). This weighted value for children's time was then added to the overall weighted value for lost time. This was based upon data which indicated that adults out number children on the PATH lines by about 19:1. The resulting final value for passenger's time, $7.03, was obtained by weighing the average value for adults by .95 and that for children by .05, then adding the results. Once determined, this average hourly rate ($7.03 per person-hour) was multiplied by the total additional travel time for all passengers for each event. This final step represents the total delay cost for all commuters on the PATH lines under flooding conditions. (See Table V-64.)

It should be pointed out that the total time for each flood event as it affects the running of the PATH trains consisted of the actual flood durations and the time required to clean and dry the switches along the tracks.

The sum of shuttle bus operating cost and PATH delay costs is the total cost of the interruption of services of the PATH trains. The total cost or damage due to each flood event was used to compute a damage frequency curve which was then integrated to compute expected annual damages shown in Table V-65. Flood control plans of improvement, which alleviate flooding of the PATH Lines, accrue PATH delay benefits. The Kearny Levee System provides protection to the PATH Lines up to the 500 year flood event. Therefore, benefits can be claimed up to the 500 year expected annual damage (EAD) for all three detailed plans.

o Industrial Content Growth Benefits. Over the project life utilized for the analysis of flood damage reduction measures for the main stem Passaic River, existing industries will experience internal growth if they are to remain competitive. Internal growth is defined to be the extent of capital deepening and the resulting increases in the quantities of raw materials, goods in process, and finished goods within the existing plant. Capital deepening and/or increase in productivity can be measured by economic indicators such as capital expenditures and value added. The collection and analysis of available data on the values of output and new capital in the areas subject to flooding within the Passaic Basin, i.e. the floodplain, has indicated that industries have experienced capital deepening, and industries will continue to experience such growth in the future with or without a project. To assess the extent of capital deepening that did occur in the floodplain, data was collected using field interviews with about 700 industries and integrated with data from the Census of Manufacturers for 1967 through 1982 with monetary values being in millions of 1979 dollars. The focus of this data was the Counties of Bergen, Essex, Hudson, Morris and Passaic in the State of New Jersey. These counties were chosen because they primarily contain the industrial centers located in the Passaic main stem floodplain. About seventy percent of the five counties are in fact located within the Passaic River Basin Study Area (PRBSA). Also, industries in the counties are fairly evenly distributed throughout. This means that more than 50% of the industries within the counties are located in the Passaic River Basin Study Area. Of the total industries in the study area, data collected and used in this analysis indicated that about 17% of these industries are found within the floodplain. Therefore, from this point on in the discussion, aggregates for the five counties will serve as proxies for the Passaic River Basin Study Area (PRBSA).

It is hypothesized that the value of industrial contents is a function of industrial activity. It is also hypothesized that the floodplain is very similar in industrial complexion to the Passaic River Basin Study Area, which is similar to the State of New Jersey. To prove both hypotheses a series of linear regression equations were used.

1. N.J. Manufacturing Production = f (U.S. Manufacturing Production)

2. PRBSA Manufacturing Production = f (N.J. Manufacturing Production)

3. PRBSA Industrial Contents = f (PRBSA Manufacturing Production)

Due to lack of appropriate information for the floodplain, it was impossible to use linear regression analysis to show the correlation between the Passaic River Basin Study Area and the floodplain. This resulted in the use of deductive reasoning to show the similarities between the Study Area and the floodplain. Following from this, a rate of capital deepening was obtained for the Passaic River Basin Study area and applied to the floodplain.

The assumption was made that in the long run the performance of the New Jersey's manufacturing sector would parallel that of the national manufacturing sector. It was initially presumed that a linear relationship existed over time between New Jersey's manufacturing production and that of the nation. The equation took the form:

N.J. Manufacturing Production = a+b (U.S. Manufacturing Production)

Statistical analysis of the relevant data resulted in the following:

N.J. Manufacturing Production = 8283 + 0.032 (National Manufacturing Production)

$R^2 = .9$ $\quad$ n = 4

All coefficients are significant at the .05 level. The t - Statistic derived for this equation indicated that the Beta value (0.032) was significantly different from zero. This means that the equation is defined and specifies a true relationship between New Jersey's manufacturing production level and the Nation's manufacturing production level. Statistical analysis also indicated that the national value of production is a good predictor of New Jersey value of production. The next step was to relate production in the State of New Jersey to production in the Passaic River Basin Study Area (PRBSA). Again a linear relationship was postulated. Similar variables for the years 1967 through 1982 were used to test this relationship. The following is the resulting equation and its statistical validity.

PRBSA Manufacturing Production = 4883.1 + 0.318 (N.J. Man.Prod.)

$R^2 = .9 \qquad n = 4$

All coefficients are significant at the .05 level. The t - Statistic derived for this equation showed that the Beta value (0.318) was significantly different from zero. This also means that the equation is defined and specifies a true relationship between manufacturing production level in the Passaic River Basin Study Area and New Jersey's manufacturing production level.

Data collected for the Passaic River Basin Study Area from the Census of Manufacturers for New Jersey between 1967 and 1982 indicated that the value of new capital increased by 118%, output increased by 131%, the labor force declined by 13% and the number of establishments declined by 4%. Also, data collected for the floodplain from interviews indicated that of the total number of firms in the floodplain, over 50% of these firms have been in operation in this area for over 10 years. In fact, over 80% of these firms have been in operation in this area for over 5 years. Research also indicated that new firms came into the Study Area between 1967 and 1982. The electric and electronic industry (SIC Code 36) showed 26% numerical growth; paper and allied products (SIC Code 26) showed 60% numerical growth; fabricated metal products (SIC Code 34) showed 17% numerical growth; the chemical industry (SIC Code 28) showed 15% numerical growth; and instruments and related products (SIC Code 38) showed 62% numerical growth. This means that the decline in number of establishments in the Passaic River Basin Study Area between 1967 and 1982 was not specific to the floodplain. The decline in the labor force and the total number of establishments, along with the increase in output and the value of new capital clearly indicates that capital deepening took place in the study area between 1967 and 1982.

The industrial complexion of the Passaic River Basin is very similar to that of the floodplain. Research shows that of the 867 industrial firms that are located in the floodplain, 10% belong to fabricated metal products industry (SIC Code 34); 3% belong to the paper and allied product industry (SIC Code 26); 3% belong to the instruments and related product industry (SIC Code 38); 9% belong to the chemical industry (SIC Code 28); 2% belong to the textile industry (SIC Code 22); and another 2% belong to the transportation industry (SIC Code 37). This distribution of firms over time in the floodplain mirrors the distribution of firms in the Passaic River Basin Study Area. Therefore, if firms over time are to remain in operation they must remain competitive. Since they not only continue to operate but have maintained their overall standing vis a vis non-floodplain industries, they must be changing at a rate comparable to growth of firms in the study area. Furthermore, because firms in the study area have experienced capital deepening as defined in preceding paragraphs, similar firms in the floodplain will also experience capital deepening. If existing firms in the floodplain are to remain competitive given changes in technology, they must upgrade their productive facilities to match those of other firms within the study area. The fact that the floodplain totals have remained consistent over the years is a clear indication that new firms have entered and existing firms have improved their technology, at the same rate as firms in the study area.

Internal growth was defined as the extent to which capital deepening and the resulting increases in the quantities of raw materials, goods in process, and finished goods within the existing plant were taking place. In the floodplain over 70% of industrial damage is allocated to damages to raw materials, goods in process and finished goods. It is reasonable to expect that as capital deepening takes place in the floodplain the real value of industrial damages will rise. This statement gains strength when the results of interviews of firms in the floodplain are analyzed. Over 95% of all the firms interviewed indicated that floodproofing does not take place as a result of the threat of future flooding. In fact, these same firms indicated that they would continue to modernize due to the fact that the marginal cost of reducing flood hazard on an individual firm basis is greater than their individual marginal benefits of new investment. This confirms that firms have not responded to the threat of flooding in the past by refusing to modernize. Entrepreneurs are rational and are expected to act in a rational manner. This being so, there is no basis to postulate that they will change their past behavior in the future with the continued threat of flooding under without project condition.

It is reasonable to project increases in flood damages, by projecting increases in the amount of real value of industrial content and their damage susceptibility. In any economy, as internal growth takes place, the level of productivity rises. This increase in productivity gives rise to an increase in the value of production as more raw materials and capital are used. As the value of production increases so does the manufacturer's cost of materials and capital not consumed in production, which indicates that there is a direct relationship between industrial content and the value of production.

$$\text{PRBSA Industrial Content} = \frac{\text{Value of Production - Value Added}}{\text{(\# of Establishments)}}$$

The above definition of industrial content represents the average individual manufacturer's cost of materials and capital not consumed in production and is a reasonably good proxy measure of industrial content. Time series data from New Jersey Census of Manufacturers for the years 1967 through 1982 comprised the data base. The model resulted in the following equation:

$$\text{PRBSA Industrial Content} = -0.098925 + 0.000066\ \text{(PRBSA Manufacturing Production)}$$

$R^2 = .9 \quad n = 4$

All coefficients are significant at the .05 level. The t - Statistic derived for this equation indicates that the Beta value (0.000066) is significantly different from zero. The t - Statistic therefore indicates that the relationship between the Passaic River Basin Study Area industrial content and production in the Passaic River Basin Study Area is clearly defined, meaning that one can be used to explain the other. The independent variable is the Passaic River Basin Study Area value of production. The model indicates that industrial activity has been a good predictor of the value of industrial content for the individual firm.

Projected output for the manufacturing sector of the United States was not available, thus it was decided to use projections of either Gross Domestic Product (GDP), Gross National Product (GNP) or labor and proprietors' income for the manufacturing sector as a proxy for deriving a projected growth rate for manufacturing output. It is somewhat justified to look at GDP and GNP, as manufacturing output accounted for 20% of GDP and GNP for the United States in 1978.

Projections of Gross National Product, Gross Domestic Product, and labor and proprietors' income for the manufacturing sector, for the United States for the period 1978 to 2030, were reviewed with the specific intention of finding growth rates for the respective categories over this period (BEA Regional Projections, 1980 OBERS Volume 1, U.S. Department of Commerce). It was found that between 1978 and 2030 GNP and GDP would grow by 2.6% per annum, and labor and proprietors' income in the manufacturing sector would grow by 2.9%. The growth rate of 2.6% was adopted, and used to project the value of New Jersey's manufacturing production between the years 1982 and 2040 with 1982 serving as the index year. The projected value of New Jersey's manufacturing production was then used to find the value of the Study Area's manufacturing production for the year 2040. Based on the linear equation showing the relationship between manufacturing content and manufacturing production in the Study Area, the content value for the Study Area for the year 2040 was found. Applying the formula for continuous growth over a period, in this case 1982 to 2040, industrial content in the Study Area was calculated to grow at a rate of 2.7% per annum.

Capital deepening includes the replacement of outdated and less productive machinery with more sophisticated equipment. Capital deepening also includes the addition of sophisticated and in most cases more expensive equipment to the present capital stock. The use of more sophisticated and advanced equipment would result in an increase in the firm's productivity. This productivity is characterized by the firm's increased usage of raw materials, and increases in goods in process and finished goods within the existing plant per manufacturing period. To the extent that there is a direct relationship between industrial flood damages and industrial contents, future benefits from the execution of a project to alleviate flooding, will increase. This increase in flood damages is further strengthened by the fact that over 90% of the interviews of managers in the floodplain show that floodproofing does not increase as a result of capital deepening.

The previous analysis clearly indicates that firms in the floodplain are "extremely similar to" firms in the Passaic River Basin Study Area. The rate of growth of capital deepening for firms within the floodplain is consistent with the rate of growth of capital deepening for firms within the Passaic River Basin Study Area. Historically, internal growth in the flood-plain has taken place within the existing plant facilities either through intensification of capital and/or labor or utilization of more sophisticated and efficient means of production. Research on firms in the floodplain indicates that they are operating near full capacity. This means that the operational growth rate of firms in the floodplain is expected to be close to the calculated 2.7% specified in the preceding paragraphs. This trend is expected to continue in the future with or without a project. The average annual equivalent factor was tabulated to be 1.5.

HYDROPOWER

The existing potential for hydropower in the Basin has been considered only in the context of flood damage reduction. One potential multipurpose reservoir site has been identified in the Rockaway River Subbasin - Longwood Valley.

Consideration has been given to the potential of hydropower development in the formulation of plans, for example, tunnel plans were considered but found to be an unreliable source, therefore, not developable. No plans have been identified which would have hydropower benefits associated with them. However, in determining plan impacts we have considered the existing and planned hydropower facilities in the Basin.

NAVIGATION

Navigation benefits are not generated by any of the flood control alternatives. No further investigation of navigational benefits were therefore warranted by any of the flood control plans. The flood alternatives do not cause any adverse effect to the existing navigation system.

INDUCED DAMAGES

For reaches in the Lower Valley adjacent, downstream and upstream of the tunnel outlet, water levels would increase under Plan 30A and 30E conditions. Induced damages for the Wanaque River caused by levee encroachment would accrue when floodwaters exceeds the design level of protection of the levee system under Plans 30A and 30E conditions. Mitigation measures, involving increasing the heights of the proposed levees and floodwalls, to eliminate the effects of increased water levels, are recommended in these areas. Flood damages induced by Plans 30A and 30E for the Lower Valley and Wanaque River communities which have not been mitigated are external diseconomies to the project. A total of $4,013,700 in damages would be induced by the projects in the 22 reaches affected. Approximately $3,064,100 in damages were eliminated by mitigation works (see Table V-66). The remaining $946,600 unmitigated damages are considered an economic cost to Plans 30A and 30E. Mitigation and integral levee/floodwall benefit figures reflect totals net of induced damages eliminated. Total induced damages, induced damages eliminated and induced damages not eliminated calculations underwent greater economic refinement during the Detailed Stage 3 Planning analysis. To be consistent with benefit price levels for Plan 30E presented on Table V-73, damage figures were tabulated in October 1986 price levels at a 8-5/8% interest rate. Induced damage mitigation measures are discussed in greater detail in Plan Formulation, Appendix C, Section 10.

INTEREST DURING CONSTRUCTION

Interest during construction (IDC) is the cost of construction money invested in a project before the beginning of the period of economic analysis and before the accumulation of benefits by the project. Interest during construction costs are added to the project cost to determine investment costs. Average annual costs are determined based on investment costs which include IDC.

Planning Guidance Notebook (EP 1105-2-45, Paragraph 2-6, page 2-2) states that costs incurred during the construction period should be increased by adding compound interest at the applicable project interest rate from the date the expenditures are made to the beginning of the period of analysis (base year). For purposes of this study, construction expenditures are assumed to occur in equal monthly increments and interest is determined assuming that expenditures are made at mid-month.

Construction of the recommended plan is estimated to be completed in 7 years 6 months. This would include land acquisition relocations and alterations, channel excavation, tunnel, levee/floodwall construction, and implementation of environmental and aesthetic measures. Economic benefits are expected to begin to accrue for each increment upon completion of construction of the corresponding increment. The pre-base year benefits were estimated for each completed increment in advance of the base year using the Federal interest rate of 8-5/8%.

An example of a IDC calculation can be shown by the fellowing levee system cost computation. The Pinch Brook levee system located in reach 020144 would be constructed during the first 4 months of the total 90 months construction period. IDC generated during the 4 months would be approximately $23,700 for the levee system. Using the constant dollar theory, this amount is then brought forward to the base year with a single payment compound factor. Total IDC at the base year and total investment cost would be approximately $43,000 and $2,233,000, respectively for the Pinch Brook levee system. This method was applied to all plan systems that are operational prior to the base year.

BENEFIT SUMMARY

Total average annual equivalent benefits including future hydrologic considerations and the appropriate benefit categories discussed above for all potential plans of protection are shown on Table V-67. Annual benefits, annual cost, benefit-to-cost ratios and net benefits are presented on Tables V-68 - V-70. Residual damages are shown on Table V-71. Separable elements benefit/cost ratios for Plans 16A, 30A and 30E are discussed in Plan Formulation, Appendix C, Section 8 in October 1985 price levels at a 8-5/8% interest rate.

Benefits were updated to October 1986 price levels and a 8-5/8% interest rate to be consistent with Plan Formulation Appendix. Integral levee/floodwall and preservation benefits presented at October 1986 price levels differ from benefits presented at October 1985 price levels in that the former underwent greater economic refinement. Plan 30E benefit to cost ratio at a 10% Federal interest rate is displayed on Table V-72. Summary of Plan 30E benefits are displayed on Table V-73. As indicated on Table V-73, the comparison of average annual equivalent benefits, solely from flood damage reduction of $107,100,000 and the average annual cost of $85,500,000 would result in a benefit-to-cost ratio of 1.3 to 1 for Plan 30E.

SECTION 7. RISK AND UNCERTAINTY

RISK AND UNCERTAINTY ANALYSIS

Benefit to Cost Sensitivity. In the Comptroller General's report to the Senate Budget Committee entitled "Better Analysis of Uncertainty Needed for Water Resources Projects," June 2, 1978, major recommendations were made to help the Corps of Engineers and decision-makers understand the significance of uncertainty in its estimates of costs and benefits.

On July 12, 1978, the President directed the Water Resources Council to "carry out a thorough evaluation of current agency practices for examining benefit and cost calculations" and "publish a planning manual that will ensure that benefits and costs are estimated using the best current techniques, and calculated accurately, consistently and in compliance with the Principles and Standards and other applicable economic requirements." One of the items addressed in the President's directive was the "uncertainty and risk of costs and benefits" associated with Federal water resources planning. The final rules put forth by the Council describing the procedures for dealing with uncertainty were more general than specific. These rules were published as Section 713.31-41 in Subpart B (18 CFR 713) of Part IX of the Federal Register, September 14, 1979. The principal thrust of these rules established the need to account for risk and uncertainty in the evaluation of water resources planning, but were noticeably lacking in instructive detail.

Only recently has a concerted effort been initiated to develop the appropriate range of methods needed by Corps district planners to fulfill the requirements generally associated with risk analysis. On 8 February 1985 the Assistant Secretary of the Army for Civil Works asked the Chief of Enigneers to "develop a plan of action to provide guidance to field operating agencies on the use of Risk Evaluation Procedures appropriate to Corps programs." On 16 April 1986 the Director of Civil Works proposed a two pronged approach consisting of a program of formal guidance and a program methods development and training. With respect to field guidance a draft EC has been prepared, dated 29 June 1987 to transmit preliminary interim guidance for the application of risk and uncertainty analysis. The following sensitivity analyses have been conducted in accordance with recent guidance.

Data characterizing the elements that must be analyzed in water resources planning within the Passaic River Basin are both quantitative and qualitative in nature. The initial thrust in the sensitivity analysis is the identification of the elements that have the greatest potential impact upon the benefit to cost evaluation criteria. Once the significant elements have been identified, the factors and/or data which go into their assessment are determined. Those significant factors and/or data subject to risk and uncertainty and the source of that risk and uncertainty are then identified and the magnitude of the potential impact of change in the significant factors and/or data are indicated.

Regarding the assessment of risk and uncertainty, several steps were carried out in the conduct of this study.

It was determined that risk and uncertainty could be associated with three areas of work that might potentially affect project formulation and justification. They are:

1. projections of population and land use

2. projections of the affluence factor for residential contents

3. expected annual damage

It was decided to use the potential impact on decision rules as a criteria for measuring the significance of changes due to risk and/or uncertainty. Item (1) was analyzed with respect to its impact on the hydrologic and hydraulic results and by implication, the economic analysis. The potential changes due to risk and/or uncertainty in the decision criteria were not significant. A sensitivity analysis was carried out with regard to different assumptions concerning item (2) above and resulted in no significant changes in the affluence factor as a result. Item (3) was analyzed by altering benefits by factors of 10% and 25%. The impact of these changes on proposed plan benefit cost ratios was calculated and the effect on project justification was observed. Benefit to cost ratios were also calculated net of industrial contents growth to analyze benefit sensitivity. Again, the potential changes due to risk and/or uncertainty in the decision criteria were not significant. An example of this analysis is shown on Table V-74, V-75, and V-76.

In light of the risk and uncertainty analysis presented herein, Plan 30E remained clearly the plan which maximized net benefits.

TABLE V-1

PASSAIC RIVER BASIN MUNICIPALITIES

NEW JERSEY

BERGEN COUNTY

1. Allendale Borough
2. Carlstadt Borough
3. East Rutherford Borough
4. Elmwood Park Borough
5. Fair Lawn Borough
6. Franklin Lakes Borough
7. Garfield City
8. Glen Rock Borough
9. Hasbrouck Heights Borough
10. Hillsdale Borough
11. Hohokus Borough
12. Lodi Borough
13. Lyndhurst Township
14. Mahwah Township
15. Maywood Borough
16. Midland Park Borough
17. Montvale Borough
18. North Arlington Borough
19. Oakland Borough
20. Paramus Borough
21. Ramsey Borough
22. Ridgewood Village
23. Rochelle Park Township
24. Rutherford Borough
25. Saddle Brook Township
26. Saddle River Borough
27. South Hackensack Township
28. Upper Saddle River Borough
29. Waldwick Borough
30. Wallington Borough
31. Washington Township
32. Woodcliff Lake Borough
33. Woodridge Borough
34. Wyckoff Township

ESSEX COUNTY

35. Belleville Town
36. Bloomfield Town
37. Caldwell Borough
38. Cedar Grove Township
39. East Orange City
40. Essex Falls Borough
41. Fairfield Borough
42. Glen Ridge Borough
43. Livingston Township
44. Millburn Township
45. Montclair Township
46. Newark City
47. North Caldwell Borough
48. Nutley Town
49. Orange City
50. Roseland Borough
51. Verona Borough
52. West Caldwell Borough
53. West Orange Town

HUDSON COUNTY

54. East Newark Borough
55. Harrison Town
56. Kearny Town

MORRIS COUNTY

57. Boonton Town
58. Boonton Township
59. Butler Borough
60. Chatham Borough
69. Chatham Township
70. Denville Township
71. Dover Town
72. East Hanover Township
73. Florham Park Borough
74. Hanover Township
75. Harding Township
76. Jefferson Township
77. Kinnelon Borough
78. Lincoln Park Borough
79. Madison Borough
80. Mendham Borough
81. Mendham Township
82. Mine Hill Township
83. Montville Township
84. Morris Township
85. Morris Plains Borough
86. Morristown Town
87. Mountain Lakes Borough
88. Mount Arlington Borough
89. Parsippany-Troy Hills Township
90. Passaic Township
91. Pequannock Township
92. Randolph Township
93. Riverdale Borough
94. Rockaway Borough
95. Rockaway Township
96. Roxbury Township
97. Victory Gardens Borough
98. Wharton Borough

PASSAIC COUNTY

99. Bloomingdale Borough
100. Clifton City
101. Haledon Borough
102. Hawthorne Borough
103. Little Falls Township
104. North Haledon Borough
105. Passaic City
106. Paterson City
107. Pompton Lakes Borough
108. Prospect Park Borough
109. Ringwood Borough
110. Totowa Borough
111. Wanaque Borough
112. Wayne Township
113. West Milford Town
114. West Paterson Borough

SOMERSET COUNTY

115. Bernards Township
116. Bernardsville Borough
117. Bridgewater Township
118. Far Hills Borough
119. Warren Township

SUSSEX COUNTY

120. Hardyston Township
121. Sparta Township
122. Vernon Township

UNION COUNTY

123. Berkeley Heights Township
124. New Providence Borough
125. Summit City

NEW YORK

ORANGE COUNTY

60. Greenwood Lake Village
61. Harriman Village
62. Monroe Town
63. Monroe Village
64. Tuxedo Town
65. Tuxedo Park Village
66. Warwick Town
67. Woodbury Town

ROCKLAND COUNTY

126. Haverstraw Town
127. Hillburn Village
128. Ramapo Town
129. Sloatsburg Village
130. Spring Valley Village
131. Stony Point
132. Suffern Village

TABLE V-2

POPULATION CHARACTERISTICS
PASSAIC RIVER BASIN STUDY AREA COUNTIES

COUNTY 1/	1950 2/	1960	1950-1960 % Change	1970	1960-1970 % Change	1980	1970-1980 % Change	1950-1980 %Change
BERGEN	294,455	431,882	47	505,746	17	467,905	-7	59
ESSEX	804,411	824,014	2	828,340	.5	750,144	-9	-7
HUDSON	55,615	51,087	-8	51,318	.4	49,900	-3	-10
MORRIS	155,292	248,537	60	357,676	44	367,292	3	137
PASSAIC	337,123	406,618	21	460,782	13	447,585	-3	33
SOMERSET	15,359	20,621	34	29,329	42	59,292	102	286
SUSSEX	5,848	11,078	89	20,377	84	34,188	68	485
UNION	21,309	42,641	100	50,494	18	46,046	-9	116
ORANGE	26,184	29,664	13	42,269	42	56,446	34	116
ROCKLAND	60,975	60,435	-.8	114,717	90	169,238	48	178
TOTAL	1,776,571	2,126,577	20	2,461,048	16	2,448,036	-.5	38

1/ County population totals are for communities within the Passaic River Basin.

2/ Population data for 1950 is available for 123 of the 132 communities in the Basin.

TABLE V-3

PER CAPITA INCOME FOR
PASSAIC RIVER BASIN COUNTIES

COUNTIES 1/	1970 2/	1980
BERGEN	9,349	10,462
ESSEX	10,270	10,566
HUDSON	7,027	6,850
MORRIS	9,342	10,463
PASSAIC	7,691	7,925
SOMERSET	10,423	14,351
SUSSEX	7,271	8,506
UNION	11,376	11,090
ORANGE	6,826	9,580
ROCKLAND	6,604	7,558
MEAN	8,618	9,735

1/ County per capita income figures are for communities within the Passaic River Basin.

2/ Per capita figures for 1970 were available for 115 of the 132 communities in the Basin. Figures are in 1979 dollars.

TABLE V-4

Activities in New Jersey Counties

County	Most Popular Activity (Number of User Days)	Second Most Popular Activity (Number of User Days)
Bergen	Bicycling (260,000)	Swimming (149,000)
Essex	Bicycling (257,000)	Swimming (142,200)
Hudson	Bicycling (167,800)	Swimming (90,900)
Morris	Bicycling (119,600)	Ice Skating (105,400)
Passaic	Bicycling (132,900)	Ice Skating (115,300)
Somerset	Bicycling (60,300)	Swimming (38,400)
Sussex	Downhill Skiing (297,600)	Bicycling (25,100)
Union	Bicycling (155,500)	Swimming (89,000)

TABLE V-5

Passaic River Flood Study

Characteristics Obtained in Windshield Survey

Symbol	Description	Structure Category: Res.	Comm.	Ind.	Util.	Res. Apts.
TY	Type	x	x	x	x	x
TN	Town	x	x	x	x	x
BA	Bank	x	x	x	x	x
MP	Map	x	x	x	x	x
SN	Stream	x	x	x	x	x
BS	Basement	x	x	x	x	x
FD	Foundation	x	x	x	x	x
AT	Attic	x				
GA	Garage	x				x
SR	Structure Type	x				x
EX	Exterior	x	x	x	x	x
ST	Stories	x	x	x	x	x
OS	Outside Structures	x	x	x	x	x
AD	Address	x	x	x	x	x
CL	Class	x	x			x
AG	Age	x	x	x		x
VL	Value	x	x	x	x	x
MF	Main Floor (MSL)	x	x	x	x	x
LO	Low Opening	x	x	x	x	x
SZ	Size	x	x	x	x	
MA	Maintenance	x	x			x
GO	Garage Opening (MSL)	x	x			x
SC	Strip Development		x			
SI	Strip Index		x			
MU	Municipality		x			
US	Usage		x	x	x	
OO	Owner/Occupant		x	x	x	
BN	Building Number			x	x	
UI	Units on First Floor					x
UT	Total Units					x

TABLE V-6

Passaic River Flood Study

Total Residential Structures in Rockaway Subbasin

Structure Type	Number
Colonial	550
Cape Cod	303
Ranch	206
Split-level	121
Two-family	93
Duplex	76
Bi-level	75
Bungalow	47
Multi-dwelling	30
Raised Ranch	22
Tudor	11
Custom	3
Converted Barn	2
Frame	2
Garage	2
Log House	1
Total	1,544

TABLE V-7

Passaic River Flood Study

Summary of Rockaway Pilot Survey

Structure Type	Total Number of Houses	Highest Subgroup Coefficient of Variation	Required Sample Size: Estimated for Accuracy	Required Sample Size: Required for Small Subgroups	Required Sample Size: Total
Colonial	550	.167	45	5	50
Cape Cod	303	.141	32	7	39
Ranch	206	.161	41	2	43
Split Level	121	.132	28	2	30
Two-family	93	.178	26(A)	4	30
Duplex	76	.079	10	1	11
Bi-level	75	.090	13	1	14
Bungalow	47	.241	23(B)	-	23
Multi-family	30	.103	9(A)	2	11
Raised Ranch	22	.174	12(B)	2	14
Total	1,523		239	26	265

Note: (A) For 95% ± 7% accuracy.

(B) For 95% ± 10% accuracy.

TABLE V-8

RESIDENTIAL STRUCTURES - ROCKAWAY PILOT SURVEY
CORRELATION COEFFICIENTS: HOUSE VALUES WITH DAMAGES
ALL STRUCTURES

Flood Level	Structural Damages	Content Damages	Other Damages
Main Floor	.460	.273	.405
Main Floor +1'	.529	.383	.426
Main Floor +2'	.534	.420	.435
Main Floor +5'	.584	.401	.482
Main Floor +9'	.632	.436	.495
Main Floor +15'	.647	.596	.515

TABLE V-9

ROCKAWAY PILOT STUDY
RESIDENTIAL STRUCTURES
CORRELATION COEFFICIENTS-STRUCTURE VALUES WITH DAMAGES
STRUCTURES GROUPED BY TYPE

STRUCTURE TYPE	MAIN FLOOR	MAIN FLOOR +1'	MAIN FLOOR +2'	MAIN FLOOR +5'	MAIN FLOOR +9'	MAIN FLOOR +15'
	STRUCTURE VALUES WITH STRUCTURAL DAMAGE					
BI-LEVEL	0.656	0.834	0.821	0.843	0.818	0.831
BUNGALOW	-0.550	-0.251	-0.202	-0.095	0.029	0.103
CAPE	0.240	0.505	0.503	0.536	0.501	0.574
COLONIAL	0.318	0.619	0.634	0.656	0.685	0.680
DUPLEX	0.222	0.261	0.266	0.285	0.394	0.628
MULTI-FAMILY	0.948	0.795	0.815	0.844	0.350	0.793
RAISED RANCH	0.631	0.595	0.599	0.616	0.616	0.616
RANCH	0.389	0.772	0.771	0.786	0.800	0.773
SPLIT LEVEL	0.607	0.455	0.475	0.338	0.413	0.384
TWO-FAMILY	0.237	-0.308	0.371	-0.320	-0.227	0.174
	STRUCTURE VALUES WITH CONTENT DAMAGES					
BI-LEVEL	-0.049	-0.181	-0.110	-0.067	-0.087	-0.095
BUNGALOW	-0.409	-0.300	-0.192	0.023	-0.006	0.013
CAPE	-0.115	0.264	0.280	0.332	0.311	0.353
COLONIAL	0.084	0.397	0.624	0.675	0.689	0.799
DUPLEX	0.251	0.088	-0.006	0.007	-0.001	0.508
MULTI-FAMILY	0.928	0.793	0.749	0.582	0.650	0.500
RAISED RANCH	0.526	0.572	0.574	0.529	0.535	0.550
RANCH	0.250	0.502	0.607	0.682	0.681	0.674
SPLIT LEVEL	0.575	0.601	0.707	0.579	0.679	0.633
TWO-FAMILY	0.335	-0.301	-0.463	-0.457	-0.537	0.107
	STRUCTURE VALUES WITH OTHER DAMAGES					
BI-LEVEL	0.314	0.257	0.171	0.145	0.097	0.094
BUNGALOW	0.351	0.307	0.280	0.113	0.116	0.151
CAPE	0.059	0.091	0.264	0.409	0.409	0.400
COLONIAL	0.270	0.368	0.451	0.503	0.495	0.482
DUPLEX	0.217	0.129	0.055	0.115	0.142	0.201
MULTI-FAMILY	0.137	0.251	0.360	0.638	0.691	0.728
RAISED RANCH	0.292	0.294	0.313	0.326	0.352	0.360
RANCH	0.342	0.397	0.509	0.525	0.531	0.568
SPLIT LEVEL	0.663	0.655	0.653	0.627	0.628	0.598
TWO-FAMILY	0.259	0.134	-0.086	-0.032	0.029	0.219

TABLE V-10

PASSAIC RIVER FULL SURVEY
RESIDENTIAL INTERVIEW SCHEDULES

RESIDENTIAL STRUCTURE TYPE	#INTERVIEWS ROCKAWAY PILOT STUDY	NUMBER OF FULL SURVEY INTERVIEWS BASED ON PILOT STUDY #INTERVIEWS/STRUCTURE TYPE / TOTAL #INTERVIEWS ON ROCKAWAY X 1600
BARN	0	NA
BI-LEVEL	14	84
BUNGALOW	18	108
CAPE	39	232
COLONIAL	35	208
CUSTOM	0	NA
DUPLEX	21	125
FRAME	0	NA
MOBILE	0	NA
RAISED RANCH	14	83
MULTI-FAMILY	13	78
RANCH	53	316
SPLIT	30	179
SHACK	0	NA
TUDOR	0	NA
TWO-FAMILY	31	185
GARAGE	0	NA
TOTAL	268	1598

TABLE V-11

PASSAIC RIVER FULL SURVEY
NUMBER OF RESIDENTIAL STRUCTURES ACTUALLY
SURVEYED BY GROUP

STRUCTURE GROUP	NUMBER OF STRUCTURES TOTAL	SURVEYED
CAPE	12512	470
COLONIAL	9011	324
RANCH	6372	291
SPLIT	4443	178
TWO-FAMILY	2636	129
BI-LEVEL	2624	102
MOBILE	352	19
SUBTOTAL	37950	1513
BUNGALOW	929	71
RAISED RANCH	578	43
MULTI-FAMILY	524	30
DUPLEX	331	35
TUDOR	129	3
FRAME	125	2
GARAGE	32	0
CUSTOM	31	4
SHACK	25	0
OTHER	20	0
SUBTOTAL	2724	188
TOTAL	40674	1701

TABLE V-12

PASSAIC RIVER FULL SURVEY
UTILITY INTERVIEW GROUPING

USAGE	NO. OF INTERVIEWS
Gas Production	1
Water Treatment	1
Tanks and Water Tanks	1
Gas Structures	1
Sub-stations	1
Pumps	8
Wells	4
Chlorine	7
Sewage Treatment Plant	6
Miscellaneous Electric	5

	35

TABLE V-13

Passaic River Full Survey

SUMMARY OF RESIDENTIAL STRUCTURES IN PASSAIC RIVER BASIN

Structure Group	Number of Structures		Structure Value			Content Value		
	Total	Surveyed	Average	Total (thousands)	Percent of Total	Average	Total (thousands)	Percent of Total
Cape	12,512	470	$52,300	$ 654,378	27.8%	$19,200	$240,230	29.0%
Colonial	9,011	324	64,400	580,308	24.7	21,100	190,132	22.9
Ranch	6,372	291	52,800	336,442	14.3	18,000	114,696	13.8
Split	4,443	178	66,200	294,127	12.4	22,600	100,412	12.1
Two-family	2,636	129	60,500	159,478	6.8	25,000	65,900	7.9
Bi-level	2,624	102	71,100	186,566	7.9	24,000	62,976	7.6
Mobile	352	19	12,700	4,470	0.2	8,600	3,027	0.4
SUBTOTAL	37,950	1,513	$58,400	$2,215,769	94.2%	$20,500	$777,373	93.7%
Bungalow	929	71	$29,100	$ 27,034	1.2%	$12,800	$ 11,891	1.4%
Raised Ranch	578	43	52,800	30,518	1.3	19,300	11,155	1.3
Multi-family	524	30	71,500	37,466	1.6	30,000	15,720	1.9
Duplex	331	35	61,700	20,423	0.9	22,700	7,514	0.9
Tudor	129	3	72,700	9,378	0.4	21,300	2,748	0.3
Frame	125	2	44,000	5,500	0.2	11,700	1,462	0.2
Garage	32	-	10,000(E)	320	-	2,000(E)	64	-
Custom	31	4	73,500	2,278	0.1	31,700	983	0.1
Shack	25	-	10,000(E)	250	-	2,000(E)	50	-
Other	20	-	57,800(E)	1,156	0.1	20,400(E)	408	0.1
SUBTOTAL	2,724	188	$49,300	$ 134,323	5.8%	$19,100	$ 51,995	6.3
TOTAL	40,674	1,701	$57,800	$2,350,092	100.0%	$20,400	$829,368	100.0%

Note: (E) Estimated.

TABLE V-14

Grouping of Residential Structures
Based on 'T' and 'F' Scores
From Full Survey

Structure Combination	Structural Damages Main Floor +1'	Structural Damages Main Floor +15'	Content Damages Main Floor +1'	Content Damages Main Floor +15'	Other Damages Main Floor +1'	Other Damages Main Floor +15'
(1) two-structure types based on 'T' test						
Raised Ranch and Bi-level	.265	.390	1.775	2.918	2.809	.724
Bungalow and Ranch	.987	4.543	3.108	6.172	1.434	6.867
Multi-family and Two-family	.191	2.428	.344	.379	.823	4.246
Duplex and Two-family	.132	.294	.589	2.064	.481	1.938
Duplex and Multi-family	.065	1.811	.830	2.051	.852	4.224
Cape and Colonial	5.600	1.377	8.465	5.684	3.963	6.035
(2) three-structure types based on 'F' test						
Multi-family, Duplex and Two-family	.030	3.250	.350	2.490	.550	12.150

TABLE V-15

Passaic River Full Survey

SUMMARY OF MEAN DAMAGES AS A PERCENT OF STRUCTURE VALUE AT MAIN FLOOR +2' FOR COLONIAL RESIDENTIAL STRUCTURES[(A)]

	Damages		
	Structural	Content	Others
Mean	19.18%	11.92%	9.96%
Standard Deviation	6.86	4.73	4.41
Coefficient of Variation	35.79	39.67	44.31
Standard Error	.38	.26	2.46

Note: (A) 324 structures were included in the survey.

TABLE V-16
Values of Regression Coefficients
For Passaic River Basin Full Survey
Residential Structure Characteristics

Type of Damages	Regression Equations With Y Intercept		Regression Equations With No Y Intercept	
Level Equations	Stepwise (1)	Lvl, Lo, Age (2)	Stepwise (3)	Lvl, Lo, Age (4)
Structural Damages				
MF − 7′	.031	.025	.055	.065
MF − 3′	.060	.066	.254	.259
MF	.093	.020	.714	.695
MF + 1′	.142	.069	.885	.877
MF + 5′	.147	.082	.920	.915
MF +15′	.146	.071	.935	.931
Content Damages				
MF − 7′	.016	.021	.098	.099
MF − 3′	.115	.115	.275	.274
MF	.078	.040	.520	.505
MF + 1′	.099	.050	.828	.823
MF + 5′	.105	.075	.883	.883
MF +15′	.130	.108	.926	.926
Other Damages				
MF − 7′	.117	.124	.163	.160
MF − 3′	.219	.212	.394	.389
MF	.159	.087	.768	.751
MF + 1′	.145	.067	.809	.799
MF + 5′	.126	.084	.894	.890
MF +15′	.224	.175	.926	.924

TABLE V-17

Passaic River Full Survey

ESTIMATED DAMAGES CALCULATED BY ALTERNATIVE METHODS FOR AVERAGE VALUE COLONIAL STRUCTURES AT MAIN FLOOR ELEVATION

Method of Calculation	Structural Damages	Content Damages	Other Damages
Mean Value	$ 3,543	$ 1,932	$ 4,122
Regression Equation with Y Intercept			
Stepwise	3,607	1,997	4,187
Value, Age, Low Opening	3,670	2,061	4,251
Regression Equation without Y Intercept			
Stepwise	2,577	1,546	1,610
Value, Age, Low Opening	4,058	2,061	4,251

TABLE V-18

Rockaway Pilot Study - Selected Commercial Content Damage as a Percent of Content Value

USE	NAME	INV	Content Value	Content Damage at MF+15 as % Total Content Value
CRAFT SHOP	ONE MANS HAND	MED	49000	0.832500
OFFICES	HANOVER RESEARCH CORP	OFF	73500	0.833333
TRAVEL AGY	TOWN & COUNTRY TRAVEL	OFF	169000	0.833333
TRUCK TERM	SANBORN'S MOTOR EXPRESS	HGH	689000	0.833333
TRUCK TERM	HEINZ	HGH	8100000	0.834018
MEDICAL	SEARLE OPTICAL LABORATORY	HGH	359000	0.834133
GAS STA	MOBIL	MED	76000	0.834545
OFFICES	A&W SCHOLZ REAL ESTATE	OFF	117000	0.836000
FURNITURE	BEDROOM STUFF	HGH	200000	0.836667
FURNITURE	SPANISH VILLAGE	HGH	100000	0.840000
CAMERA	FOTOMAT	HGH	6000	0.841667
LIQUOR	BERKELEY HTS LIQUORS	HGH	173000	0.842500
RET HARDWR	SACKS	HGH	257000	0.846154
GAS STAT	SHELL	MED	43000	0.847328
CLOTHING	OFO	MED	360000	0.847433
OFFICES	ALAN V MOLNER REAL ESTATE INC	OFF	143000	0.850000
RESTAURANT	LA VALLE RESTAURANT	MED	67000	0.850000
STORE	REBCO FABRIC SHOP	MED	462000	0.850000
AUTO PARTS	SPEEDWAY HUT O STORE	MED	137000	0.852000
GROCERY	ELLEN HOS ORIENTAL GROCERY	HGH	33000	0.853333
HALL	AMERICAN LEGION	MED	93000	0.854067
FOOD STORE	VALLEY SPA	HGH	72000	0.855000
HALL	K OF C	MED	178000	0.857143
AUTO REPAR	HADLEYS AUTO REPAIR	HGH	77000	0.860000
MEDICAL	CHARLES TAHLEE & SON	HGH	111000	0.860000
SHOE STORE	FLORHAM IMPORTED SHOES	MED	60000	0.860000
FURNITURE	MIKES AUCTION	HGH	170000	0.861111
AIRPORT	LINCOLN PARK AIRPORT	HGH	761000	0.862500
VACANT	SALVATION ARMY THRIFT STORE	MED	525000	0.862857
ELEC SALES	RADIO SHACK	HGH	170000	0.863158
RESTAURANT	TOP BURGER	MED	220000	0.863333
SERV ST	EXXON	MED	100000	0.865625
OF/WARE	LYNDALE BEVERAGE CENTER	HGH	375000	0.866500
HARDWARE	N JERSEY PLUMBING AND HEATING	HGH	61000	0.866667
PORK STORE	FARM VIEW PORK STONE	MED	98000	0.866667
SUPER MKT	ARNOLD THRIFT MART	HGH	65000	0.866667
CAMERA SH	CHRIS CAMERA CENTER	HGH	93000	0.868000
OFFICES	WILLIAM COPELAND & SONS	OFF	23000	0.869333
HAIR SALON	GEMORE'S BOUTIQUE	MED	61000	0.870000
OFFICES	RJM ASSOC ADVERTISING	OFF	42000	0.875000
LUNCHEONET	COSMOS COFFEE SHOP	MED	114000	0.876000
OFFICES	HARRIS LUMBER	OFF	193000	0.877500
GIFT SHOP	MID-TOWN CENTRE	MED	63000	0.880000
RESTAURANT	FIRE SIDE INN	MED	720000	0.881967
OFFICES	FRANK TAIBI & SONS FUEL OIL	OFF	195000	0.883333
SHOE ST	PAL SHOES	MED	50000	0.883333
COPY CENTE	NORTH JERSEY COPY CENTER	HGH	135000	0.884000
CONST CO	DEHNER BROS GEN CONTRACTORS	MED	30000	0.884615
FLORIST	LITTLE FALLES FLORIST	MED	72000	0.885714
WELDING	A&E WELDING CO	HGH	77000	0.886538
DEPT STORE	MCCRORY	HGH	591000	0.887069
PHOTO	PHOTO PLAZA	HGH	6000	0.888000
STEREO	MIKES MUSIC CENTER	HGH	51000	0.888333
GAS STA	EXXON GAS STATION	MED	82000	0.888889

TABLE V-19

PASSAIC RIVER FULL SURVEY
STATISTICAL SUMMARY - COMMERCIAL STRUCTURES GROUPS

STRUCTURAL DAMAGES AT MAIN FLOOR AS PERCENT OF STRUCTURE VALUE

GROUP	TOTAL NUMBER IN BASIN	DAMAGES AT NUMBER IN SAMPLE	MEAN	STANDARD ERROR	STANDARD ERROR/ MEAN	STANDARD ERROR/ MEAN
HIGH	2320	277	0.62	0.103	16.7	278.9
MEDIUM	2933	309	1.51	0.225	14.9	222
OFFICE	998	113	1.8	0.546	30.3	918.1
						1419
					(SUM/X)	473
1	510	70	0.48	0.142	29.7	882.1
2	789	73	0.37	0.137	37.4	1398.8
3	668	71	2.58	0.872	33.8	1142.4
4	948	101	1.46	0.434	29.7	882.1
5	817	87	1.55	0.451	29.1	846.8
6	752	78	1.31	0.332	25.3	640.1
7	854	75	0.9	0.348	38.7	1497.7
8	334	73	1.22	0.301	24.7	610.1
9	246	74	0.76	0.239	31.4	986
10	333	49	0.89	0.387	43.4	1883.6
					SUM	10769.7
						X .3 *
						323.1

*ADJUSTMENTS FOR SMALL SAMPLE SIZE

TABLE V-20

PASSAIC RIVER FULL SURVEY
STATISTICAL SUMMARY-COMMERCIAL STRUCTURES 1-STORY

ELEVATION	N	SUM	MEAN	STANDARD DEVIATION	C.V.	STD ERROR OF MEAN
MF -16	509	0.00000000	0.00000000	0.00000000		0.00000000
MF -15	509	0.00442338	0.00000869	0.00019606	2256.103	0.00000869
MF -14	509	0.00803430	0.00001578	0.00035611	2256.103	0.00001578
MF -13	509	0.00972048	0.00001910	0.00043085	2256.103	0.00001910
MF -12	509	0.01140665	0.00002241	0.00050559	2256.103	0.00002241
MF -11	509	0.03430699	0.00006740	0.00110399	1637.953	0.00004893
MF -10	509	0.05478125	0.00010763	0.00188900	1755.163	0.00008373
MF -9	509	0.12641181	0.00024835	0.00266409	1072.704	0.00011808
MF -8	509	0.16865741	0.00033135	0.00300330	906.382	0.00013312
MF -7	509	0.65365972	0.00128420	0.00894815	696.786	0.00039662
MF -6	509	1.02557788	0.00201489	0.01349428	669.729	0.00059812
MF -5	509	1.29560011	0.00254538	0.01643493	645.676	0.00072847
MF -4	509	1.52120256	0.00298861	0.01827387	611.450	0.00080997
MF -3	509	1.85347744	0.00364141	0.02048731	562.620	0.00090808
MF -2	509	2.38352606	0.00468276	0.02353259	502.537	0.00104306
MF -1	509	3.11712247	0.00612401	0.02760318	450.737	0.00122349
MAIN FLOOR	509	4.26243665	0.00837414	0.03347797	399.778	0.00148389
MF +1	509	39.61791379	0.07783480	0.07056929	90.665	0.00312793
MF +2	509	45.73042386	0.08984366	0.07639042	85.026	0.00338595
MF +3	509	52.17229696	0.10249960	0.08120091	79.221	0.00359917
MF +4	509	58.61417007	0.11515554	0.08804774	76.460	0.00390265
MF +5	509	65.05604318	0.12781148	0.09649841	75.501	0.00427722
MF +6	509	67.55613558	0.13272325	0.09934664	74.852	0.00440346
MF +7	509	70.05622798	0.13763503	0.10250516	74.476	0.00454346
MF +8	509	72.55602039	0.14254680	0.10594623	74.324	0.00469598
MF +9	509	75.05641279	0.14745857	0.10964325	74.355	0.00485985
MF +10	509	77.79676027	0.15284236	0.11235910	73.513	0.00498023
MF +11	509	80.53710775	0.15822614	0.11551742	73.008	0.00512022
MF +12	509	83.27745524	0.16360993	0.11908301	72.785	0.00527826
MF +13	509	86.01780272	0.16899372	0.12302045	72.796	0.00545279
MF +14	509	88.75815020	0.17437751	0.12729525	73.000	0.00564226
MF +15	509	91.49849768	0.17976129	0.13187461	73.361	0.00584524

TABLE V-21

PASSAIC RIVER FULL SURVEY
STATISTICAL SUMMARY-COMMERCIAL STRUCTURES 2-STORY

ELEVATION	N	SUM	MEAN	STANDARD DEVIATION	C.V.	STD ERROR OF MEAN
MF -16	188	0.00184834	0.00000983	0.00013480	1371.131	0.00000983
MF -15	188	0.00488152	0.00002597	0.00035602	1371.131	0.00002597
MF -14	188	0.05977304	0.00317940	0.00394771	1241.644	0.00028792
MF -13	188	0.08385480	0.00044604	0.00458184	1027.234	0.00033416
MF -12	188	0.10290924	0.00054739	0.00532358	972.540	0.00038826
MF -11	188	0.12101879	0.00064372	0.00590349	917.094	0.00043056
MF -10	188	0.13531013	0.00071973	0.00648366	900.841	0.00047287
MF -9	188	0.27736052	0.00147532	0.00868185	588.471	0.00063319
MF -8	188	0.31043175	0.00165123	0.00933747	565.485	0.00068101
MF -7	188	0.59706735	0.00317589	0.01288704	405.777	0.00093988
MF -6	188	0.77449541	0.00411966	0.01503671	364.999	0.00109666
MF -5	188	0.94168592	0.00500897	0.01643769	328.165	0.00119884
MF -4	188	1.08037077	0.00574665	0.01809446	314.869	0.00131967
MF -3	188	1.30947408	0.00696529	0.02017587	289.663	0.00147148
MF -2	188	1.69083244	0.00899379	0.02309605	256.800	0.00168445
MF -1	188	2.22498919	0.01183505	0.02659551	224.718	0.00193968
MAIN FLOOR	188	3.03926642	0.01616631	0.03095835	191.499	0.00225787
MF +1	188	17.38431546	0.09246976	0.09087757	98.278	0.00662793
MF +2	188	18.89731030	0.10051761	0.09343069	92.950	0.00681413
MF +3	188	20.57647582	0.10944934	0.09673865	88.387	0.00705539
MF +4	188	22.25564133	0.11838107	0.10104533	85.356	0.00736949
MF +5	188	23.93480684	0.12731280	0.10622931	83.440	0.00774757
MF +6	188	24.87954606	0.13233801	0.11016266	83.243	0.00803444
MF +7	188	25.82428528	0.13736322	0.11444162	83.313	0.00834651
MF +8	188	26.76902451	0.14238843	0.11902893	83.595	0.00888108
MF +9	188	27.71376373	0.14741364	0.12389033	84.043	0.00903563
MF +10	188	33.04490244	0.17577076	0.26821459	152.593	0.01956156
MF +11	188	38.37604115	0.20412788	0.48912060	239.615	0.03567279
MF +12	188	43.70717986	0.23248500	0.71919991	309.353	0.05245304
MF +13	188	49.03831856	0.26084212	0.95182335	364.904	0.06941885
MF +14	188	54.36945727	0.28919924	1.18549421	409.923	0.08646105
MF +15	188	59.70059598	0.31755636	1.41969536	447.069	0.10354193

TABLE V-22

Passaic River Study Commercial Content Damage Function Groups

1.	Schools, construciton, garages, fire stations, medical, police, recreation bldgs., train/bus stations, pump house, travel agency, DPW, used cars.
2.	Animal shelter, auto body, florist, funeral home, jeweler, lab, laundromat, service station.
3.	Auto parts, barber shop, bike shop, candy store, gas station, hardware, motorcycle, photo store, realty, sport store.
4.	Offices.
5.	Auto sales, bar & grill, cleaners, furniture store, plumbing, post office, printers, restaurant, tool shop.
6.	Caterer, church, coffee shop, food store, liquor store, maintenance shop, motel, office/warehouse, retail goods, snack bar, supermarket, tire sales.
7.	Beauty salon, dairy store, deli store, drugstore, electronics, ice cream shop, paints, warehouse.
8.	Antiques, bookstore, copy center, general store, gift store, health club, shoe store.
9.	Clothes, department store, truck center, pet care.
10.	Appliances, art supply, card shop, doctor's office, fabric store, garden ship, grocery, hobby center, music supply, toy store.

TABLE V-23

Passaic River Study Damage Function Groupings

Residential Damage Functions*

Bi-level
Cape
Colonial
Mobile Home
Other
Ranch
Split
Two-family

Commercial Damage Functions

Contents	- Groups 1-10 With and Without Basements
Structure	- With and Without Basements
Other	- With and Without Basements

*For each Group 3 damage functions (Structure, Content and Other) were developed.

TABLE V-24

Passaic River Damage Function Groupings

Apartment Damage Functions*

Garden Apartments
High Rise Apartments

Utility Damage Functions*

Chlorination Plant
Electric Substations
Gas Metering
Gas Production
Pump House
Sewerage Treatment Plant
Tanks and Water Tanks
Water Treatment
Water Well

Industrial Damage Functions*

Book Manufacturing
Chemical Manufacturing
Clothes Manufacturing
Contractor
Cosmetic Manufacturing
Dyes
Electronic Manufacturing
Engine Manufacturing
Finishing
Food Manufacturing
Foundry
Fuel Storage (Industrial)
Garage (Industrial)
Industrial Auto Body
Industrial Office
Lab (Industrial)
Light Industry
Machine Shop
Manufacturing
Metals
Office/Manufacturing
Office/Warehouse
Other
Packing
Paint Manufacturing
Paper Manufacturing
Plastic Manufacturing
Printing
Sheetmetal
Steel Fabrication
Textiles
Tool and Die
Trucking
Warehouse
Workshop

*For each Group 3 damage function (Structure, Content and Other) were developed.

TABLE V-25

BASE CONDITION DEVELOPMENT FOR STUDY AREAS

TYPE OF STRUCTURES	100 YEAR FLOODPLAIN	500 YEAR FLOODPLAIN
	LOWER PASSAIC	
RESIDENTIAL	5,267	6,103
NON-RESIDENTIAL *	1,770	1,881
TOTAL	7,037	7,984
	CENTRAL PASSAIC	
RESIDENTIAL	4,149	5,683
NON-RESIDENTIAL *	1,407	1,593
TOTAL	5,556	7,276
	UPPER PASSAIC	
RESIDENTIAL	870	1,089
NON-RESIDENTIAL *	276	297
TOTAL	1,146	1,386
	POMPTON RIVER	
RESIDENTIAL	4,587	5,283
NON-RESIDENTIAL*	613	657
TOTAL	5,200	5,940
	PEQUANNOCK RIVER	
RESIDENTIAL	317	328
NON-RESIDENTIAL *	19	22
TOTAL	336	350
	RAMAPO RIVER	
RESIDENTIAL	1,054	1,201
NON-RESIDENTIAL *	76	92
TOTAL	1,130	1,293
	WANAQUE RIVER	
RESIDENTIAL	188	233
NON-RESIDENTIAL *	27	40
TOTAL	215	273

* THE NON RESIDENTIAL STRUCTURE TYPE INCLUDES INDUSTRIAL, COMMERCIAL, UTILITY AND APARTMENT STRUCTURES. IN MANY CASES, INDUSTRIAL COMPLEXES COUNTED AS ONE ESTABLISHMENT, CONTAINED MORE THAN ONE STRUCTURE. FOR EXAMPLE, IN THE LOWER PASSAIC REACHES, APPROXIMATELY 192 INDUSTRIAL COMPLEXES WERE FOUND TO CONTAIN 720 INDIVIDUAL STRUCTURES. SEVERAL APARTMENT BUILDINGS COMPRISING ONE COMPLEX WERE ALSO COUNTED AS ONE STRUCTURE.

TABLE V-26

DAMAGES IN DOLLARS FOR EXISTING CONDITIONS

(DOLLARS in 1,000's)

RIVER	MAY 1968 FLOOD [1/] CURRENT [2/] CONDITIONS	10YR FLOOD EVENT	100YR FLOOD EVENT [3/]	500YR FLOOD EVENT
LOWER VALLEY	29,300	28,700	403,600	1,188,100
CENTRAL BASIN	25,900	33,200	312,800	905,700
UPPER PASSAIC	2,300	1,500	6,000	16,000
POMPTON RIVER [4/]	81,500	80,200	321,000	581,900
TOTAL	139,000	143,600	1,043,400	2,691,700

1/ HISTORICAL FLOOD DAMAGE DATA FROM NEWSPAPER ACCOUNTS AND CORPS POST FLOOD REPORTS.

2/ FIGURES UPDATED TO REFLECT INCREASES IN DEVELOPMENT (AN APPROXIMATE 100% INCREASE IN THE NUMBER OF STRUCTURES FROM 1968-1985) AND OCT. 1985 PRICE LEVELS.

3/ EXCLUDES DAMAGES DUE TO TIDAL FLOODING FOR COMPARISON WITH MAY 1968 STORM DATA.

4/ INCLUDES POMPTON RIVER TRIBUTARIES - WANAQUE, PEQUANNOCK, AND RAMAPO RIVERS.

TABLE V-27

MUNICIPALITIES IN THE PASSAIC RIVER BASIN
STUDY AREA

LOWER PASSAIC SUBBASIN

COUNTY	MUNICIPALITY	REACHES
BERGEN	EAST RUTHERFORD BOROUGH	010091
	ELMWOOD PARK BOROUGH	010141,010151,010161,010171
	FAIRLAWN BOROUGH	010171,010181,010183,010191
	GARFIELD CITY	010104,010106,010111,010113 010115,010117,010121,010123 010131,010141
	LODI BOROUGH	010108,010109,010117
	LINDHURST TOWNSHIP	010051,010061
	NORTH ARLINGTON BOROUGH	010041,010051
	RUTHERFORD BOROUGH	010071,010081,010091
	SADDLE BROOK TOWNSHIP	010107,010115
	SOUTH HACKENSACK TOWNSHIP	010107,010108
	WALLINGTON BOROUGH	010091,010101,010103,010105
	WOODBRIDGE BOROUGH	010107,010108
ESSEX	BELLEVILLE TOWN	010032,010042,010052
	NEWARK CITY	010012,010014,010022
	NUTLEY TOWN	010052,010062
	MILLBURN TOWNSHIP	020196,020198,020202
HUDSON	EAST NEWARK BOROUGH	010021
	HARRISON TOWN	010013,010015,010017,010021
	KEARNY TOWN	010011,010013,010021,010031
PASSAIC	CLIFTON CITY	010072,010082,010122,010132 010142
	HAWTHORNE BOROUGH	010191,010201,010203
	LITTLE FALLS TOWNSHIP	010262,010272
	PASSAIC CITY	010072,010082,010092,010102 010112,010122,010182
	PATERSON CITY	010152,010162,010172,010192 010202,010203,010211,010212 010221,010222,010223,010224 400011,400012
	TOTOWA BOROUGH	010223,010231,010241,010251 010261,010271
	WEST PATERSON BOROUGH	010226,010232,010242,010244 010252,500011,500012,500014 500016

CENTRAL PASSAIC SUBBASIN

COUNTY	MUNICIPALITY	REACHES
ESSEX	CALDWELL BOROUGH	020028
	FAIRFIELD BOROUGH	020024,020026,020028,020029 020032,020040,020052,020062 020072
	LIVINGSTON TOWNSHIP	020162,020164,020172,020182

CENTRAL PASSAIC SUBBASIN (CON'T)

COUNTY	MUNICIPALITY	REACHES
	LIVINGSTON TOWNSHIP	020192,020194,020196,020198
	ROSELAND BOROUGH	020152
	WEST CALDWELL BOROUGH	020054,020062,020072
MORRIS	CHATHAM BOROUGH	020195,020201,020211,020213 020221,020222,020230
	EAST HANOVER TOWNSHIP	020071,020121,020122,020130 020141,020142,020144,020146 020148,020151,020161,020171
	FLORHAM PARK BOROUGH	020146,020148,020181,020191 020193,020195,020197,020201
	HANOVER TOWNSHIP	020130,020201
	MADISON BOROUGH	020197
	MILLBURN TOWNSHIP	020202
	MONTVILLE TOWNSHIP	020040,020041,020043,020051 020061,020071,020081,020091 020093,020095,020101,020103 020110,020111
	PARSIPPANY-TROY HILLS	020082,020084,020086,020092 020093,020094,020102,020110 020121
PASSAIC	LITTLE FALLS TOWNSHIP	020012,020022
	TOTOWA TOWNSHIP	600013,600015,600017
	WAYNE TOWNSHIP	010272,020011,020013,020015 020017,0200211,020031

UPPER PASSAIC SUBBASIN

COUNTY	MUNICIPALITY	REACHES
MORRIS	CHATHAM TOWNSHIP	030010,030021,030031
SOMERSET	WARREN TOWNSHIP	030080,030090,030100
UNION	BERKELEY HEIGHTS TOWNSHIP	030032,030040,030050,030060 030070
	NEW PROVIDENCE BOROUGH	030022
	SUMMIT CITY	020212

POMPTON SUBBASIN

COUNTY	MUNICIPALITY	REACHES
MORRIS	LINCOLN PARK BOROUGH	020040,600012,600014,600016 600018,600022,600032,600034
	PEQUANNOCK TOWNSHIP	600042,600051,600052,600062 660012,660024,660026
	RIVERDALE BOROUGH	680012,680022,680032,680042
PASSAIC	BLOOMINGDALE BOROUGH	680041
	POMPTON LAKES BOROUGH	660022,670011,670012,670013 670014,670021,670022,670031 670032,670040,680011,680021 680031,680041
	WAYNE TOWNSHIP	600011,600019,600021,600023 600025,600031,600041,600061 660011,660021,660023

TABLE V-28

COMPARISON OF APRIL 1984 FLOOD DAMAGES TO
EAD AT STAGE DAMAGES (RESIDENTIAL ONLY)

Area	Post Flood Report Figures	EAD @ Stage Calibrated Figures
Lower Valley	18,315	16,588
Central Basin	26,793	26,702
Pompton	81,046	78,427
Lower Ramapo	21,378	24,286
Wanaque	2,435	1,972
Pequannock	1,890	4,274
Total	151,857	152,249

Dollars are shown in Thousands.

TABLE V-29
TOTAL EXPECTED ANNUAL DAMAGES
(DOLLARS SHOWN IN THOUSANDS)

	RES	APT	COM	IND	UTL	RESCON	APTCON	MUN	TOTAL*
LOWER PASSAIC	2,774	202	4,144	16,393	793	1,086	54	4,580	30,027
CENTRAL PASSAIC	4,955	39	9,917	4,540	76	1,874	13	3,426	24,839
UPPER PASSAIC	257	0	149	32	10	90	0	91	629
POMPTON RIVER	9,007	216	6,333	1,755	178	2,934	88	3,282	23,793
PEQUANNOCK RIVER	261	0	4	0	0	98	0	44	407
LOWER RAMAPO RIVER	2,503	0	166	4	1	697	0	506	3,877
WANAQUE RIVER	266	2	67	7	0	93	1	61	497
TOTAL	20,023	459	20,780	22,731	1,058	6,872	156	11,991	84,069

*TOTALS MAY NOT MATCH DUE TO ROUNDING.

TABLE V-30

LOWER VALLEY
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
010011	0	0	154,900	1,882,000	300	0	0	366,700	2,403,9
010012	13,100	0	74,400	5,494,300	0	4,500	0	1,005,500	6,591,8
010013	0	0	27,400	0	0	0	0	4,900	32,3
010014	7,100	28,600	45,300	97,500	496,800	2,700	300	122,100	800,4
010015	0	0	1,000	4,900	286,600	0	0	52,700	345,2
010017	8,300	55,800	23,200	249,700	0	3,100	14,200	63,800	418,1
010021	6,500	300	56,200	154,900	0	2,500	100	39,700	260,2
010022	0	0	6,700	54,600	500	0	0	11,100	72,9
010031	200	700	0	0	100	0	0	200	1,2
010032	22,100	0	13,700	396,300	0	7,800	0	79,200	519,1
010041	4,500	4,400	38,100	8,600	0	1,800	1,500	10,600	69,5
010042	43,800	23,800	23,500	85,400	0	18,700	6,700	36,300	238,2
010051	3,000	0	43,400	0	0	1,200	0	8,600	56,2
010052	19,100	200	117,800	15,100	0	7,000	0	28,700	187,9
010061	92,000	0	36,800	0	100	37,400	0	29,900	196,2
010062	0	0	0	0	0	0	0	0	
010071	98,400	200	125,100	14,800	0	40,000	100	50,100	328,7
010072	2,200	0	4,000	259,500	0	900	0	48,000	314,6
010081	10,200	2,900	0	0	0	4,100	900	3,300	21,4
010082	0	0	0	0	0	0	0	0	
010091	112,000	500	131,300	82,700	0	44,500	200	66,800	438,0
010092	0	4,000	400	2,600	0	0	900	1,400	9,3
010103	318,100	7,300	134,000	44,500	500	125,600	3,200	114,000	747,2
010102	38,500	0	8,100	650,400	2,000	15,200	0	128,600	842,8
010103	0	0	0	0	0	0	0	0	
010104	0	200	7,600	0	0	0	0	1,400	9,2
010105	0	0	0	31,900	0	0	0	5,700	37,6
010106	0	5,200	0	0	0	0	1,000	1,100	7,3
010107	4,000	0	18,800	2,500	1,200	1,600	0	5,100	33,2
010108	0	0	2,000	0	0	0	0	400	2,4
010109	63,300	0	17,300	0	0	24,500	0	18,900	124,0
010111	31,500	800	72,900	60,700	0	11,800	400	32,100	210,2
010118	0	0	46,700	756,500	0	0	0	144,600	947,8
010119	0	0	0	50,100	0	0	0	9,000	59,1
010112	5,400	22,000	36,000	258,800	0	2,000	8,300	59,900	392,4
010113	100	0	500	0	0	0	0	100	7
010115	0	0	0	0	0	0	0	0	
010117	0	0	0	0	0	0	0	0	
300011	200	100	0	0	0	100	100	100	6
300012	0	0	200	0	0	0	0	100	3
010121	59,200	700	102,700	24,100	0	23,800	600	38,000	249,1
010122	0	0	0	31,500	0	0	0	5,700	37,2
010123	10,900	0	49,700	7,700	0	4,100	0	13,000	85,4
010131	100	0	6,100	1,400	0	100	0	1,400	9,1
010132	0	0	0	60,100	0	0	0	10,800	70,9

TABLE V-30 (CONT)

LOWER VALLEY
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
010141	0	0	500	0	0	0	0	100	60
010142	5,500	0	4,600	1,200	0	2,000	0	2,400	15,70
010151	0	0	64,000	0	0	0	0	11,500	75,50
010152	0	0	0	0	0	0	0	0	
010161	6,300	0	20,700	215,400	0	2,600	0	44,100	289,10
010162	100	0	0	100	0	0	0	0	20
010171	234,600	0	57,400	0	1,800	84,000	0	68,000	445,80
010172	0	3,200	400	6,900	0	0	2,400	2,300	15,20
010181	500	0	3,100	31,300	0	200	0	6,300	41,40
010182	100	0	1,700	4,600	0	0	0	1,200	7,60
010183	0	0	0	600	0	0	0	100	70
010191	45,400	0	64,500	851,600	2,800	18,100	0	176,800	1,159,20
010192	100	0	4,000	53,000	0	0	0	10,300	67,40
010201	1,000	0	10,300	11,900	0	400	0	4,200	27,80
010202	20,800	16,900	951,700	2,981,100	0	7,600	4,700	716,900	4,699,70
010203	381,400	5,900	581,700	309,000	0	140,600	1,300	255,600	1,675,50
010211	2,000	0	27,600	25,100	0	700	0	10,000	65,40
010212	0	0	29,700	100	0	0	0	5,400	35,20
010221	3,400	0	69,400	34,100	0	500	0	19,300	126,70
010222	1,000	0	3,000	0	0	300	0	800	5,10
010223	440,200	5,300	125,500	6,800	0	177,300	2,700	136,400	894,20
010224	700	0	14,200	0	0	200	0	2,700	17,80
010226	31,600	0	170,400	0	0	12,500	0	38,600	253,10
010231	9,400	0	0	0	0	3,900	0	2,400	15,70
010232	800	0	2,500	0	0	400	0	700	4,40
010241	27,100	0	0	0	0	10,600	0	6,800	44,50
010242	293,500	10,500	175,200	86,600	100	123,300	4,000	124,800	818,00
010244	237,400	0	125,500	0	0	93,100	0	82,100	538,10
010251	29,100	2,400	6,100	5,100	0	11,600	800	9,900	65,00
010252	25,300	0	37,400	850,800	0	10,000	0	166,200	1,089,70
010261	0	0	0	200	0	0	0	0	20
010262	100	0	26,200	300	0	100	0	4,800	31,50
010271	0	0	0	0	0	0	0	0	
010272	0	0	10,600	0	0	0	0	1,900	12,50
400011	100	0	800	0	0	0	0	200	1,10
400012	1,200	0	0	0	0	500	0	300	2,00
500011	0	0	44,000	41,700	0	0	0	15,400	101,10
500012	1,400	0	52,700	69,800	0	600	0	22,400	146,90
500014	0	0	14,200	22,700	0	0	0	6,600	43,50
500016	0	0	18,400	100	0	0	0	3,300	21,80
SUBTOTAL	2,773,900	201,900	4,143,800	16,393,200	792,800	1,086,100	54,400	4,580,400	30,026,50

TABLE V-31

CENTRAL BASIN
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
020011	500	0	0	0	0	200	0	100	8
020012	441,700	0	15,500	10,300	1,500	188,500	0	105,200	762,7
020013	13,000	0	27,300	0	0	4,800	0	7,200	52,3
020015	118,300	0	0	0	100	44,900	0	26,100	189,4
020017	7,000	0	222,300	5,100	0	2,400	0	37,900	274,7
020021	830,200	0	3,997,800	0	0	312,700	0	822,500	5,963,2
020022	202,200	1,300	100,100	22,700	0	76,600	700	64,600	468,2
020024	359,200	0	229,200	547,200	2,200	144,200	0	205,100	1,487,1
020026	300	0	2,400	15,400	0	100	0	2,900	21,1
020028	0	0	0	62,500	0	0	0	10,000	72,5
020029	29,600	0	112,700	0	0	11,300	0	24,600	178,2
020031	160,300	0	56,700	0	0	57,900	0	44,000	318,9
020032	104,200	0	0	0	0	40,800	0	23,200	168,2
020040	266,500	0	35,200	0	8,000	102,900	0	66,000	478,6
020041	300	0	0	0	500	100	0	100	1,0
020043	22,700	0	0	100	0	10,000	0	5,200	38,0
020051	17,800	0	11,500	7,500	0	6,200	0	6,900	49,9
020052	1,251,200	0	3,181,700	1,624,000	2,100	463,500	0	1,043,600	7,566,1
020054	143,700	0	785,900	7,200	0	59,200	0	159,400	1,155,4
020061	1,300	0	7,000	0	0	500	0	1,400	10,2
020062	19,900	0	85,800	0	0	7,300	0	18,100	131,1
020071	0	0	0	0	0	0	0	0	
020072	0	0	0	0	0	0	0	0	
020081	100	0	40,100	0	100	0	0	6,400	46,7
020082	300	0	0	0	0	100	0	100	5
020084	1,000	37,200	27,500	2,400	0	400	12,700	13,000	94,2
020086	100	0	6,800	0	0	0	0	1,100	8,0
020091	0	0	0	300	0	0	0	0	[illegible]
020092	18,500	0	100,500	0	300	6,700	0	20,200	146,2
020093	38,900	0	900	97,200	0	14,300	0	24,200	175,5
020094	360,300	0	3,100	0	100	130,700	0	79,100	573,3
020095	27,400	0	1,300	0	0	9,600	0	6,100	44,4
020101	25,600	0	5,600	0	0	13,800	0	7,200	52,2
020102	173,500	0	0	0	0	59,800	0	37,300	270,
020103	3,300	0	0	0	0	1,100	0	700	5,
020110	0	0	0	0	0	0	0	0	
020111	0	0	0	0	0	0	0	0	
020121	3,100	0	300	0	0	900	0	700	5,
020122	97,700	0	0	0	100	31,400	0	20,700	149,
020130	800	0	0	7,700	0	300	0	1,400	10,
020141	8,900	0	258,300	0	0	3,500	0	43,300	314,
020142	0	0	300	0	100	0	0	100	[illegible]
020144	154,800	0	130,700	960,400	0	49,600	0	207,300	1,502,
020146	6,400	0	98,100	500	300	2,200	0	17,200	124,
020148	8,500	0	29,600	0	900	2,900	0	6,700	48,

TABLE V-31 (CONT)

CENTRAL BASIN
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
020151	17,600	0	130,300	0	0	6,100	0	24,600	178,60
020152	2,800	0	1,300	3,500	0	1,100	0	1,400	10,10
020161	5,300	0	0	0	0	1,500	0	1,100	7,90
020162	0	0	0	193,800	9,100	0	0	32,500	235,40
020164	3,700	0	3,900	2,600	0	1,400	0	1,900	13,50
020171	4,000	0	12,800	0	0	1,500	0	2,900	21,20
020172	0	0	0	0	100	0	0	0	10
020181	0	0	56,500	13,700	0	0	0	11,200	81,40
020182	0	0	0	0	0	0	0	0	
020191	0	0	100	0	25,000	0	0	4,000	29,10
020192	0	0	100	12,000	0	0	0	1,900	14,00
020193	0	0	0	0	0	0	0	0	
020194	0	0	0	0	0	0	0	0	
020195	100	0	100	0	0	0	0	0	20
020196	0	0	400	0	1,700	0	0	300	2,40
020197	0	0	0	0	0	0	0	0	
020198	0	0	0	0	19,600	0	0	3,100	22,70
020201	0	0	200	0	300	0	0	100	60
020202	0	0	0	0	800	0	0	100	90
020211	200	0	800	0	0	100	0	200	1,30
020212	100	0	0	0	100	100	0	0	30
020213	0	0	0	0	0	0	0	0	
020221	1,500	0	118,300	785,500	0	500	0	144,900	1,050,70
020222	0	0	200	0	400	0	0	100	70
020230	0	0	2,700	0	0	0	0	400	3,10
600013	300	0	5,100	158,400	2,500	100	0	26,600	193,00
600015	300	0	9,800	0	0	100	0	1,600	11,80
600017	100	0	100	0	0	0	0	0	20
SUBTOTAL	4,955,100	38,500	9,916,900	4,540,000	75,900	1,873,900	13,400	3,425,800	24,839,50

TABLE V-32

UPPER PASSAIC RIVER
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
030010	0	0	700	0	0	0	0	100	800
030021	0	0	0	0	0	0	0	0	0
030022	18,200	0	23,700	0	0	8,200	0	8,500	58,600
030031	200	0	0	0	0	100	0	100	400
030032	75,400	0	12,300	0	0	21,900	0	18,600	128,200
030040	10,200	0	31,800	12,300	1,100	3,600	0	10,000	69,000
030050	42,300	0	500	0	0	16,000	0	10,000	68,800
030060	32,100	0	0	0	0	11,900	0	7,500	51,500
030070	1,700	0	0	0	0	700	0	400	2,800
030080	31,200	0	6,900	0	0	10,600	0	8,300	57,000
030090	17,400	0	23,400	12,500	900	6,300	0	10,300	70,800
030100	27,800	0	49,600	7,300	7,800	10,700	0	17,500	120,700
SUBTOTAL	256,500	0	148,900	32,100	9,800	90,000	0	91,300	628,600

TABLE V-33

POMPTON RIVER
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
600011	847,000	0	1,037,800	700	600	271,200	0	345,200	2,502,50
600012	357,100	0	229,900	0	128,700	86,400	0	128,300	930,40
600014	693,300	0	24,700	0	3,900	180,600	0	144,400	1,046,90
600016	36,500	0	0	0	0	9,400	0	7,300	53,20
600018	34,800	0	0	0	0	7,400	0	6,800	49,00
600019	1,100	0	22,600	0	0	400	0	3,900	28,00
600021	480,800	0	0	0	0	134,400	0	98,400	713,60
600022	226,700	1,600	576,600	488,700	700	91,000	900	221,800	1,608,00
600023	156,400	0	0	0	0	61,400	0	34,800	252,60
600025	280,400	0	887,400	2,600	400	92,200	0	202,100	1,465,10
600031	1,464,700	0	156,500	524,700	0	385,500	0	405,000	2,936,40
600032	558,900	0	52,300	171,300	24,500	169,400	0	156,200	1,132,60
600034	1,206,800	211,700	195,700	38,700	10,400	449,700	84,800	351,600	2,549,40
600041	18,200	0	500	312,000	3,300	5,800	0	54,400	394,20
600042	1,793,400	2,900	972,400	74,200	0	628,000	1,900	555,600	4,028,40
600051	12,700	0	16,400	0	1,600	4,900	0	5,700	41,30
600052	795,400	0	1,847,000	142,400	0	338,400	0	499,700	3,622,90
600061	2,700	0	300	0	4,200	1,000	0	1,300	9,50
600062	40,400	0	313,200	0	0	16,800	0	59,300	429,70
SUBTOTAL	9,007,300	216,200	6,333,300	1,755,300	178,300	2,933,900	87,600	3,281,800	23,793,70

TABLE V-34

WANAQUE RIVER
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
670011	164,100	0	8,800	0	0	54,100	0	31,800	258,8
670012	54,000	0	2,500	0	0	21,100	0	10,900	88,5
670013	4,300	0	0	0	0	1,700	0	800	6,8
670014	600	0	0	0	0	200	0	100	9
670021	100	600	5,600	0	0	0	200	900	7,4
670022	29,400	0	0	0	0	11,300	0	5,700	46,4
670031	2,000	0	9,300	7,400	100	800	0	2,700	22,3
670032	8,000	0	0	0	0	3,000	0	1,500	12,5
670040	3,000	1,000	41,100	0	0	1,200	300	6,500	53,1
SUBTOTAL	265,500	1,600	67,300	7,400	100	93,400	500	60,900	496,7

TABLE V-35

PEQUANNOCK RIVER
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
680011	144,400	0	0	0	0	54,500	0	23,900	222,80
680012	83,700	0	2,900	0	300	31,000	0	14,100	132,00
680021	5,600	0	0	0	0	2,700	0	1,000	9,30
680022	700	0	0	0	0	300	0	100	1,10
680031	23,400	0	800	0	0	8,500	0	3,900	36,60
680032	3,400	0	0	0	0	1,400	0	600	5,40
680041	0	0	0	0	0	0	0	0	
680042	0	0	0	0	0	0	0	0	
SUBTOTAL	261,200	0	3,700	0	300	98,400	0	43,600	407,20

TABLE V-36

LOWER RAMAPO
DAMAGE DATA FOR EXISTING CONDITIONS
EXPECTED ANNUAL DAMAGES

REACHES	RES	APT	COMM	IND	UTL	RESCON	APTCON	MUN	TOTAL
660011	200	0	100	0	0	100	0	100	50
660012	4,300	0	38,300	3,800	0	1,500	0	7,200	55,10
660021	155,700	0	0	0	0	50,800	0	31,000	237,50
660022	1,965,400	0	60,100	0	600	543,000	0	385,400	2,954,50
660023	4,900	0	37,900	0	0	1,800	0	6,700	51,30
660024	194,400	0	5,100	0	0	50,100	0	37,400	287,00
660026	178,400	0	24,000	0	0	50,100	0	37,900	290,40
SUBTOTAL	2,503,300	0	165,500	3,800	600	697,400	0	505,700	3,876,30

TABLE V-37

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 010102

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	714.17
2	50.00	-1.	7.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	714.17
3	20.00	-1.	8.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	714.17
4	10.00	-1.	9.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	714.17
5	4.00	-1.	11.55	210.95	0.00	23.44	4391.56	0.00	80.05	0.00	4705.99	616.89
6	2.00	-1.	13.49	422.41	0.00	38.46	11022.53	33.82	144.83	0.00	11662.04	458.90
7	1.00	-1.	15.41	819.25	0.00	106.98	16737.74	84.55	262.59	0.00	18011.11	313.77
8	.20	-1.	21.10	3398.59	0.00	1210.74	43987.77	140.98	1710.52	0.00	50448.59	100.90
EXP ANNUAL DAMAGE				38.51	0.00	8.10	650.40	1.98	15.19	0.00	714.17	

Figures exclude municipal damages.

TABLE V-38

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 010171

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	29.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	377.79
2	50.00	-1.	30.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	377.79
3	20.00	-1.	31.88	390.06	0.00	13.77	0.00	.02	134.44	0.00	538.29	347.60
4	10.00	-1.	33.11	622.69	0.00	97.87	0.00	.84	216.42	0.00	937.82	277.90
5	4.00	-1.	34.79	1211.06	0.00	249.43	0.00	16.99	421.01	0.00	1898.49	199.37
6	2.00	-1.	36.19	2040.71	0.00	609.49	0.00	33.44	703.10	0.00	3386.73	150.23
7	1.00	-1.	37.39	3180.72	0.00	1448.36	0.00	45.54	1136.14	0.00	5810.75	106.38
8	.20	-1.	41.14	9166.50	0.00	3529.65	0.00	52.18	3806.31	0.00	16554.65	33.11
EXP ANNUAL DAMAGE				234.58	0.00	57.41	0.00	1.79	84.01	0.00	377.79	

Figures exclude municipal damages.

TABLE V-39

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 010203

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	37.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1419.82
2	50.00	-1.	38.94	213.65	2.10	146.19	11.98	0.00	76.66	0.00	450.58	1372.09
3	20.00	-1.	40.53	437.77	3.56	576.20	130.01	0.00	149.37	.18	1297.09	1151.74
4	10.00	-1.	42.15	853.72	6.11	1348.86	336.21	0.00	291.72	1.13	2897.74	958.42
5	4.00	-1.	44.35	1866.59	12.57	3837.68	1239.42	0.00	673.44	4.17	7633.87	680.75
6	2.00	-1.	45.79	2805.00	20.21	5402.91	2301.27	0.00	1091.55	5.47	11626.41	493.30
7	1.00	-1.	47.24	3931.04	31.64	6938.57	7181.40	0.00	1620.18	7.63	19710.45	345.60
8	.20	-1.	52.10	8050.02	789.46	13654.28	24066.85	0.00	3589.96	200.68	50351.25	100.70
EXP ANNUAL DAMAGE,		YEAR 1985		391.36	5.46	581.69	309.01	0.00	140.64	1.26	1419.82	

Figures exclude municipal damages

TABLE V-40

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 020021

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	152.62	386.59	0.00	1767.34	0.00	0.00	120.06	0.00	2273.99	5140.69
2	50.00	-1.	163.87	712.94	0.00	2646.19	0.00	0.00	230.81	0.00	3589.95	3715.93
3	20.00	-1.	165.06	1020.02	0.00	3624.91	0.00	0.00	400.74	0.00	5045.67	2462.14
4	10.00	-1.	166.33	1380.53	0.00	5072.50	0.00	0.00	581.52	0.00	7034.55	1872.67
5	4.00	-1.	168.03	2005.13	0.00	7141.76	0.00	0.00	925.48	0.00	10072.37	1374.64
6	2.00	-1.	169.54	2538.81	0.00	18393.68	0.00	0.00	1232.37	0.00	22164.87	1116.93
7	1.00	-1.	170.90	2962.54	0.00	43846.98	0.00	0.00	1512.16	0.00	48321.68	783.10
8	.20	-1.	174.42	3649.37	0.00	99496.00	0.00	0.00	1911.12	0.00	105056.48	210.11
EXP ANNUAL DAMAGE,		YEAR 1985		830.22	0.00	3997.79	0.00	0.00	312.68	0.00	5140.68	

Figures exclude municipal damages

TABLE V-41

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 020052

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	167.56	439.07	0.00	557.32	0.00	0.00	187.44	0.00	1183.83	6522.51
2	50.00	-1.	168.60	806.25	0.00	1215.98	80.78	0.00	318.59	0.00	2421.60	5649.78
3	20.00	-1.	169.51	1171.75	0.00	1731.90	170.36	0.00	435.43	0.00	3509.45	4799.49
4	10.00	-1.	170.39	1843.33	0.00	3133.06	464.10	0.00	639.79	0.00	6080.28	4366.73
5	4.00	-1.	171.77	3660.97	0.00	13305.99	3206.03	0.00	1183.03	0.00	21356.01	3745.53
6	2.00	-1.	173.33	7467.12	0.00	36069.47	21876.19	14.28	2402.67	0.00	67829.73	2979.50
7	1.00	-1.	174.02	9751.32	0.00	48009.83	38496.54	43.47	3188.23	0.00	99489.38	2152.99
8	.20	-1.	177.82	28490.33	0.00	130182.24	159844.94	361.24	11123.02	0.00	330001.77	694.77
9	.10	-1.	178.17	30496.41	0.00	136675.75	169892.66	395.34	12066.01	0.00	349525.17	349.53
EXP ANNUAL DAMAGE				1251.21	0.00	3181.69	1623.98	2.14	463.50	0.00	6522.51	

Figures exclude municipal damages

TABLE V-42

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 020102

Existing Conditions

	FREQ	FLOW	STAGE	RES	APT	COM	IND	JTL	RESCON	APTCON	TOTAL	ACC EAD
1	100.00	-1.	174.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	233.30
2	50.00	-1.	175.05	211.25	0.00	0.00	0.00	0.00	73.77	0.00	285.01	221.27
3	20.00	-1.	175.57	269.96	0.00	0.00	0.00	0.00	91.45	0.00	361.41	126.16
4	10.00	-1.	176.25	361.04	0.00	0.00	0.00	0.00	117.97	0.00	479.01	85.53
5	4.00	-1.	177.00	488.63	0.00	0.00	0.00	0.00	153.66	0.00	642.28	52.62
6	2.00	-1.	177.65	675.48	0.00	0.00	0.00	0.00	211.98	0.00	887.46	37.73
7	1.00	-1.	178.80	1098.07	0.00	0.00	0.00	0.00	370.68	0.00	1468.75	26.71
8	.20	-1.	131.97	2496.41	0.00	0.00	0.00	0.00	1143.24	0.00	3639.65	8.88
9	.10	-1.	133.82	3173.21	0.00	0.00	0.00	0.00	1583.54	0.00	4756.75	4.76
EXP ANNUAL DAMAGE,	YEAR 1985			173.52	0.00	0.00	0.00	0.00	59.78	0.00	233.30	

Figures exclude municipal damages

TABLE V-43

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 030050

EXISTING CONDITIONS

FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	RESCON	APTCON	TOTAL	ACC EAD
100.00	-1.	208.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.66
80.00	-1.	208.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.66
50.00	-1.	208.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.66
20.00	-1.	209.97	64.45	0.00	.63	0.00	0.00	25.55	0.00	90.53	44.15
10.00	-1.	210.84	113.96	0.00	1.04	0.00	0.00	45.33	0.00	160.33	32.16
2.00	-1.	212.43	286.11	0.00	4.21	0.00	0.00	103.86	0.00	394.18	13.81
1.00	-1.	213.12	422.49	0.00	9.15	0.00	0.00	147.16	0.00	578.80	9.06
.20	-1.	214.60	938.82	0.00	35.43	0.00	0.00	303.90	0.00	1278.15	2.66
EXP ANNUAL DAMAGE			42.93	0.00	.55	0.00	0.00	16.18	0.00	59.66	

Figures exclude municipal damages

TABLE V-44

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 600025

EXISTING CONDITIONS

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	MISC
1	100.00	-1.	165.55	0.00	0.00	0.00	0.00	0.00	0.00
2	50.00	-1.	165.85	0.00	0.00	0.00	0.00	0.00	0.00
3	20.00	-1.	168.94	422.18	0.00	121.34	0.00	0.00	0.00
4	10.00	-1.	170.59	828.48	0.00	333.57	0.00	.33	0.00
5	4.00	-1.	172.66	1450.72	0.00	1689.35	0.00	1.06	0.00
6	2.00	-1.	174.55	2133.14	0.00	3260.91	0.00	1.62	0.00
7	1.00	-1.	175.91	2316.75	0.00	4592.23	.43	2.57	0.00
8	.20	-1.	179.92	4606.76	0.00	7783.38	206.32	61.74	0.00
EXP ANNUAL DAMAGE				280.42	0.00	236.15	.50	.38	0.00

EXISTING CONDITIONS (con't)

	FREQ	FLOW	STAGE	RESCON	APTCON	COMCON	INDCON	TOTAL	ACC EAD
1	100.00	-1.	165.55	0.00	0.00	0.00	0.00	0.00	262.94
2	50.00	-1.	166.85	0.00	0.00	0.00	0.00	0.00	262.94
3	20.00	-1.	168.94	121.01	0.00	221.21	0.00	885.74	116.51
4	10.00	-1.	170.59	244.55	0.00	851.92	.56	2259.41	982.90
5	4.00	-1.	172.66	478.56	0.00	4867.80	5.11	8491.60	721.28
6	2.00	-1.	174.55	768.94	0.00	9959.41	6.00	16130.02	485.32
7	1.00	-1.	175.91	1081.01	0.00	14232.59	6.64	22732.21	295.36
8	.20	-1.	179.92	2264.56	0.00	20659.30	713.56	36305.63	72.61
EXP ANNUAL DAMAGE				92.20	0.00	651.23	2.05	1262.94	

Figures exclude municipal damages

TABLE V-45

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 600034

EXISTING CONDITIONS

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	MISC
1	100.00	-1.	169.19	0.00	0.00	0.00	0.00	0.00	0.00
2	50.00	-1.	171.45	0.00	0.00	0.00	0.00	0.00	0.00
3	20.00	-1.	174.01	1368.32	197.39	33.89	1.41	17.43	0.00
4	10.00	-1.	176.05	3840.64	654.91	77.29	3.02	36.57	0.00
5	4.00	-1.	177.04	5473.43	1184.35	150.62	4.68	44.39	0.00
6	2.00	-1.	179.41	10455.90	1940.26	891.20	88.32	63.22	0.00
7	1.00	-1.	180.94	15062.39	3421.98	1563.02	201.63	138.22	0.00
8	.20	-1.	185.68	34786.77	5035.19	4023.02	730.17	257.15	0.00
EXP ANNUAL DAMAGE				1206.80	211.66	64.83	7.36	10.43	0.00

EXISTING CONDITIONS (con't)

	FREQ	FLOW	STAGE	RESCON	APTCON	COMCON	INDCON	TOTAL	ACC EAD
1	100.00	-1.	169.19	0.00	0.00	0.00	0.00	0.00	2197.85
2	50.00	-1.	171.45	0.00	0.00	0.00	0.00	0.00	2197.85
3	20.00	-1.	174.01	475.38	44.51	83.71	2.70	2225.32	1903.43
4	10.00	-1.	176.05	1330.86	233.67	130.84	3.94	6311.74	1528.81
5	4.00	-1.	177.04	1938.78	575.04	239.22	11.07	9671.56	1055.41
6	2.00	-1.	179.41	3966.90	852.13	1748.64	387.58	20394.14	775.94
7	1.00	-1.	180.94	5770.33	1311.92	3327.14	751.58	31548.72	527.90
8	.20	-1.	185.68	16060.41	2774.26	6459.15	3149.14	75275.27	150.55
EXP ANNUAL DAMAGE				449.74	84.82	130.67	31.34	2197.85	

Figures exclude municipal damages

TABLE V-46

EXPECTED ANNUAL DAMAGES ($1,000)
REACH 600042

EXISTING CONDITIONS

	FREQ	FLOW	STAGE	RES	APT	COM	IND	UTL	MISC
1	100.00	-1.	171.47	0.00	0.00	0.00	0.00	0.00	0.00
2	50.00	-1.	173.06	725.31	0.00	0.00	0.00	0.00	0.00
3	20.00	-1.	175.09	2620.23	0.00	239.81	0.00	0.00	0.00
4	10.00	-1.	177.44	5973.13	0.00	1332.24	0.00	0.00	0.00
5	4.00	-1.	179.53	6148.74	0.00	1391.44	0.00	0.00	0.00
6	2.00	-1.	181.51	12490.99	0.00	3781.79	0.00	0.00	0.00
7	1.00	-1.	183.08	16864.39	0.00	5004.60	0.00	0.00	0.00
8	.20	-1.	187.83	32995.74	993.41	8282.13	2524.61	0.00	0.00
EXP ANNUAL DAMAGE				1793.42	2.91	324.81	11.86	.02	0.00

EXISTING CONDITIONS (con't)

	FREQ	FLOW	STAGE	RESCON	APTCON	COMCON	INDCON	TOTAL	ACC EAD
1	100.00	-1.	171.47	0.00	0.00	0.00	0.00	0.00	3472.82
2	50.00	-1.	173.06	0.00	0.00	0.00	0.00	725.31	3415.75
3	20.00	-1.	175.09	903.24	0.00	309.50	0.00	4071.78	2855.98
4	10.00	-1.	177.44	2230.22	0.00	2300.64	0.00	11836.23	2170.98
5	4.00	-1.	179.53	2311.39	0.00	2458.17	0.00	12309.74	1420.33
6	2.00	-1.	181.51	5359.15	0.00	8963.96	0.00	30595.88	1022.52
7	1.00	-1.	183.08	7362.70	0.00	12391.53	0.00	41623.22	668.42
8	.20	-1.	187.83	14924.79	684.10	19376.33	14596.19	94377.32	198.77
EXP ANNUAL DAMAGE				627.96	1.94	647.56	62.33	3472.82	

Figures exclude municipal damages

TABLE V-47
POPULATION PROJECTIONS
PASSAIC RIVER BASIN COUNTIES

County	1980 Census	1990	2000	2010	2020	2030	2040
BERGEN	467,905	529,169	551,922	564,096	572,732	600,271	618,562
ESSEX	750,144	785,243	785,243	801,654	816,390	814,351	820,853
HUDSON	49,900	50,293	51,380	52,485	53,511	54,625	55,709
MORRIS	367,292	438,403	485,044	496,516	510,122	558,025	588,846
PASSAIC	447,585	499,500	520,000	531,456	542,377	564,404	581,092
SOMERSET 1/	30,117	36,888	41,398	42,391	43,429	48,495	51,569
SUSSEX	34,188	39,557	43,105	44,278	45,474	53,356	57,555
UNION	46,046	48,391	48,391	49,356	50,262	50,203	50,613
ORANGE	56,446	64,084	79,112	92,882	106,890	120,898	134,907
ROCKLAND	169,238	160,519	179,469	199,157	219,379	239,601	259,822
TOTAL	2,418,861	2,652,047	2,785,064	2,874,271	2,960,566	3,104,229	3,219,528

SOURCE: New Jersey Statewide Supply Master Plan, extrapolated to the year 2040

SOURCE: U.S. Department of Commerce Bureau of Census Social and Economic Characteristics, 1980

1/ 1980 Census and projection data excludes population figures for Bridgewater Township due to the small portion of the township which is in the Passaic River Basin.

TABLE V-48

EMPLOYMENT PROJECTIONS
PASSAIC RIVER BASIN COUNTIES

County	1980	1990	2000	2010	2020	2030	2040
BERGEN	220,018	248,603	273,981	296,967	301,213	324,196	341,879
ESSEX	1,214,787	1,189,860	1,339,335	1,474,128	1,515,246	1,613,865	1,699,039
HUDSON	4,229	4,096	4,535	4,933	5,015	5,434	5,749
MORRIS	136,944	162,203	182,181	202,396	207,396	225,306	229,380
PASSAIC	350,113	362,785	400,848	434,399	440,051	475,858	502,397
SOMERSET	1,250	1,489	1,648	1,788	1,814	1,964	2,075
SUSSEX	474	547	613	674	691	754	804
UNION	4,851	5,218	5,784	6,288	6,387	6,836	7,211
ORANGE	3,287	4,115	5,080	5,964	6,864	7,764	8,663
ROCKLAND	18,096	21,287	23,800	26,411	29,093	31,774	34,456
TOTAL	1,954,048	2,000,203	2,237,805	2,453,948	2,513,770	2,693,751	2,831,653

SOURCE: New Jersey Department of Labor and Industry (ODEA)

TABLE V-49

PER CAPITA INCOME PROJECTIONS
(in actual dollars)*

SMSA		(Census Data) 1980	1990	2000	2030
5600:	New York, New York-New Jersey	7,905	8,109	9,941	16,998
6040:	Paterson-Clifton-Passaic, New Jersey	7,214	7,522	9,107	15,624
5640:	Newark, New Jersey	8,680	8,632	10,481	18,048
3640:	Jersey City, New Jersey	6,476	7,413	9,022	15,567

*Derived from 1980 OBERS population and personal income projections, no-change-in-share series.

TABLE V-50

EXISTING AND FUTURE CONDITIONS LAND USE
PASSAIC RIVER BASIN COUNTIES

COUNTY	EXISTING BASIN ACRES	EXISTING DEVELOPED ACRES* (1978)	1990 DEVELOPED ACRES	2040 DEVELOPED ACRES
BERGEN	74,130	51,821	53,006	55,666
ESSEX	56,729	43,274	45,676	47,728
HUDSON	4,215	3,037	3,422	3,422
MORRIS	201,290	82,610	93,936	96,051
PASSAIC	121,714	51,480	55,205	57,767
SOMERSET	24,214	10,403	13,003	14,252
SUSSEX	14,648	703	3,303	4,214
UNION	7,603	4,916	4,928	5,233
ORANGE	59,863	8,864	17,280	31,326
ROCKLAND	35,741	11,282	15,532	24,985
TOTAL	600,147	268,390	305,291	340,644

*DEVELOPED ACRES INCLUDE:

RESIDENTIAL, COMMERCIAL, INDUSTRIAL AND OTHER URBAN AND INSTITUTIONAL LAND USAGE

TABLE V-51
BASE YEAR WITHOUT PROJECT CONDITION
IMPACT OF FUTURE HYDROLOGY ($1,000 DOLLARS)

	EXISTING CONDITIONS 1985	1990	BASE CONDITION 2000	2050	EQUIVALENT ANNUAL DAMAGES (AAE)
PASSAIC RIVER					
LOWER VALLEY	30,027	32,424	35,623	47,155	36,653
CENTRAL BASIN	24,839	28,883	30,895	40,297	33,277
UPPER PASSAIC	629	666	684	764	704
POMPTON RIVER	23,794	25,451	26,334	29,930	27,268
WANAQUE RIVER	497	518	528	562	536
PEQUANNOCK RIVER	407	411	415	450	425
LOWER RAMAPO RIVER	3,877	4,206	3,992	4,383	4,416
TOTAL	84,070	92,559	98,471	123,541	103,279

Table V-52
Summary of Stage 3
Detailed Plans

Plans	Description
16A	Levee/Floodwall/Non-Structural/Channel Plan, variable 10 year-500 year level of protection, Channel modification Route 3 to Beatties Dam, Tidal area and Central Basin Levee/floodwall systems plus non-structural along Central Basin and Pompton Valley and Upper Tributaries reaches, 5,350 acres of natural storage preserved.
30A	Single Inlet Tunnel Plan, variable 50 year-500 year level of protection, 35-foot-diameter tunnel appproximately 2,000 feet upstream of Beatties Dam to near the Third River/ Passaic River confluence, Channel modification in Central Basin, Pompton Valley and Upper Tributaries,1/ Levee/flood-wall in Tidal area, Central Basin and Upper Tributaries,1/ 5,350 acres of natural storage preserved.
30E	Pompton River/Passaic River Dual Inlet Tunnel Diversion Plan, variable 100 year-500 year level of protection, 39-foot-diameter tunnel from Pompton River, to near Third River/ Passaic River confluence, 22-foot-diameter spur tunnel near Two Bridges, Channel modification in Central Basin, and Upper Tributaries, 1/ Levee/floodwalls in Tidal area, Central Basin and Upper Tributaries, 1/ 5,350 acres of natural storage preserved.

1/ Upper Tributaries includes the Lower Ramapo, Pequannock and Wanaque Rivers.

TABLE V-53

Flood Damages With and Without Project Conditions
Oct. 1985 Price Level at 8-5/8% Interest Rate
(DOLLARS IN $1,000)

	Damages Under with Plan Condition				Project Benefits					
		Base Year				Base Year		Average Annual	Benefits In 2/	Total
								Equivalent	Advance of	Average Annual 3/
Plan	1990 1/	2000	2050	AAED	1990	2000	2050	Benefits	Base Year (AAE)	Equivalent Benefits
Without Project 4/	91,900	97,800	122,800	102,600	N/A	N/A	N/A	N/A	N/A	N/A
16A	91,900	54,900	68,600	56,600	N/A	42,900	54,200	46,000	5,300	51,300
30A	91,900	24,400	31,800	25,200	N/A	73,400	91,000	77,400	13,800	91,200
30E	91,900	16,600	22,300	17,200	N/A	81,200	100,500	85,400	17,800	103,200

1/ Between the years 1990 and 2000 project features would come on line as shown on construction schedule, see Supporting Documentation Part IV, Cost Estimate Section, Figure IV-1.
2/ Benefits in advance of base year include tunnel, levee/floodwall and preservation inundation reduction benefits.
3/ Figures include channel, tunnel, non-structural, levee/floodwall and preservation prebase year and postbase year benefits.
4/ Figures exclude Upper Passaic damages of 666,000 (actual dollars).

TABLE V-54

SAMPLE AFFLUENCE FACTOR COMPUTATION - FACT-5A PROGRAM
CENTRAL PASSAIC RIVER
(8 5/8%, 100 YEAR PROJECT LIFE)

```
 FACT-5A
===> FACT-5A
WHAT IS THE INCOME GROWTH RATE DATA TYPE?
 1= GROWTH RATES (%); 2= PROJECTED INCOMES
>1
INPUT GROWTH RATES OF INCOME FOR PRESENT TO BASE YEAR AND
SUBSEQUENT TEN YEAR PERIODS. PUT THE NUMBERS(THERE SHOULD
BE SIX) ON ONE LINE, SEPARATED BY COMMAS.
>2.34,2.17,1.78,1.51,1.31,1.37
HOW MANY YEARS TO THE BASE YEAR
>22
 WHAT IS THE INTEREST RATE FOR THIS PROJECT
>8.625
WHAT % OF RESIDENTIAL VALUE IS CONTENTS
>35.6
           YEARS AFTER BASE       BASE FACTOR       % CONTENTS
                   0                 1.663             59.2

                  10                 2.062             73.4

                  20                 2.460             87.6

                  30                 2.857            101.7

                  40                 3.254            115.9

                  50                 3.729            132.7

GROWTH ASSUMED TO END AFTER 12 YEARS


   WHAT IS THE PROJECT LIFE
>100

         ACCUMULATED PRESENT WORTH OVER PROJECT LIFE IS     22.8660

          AVERAGE ANNUAL EQUIVALENT FACTOR IS      1.97


DO YOU WISH TO USE A DIFFERENT % FOR CONTENTS?
(YES, TYPE 1; NO, TYPE 0)
>0
>
```

TABLE V-55
Summary of Affluence Factors

Stream	CV/SV	Affluence Factor
Lower Passaic	35.4%	1.97
Central Passaic	35.6%	1.97
Upper Passaic	33.5%	2.01
Pompton	34.0%	2.00
Lower Ramapo	33.9%	2.01
Wanaque	33.6%	2.01
Pequannock	34.3%	2.00

TABLE V-56

SAMPLE COMPUTATION OF THE RATIO OF CONTENT TO
STRUCTURE VALUE FOR RESIDENTIAL STRUCTURES
LOWER PASSAIC MAINSTEM

	# Of Structures By Type		CV/SV		
Bilevel	61	X	.324	=	19.764
Cape	2540		.356		904.24
Colonial	1810		.312		564.72
Mobile Home	0		.654		0
Other	497		.397		197.3
Ranch	452		.329		148.7
Split	149		.326		48.57
Two Family	1425		.399		568.58
Total	6934				(2451.87)

(2451.87) ÷ Total # of structures = .354 weighted content value

Weighted Average $\frac{2451.87}{6934}$ = .354 Content to structure value

TABLE V-57

SAMPLE OF COMPUTATION OF THE RATIO OF CONTENT TO STRUCTURE VALUE FOR RESIDENTIAL STRUCTURES CENTRAL PASSAIC MAINSTEM

	# Of Structures By Type		CV/SV		
Bilevel	1150	X	.324	=	372.6
Cape	1635		.356		582.06
Colonial	2099		.312		654.89
Mobile Home	199		.654		304.28
Other	482		.397		191.35
Ranch	1666		.329		548.11
Split	1528		.326		498.13
Two Family	42		.399		16.76
Total	8801				(3168.18)

(3168.18) ÷ Total # of structures = .356 weighted content value

Weighted Average $\frac{3168.18}{8801}$ = .356 Content to structure value

TABLE V-58

AVERAGE POPULATION GROWTH RATE: IN SMSA'S WITHIN PASSAIC RIVER BASIN SERVICE AREA

	Hudson County/Jersey City SMSA				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
	Growth Rate				
New Jersey* Water Supply Master Plan	1.022	1.022	1.022	1.020	1.020
OBERS SMSA	1.056	1.037	1.031	1.031	1.031

	Essex, Morris, Somerset, Union Counties/Newark SMSA				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New Jersey Water Supply Master Plan	1.039	1.038	1.022	1.021	1.021
OBERS SMSA	1.073	1.045	1.035	1.034	1.033

	Passaic County/Passaic-Clifton-Paterson SMSA				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New Jersey Water Supply Master Plan	1.043	1.041	1.022	1.021	1.021
OBERS SMSA	1.066	1.039	1.033	1.032	1.031

	New York , New York - New Jersey SMSA				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New Jersey Water Supply Master Plan OBERS SMSA	.987	.976	.996	.996	.996

	**Bergen County, New Jersey				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New Jersey Water Supply Master Plan	1.046	1.043	1.022	1.021	1.021

	**Orange County, New York				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New York Eco. Dev. Bd.	1.25	1.23	1.17	1.15	1.13

TABLE V-58 (cont'd)

	**Rockland County, New York				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New York Eco. Dev. Bd.	1.18	1.12	1.11	1.10	1.09

	Total Jersey City, Newark and Passaic-Clifton-Paterson SMSA's				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
New Jersey Water Supply Master Plan	1.037	1.035	1.022	1.021	1.021
OBERS SMSA	1.069	1.042	1.034	1.033	1.032

	***Total Jersey City, Newark, Passaic-Clifton-Paterson and New York - Northeastern New Jersey SMSA				
	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030
OBERS SMSA	1.007	.993	1.006	1.006	1.006

*The New Jersey Water Supply Master Plan projections are 208 policy projections and were used for Passaic River Basin population and employment projections, however, they have been extrapolated to the year 2030.

**These counties are included in the New York, New York - New Jersey SMSA in addition to the Bronx, Kings, New York, Putnam, Queens, Richmond and Westchester, New York.

***Includes some areas outside of the Passaic River Study Baisn.

TABLE V-59

Residential Intensification Benefits
October 1985 Price Levels @ 8-5/8% Interest Rate

	Lower Valley	Central Basin	Pompton Basin
Average Flood Hazard Area Residential Market Values (Without Project Conditions)	$106,000	$108,000	$110,000
Percent Increase in Market Value due to reduction of flood hazard	38%	37%	32%
Average Residential Market Values with reduction of flood hazard (With Project Conditions)	$146,300	$148,000	$145,200
Average Residential Basement Values (6% of MV)			
w/flood hazard	$8,778	$8,880	$8,712
w/o flood hazard	$6,360	$6,480	$6,600
Net Increase in Basement Value due to reduction in flood hazard	$2,418	$2,400	$2,112
Average Annual Benefits per Residential Structures	$208	$207	$182
Number Structures Benefiting (60% of total in 10 yr floodplain)	684	2,058	3,085
Total Annual Benefits	$142,300	$426,000	$561,500

TABLE V-60

SAMPLE COMPUTATION
ADDITIONAL VEHICULAR OPERATING COSTS ASSOCIATED
WITH INUNDATED ROADWAY (100 YR EVENT)
Oct. 85 Price Level @ 8-5/8% Interest Rate

Location	Route 46 at Two Bridges Rd. to Route 23 and I-80 Interchange in Wayne, N.J.	
Flood Depth	4.8	feet
Duration Depth Exceeds an Elevation 1 Foot Above Roadway	99	hours
Average Annual Daily Traffic (A.A.D.T.)	24,100	
A.A.D.T. per hour	1,000	
Total Vehicles Affected	99,000	
Automobiles	82,000	
Trucks	17,000	
Original Route Mileage	24.2	miles
Alternate Route Mileage	29.8	miles
Additional Mileage per Vehicle	5.6	miles
Total Additional Mileage		
Automobiles (82,000 * 5.6)	459,200	miles
Trucks (17,000 * 5.6)	95,200	miles
Total Additional Operating Costs		
Automobiles (459,200 * $0.25/mile	$114,800	
Trucks (95,200 * $0.40/mile)	$38,100	
TOTAL ADDITIONAL OPERATING COSTS TO ALL VEHICLES	$152,900	

TABLE V-61

SAMPLE COMPUTATION - ADDITIONAL TRAVEL COSTS ASSOCIATED WITH INUNDATED ROADWAY (100 YR EVENT)

Location	Route 46 at Two Bridges Rd. to Route 23 and I-80 Interchange in Wayne, N.J.	
Total Vehicles Affected	99,000	
Automobiles	82,000	
Trucks	17,000	
Original Route Mileage	24.2	miles
Total Travel Time on Original Route		
Automobiles		
(82,000 * 24.2/45 mph)	44,100	hours
(17,000 * 24.2/45 mph)	9,100	hours
Alternate Route Mileage	29.8	miles
Total Travel Time on Alternate Route		
Automobiles		
(82,000 * 29.8/10 mph)	244,400	hours
Trucks		
(17,000 * 29.8/10 mph)	50,700	hours
Additional Travel Time		
Automobiles (244,400 - 44,100)	200,300	hours
Trucks (50,700 - 9,100)	41,600	hours
TOTAL DELAY COSTS		
Automobiles		
(200,300 * $6.67/person-hour * 2 persons/vehicle)	$2,672,000	
Trucks (41,600 * $12.18/person-hour)	$506,700	
TOTAL DELAY COST TO ALL VEHICLES	$3,178,700	

TABLE V-62

PASSAIC RIVER BASIN
TRAFFIC FLOW COSTS AT STAGE
[Dollars in thousands]
October 1985 Price Levels @ 8-5/8% Interest Rate

TYPE OF COST	10 YR. FLOOD EVENT	50 YR. FLOOD EVENT	100 YR. FLOOD EVENT	500YR. FLOOD EVE
DETOUR COSTS: (Additional Mileage)				
AUTO	450	1,075	1,411	7,511
TRUCKS	191	454	567	2,662
DELAY COSTS:				
AUTO	1,916	5,922	9,055	30,209
TRUCKS	943	2,605	4,000	12,017
TOTAL	3,500	10,056	15,033	52,399

TABLE V-63

PASSAIC RIVER BASIN
EXPECTED ANNUAL TRAFFIC COSTS
October 1985 Price Levels, 8-5/8% Interest Rate

Frequency (%)	Total Expected Annual Damage ($1,000)
0.2	2,600
1.0	2,415
2.0	2,286
5.0	2,048
10.0	1,815
20.0	1,540
100.0	0

TABLE V-64

PASSAIC RIVER BASIN
TOTAL COST OF DELAY OF TRAINS ON PATH LINES
October 1985 Price Levels @ 8-5/8% Interest Rate
(ACTUAL DOLLARS)

Flood Event	Delay Cost	Shuttle Bus Operation Cost	Total Cost
10 year	263,600	3,000	266,600
50 year	790,800	9,000	799,800
100 year	1,054,500	12,000	1,066,500
500 year	2,108,900	24,000	2,132,900

TABLE V-65

PASSAIC RIVER BASIN
EXPECTED ANNUAL PATH LINES COST
(ACTUAL DOLLAR VALUE)

Frequency (%)	Total EAD
0.2	1,327,200
1.0	1,214,000
2.0	1,120,000
5.0	925,300
10.0	733,500
20.0	537,500
100.0	0

TABLE V-66

Induced Damages (AAE)
October 1986 Price Level @ 8-5/8% Interest Rate
(Dollars are in $1,000's)

Damage Reach	Total Induced Damages 1/	Induced Damages Eliminated	Induced Damages not Eliminated
010031	3.9	0.0	3.9
010032	412.2	320.6	91.6
010041	164.5	111.0	53.5
010042	562.7	376.3	186.4
010051	160.1	124.5	35.6
010052	271.7	225.1	46.6
010061	272.4	236.2	36.2
010071	709.6	575.1	134.5
010072	651.1	557.2	93.9
010081	18.1	13.2	4.9
010091	734.8	496.6	238.2
010092	9.8	4.8	5.0
010101	23.5	23.5	0.0
010102 2/	0.0	0.0	0.0
010107	1.6	0.0	1.6
010109	0.5	0.0	0.5
010112 2/	0.0	0.0	0.0
010118	2.4	0.0	2.4
010119	3.5	0.0	3.5
670031 3/	2.5	0.0	2.5
670032 3/	0.7	0.0	0.7
670040 3/	8.1	0.0	8.1
	4013.7	3064.1	946.6

1/ Total induced damage figures reflect induced effects of Tunnel and Levee/Floodwall systems.

2/ Average Annual equivalent induced damage figures do not reflect increases in flood stages under with project conditions during the 1 year through the 10 year flood events.

3/ Induced damages caused by levee encroachment occur when floodwater exceeds the design level of protection of the levee system.

TABLE V-67
BENEFITS OF DETAILED PLANS ($1,000)
October 1985 Price Levels @ 8-5/8% Interest Rate

PLAN	INUNDATION* REDUCTION	AFFLUENCE	RESIDENTIAL INTENSIFICATION	TRAFFIC FLOWS	INDUSTRIAL CONTENT GROWTH	FIA COST REDUCTION	PATH DELAY	TOTAL BENEFITS
16A	51,300	3,900	600	700	1,400	600	1,300	59,800
30A	91,200	6,600	1,100	2,300	2,500	700	1,300	105,700
30E	103,200	6,700	1,100	2,400	2,600	900	1,300	118,200

*INUNDATION REDUCTION BENEFITS INCLUDE CHANNEL, TUNNEL, NONSTRUCTURAL, LEVEE/FLOODWALL AND PRESERVATION PREBASE YEAR AND POSTBASE YEAR BENEFITS.

NUMBERS MAY NOT MATCH PLAN FORMULATION APPENDIX DUE TO ROUNDING.

TABLE V-68
BENEFIT OF DETAILED PLANS ($1,000)
NET OF FUTURE HYDROLOGIC CONSIDERATION
October 1985 Price Levels at 8-5/8% Interest Rate

PLAN	INUNDATION 1/ REDUCTION	TRAFFIC FLOW	FIA COST REDUCTION	PATH DELAY	TOTAL BENEFITS
16A	48,000	700	600	1,300	50,600
30A	85,900	2,300	700	1,300	90,200
30E	96,400	2,400	900	1,300	101,000

1/ Figures include channel, tunnel nonstructural levee/floodwall and preservation prebase year and postbase year inundation reduction benefits.

TABLE V-69

BENEFIT/COST RATIOS - DETAILED PLANS
Oct. 1985 Price Level at 8-5/8% Interest Rate
(DOLLARS IN $1000's)

PLAN NUMBER	TOTAL ANNUAL BENEFITS (AAE)	ANNUAL COST	B/C RATIO	NET BENEFITS
16A	59,800	38,600	1.5	21,200
30A	105,700	79,900	1.3	25,800
30E	118,200	83,000	1.4	35,200

TABLE V-70

BENEFIT/COST RATIOS - DETAILED PLANS
NET OF FUTURE HYDROLOGIC CONSIDERATION
Oct. 1985 Price Levels at 8-5/8% Interest Rate
(DOLLARS IN $1000's)

PLAN NUMBER	TOTAL ANNUAL BENEFITS(AAE)	ANNUAL COST	B/C RATIO	NET BENEFTIS
16A	50,600	38,600	1.3	12,000
30A	90,200	79,900	1.1	10,300
30E	101,000	83,000	1.2	18,000

TABLE V - 71

RESIDUAL DAMAGES
October 1985 Price Levels at 8-5/8% Interest Rate
(Dollars In Thousands)

PLANS	WITHOUT PROJECT 1/ EQUIVALENT ANNUAL DAMAGES (AAE)	INUNDATION 2/ REDUCTION	AAE RESIDUAL DAMAGES	PERCENT (AAE) DAMAGE REDUCTION (%)	WITHOUT PROJECT 500 YR DAMAGES	500 YR RESIDUAL DAMAGES	PERCENT (500 YR) DAMAGE REDUCTION (%)
16A	102,600	46,000	56,600	45	2,700,000	2,200,000	19
30A	102,600	77,400	25,200	75	2,700,000	1,400,000	48
30E	102,600	85,400	17,200	83	2,700,000	1,300,000	52

1/ Without Project AAED exclude Upper Passaic Damages.
2/ Figures exclude levee/floodwall,tunnel, and preservation inundation reduction benefits in advance of the base year

TABLE V-72
BENEFIT/COST RATIOS
RECOMMENDED PLAN 30E
(October 1986 price level at 10% interest rate)

PLANS	ANNUAL BENEFITS (AAE)	ANNUAL COST	B/C	NET BENEFITS
30E	$119,300	101,200	1.2	18,100

TABLE V-73

PLAN 30E BENEFIT SUMMARY
Oct 1986 Price Levels @ 8 5/8% Interest Rate

BENEFIT CATEGORIES	($1,000)
Inundation Reduction	61,500
Tunnel/Channel	5,100
Integral Levees/Floodwalls (1)	13,500
Tidal Levees/Floodwalls	7,800
Fluvial Levees/Floodwalls	1,100
Preservation (1)	
Benefits In Advance Of The Base Year	
Tunnel	6,600
Levees	9,400
Preservation	2,100
Total Benefits from Inundation Reduction	107,100
Other Benefits	
Affluence	6,800
FIA Cost Reduction	1,100
Traffic Flow	2,500
PATH Delays	1,300
Residential Intensification	1,100
Industrial Content	2,600
Total Benefits	122,500
Total Annual Cost	85,500
B/C Ratio	1.4
Net Benefits	37,000

(1) Integral levee/floodwall and preservation benefits presented at October 1986 price level differ from benefits presented at October 1985 price level in that the former underwent greater economic refinement.

TABLE V-74

BENEFIT COST SENSITIVITY
Oct. 1985 Price Levels at 8-5/8% Interest Rate
(DOLLARS IN $1,000)

PLAN NUMBER	TOTAL ANNUAL BENEFITS(AAE)	BENEFIT WITH 10% REDUCTION	ANNUAL COST	B/C RATIO
16A	59,800	53,800	38,600	1.4
30A	105,700	95,100	79,900	1.2
30E	118,200	106,400	83,000	1.3

TABLE V-75

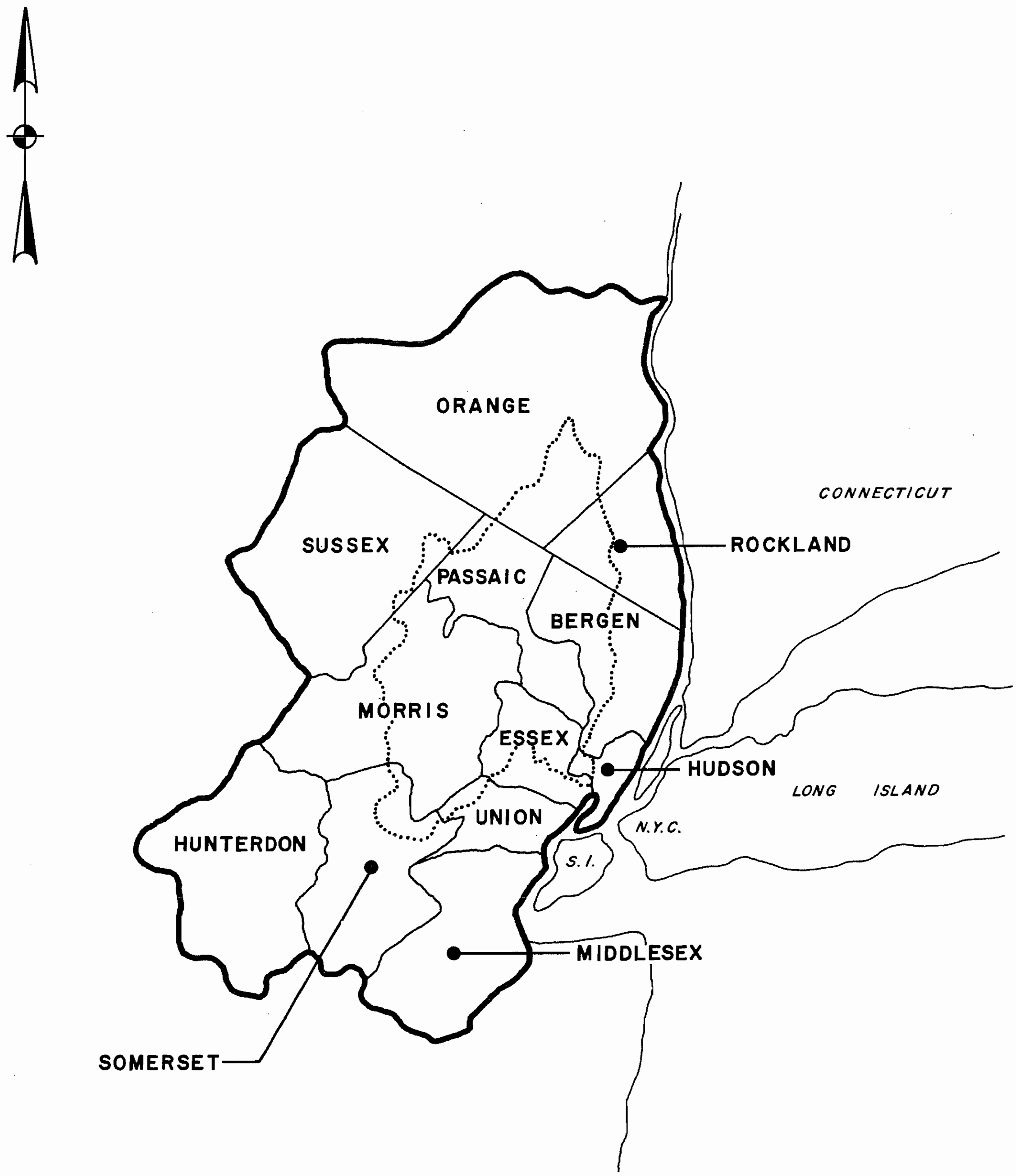
BENEFIT/COST SENSITIVITY
Oct 1985 Price Levels at 8-5/8% Interest Rate
(DOLLARS IN $1,000)

PLAN NUMBER	TOTAL ANNUAL BENEFITS	BENEFITS WITH 25% REDUCTION	ANNUAL COST	B/C RATIO
16A	59,800	44,900	38,600	1.2
30A	105,700	79,300	79,900	.99
30E	118,200	88,700	83,000	1.07

TABLE V-76

BENEFIT/COST SENSITIVITY
BENEFITS EXCLUDING INDUSTRIAL CONTENT GROWTH
Oct. 1985 Price Levels at 8-5/8% Interest Rate
(DOLLARS IN $1000)

PLAN NUMBER	TOTAL ANNUAL BENEFITS	ANNUAL COST	B/C RATIO	NET BENEFITS
16A	58,400	38,600	1.5	19,800
30A	103,200	79,900	1.3	23,300
30E	115,600	83,000	1.4	32,600



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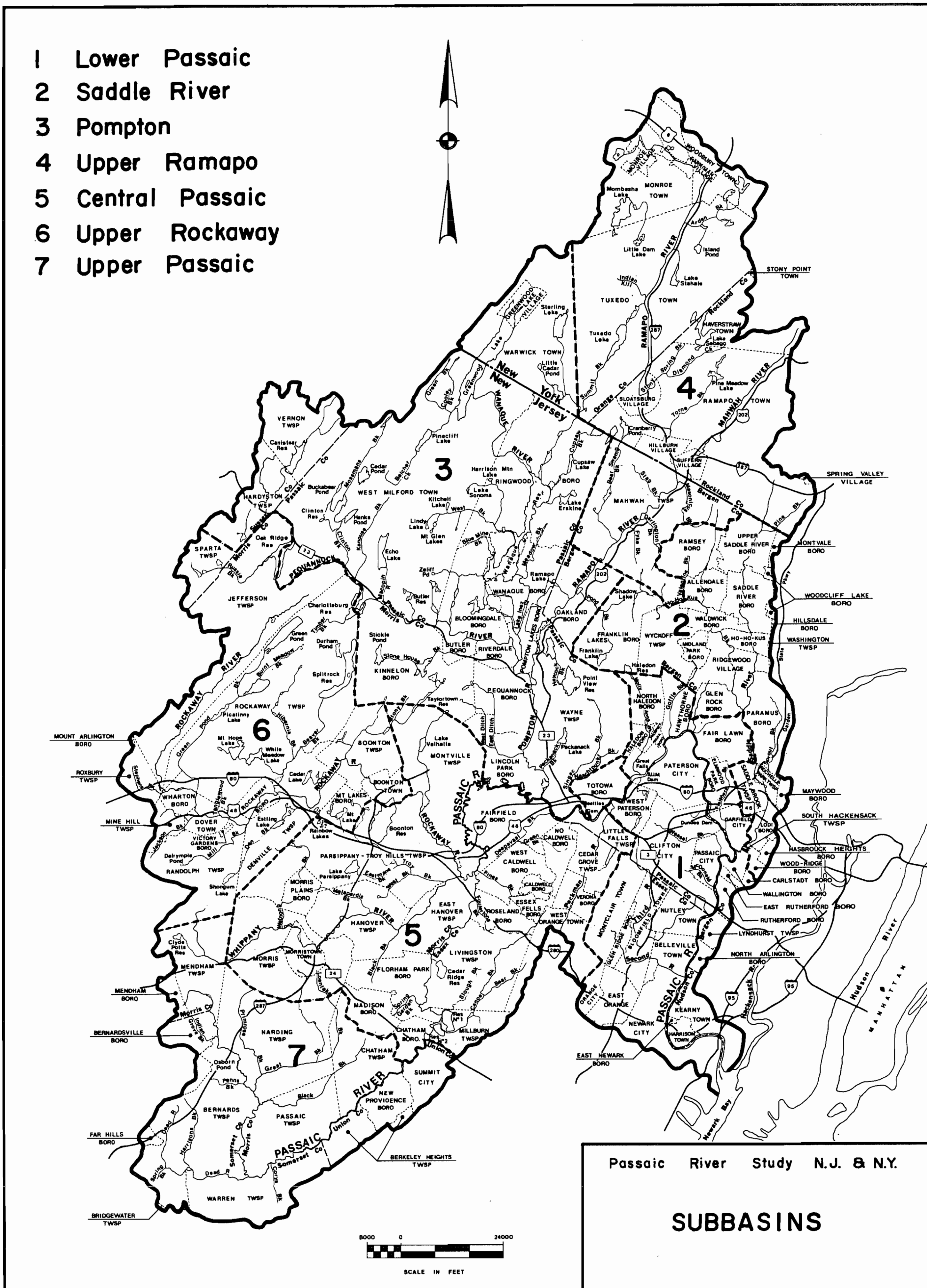
SERVICE AREA

FIGURE V-1



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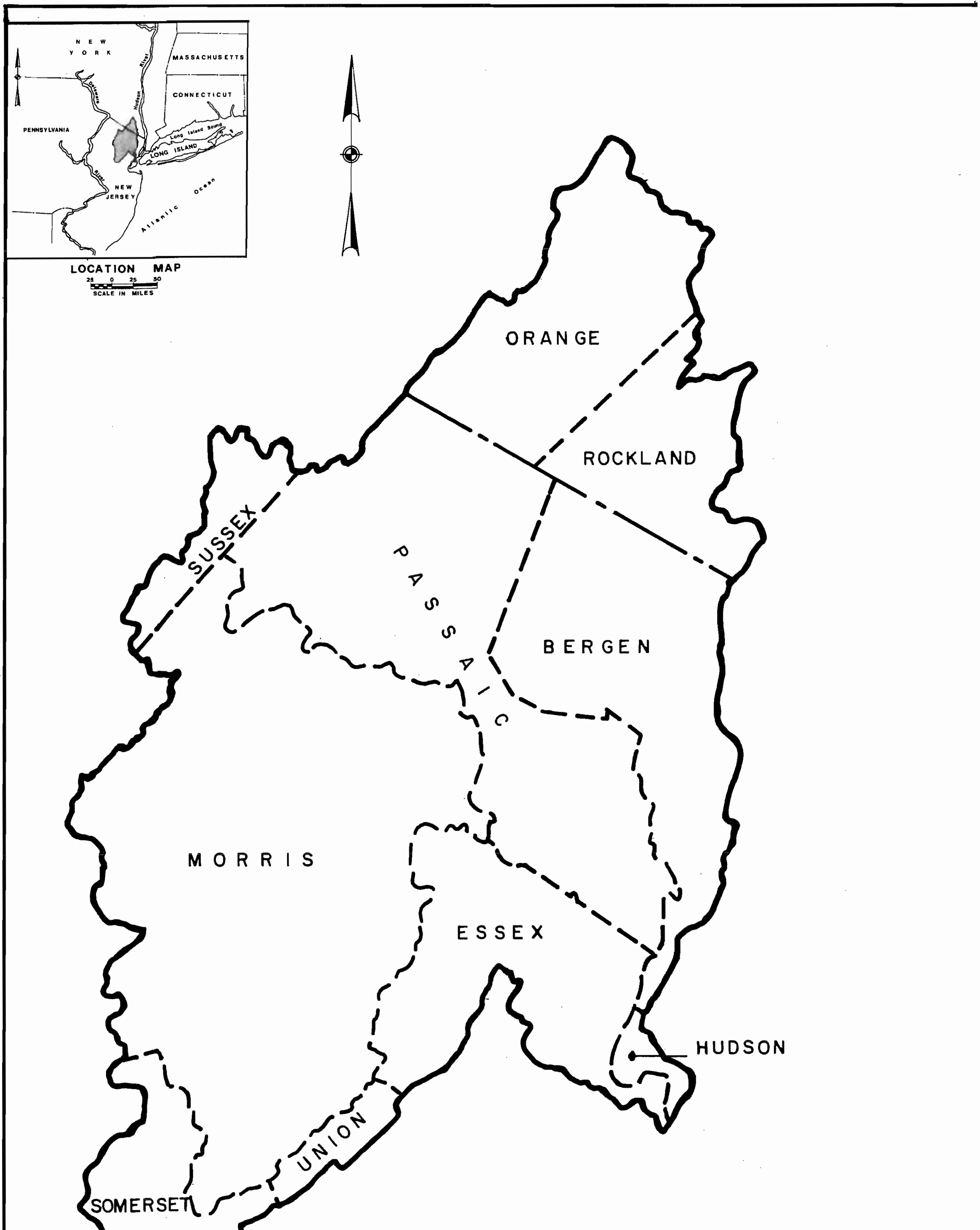
SUBBASINS

FIGURE II-2



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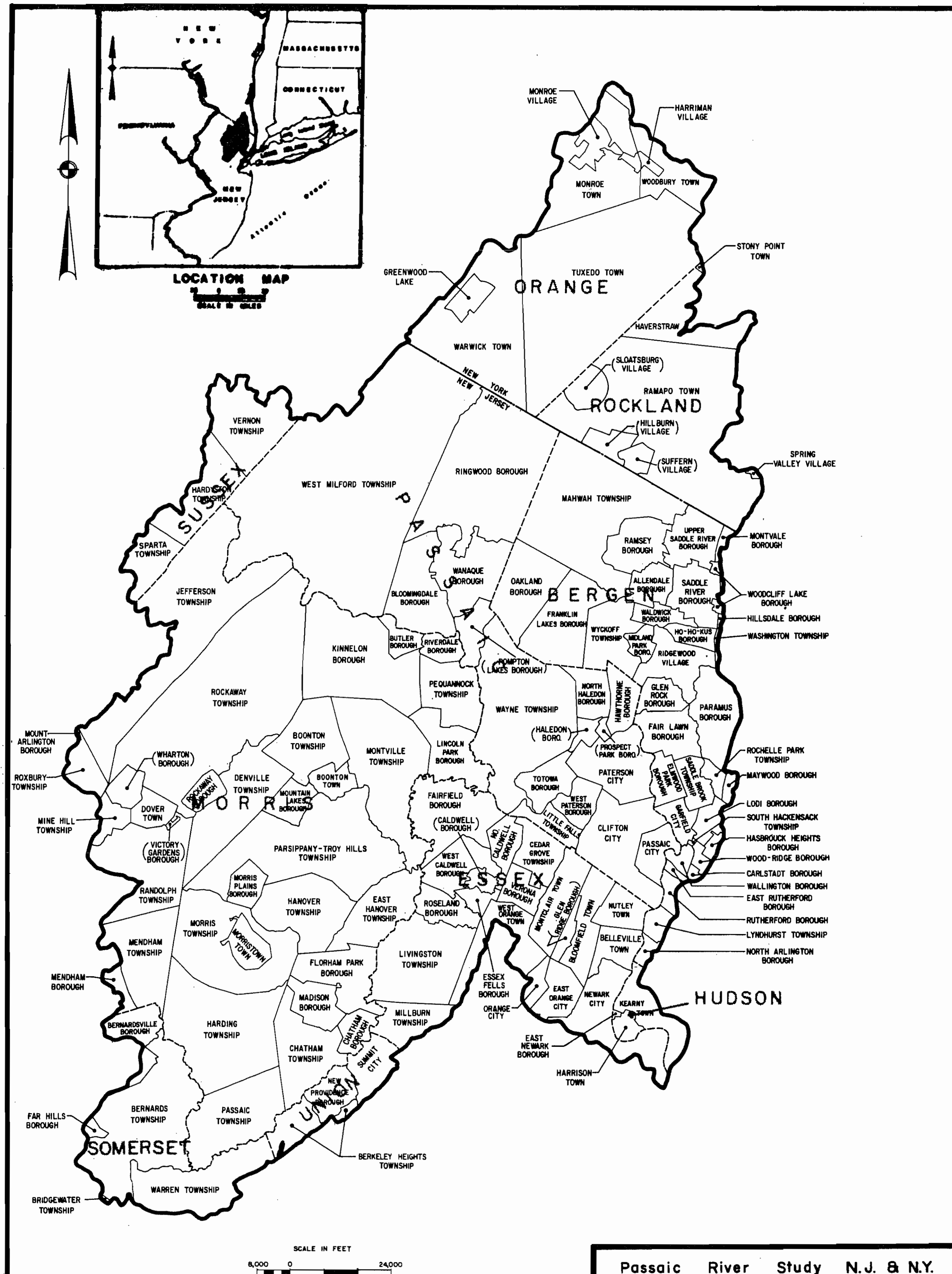
STUDY AREA BY COUNTIES

FIGURE V-3



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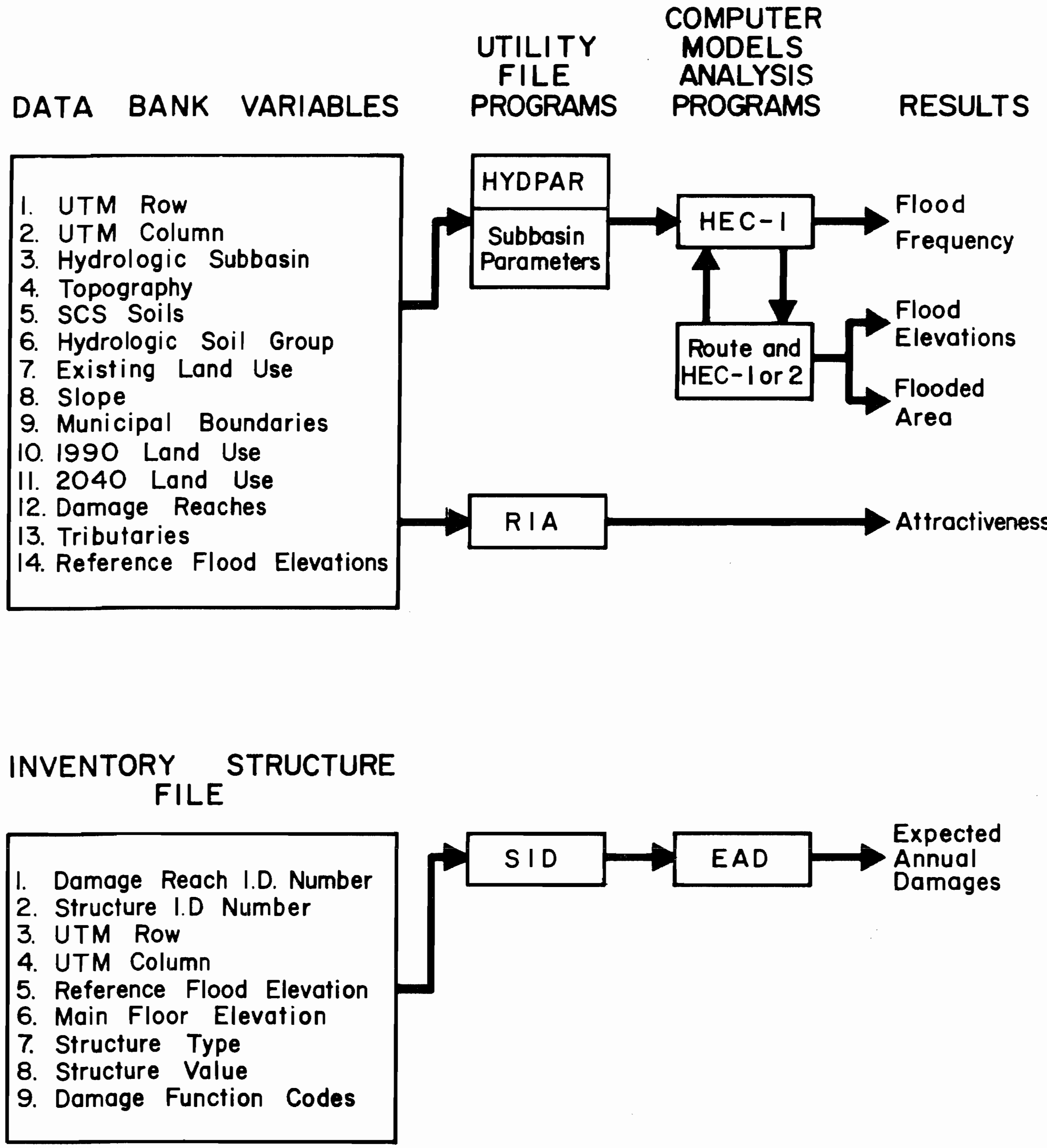
COUNTIES AND MUNICIPALITIES

FIGURE V-4



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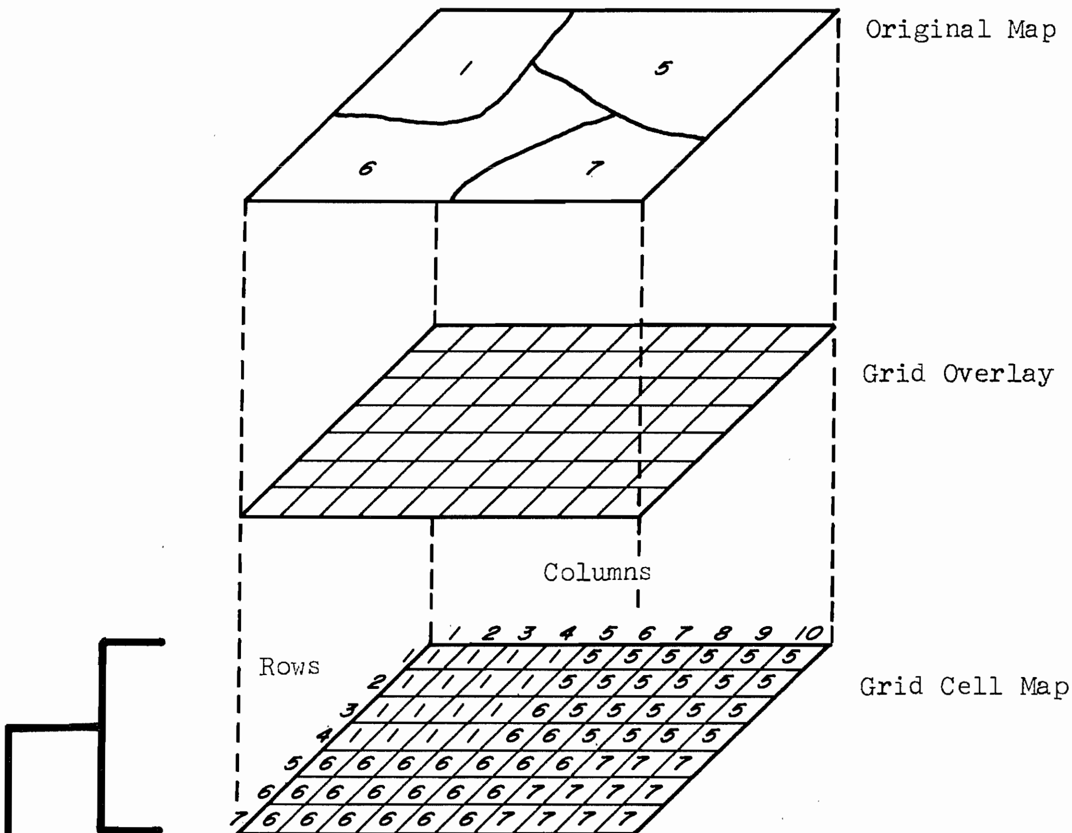
PASSAIC DATA SYSTEM

FIGURE V-5



STORED DATA FILE
(single variable file)

Row	Column	Value
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1	2	1
1	3	1
1	4	1
1	5	5
1	6	5
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.

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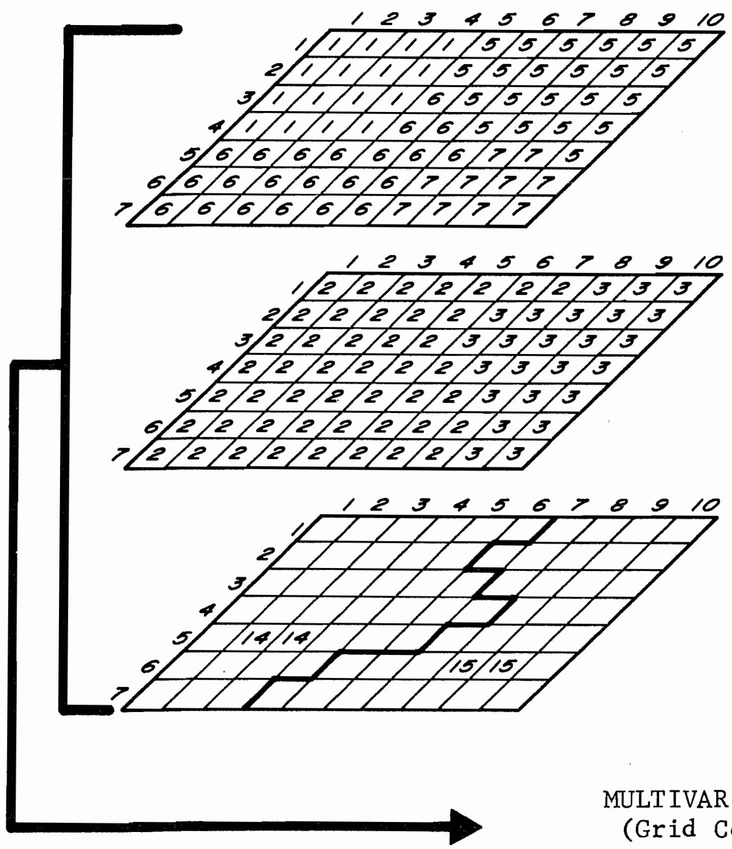
SINGLE VARIABLE DATA BANK



EXISTING LAND USE (DATA VARIABLE 5)

Code 6 RESIDENTIAL HIGH DENSITY
Code 1 BARREN LAND
Etc.

SLOPE (DATA VARIABLE 6)

Code 2 is 4-8% slope
Code 3 is 9-12% slope
Etc.

MUNICIPAL BOUNDARIES (DATA VARIABLE 7)

Code 14 is Fairfield
Code 15 is Caldwell
Etc.

MULTIVARIABLE FILE STRUCTURE
(Grid Cell Value Assignments)

Grid Cell Location		Data var. 1	Data var. 2	Data var. m
ROW	COLUMN			
1	1	1	2	0
1	2	1	2	8
1	3	1	2	0
1	4	1	2	0
1	5	6	2	0
1	.	.	.	.
1	10	6	3	15
2	1	1	2	14
2	2	1	2	14
2	3	1	2	14
2	.	.	.	.
2	.	.	.	.
.	.	.	.	.
.	.	.	.	.
k	.	.	.	.
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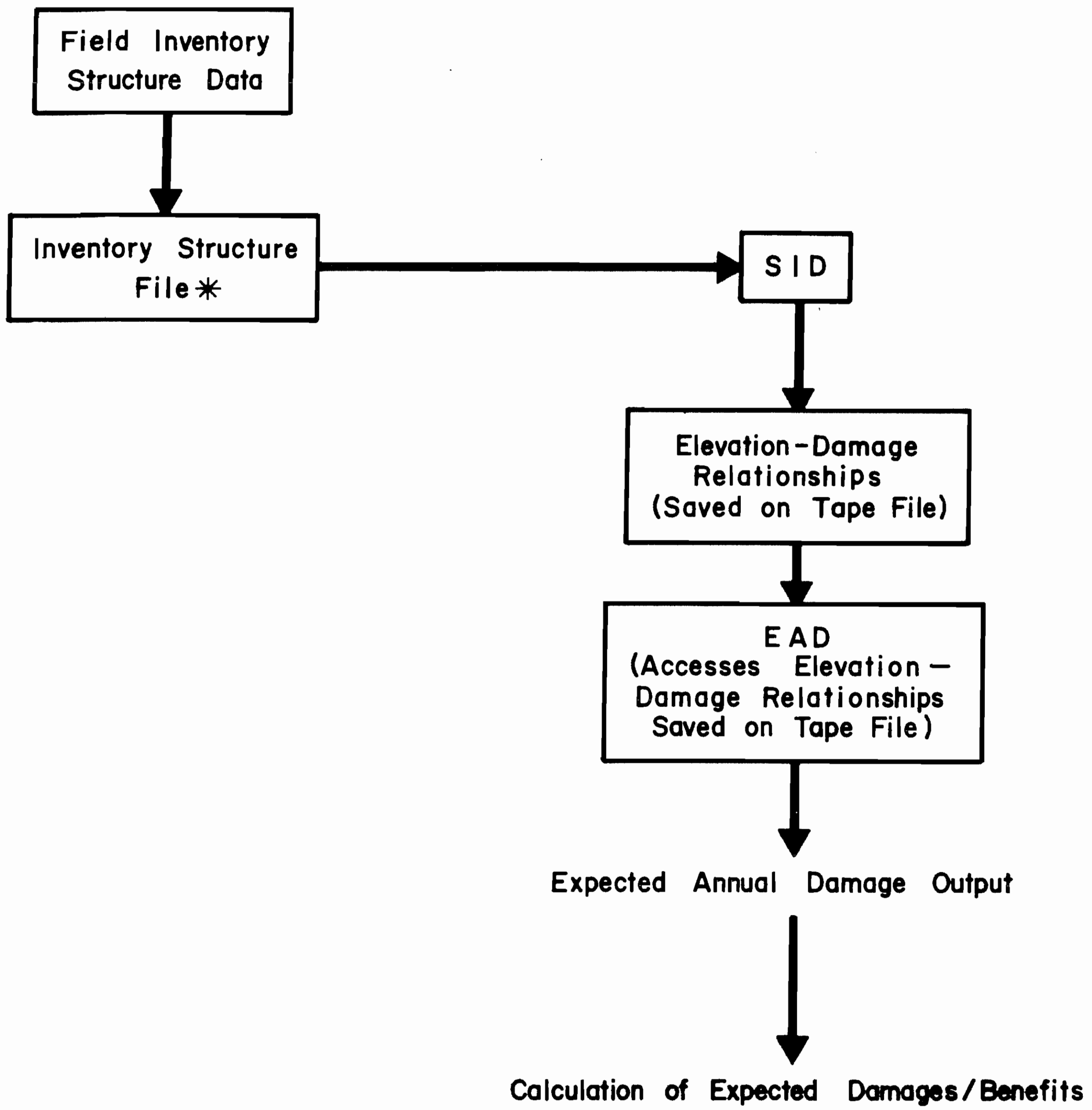
MULTIVARIABLE DATA BANK

FIGURE



* Detailed in Figure V-5

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SID DATA MANAGEMENT SYSTEM

FIGURE V-8

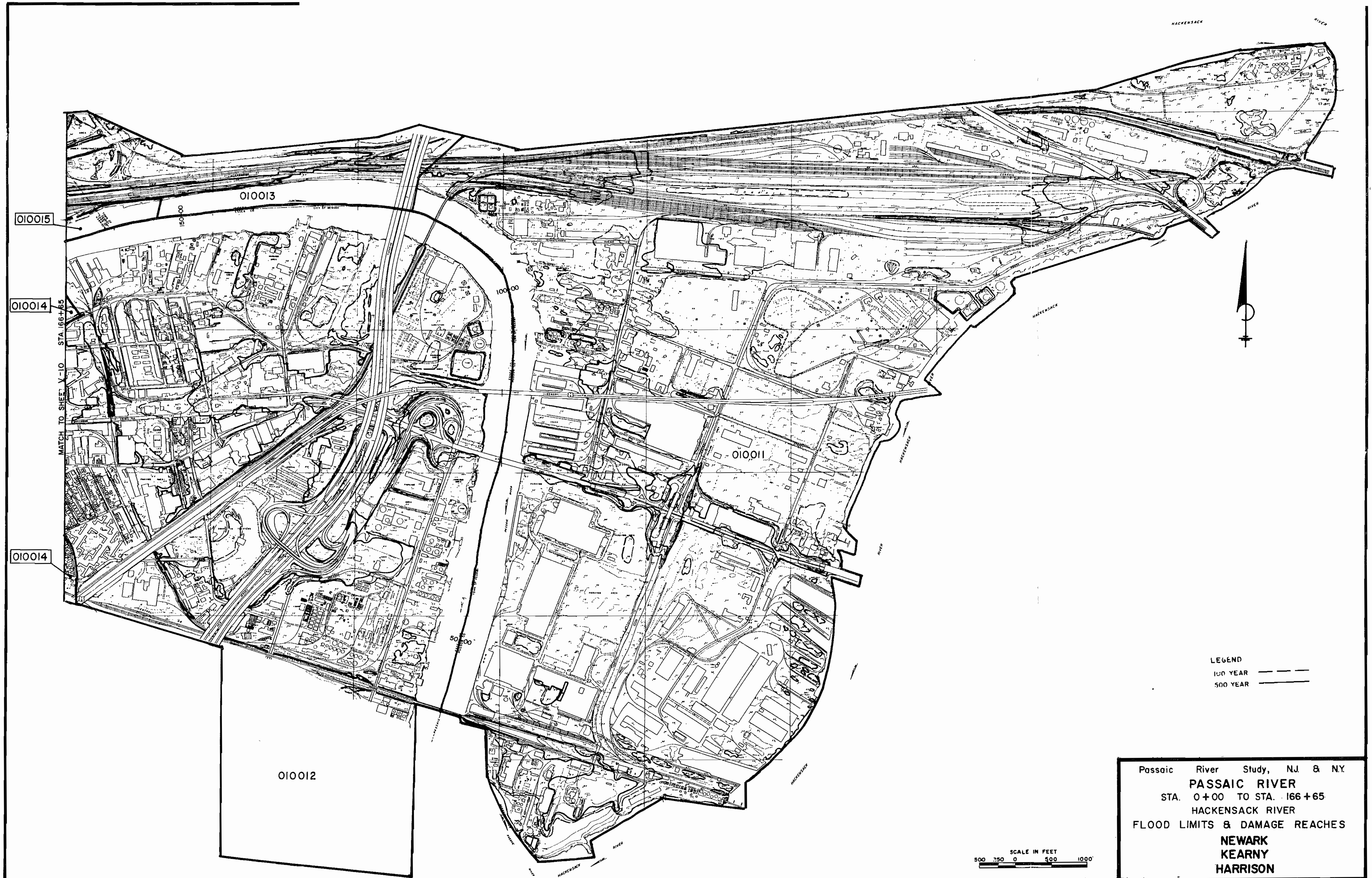
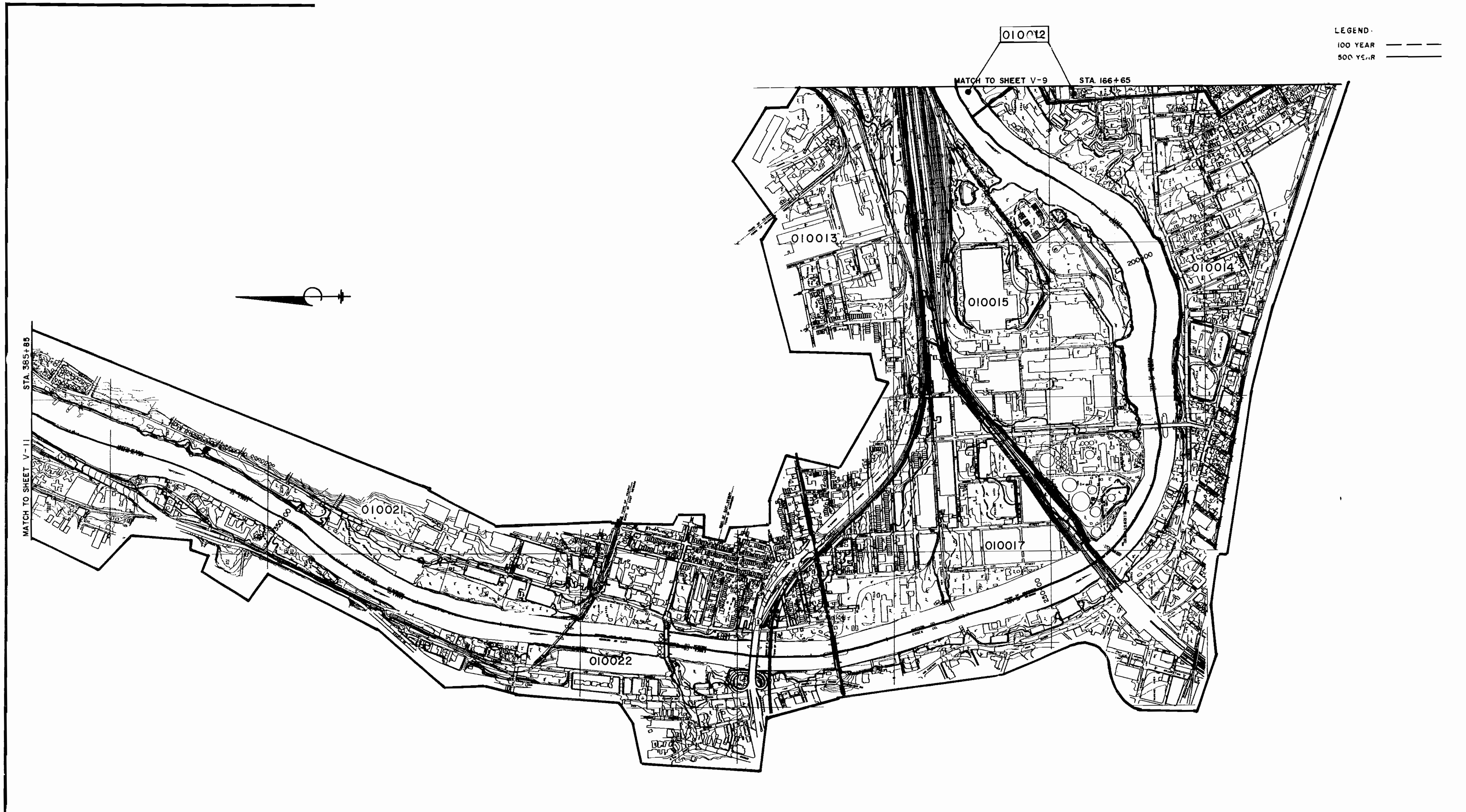

010013
010015
010014
STA. 166+65
MATCH TO SHEET V-10
010014
010011
010012
LEGEND
100 YEAR
500 YEAR
SCALE IN FEET
Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 0+00 TO STA. 166+65
HACKENSACK RIVER
FLOOD LIMITS & DAMAGE REACHES
NEWARK
KEARNY
HARRISON

FIGURE NO. V-9



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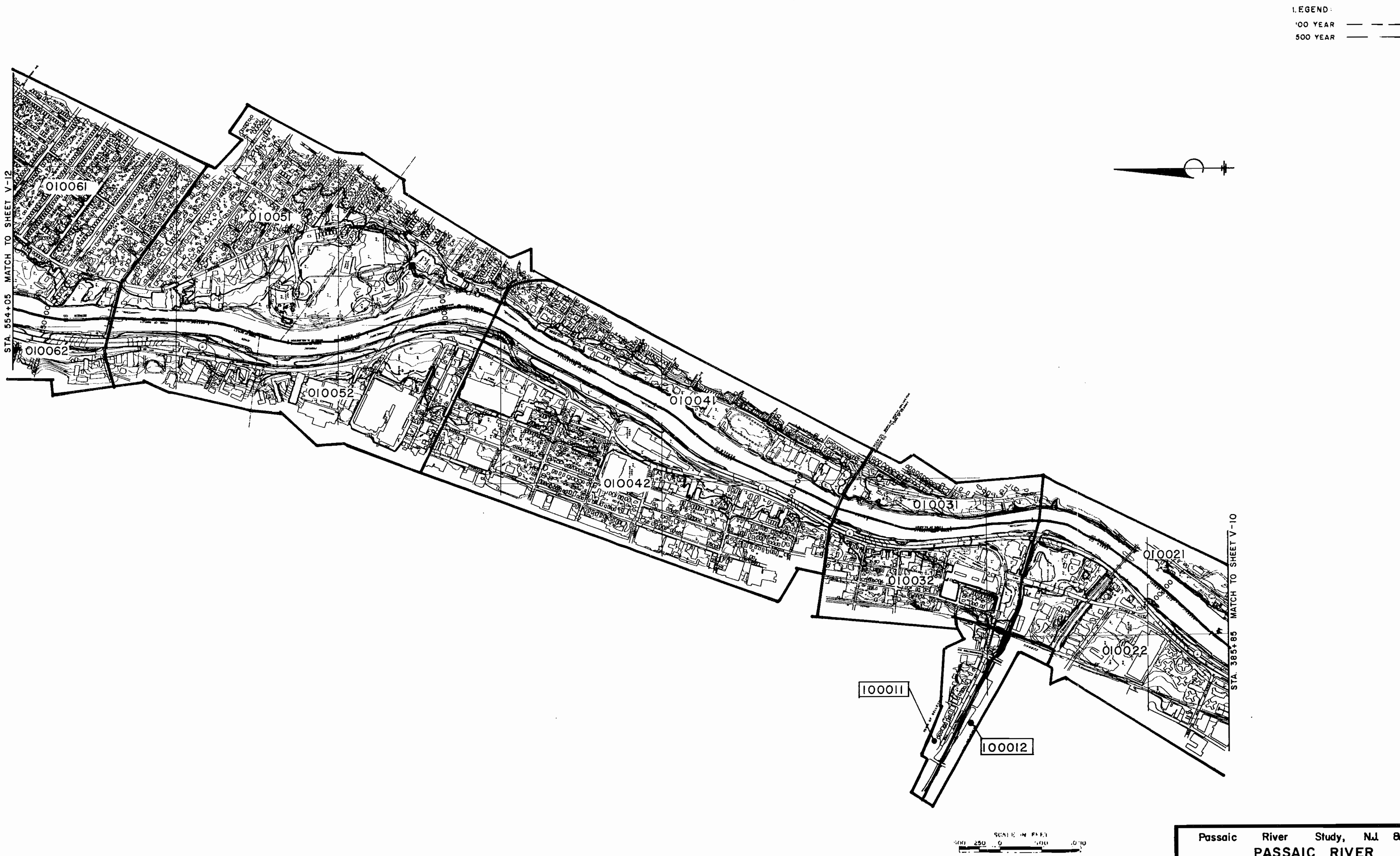
PASSAIC RIVER

STA. 166+65 TO STA. 385+85

FLOOD LIMITS & DAMAGE REACHES

NEWARK KEARNY
HARRISON EAST NEWARK

FIGURE V-10



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PASSAIC RIVER

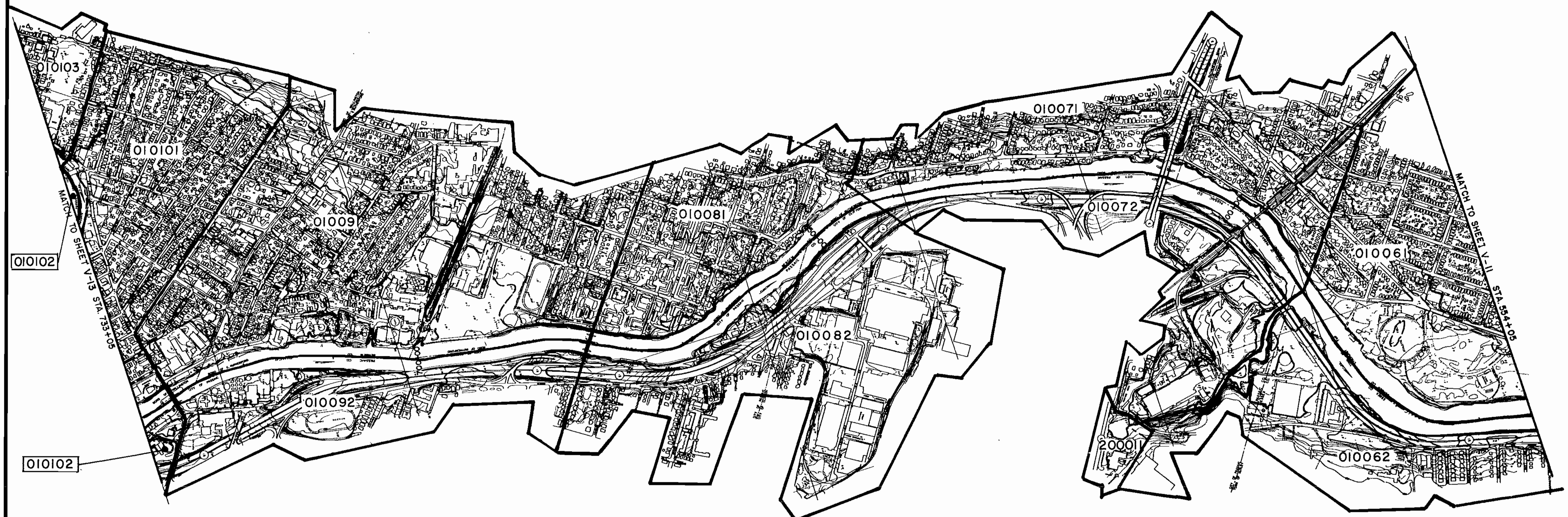
STA. 385+85 TO STA. 554+05

FLOOD LIMITS & DAMAGE REACHES

NEWARK KEARNY
BELLEVILLE NORTH ARLINGTON
NUTLEY LYNDHURST

FIGURE V-11

LEGEND:
100 YEAR
500 YEAR



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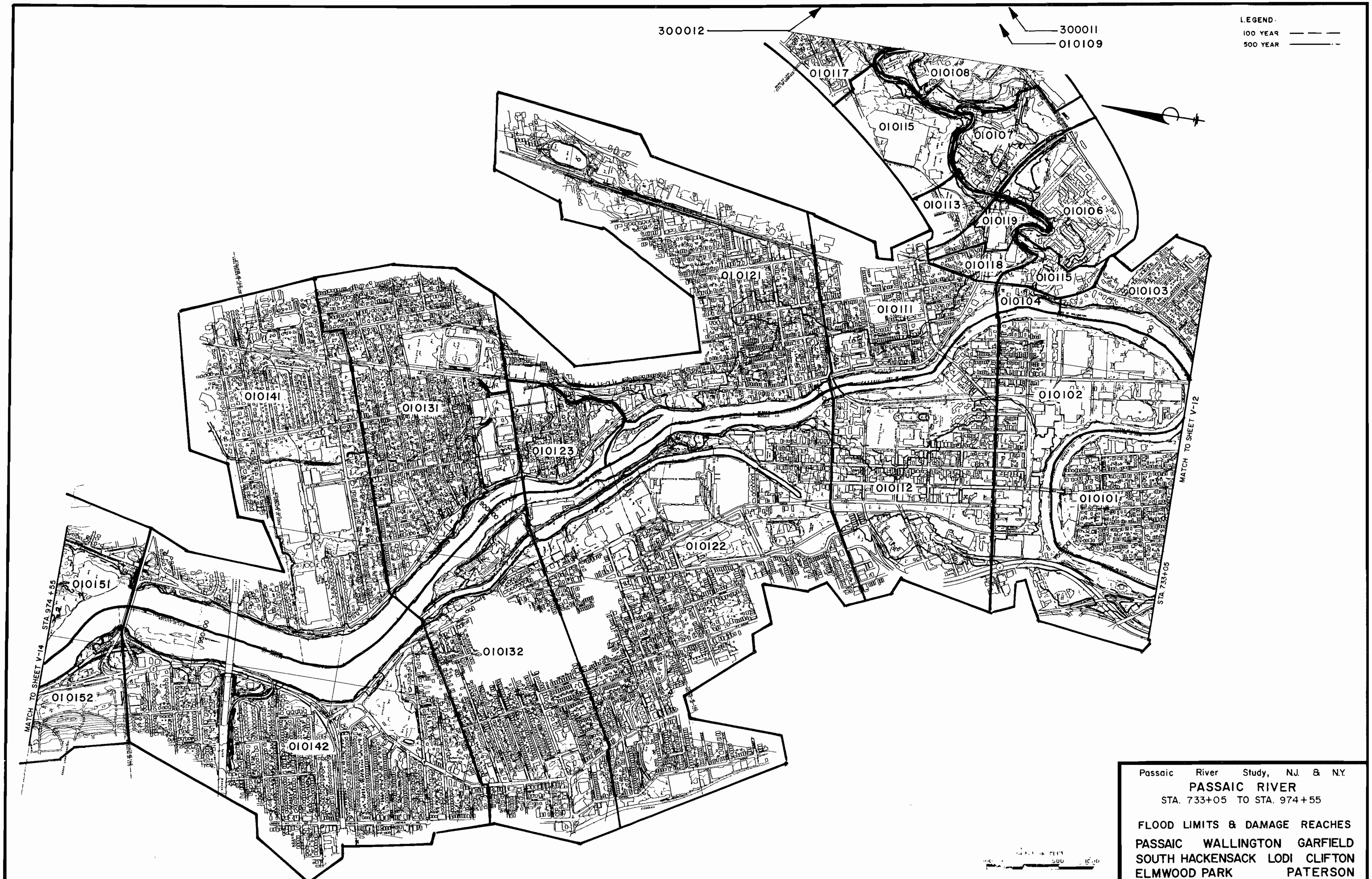
PASSAIC RIVER
STA. 554+05 TO STA. 733+05

FLOOD LIMITS & DAMAGE REACHES

EAST RUTHERFORD
NUTLEY LYNDHURST RUTHERFORD
PASSAIC CLIFTON WALLINGTON

FIGURE V-12



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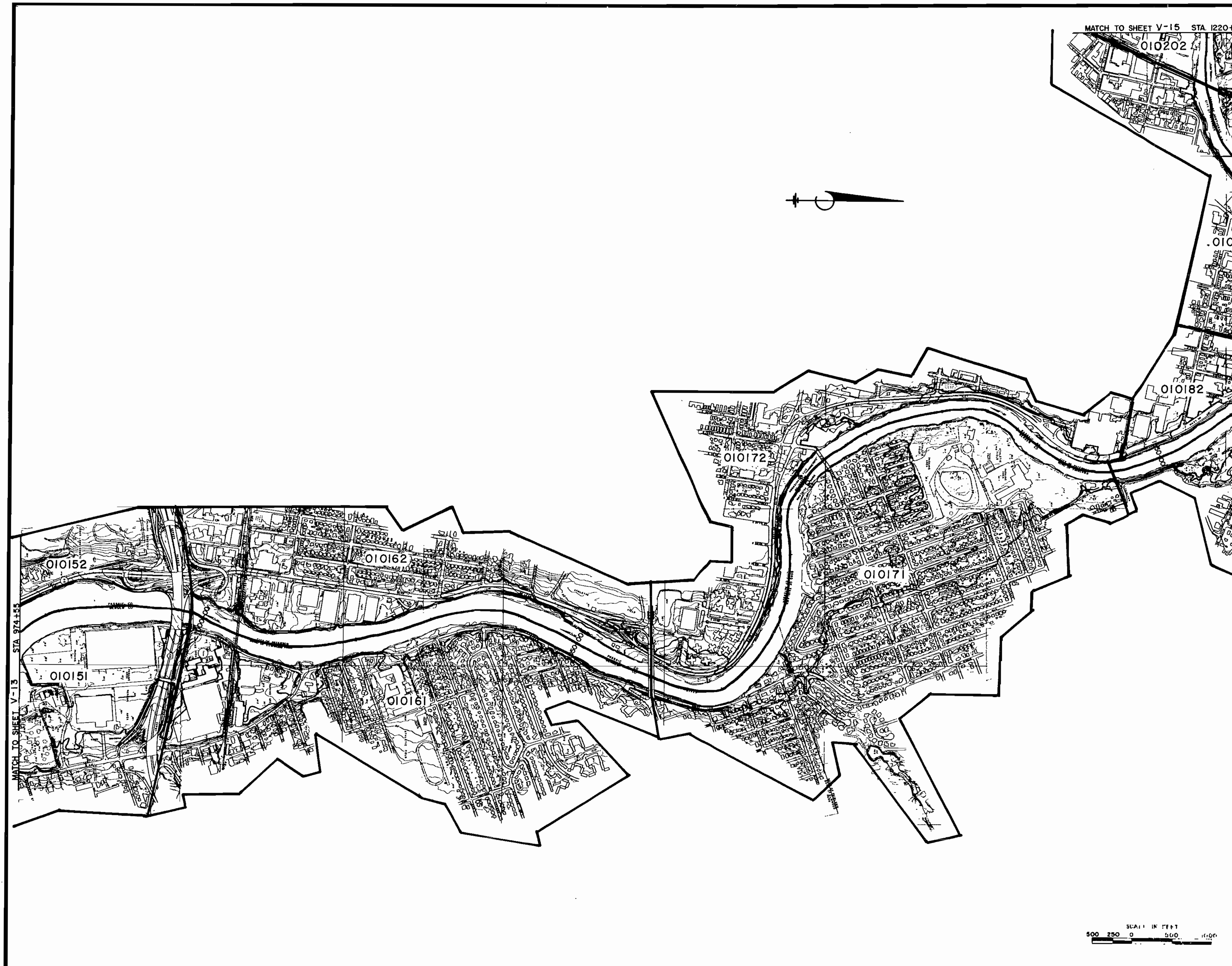
PASSAIC RIVER

STA. 733+05 TO STA. 974+55

FLOOD LIMITS & DAMAGE REACHES

PASSAIC WALLINGTON GARFIELD
SOUTH HACKENSACK LODI CLIFTON
ELMWOOD PARK PATERSON

FIGURE V-13



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PASSAIC RIVER

STA. 974+55 TO STA. 1220+55

FLOOD LIMITS & DAMAGE REACHES

PATERSON **ELMWOOD PARK**

FAIRLAWN **HAWTHORNE**

FIGURE NO. V-14

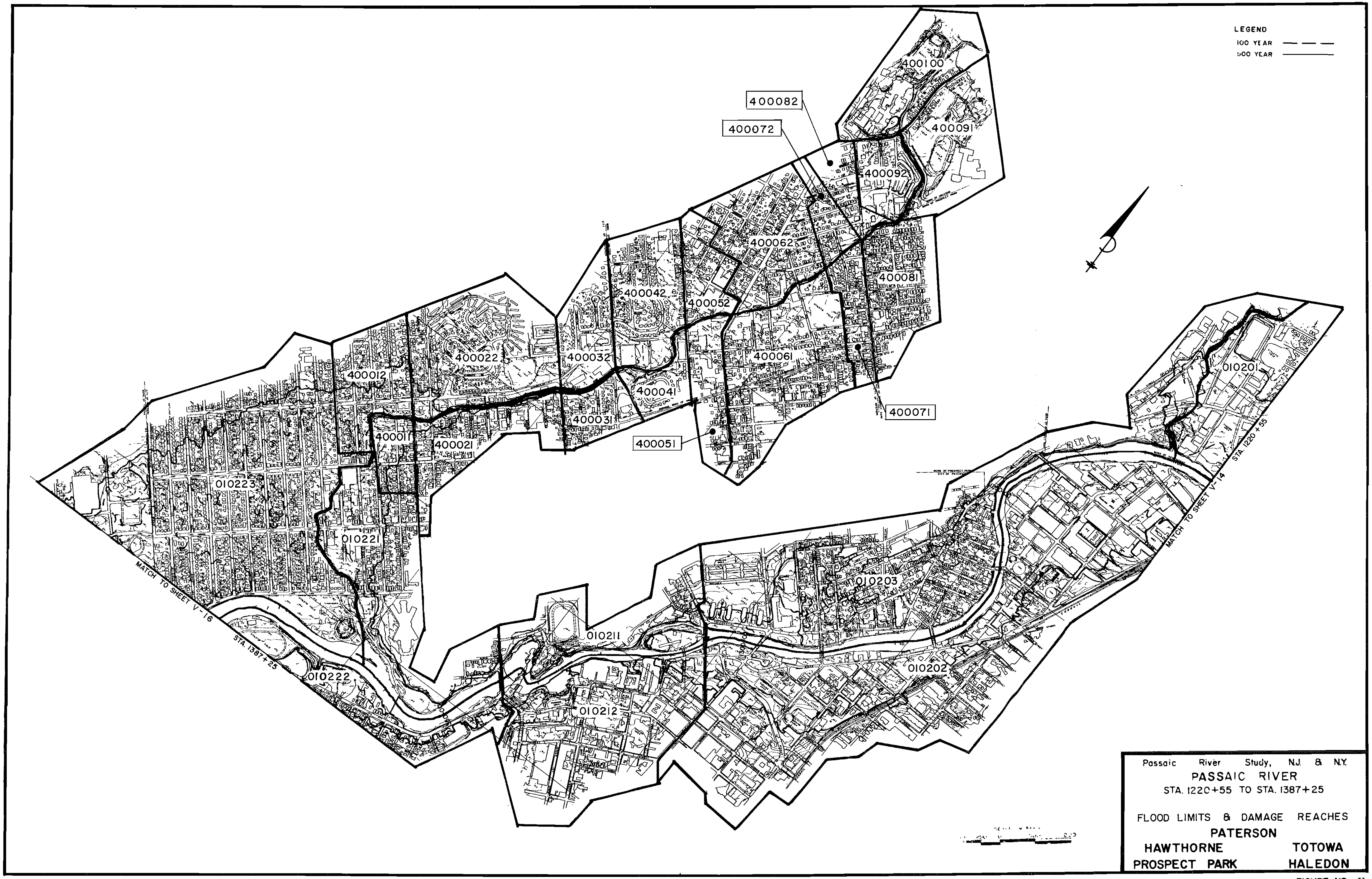
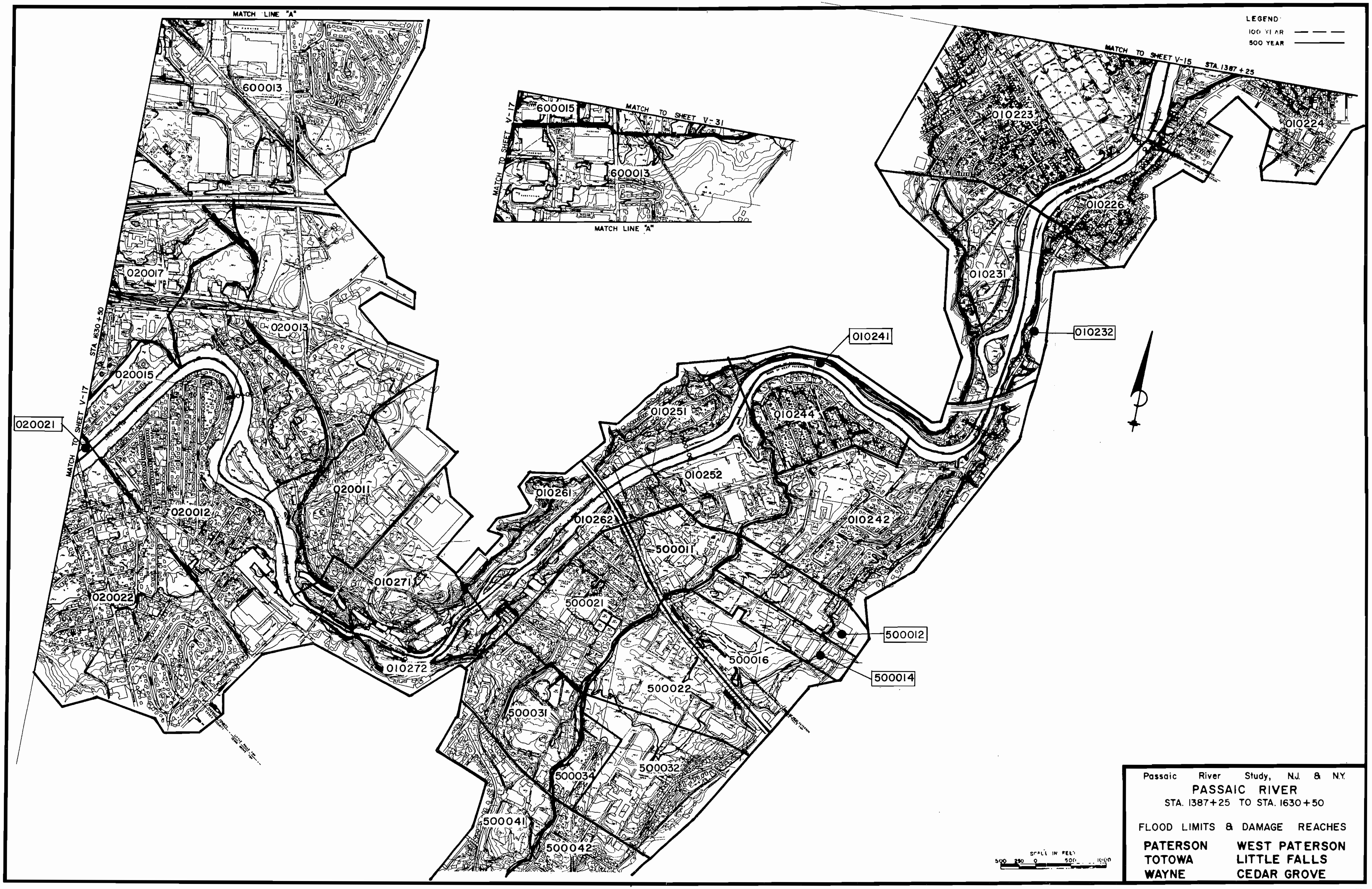


FIGURE NO. V-15



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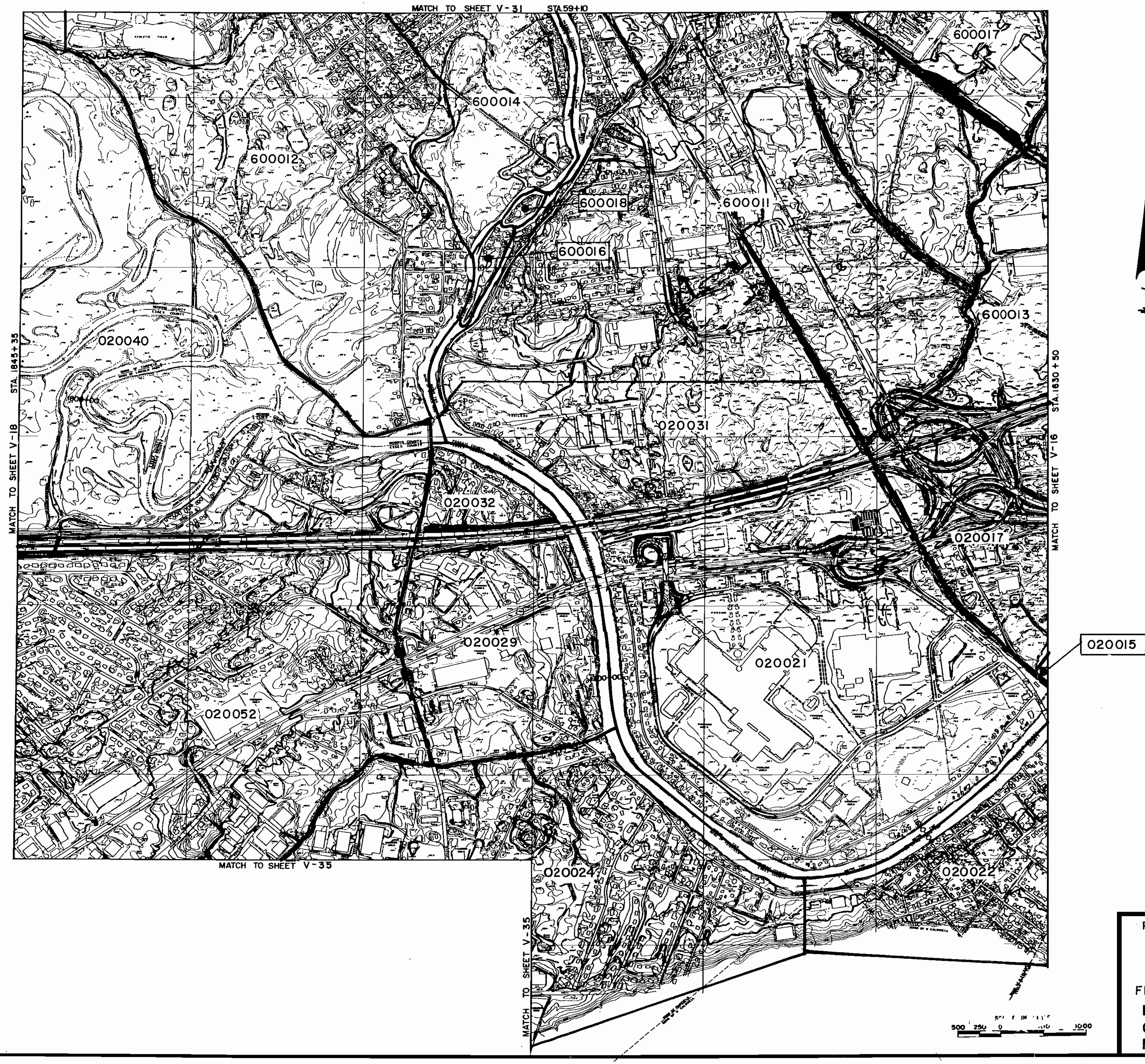
PASSAIC RIVER
STA. 1387+25 TO STA. 1630+50
FLOOD LIMITS & DAMAGE REACHES
PATERSON WEST PATERSON
TOTOWA LITTLE FALLS
WAYNE CEDAR GROVE

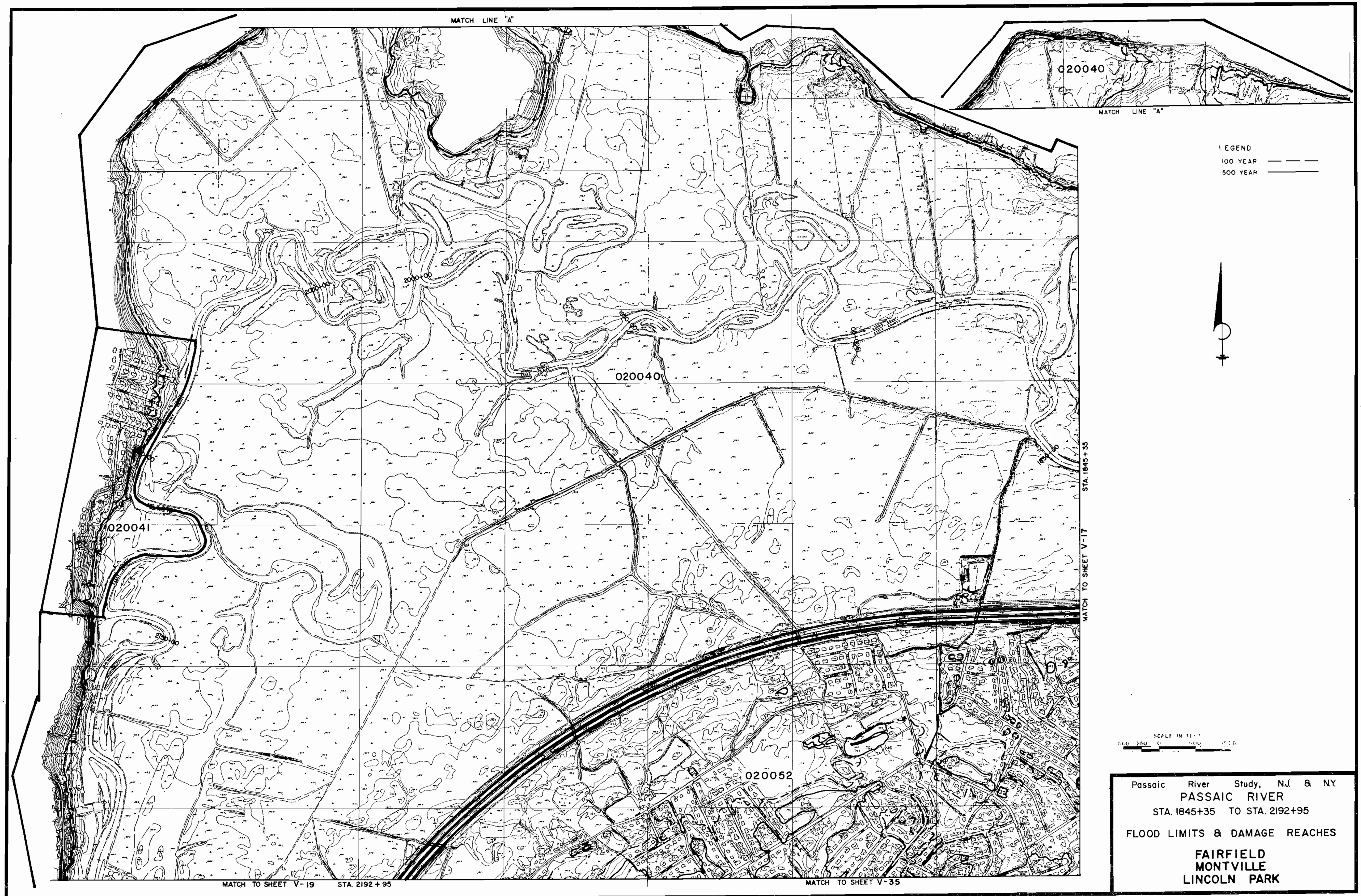
FIGURE NO V-16



LEGEND:
100 YEAR
500 YEAR

Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 1630+50 TO STA. 1845+35
POMPTON RIVER
FLOOD LIMITS & DAMAGE REACHES
LITTLE FALLS LINCOLN PARK
CEDAR GROVE FAIRFIELD
NORTH CALDWELL WAYNE

FIGURE NO. V-17



Passaic River Study, N.J. & N.Y.

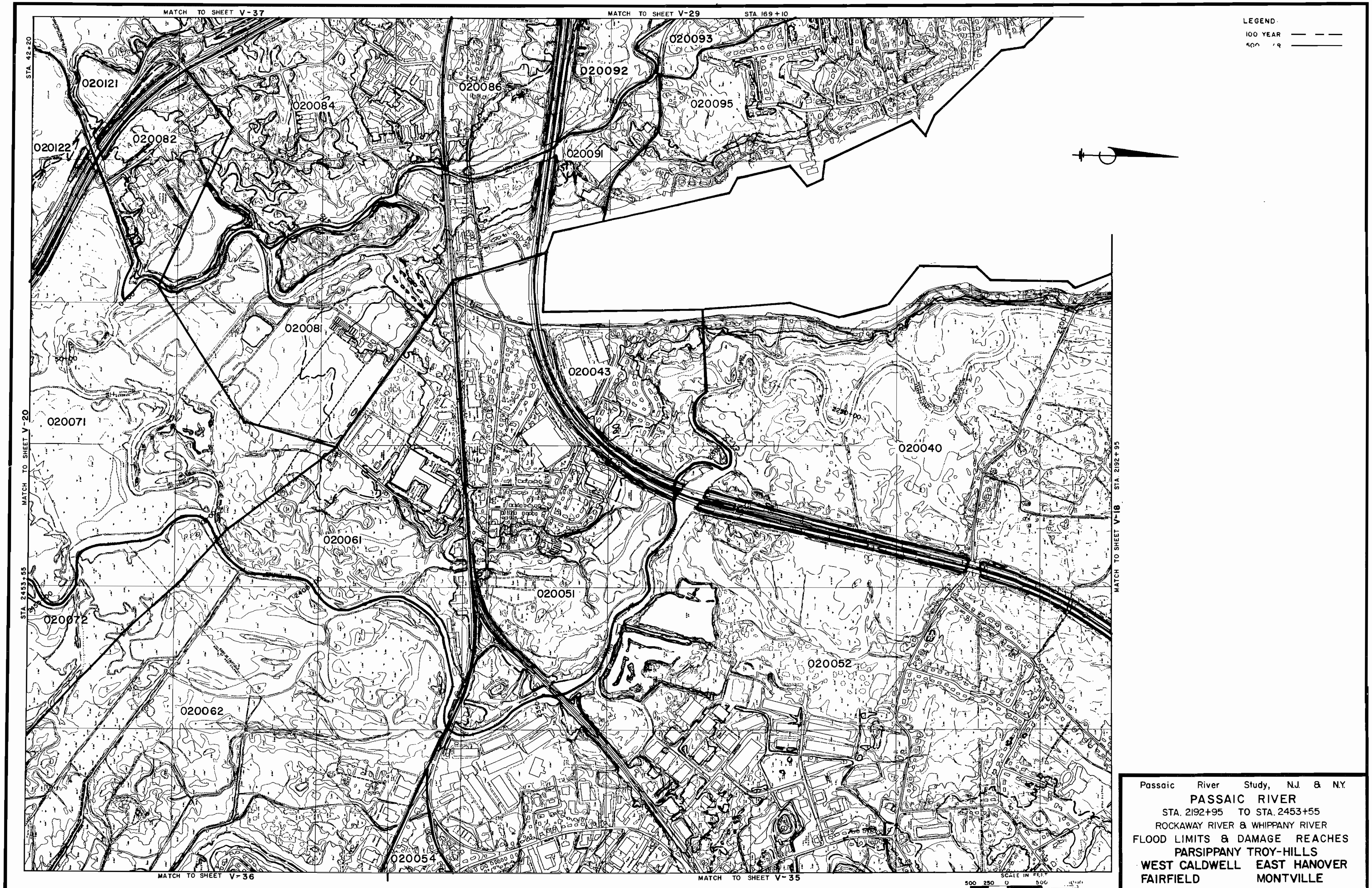
PASSAIC RIVER

STA. 1845+35 TO STA. 2192+95

FLOOD LIMITS & DAMAGE REACHES

FAIRFIELD
MONTVILLE
LINCOLN PARK

FIGURE V-18



Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 2192+95 TO STA. 2453+55

ROCKAWAY RIVER & WHIPPANY RIVER

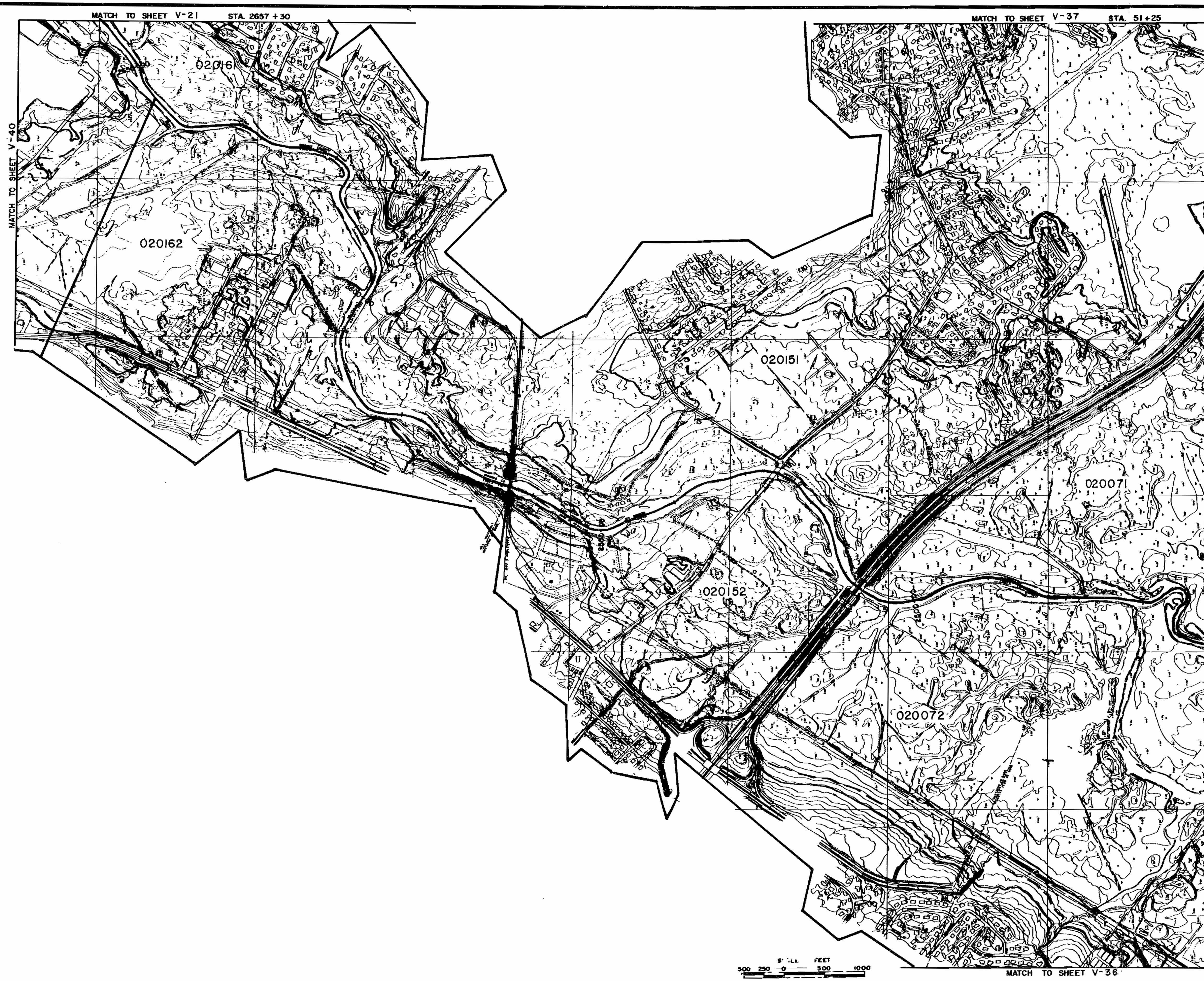
FLOOD LIMITS & DAMAGE REACHES

PARSIPPANY TROY-HILLS

WEST CALDWELL EAST HANOVER

FAIRFIELD MONTVILLE

FIGURE NO. V-19



LEGEND:
100 YEAR
500 YEAR

Passaic River Study, N.J. & N.Y.

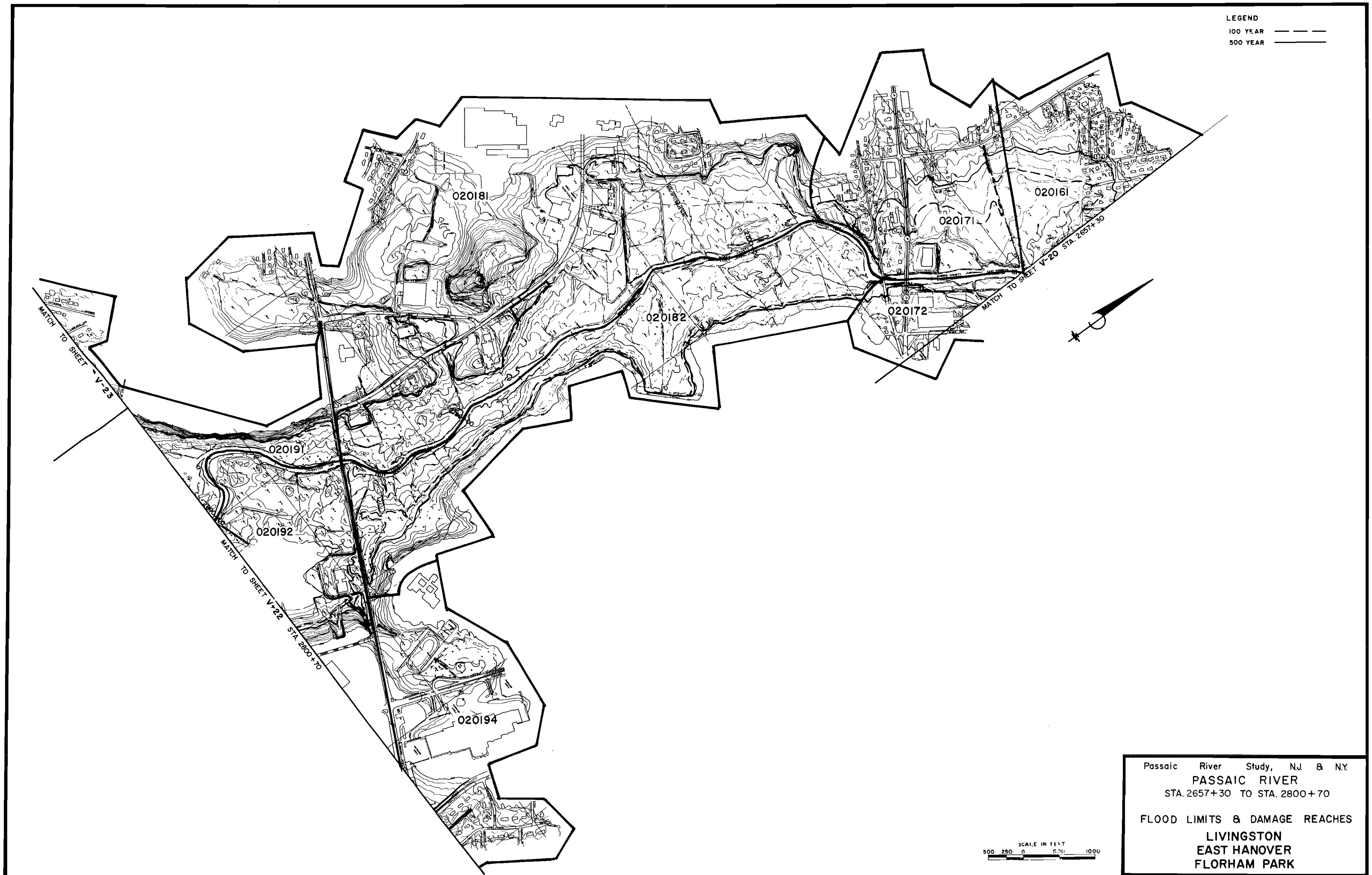
PASSAIC RIVER

STA. 2453+55 TO STA. 2657+30

FLOOD LIMITS & DAMAGE REACHES

WEST CALDWELL ROSELAND
EAST HANOVER LIVINGSTON

FIGURE NO. V-20



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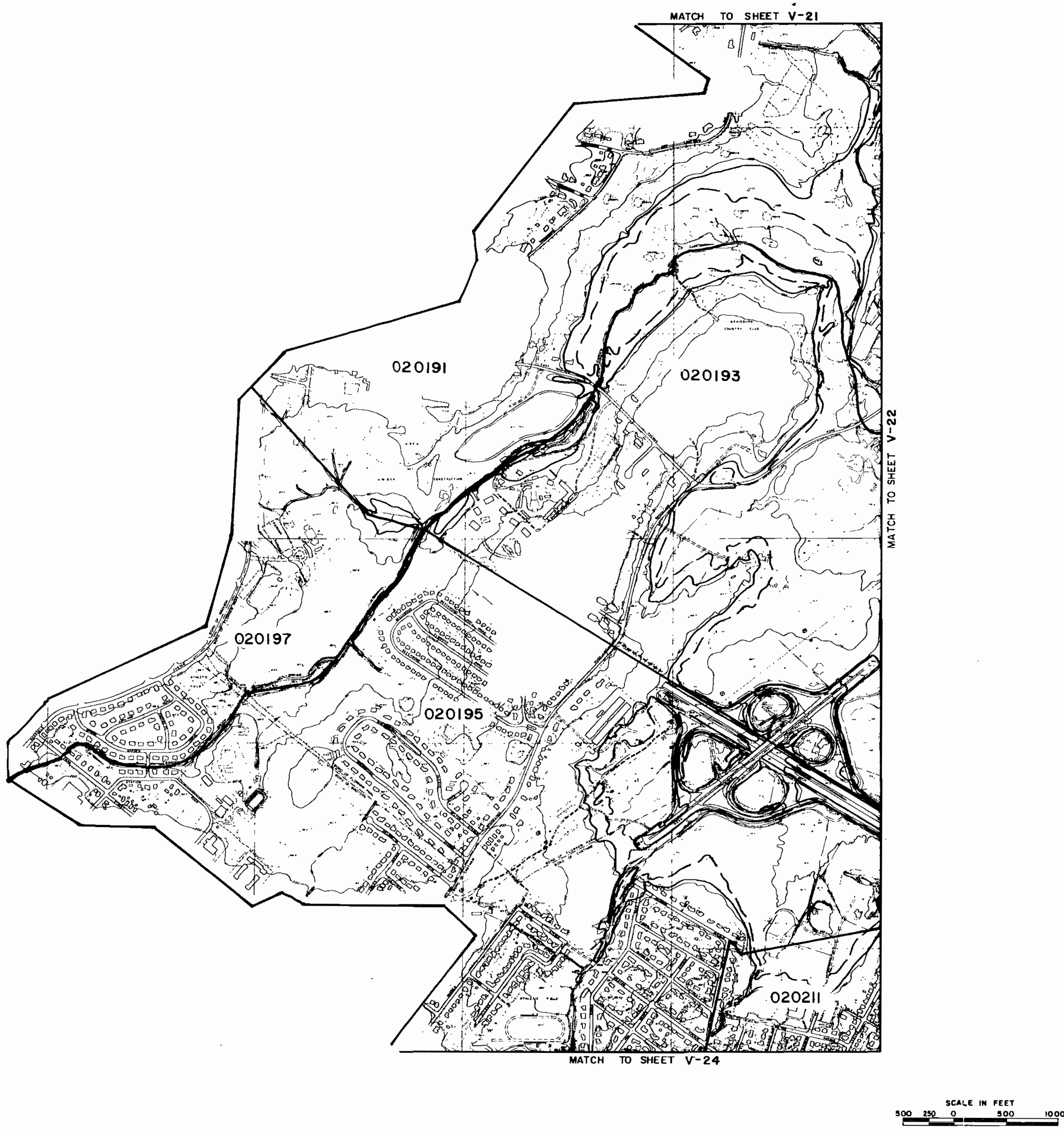
PASSAIC RIVER
STA. 2657+30 TO STA. 2800+70

FLOOD LIMITS & DAMAGE REACHES
LIVINGSTON
EAST HANOVER
FLORHAM PARK

FIGURE NO. V-21



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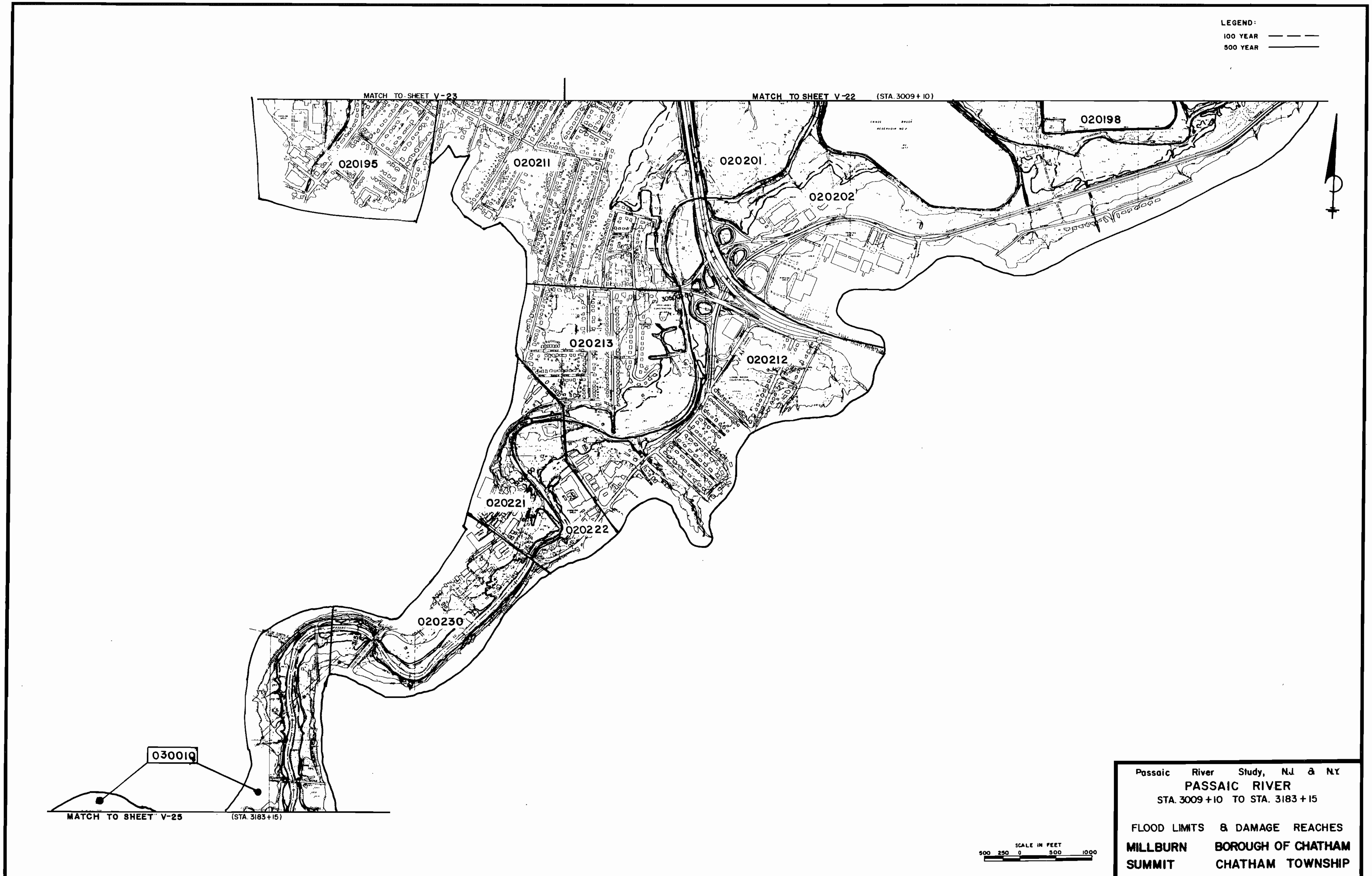
PASSAIC RIVER

FLOOD LIMITS & DAMAGE REACHES

CHATHAM FLORHAM PARK

FIGURE NO. V-23



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PASSAIC RIVER

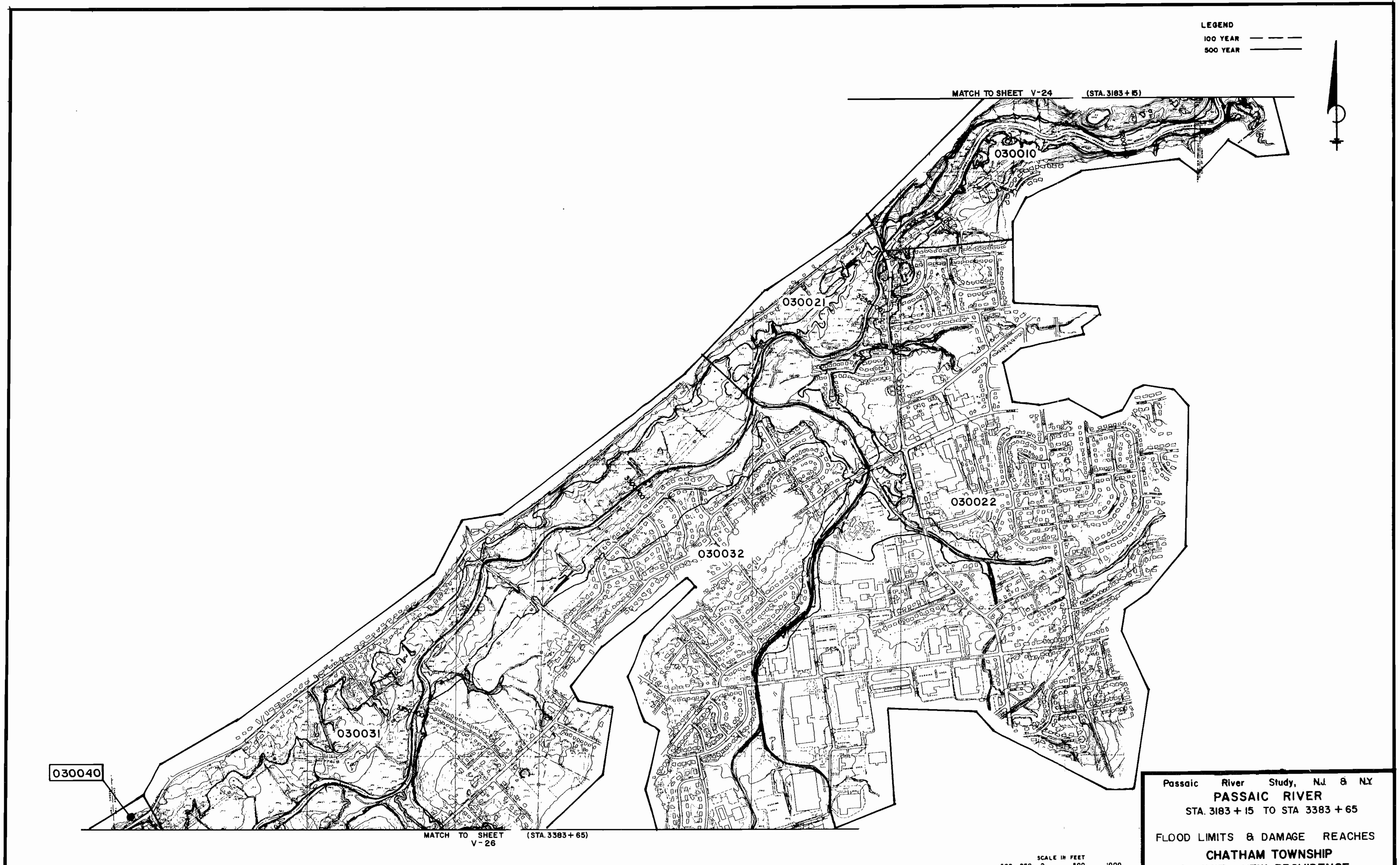
STA. 3009+10 TO STA. 3183+15

FLOOD LIMITS & DAMAGE REACHES

MILLBURN **BOROUGH OF CHATHAM**

SUMMIT **CHATHAM TOWNSHIP**

FIGURE NO V-24



Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 3183 + 15 TO STA 3383 + 65

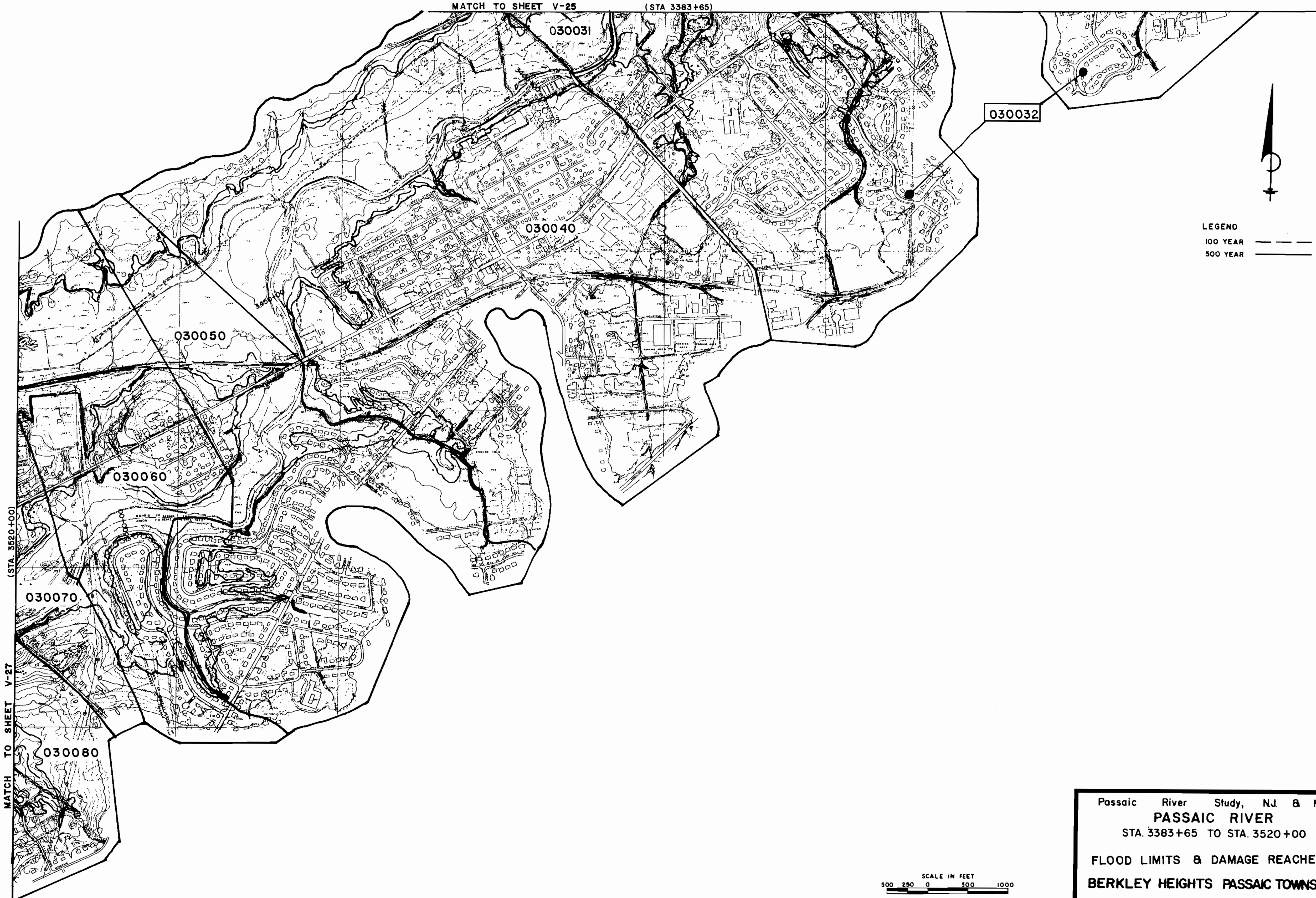
FLOOD LIMITS & DAMAGE REACHES

CHATHAM TOWNSHIP

SUMMIT NEW PROVIDENCE

BERKELY HEIGHTS

FIGURE NO. V-25



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PASSAIC RIVER

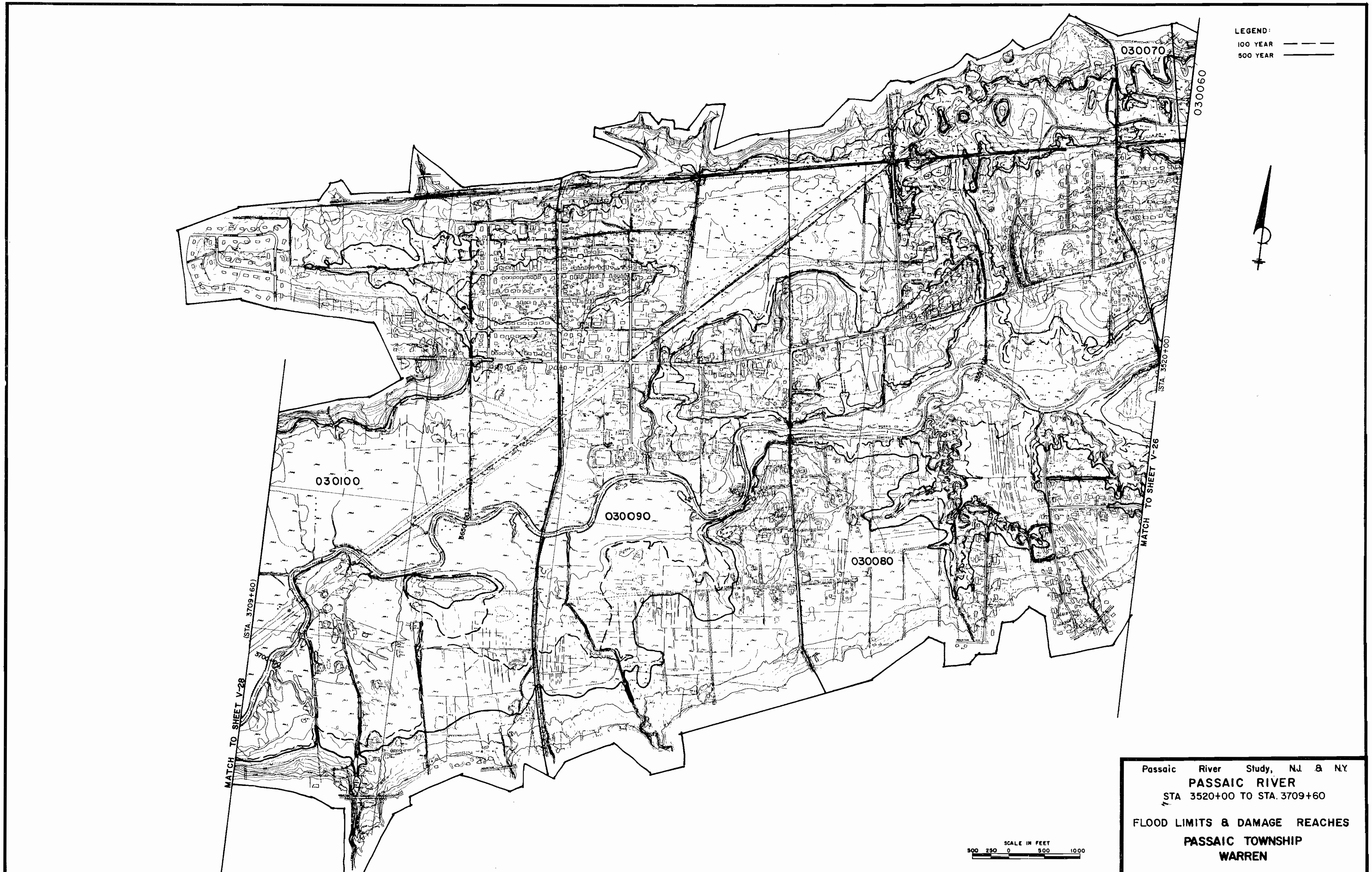
STA. 3383+65 TO STA. 3520+00

FLOOD LIMITS & DAMAGE REACHES

BERKLEY HEIGHTS PASSAIC TOWNSHIP

CHATHAM TOWNSHIP WARREN

FIGURE NO V-26



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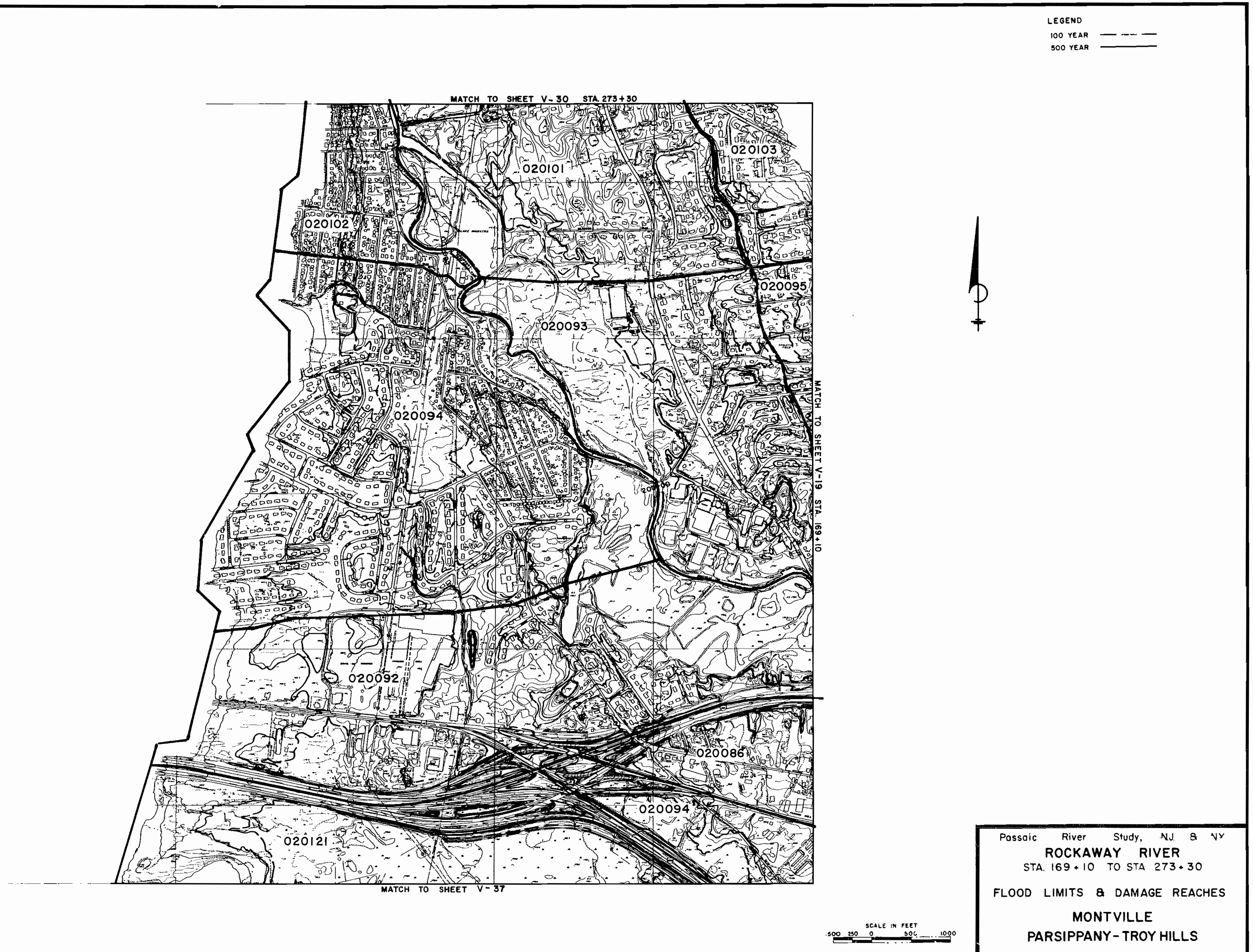
PASSAIC RIVER
STA 3520+00 TO STA. 3709+60

FLOOD LIMITS & DAMAGE REACHES
PASSAIC TOWNSHIP
WARREN

FIGURE NO V-27



Passaic River Study, NJ & NY

ROCKAWAY RIVER

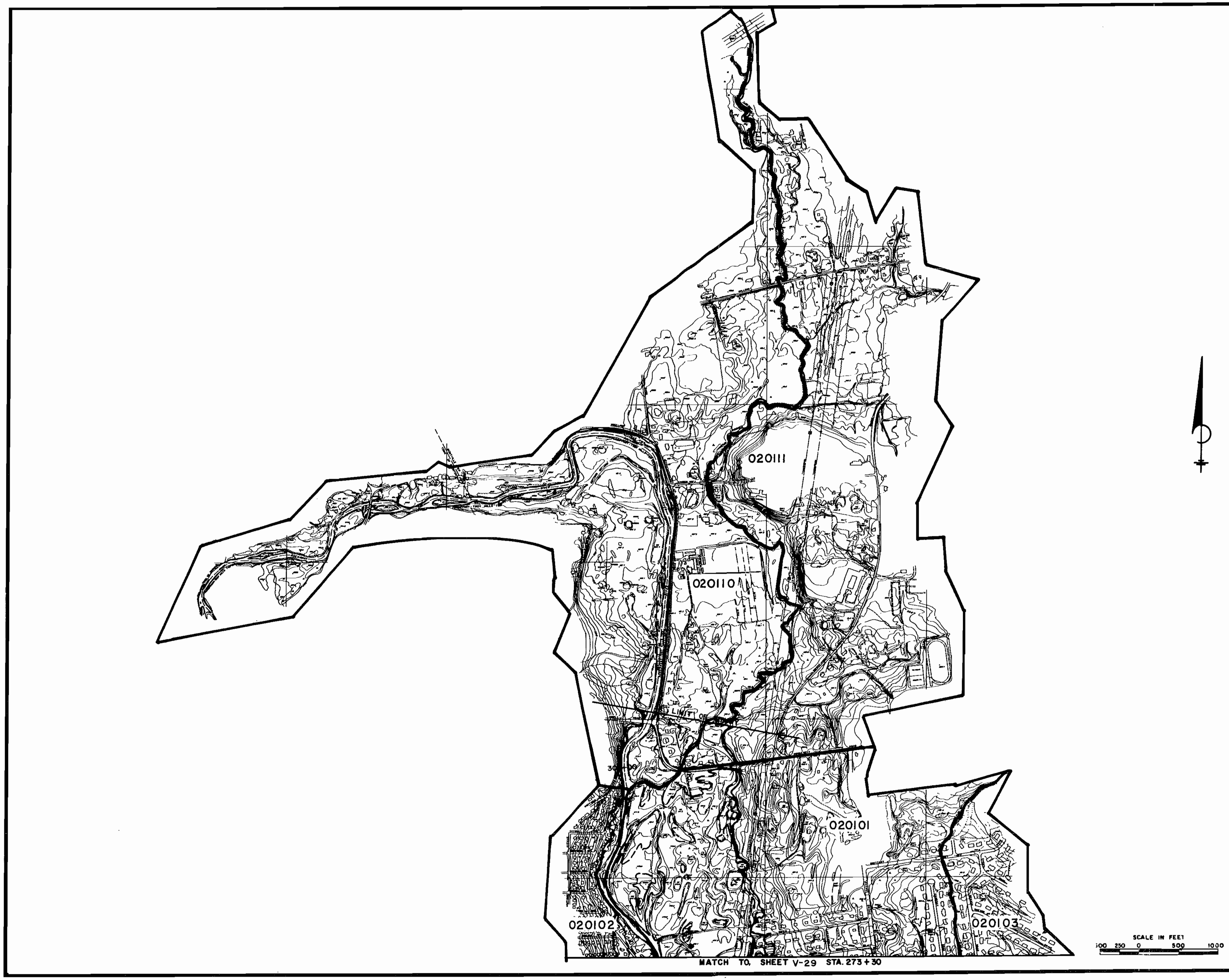
STA. 169+10 TO STA 273+30

FLOOD LIMITS & DAMAGE REACHES

MONTVILLE

PARSIPPANY-TROY HILLS

FIGURE V-29



Passaic River Study, N.J. & N.Y.

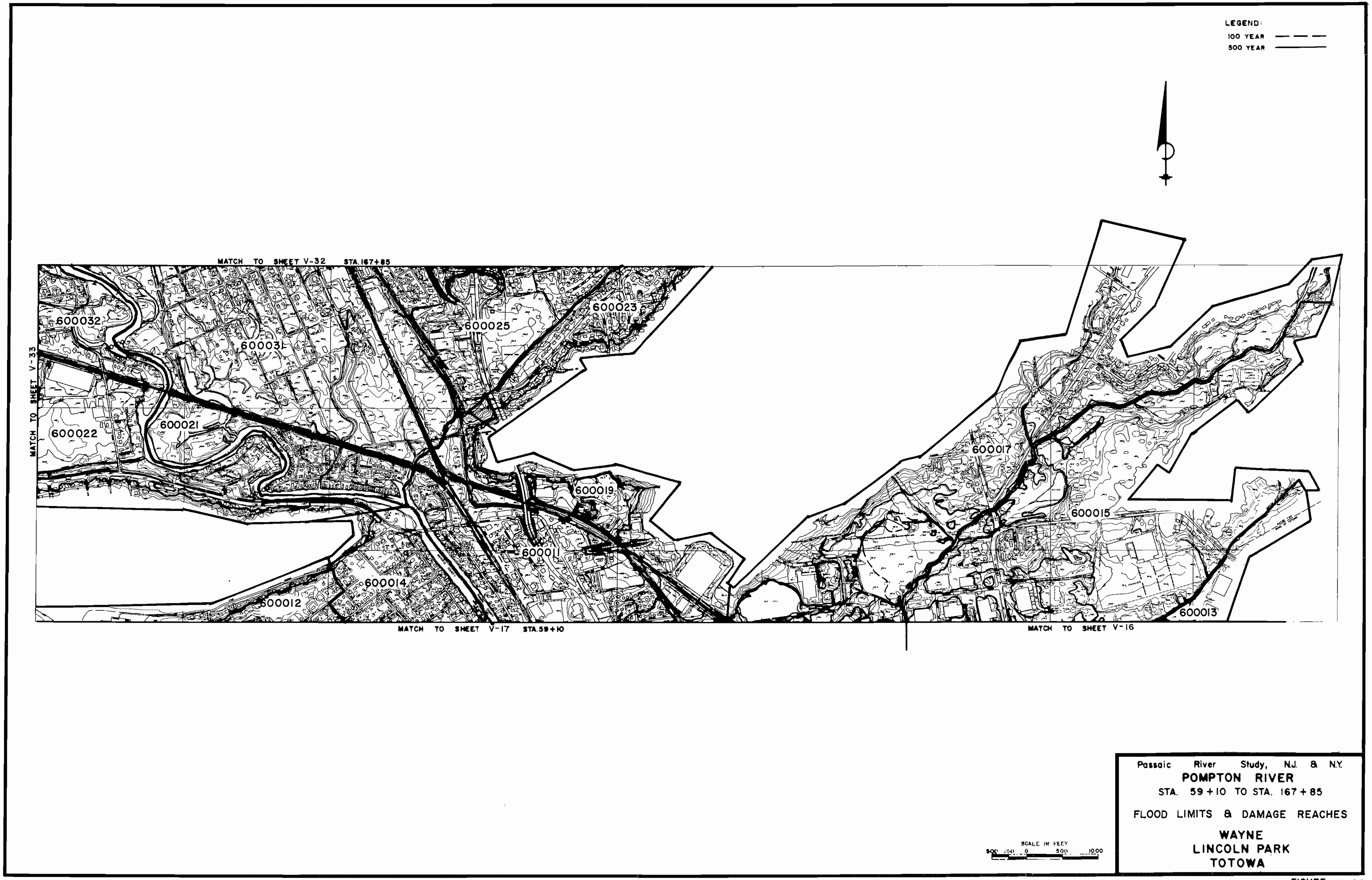
ROCKAWAY RIVER

STA. 273+30 TO LIMIT OF STUDY

FLOOD LIMITS & DAMAGE REACHES

BOONTON
MONTVILLE
PARSIPPANY-TROY HILLS

FIGURE V-30

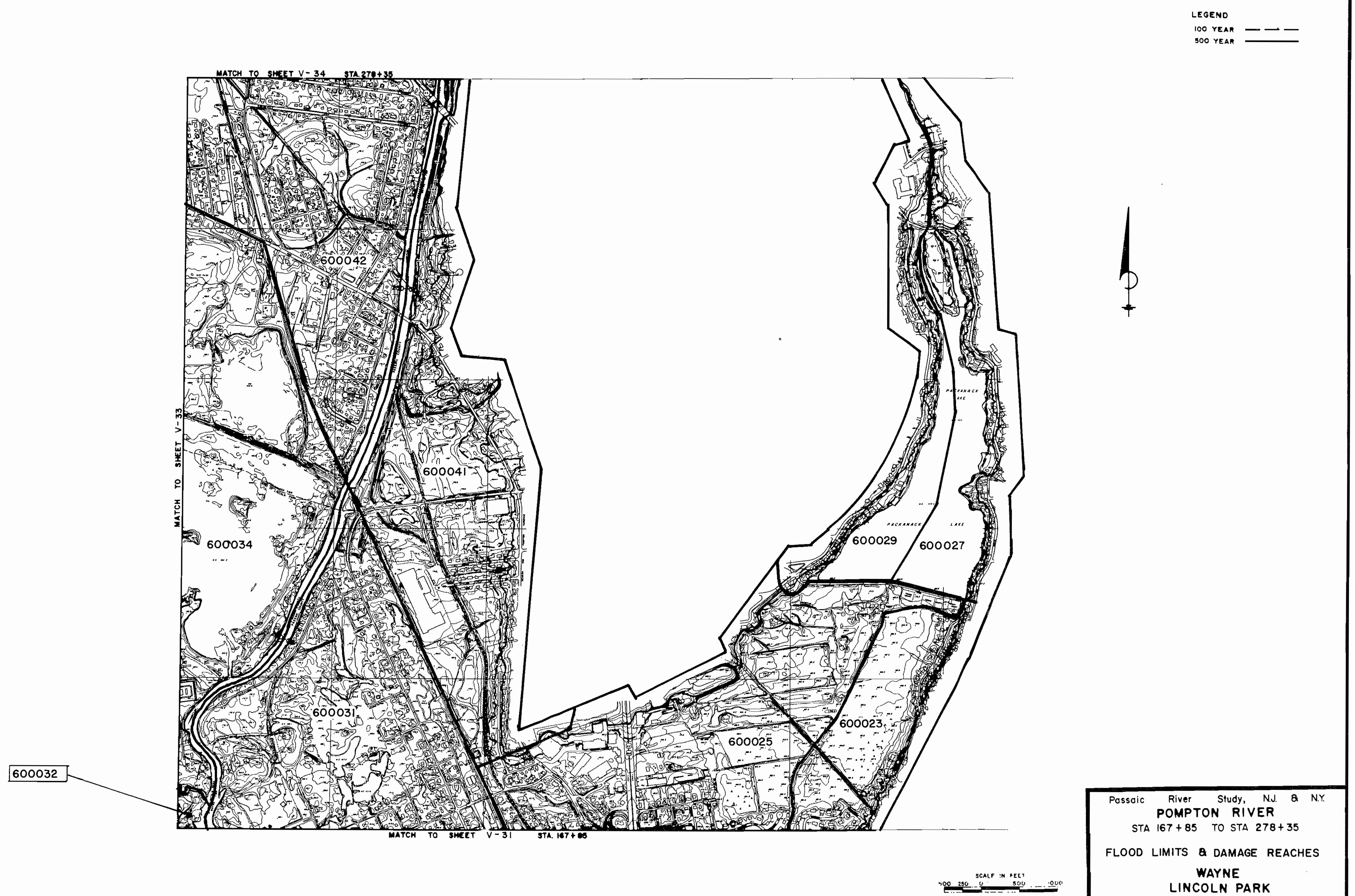


Passaic River Study, N.J. & N.Y.
POMPTON RIVER
STA. 59+10 TO STA. 167+85

FLOOD LIMITS & DAMAGE REACHES

WAYNE
LINCOLN PARK
TOTOWA

FIGURE V-31



Passaic River Study, N.J. & N.Y.
POMPTON RIVER
STA 167+85 TO STA 278+35

FLOOD LIMITS & DAMAGE REACHES

WAYNE
LINCOLN PARK
PEQUANNOCK

FIGURE V-32

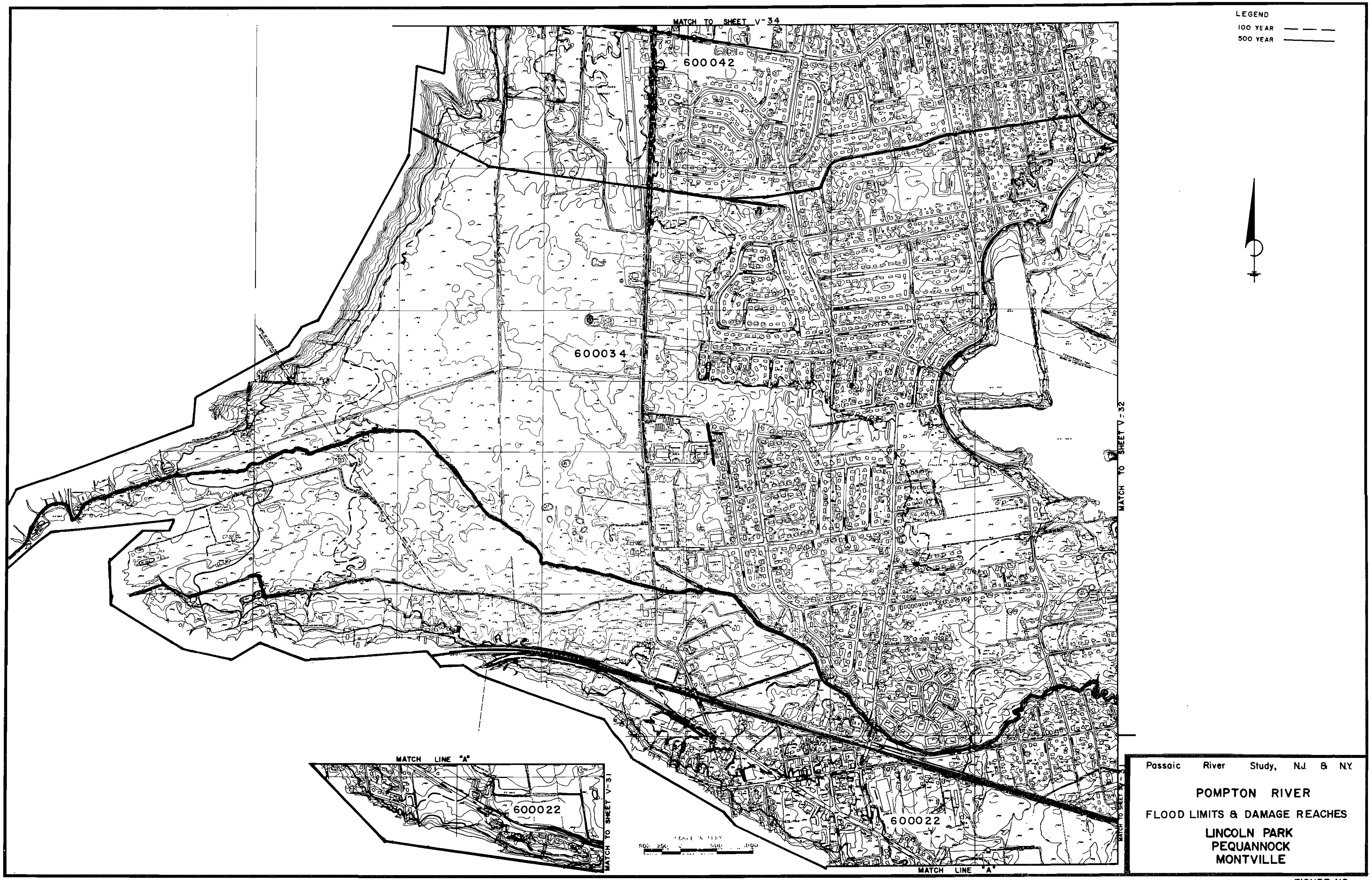
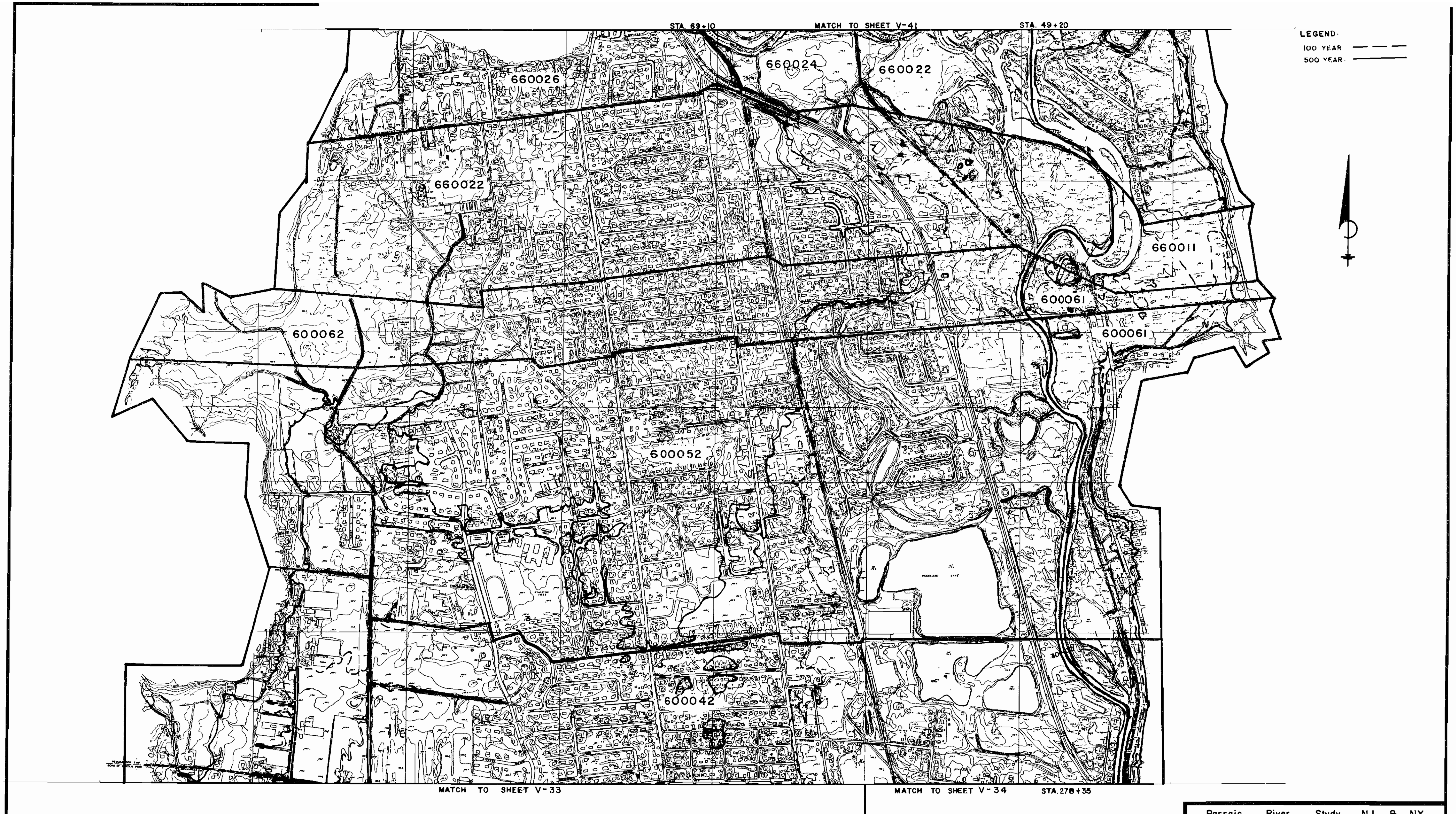


FIGURE NO. V-33



Passaic River Study, N.J. & N.Y.

POMPTON RIVER

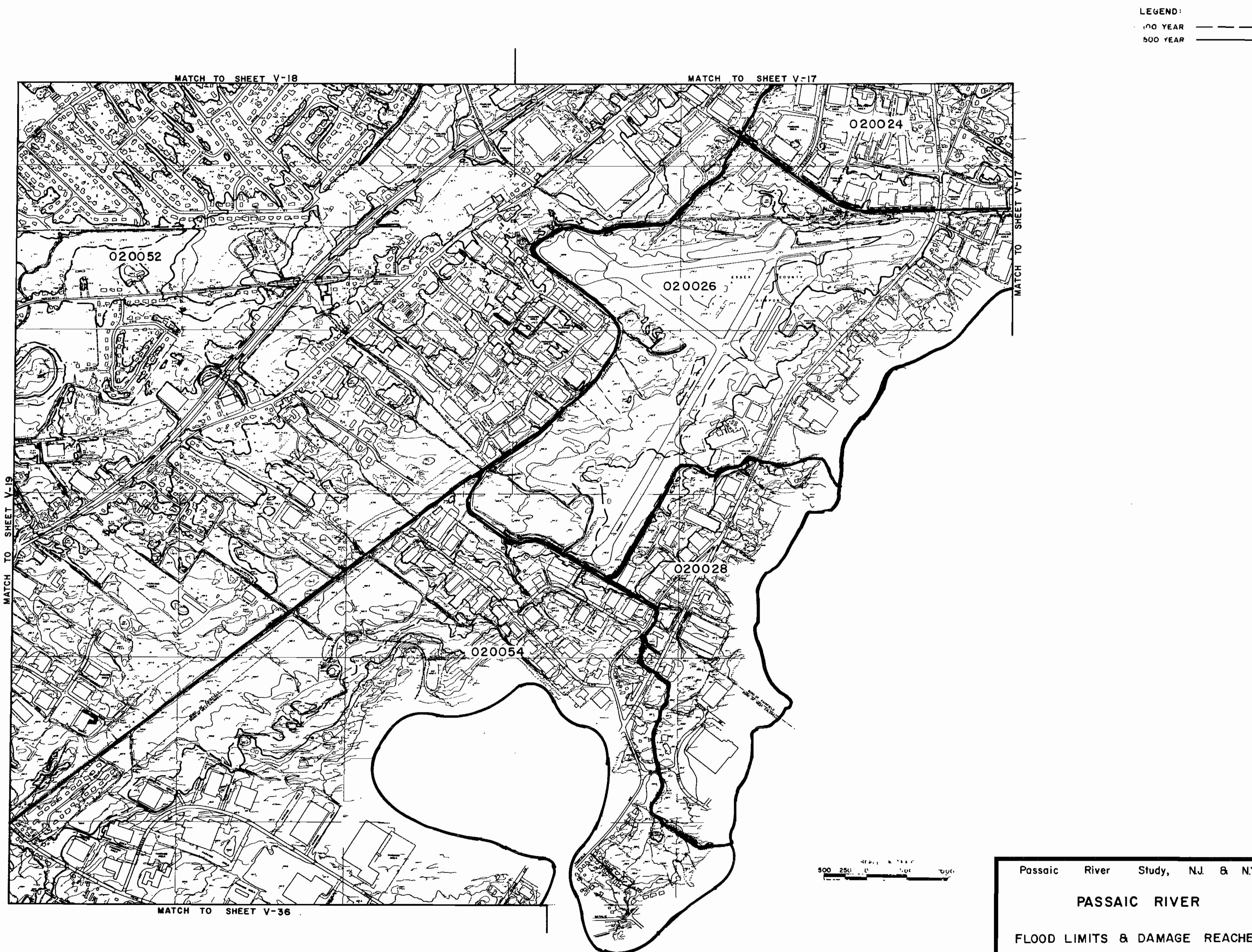
STA. 278 + 35 TO CONFLUENCE OF PEQUANNOCK & RAMAPO RIVERS

FLOOD LIMITS & DAMAGE REACHES

POMPTON LAKES WAYNE

PEQUANNOCK LINCOLN PARK

FIGURE NO. V-34



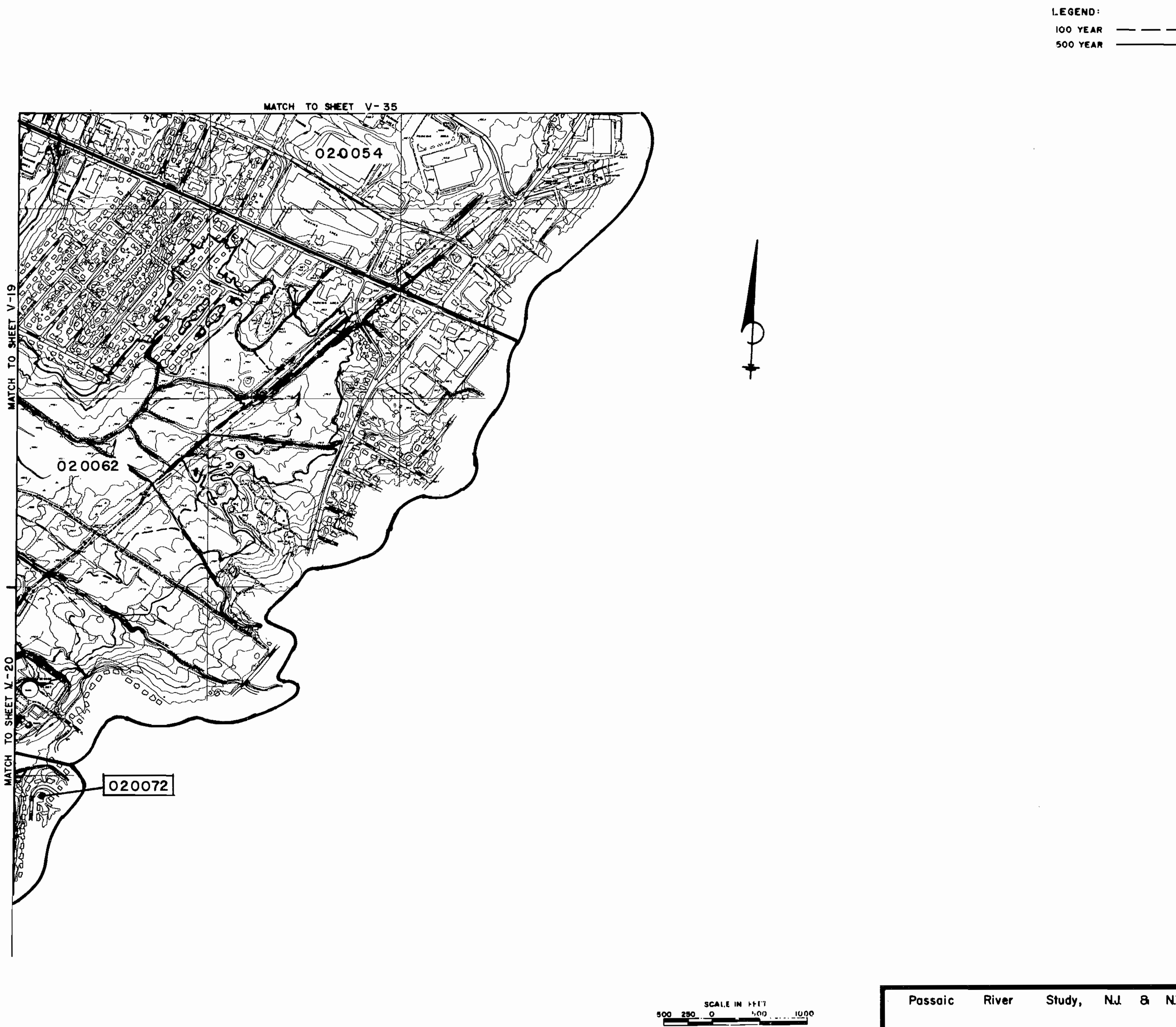
Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS & DAMAGE REACHES

FAIRFIELD WEST CALDWELL

FIGURE NO. V-35



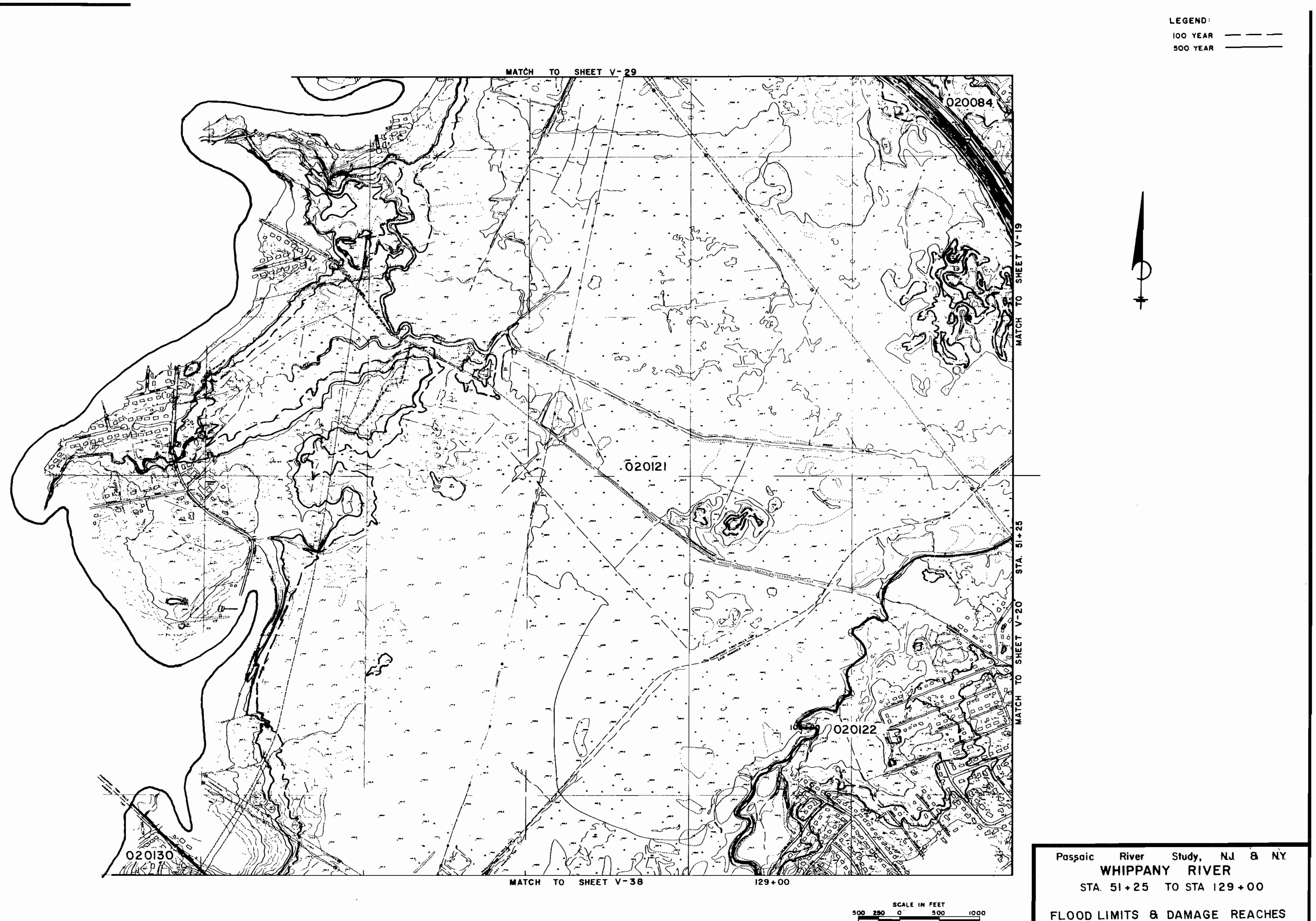
Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS & DAMAGE REACHE

WEST CALDWELL

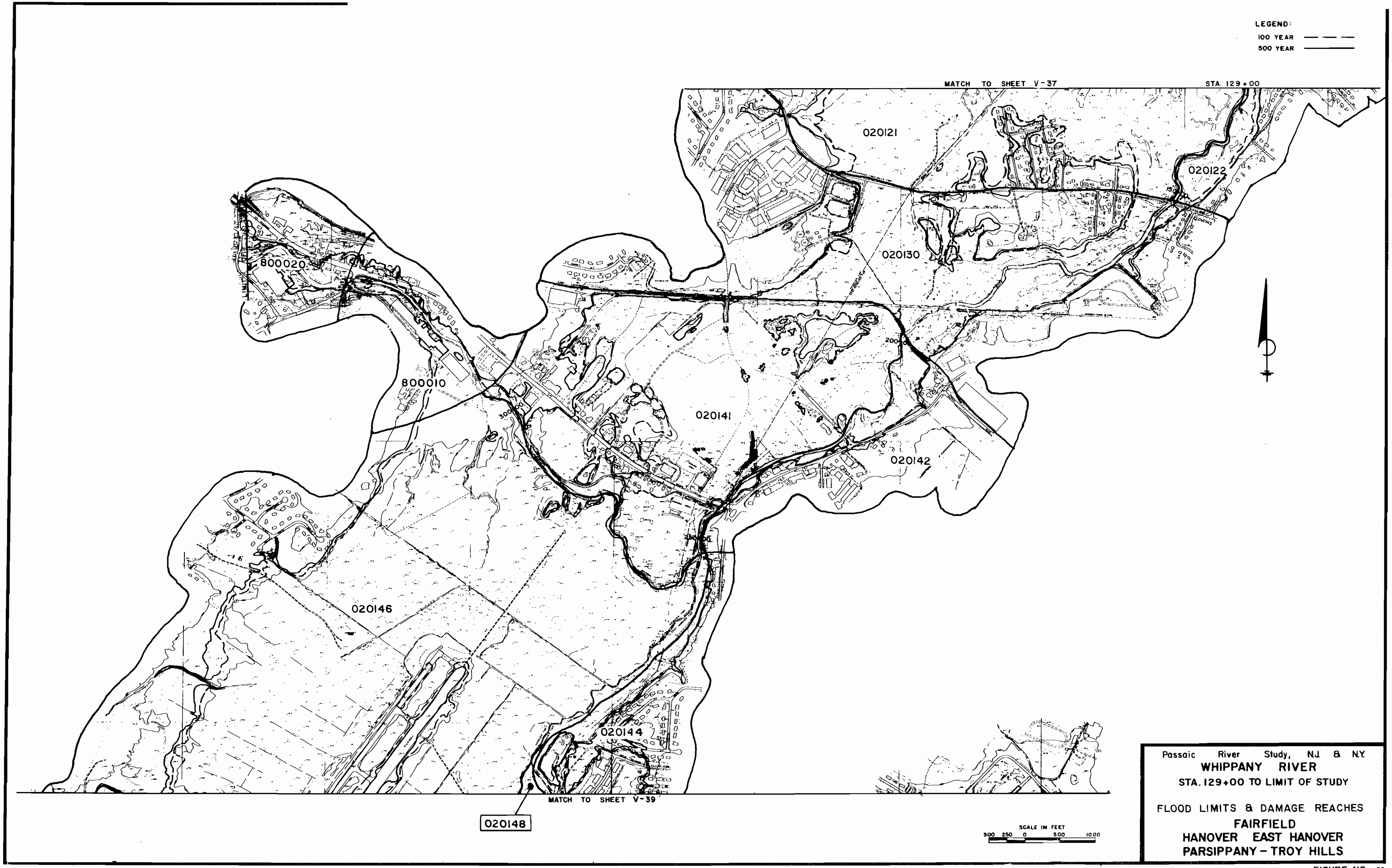
FIGURE NO. V-36



Passaic River Study, N.J. & N.Y.
WHIPPANY RIVER
STA. 51+25 TO STA 129+00

FLOOD LIMITS & DAMAGE REACHES
EAST HANOVER
HANOVER
PARSIPPANY - TROY HILLS

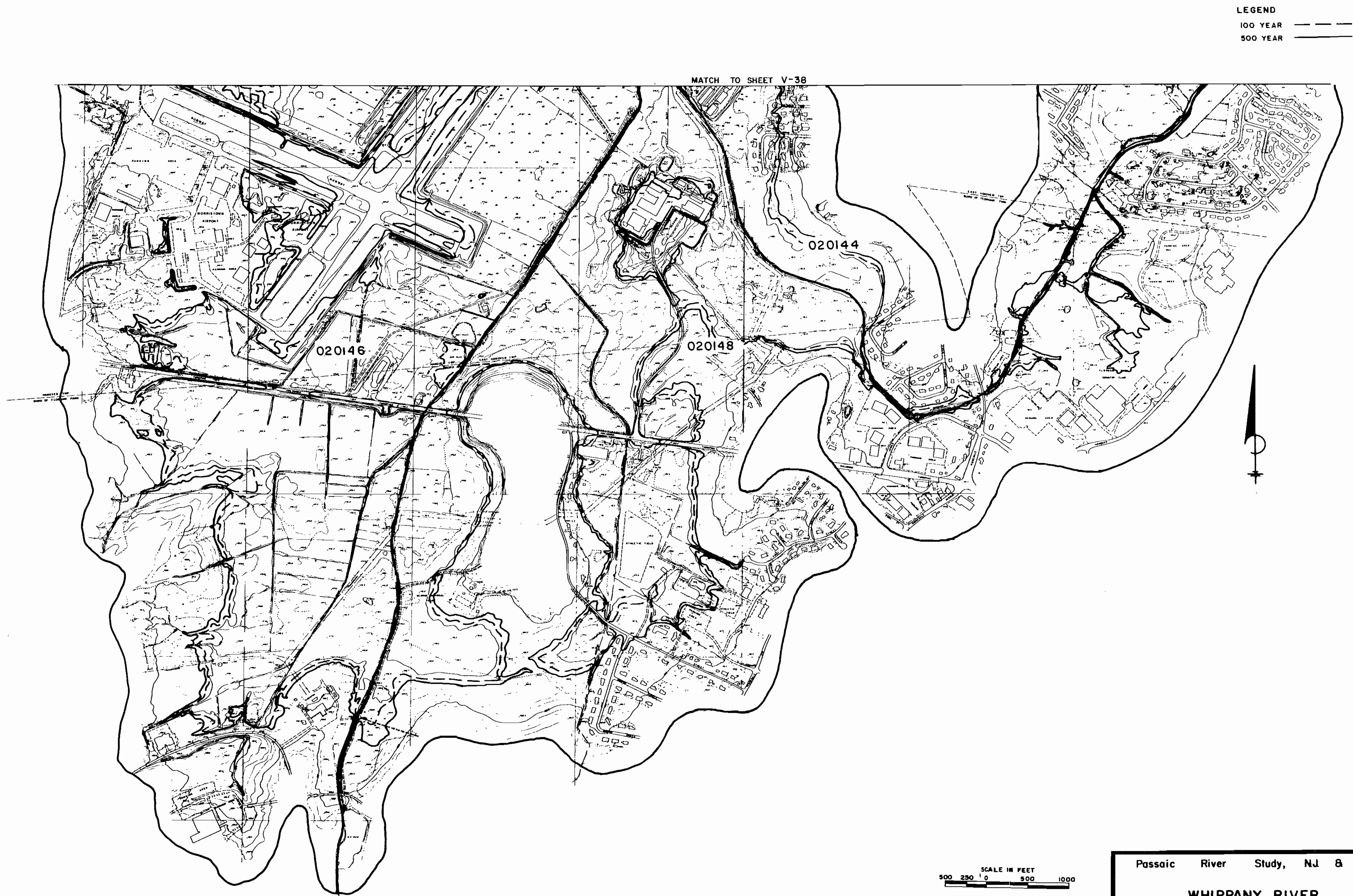
FIGURE NO. V-37



Passaic River Study, N.J. & N.Y.
WHIPPANY RIVER
STA. 129+00 TO LIMIT OF STUDY

FLOOD LIMITS & DAMAGE REACHES
FAIRFIELD
HANOVER EAST HANOVER
PARSIPPANY - TROY HILLS

FIGURE NO. V-38



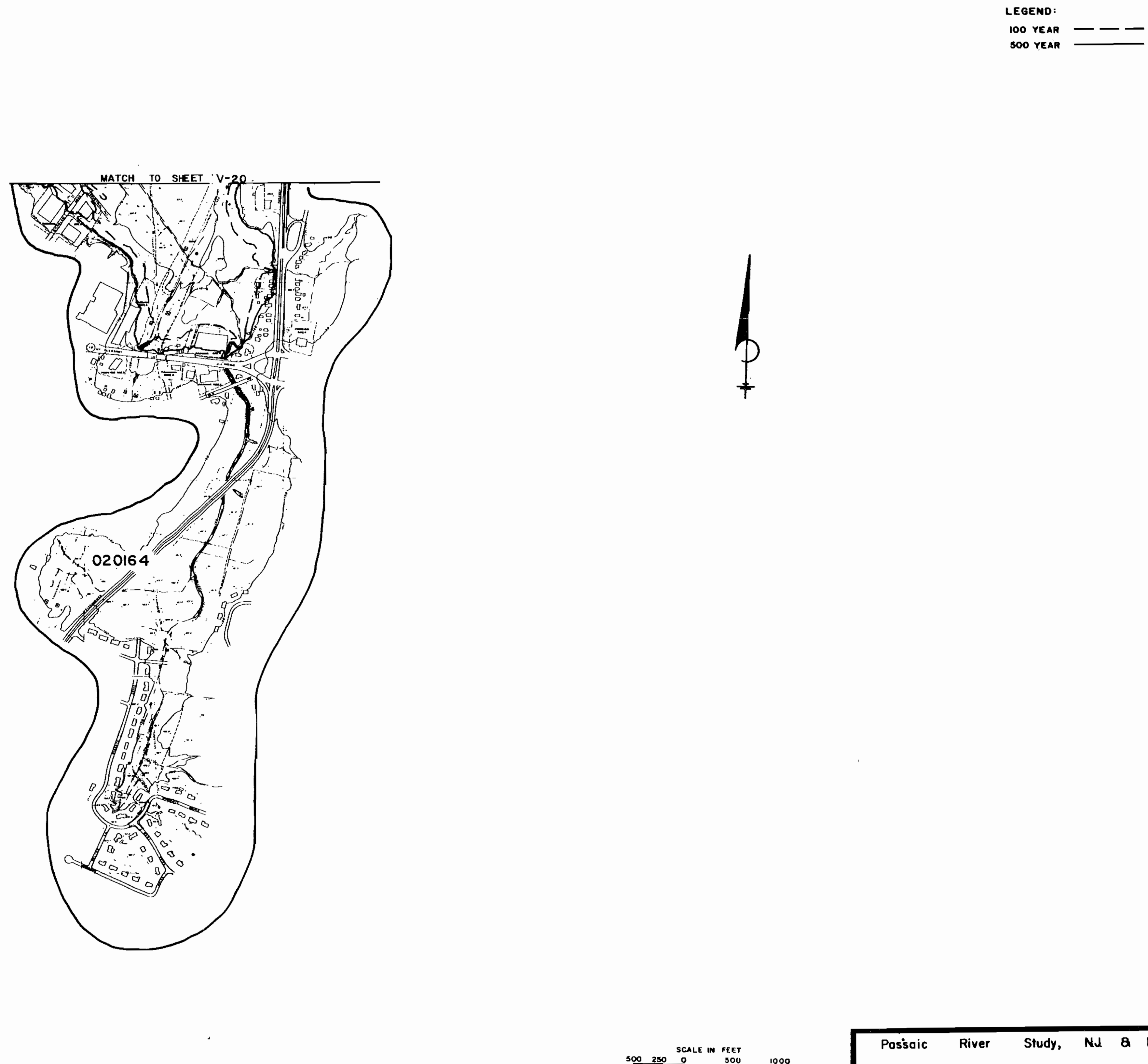
Passaic River Study, N.J. & N.Y.

WHIPPANY RIVER

FLOOD LIMITS & DAMAGE REACHES

HANOVER
EAST HANOVER
FLORHAM PARK

FIGURE NO. V-39



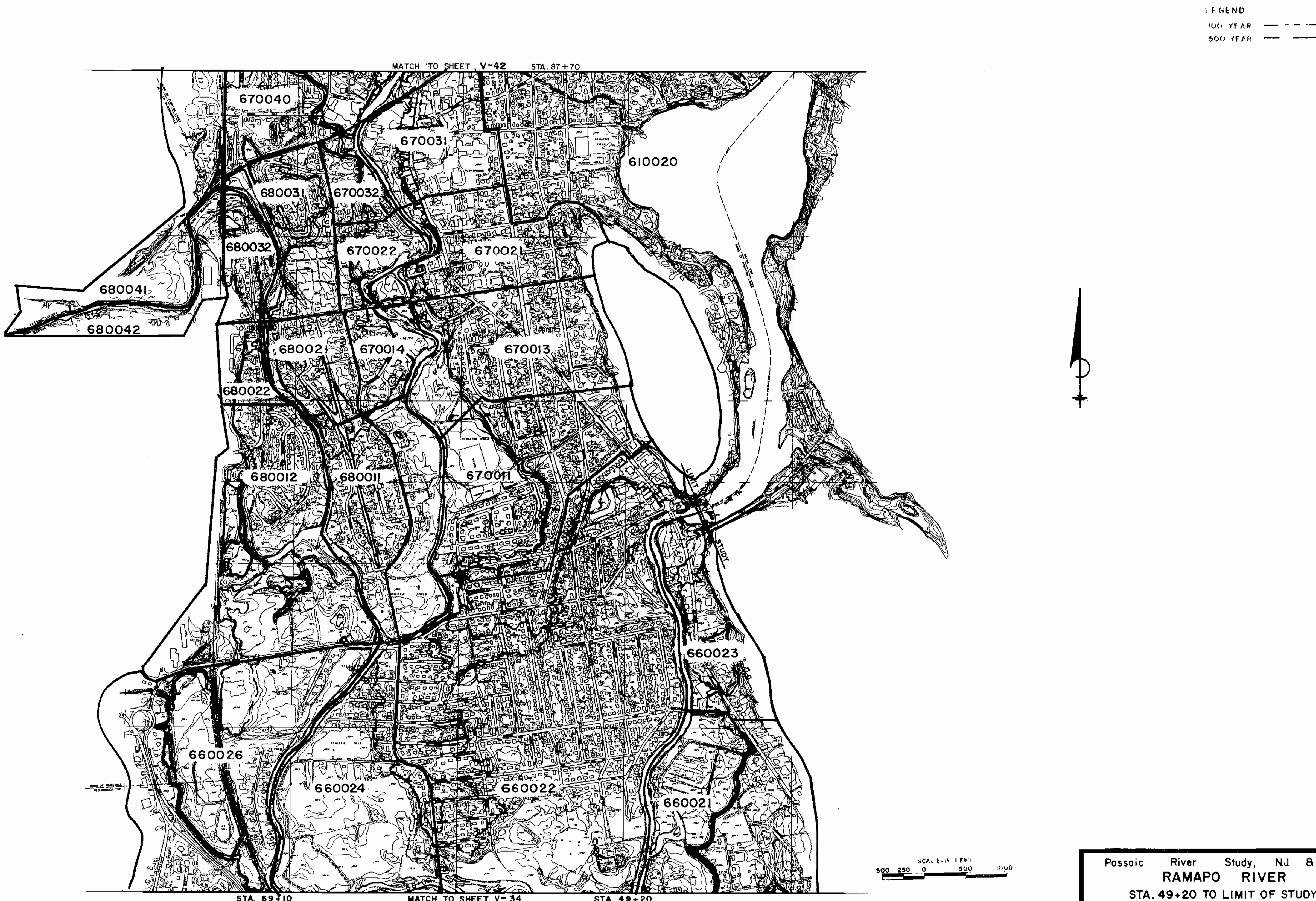
Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS & DAMAGE REACHES

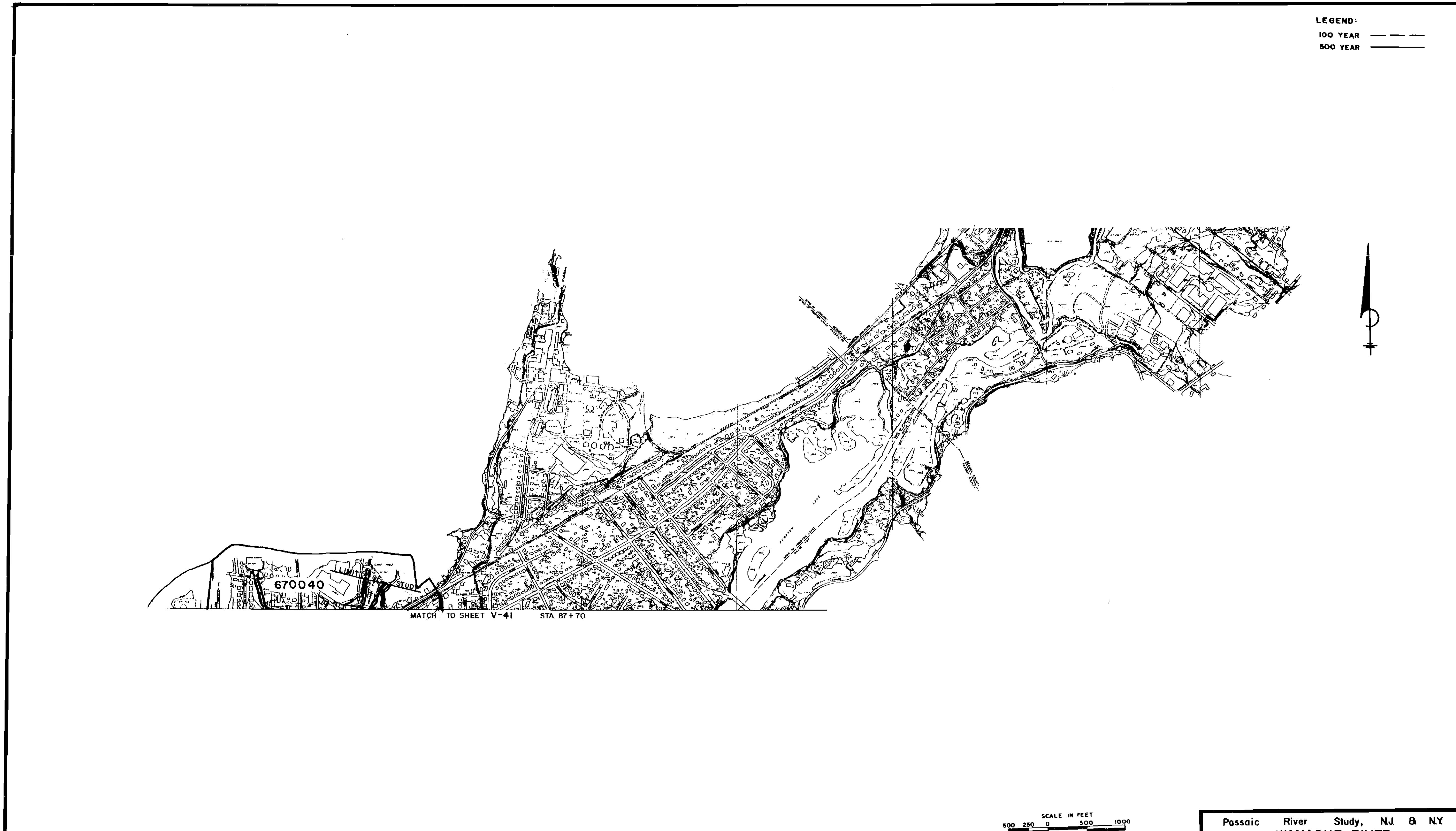
LIVINGSTON

FIGURE NO. V-40



Passaic River Study, N.J. & N.Y.
RAMAPO RIVER
STA. 49+20 TO LIMIT OF STUDY
PEQUANNOCK & WANAQUE RIVERS
FOOD LIMITS & DAMAGE REACES
POMPTON LAKES
PEQUANNOCK RIVERDALE
BLOOMINGDALE WAYNE

FIGURE NO. V-41



Passaic River Study, N.J. & N.Y.

WANAQUE RIVER

STA. 87+70 TO LIMIT OF STUDY

FLOOD LIMITS & DAMAGE REACHES

WAYNE

OAKLAND

POMPTON LAKES

FIGURE NO. V-42

PASSAIC RIVER BASIN
NEW YORK ARMY CORPS OF ENGINEERS
EXISTING LAND USE

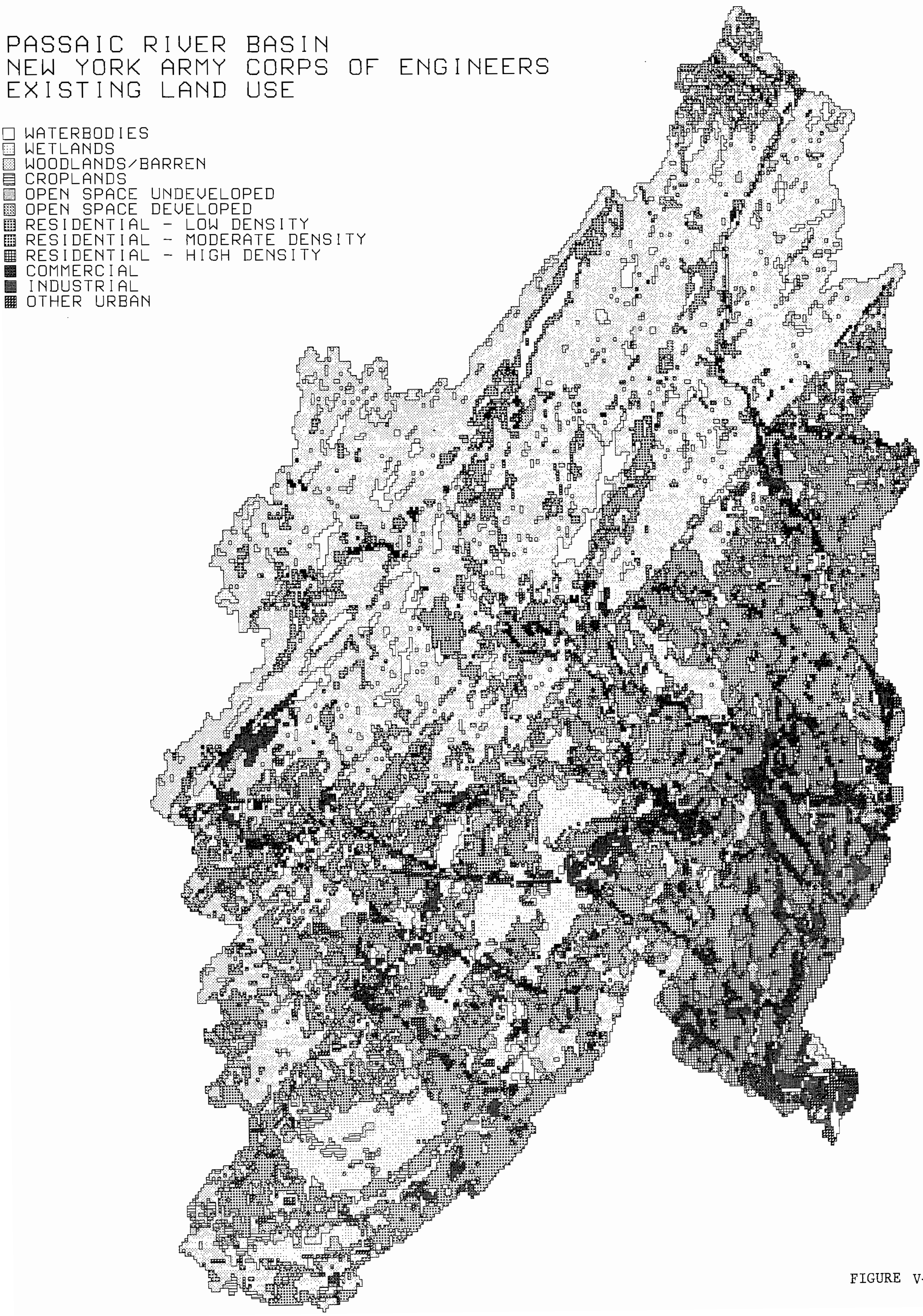


FIGURE V-43

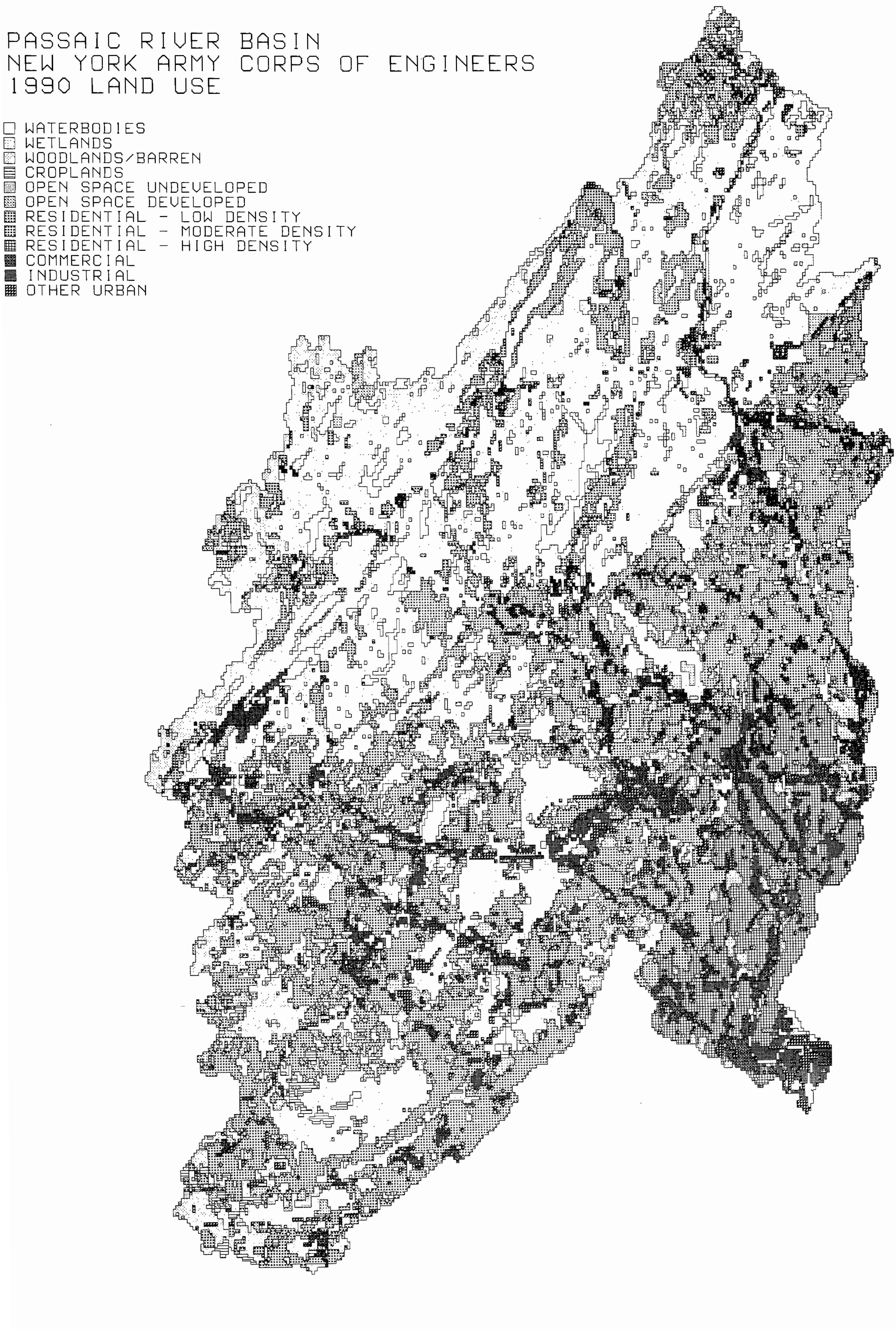

PASSAIC RIVER BASIN
NEW YORK ARMY CORPS OF ENGINEERS
1990 LAND USE
WATERBODIES
WETLANDS
WOODLANDS/BARREN
CROPLANDS
OPEN SPACE UNDEVELOPED
OPEN SPACE DEVELOPED
RESIDENTIAL - LOW DENSITY
RESIDENTIAL - MODERATE DENSITY
RESIDENTIAL - HIGH DENSITY
COMMERCIAL
INDUSTRIAL
OTHER URBAN

FIGURE V-44

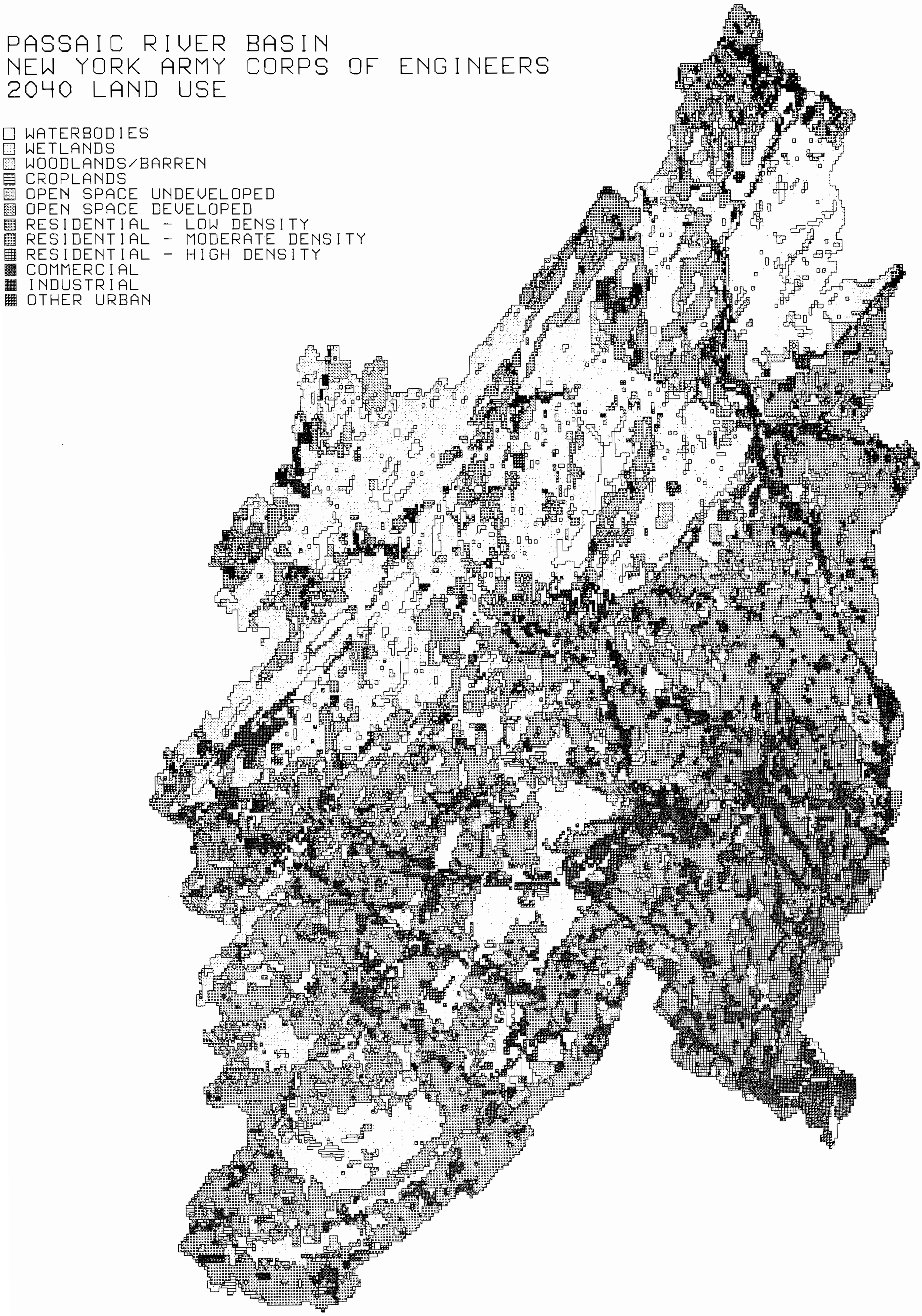

PASSAIC RIVER BASIN
NEW YORK ARMY CORPS OF ENGINEERS
2040 LAND USE
WATERBODIES
WETLANDS
WOODLANDS/BARREN
CROPLANDS
OPEN SPACE UNDEVELOPED
OPEN SPACE DEVELOPED
RESIDENTIAL - LOW DENSITY
RESIDENTIAL - MODERATE DENSITY
RESIDENTIAL - HIGH DENSITY
COMMERCIAL
INDUSTRIAL
OTHER URBAN

FIGURE V-45

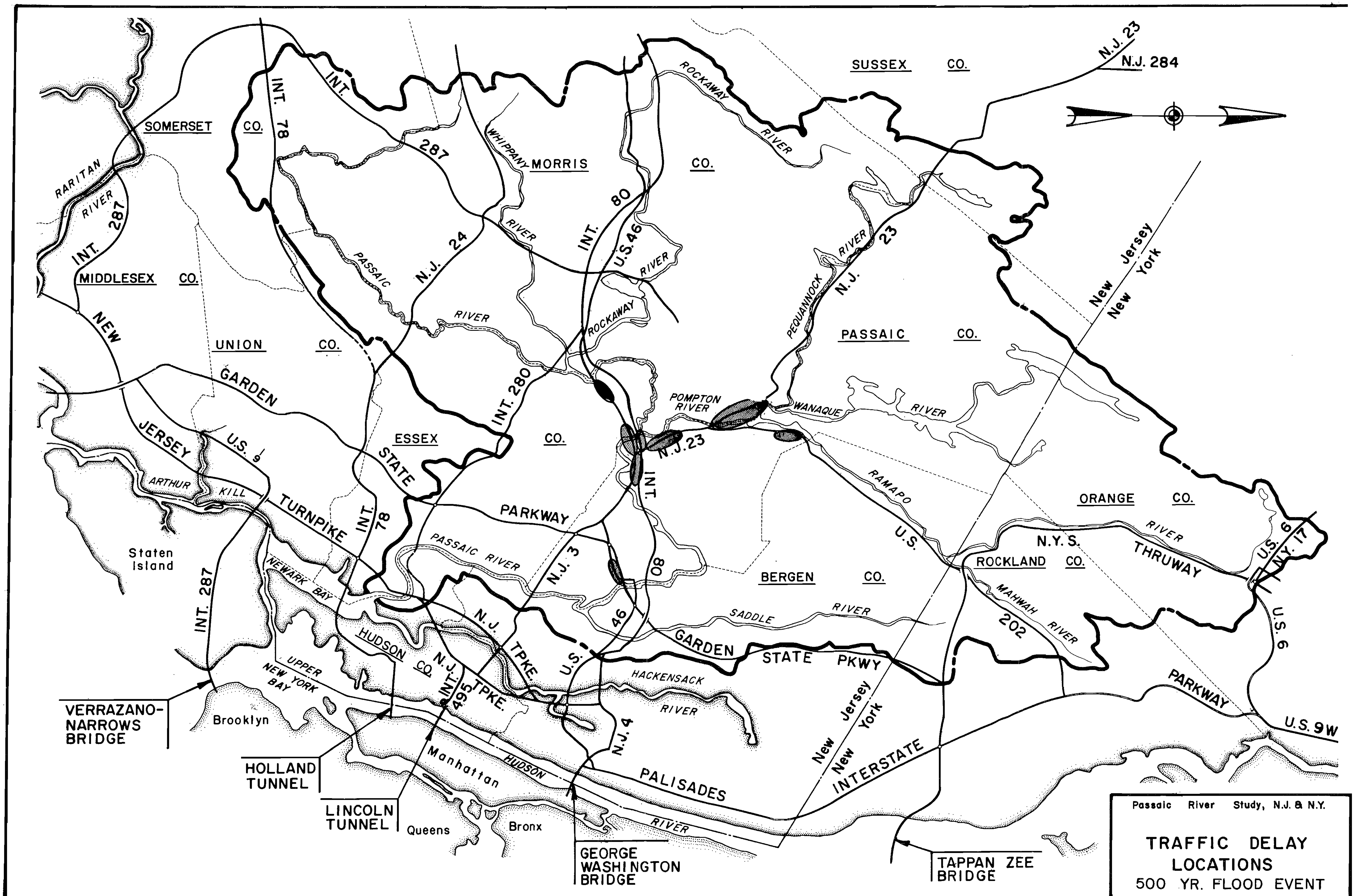

SUSSEX CO.
N.J. 23
N.J. 284
SOMERSET CO.
MORRIS CO.
MIDDLESEX CO.
UNION CO.
ESSEX CO.
PASSAIC CO.
BERGEN CO.
HUDSON CO.
ORANGE CO.
ROCKLAND CO.
RARITAN RIVER
INT. 287
INT. 78
INT. 287
INT. 80
U.S. 46
N.J. 24
INT. 280
N.J. 23
N.J. 3
INT. 80
U.S. 46
N.J. 4
INT. 495
U.S. 9
U.S. 202
U.S. 6
N.Y. 17
U.S. 9W
WHIPPANY RIVER
ROCKAWAY RIVER
PASSAIC RIVER
PEQUANNOCK RIVER
POMPTON RIVER
WANAQUE RIVER
RAMAPO RIVER
MAHWAH RIVER
SADDLE RIVER
HACKENSACK RIVER
HUDSON RIVER
ARTHUR KILL
NEWARK BAY
UPPER NEW YORK BAY
NEW JERSEY TURNPIKE
N.J. TPKE.
GARDEN STATE PARKWAY
GARDEN STATE PKWY
N.Y.S. THRUWAY
PALISADES INTERSTATE PARKWAY
New Jersey
New York
Staten Island
Brooklyn
Manhattan
Queens
Bronx
VERRAZANO-NARROWS BRIDGE
HOLLAND TUNNEL
LINCOLN TUNNEL
GEORGE WASHINGTON BRIDGE
TAPPAN ZEE BRIDGE
Passaic River Study, N.J. & N.Y.
TRAFFIC DELAY LOCATIONS
500 YR. FLOOD EVENT

FIGURE V-46