

FLOOD INSURANCE STUDY



HUNTERDON COUNTY, NEW JERSEY (ALL JURISDICTIONS)

VOLUME 1 OF 5



Community Name	Community Number
ALEXANDRIA, TOWNSHIP OF	340230
BETHLEHEM, TOWNSHIP OF	340554
BLOOMSBURY, BOROUGH OF	340231
CALIFON, BOROUGH OF	340232
CLINTON, TOWN OF	340233
CLINTON, TOWNSHIP OF	340505
DELAWARE, TOWNSHIP OF	340506
EAST AMWELL, TOWNSHIP OF	340498
FLEMINGTON, BOROUGH OF	340520
FRANKLIN, TOWNSHIP OF	340507
FRENCHTOWN, BOROUGH OF	340234
GLEN GARDNER, BOROUGH OF	340235
HAMPTON, BOROUGH OF	340236
HIGH BRIDGE, BOROUGH OF	340508
HOLLAND, TOWNSHIP OF	340509
KINGWOOD, TOWNSHIP OF	340499
LAMBERTVILLE, CITY OF	340237
LEBANON, BOROUGH OF	345299

Hunterdon County

Community Name	Community Number
LEBANON, TOWNSHIP OF	340510
MILFORD, BOROUGH OF	340239
RARITAN, TOWNSHIP OF	340240
READINGTON, TOWNSHIP OF	340514
STOCKTON, BOROUGH OF	345322
TEWKSBURY, TOWNSHIP OF	340516
UNION, TOWNSHIP OF	340242
WEST AMWELL, TOWNSHIP OF	340243

EFFECTIVE DATE:
MAY 2, 2012



Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
34019CV001B

**NOTICE TO
FLOOD INSURANCE STUDY USERS**

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: September 25, 2009

Revised Countywide FIS Date: May 2, 2012 - To change Base Flood Elevations and Special Flood Hazard Areas.

TABLE OF CONTENTS

VOLUME 1 - May 2, 2012

1.0	INTRODUCTION	1
1.1	Purpose of Study.....	1
1.2	Authority and Acknowledgements.....	1
1.3	Coordination.....	7
2.0	AREA STUDIED	
2.1	Scope of Study.....	9
2.2	Community Description.....	19
2.3	Principal Flood Problems.....	42
2.4	Flood Protection Measures.....	54
3.0	ENGINEERING METHODS	56
3.1	Hydrologic Analyses.....	56
3.1.1	<i>Pre-Countywide Analysis</i>	56
3.1.2	<i>September 25, 2009 Countywide Study</i>	64
3.1.3	<i>Revised Analysis</i>	65
3.2	Hydraulic Analysis.....	76
3.2.1	<i>Pre-Countywide Analysis</i>	76
3.2.2	<i>September 25, 2009 Countywide Study</i>	90
3.2.3	<i>Revised Analysis</i>	91
3.3	Vertical Datum.....	94

VOLUME 2 - May 2, 2012

4.0	FLOODPLAIN MANAGEMENT APPLICATIONS	96
4.1	Floodplain Boundaries.....	96
4.2	Floodways.....	97
5.0	INSURANCE APPLICATION	185
6.0	FLOOD INSURANCE RATE MAP	185
7.0	OTHER STUDIES	188
8.0	LOCATION OF DATA	188
9.0	BIBLIOGRAPHY AND REFERENCES	188

FIGURES

Figure 1.	Floodway Schematic.....	98
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TABLES

Table 1.	Historic Consultation Coordination Officer Meeting Dates.....	7
Table 2.	Streams Studied by Detailed Methods.....	9
Table 3.	Streams Studied by Approximate Methods.....	12
Table 4.	Scope of Revision for September 25, 2009 FIS.....	18
Table 5.	Letters of Map Change.....	18
Table 6.	Population Estimates.....	19

TABLE OF CONTENTS - continued

Table 7. Regulatory Lakes and Reservoirs Upstream of Hunterdon County Flooding Sources	55
Table 8. Stream Gage Information	64
Table 9. Summary of Discharges	66
Table 10. Manning’s “n” Values	91
Table 11. Floodway Data	99
Table 12. Community Map History.....	186

VOLUME 3 - May 2, 2012

EXHIBITS

Exhibit 1 – Flood Profiles

Alexauken Creek	Panels	01P-04P
Assiscong Creek	Panels	05P-10P
Back Brook	Panels	11P-13P
Beaver Brook	Panels	14P-19P
Brookville Creek	Panels	20P-23P
Bushkill Brook	Panels	24P-26P
Capoolong Creek	Panels	27P-29P
Chambers Brook	Panels	30P-32P
Delaware River	Panels	33P-45P
First Neshanic River	Panels	46P-47P
Harihokake Creek	Panels	48P-53P
Holland Brook	Panels	54P-58P
Lamington River	Panels	59P-67P
Lamington River Tributary A	Panels	68P-71P
Little Nishisakawick Creek	Panels	72P
Lockatong Creek	Panels	73P-79P
Lockatong Creek Tributary No. 1	Panels	80P
Lockatong Creek Tributary No. 2	Panels	81P-82P
Milford Creek	Panels	83P-86P
Muddy Run	Panels	87P-89P
Mulhockaway Creek	Panels	90P-98P

VOLUME 4 - May 2, 2012

EXHIBITS - continued

Exhibit 1 – Flood Profiles - continued

Musconetcong River	Panels	99P-123P
Neshanic River	Panels	124P-129P
Nishisakawick Creek	Panels	130P-131P
Pleasant Run	Panels	132P
Quequacommissacong Creek	Panels	133P
Rockaway Creek	Panels	134P-155P
Rockaway Creek Tributary B	Panels	156P-158P
Rocky Run	Panels	159P-168P
Route 202 Tributary	Panels	169P-170P
Second Neshanic River	Panels	171P-173P

TABLE OF CONTENTS - continued

Sidney Brook	Panels	174P-180P
South Branch Raritan River	Panels	181P-212P

VOLUME 5 - May 2, 2012

EXHIBITS – continued

Exhibit 1 – Flood Profiles - continued

South Branch Raritan River Tributary A	Panels	213P-214P
South Branch Rockaway Creek	Panels	215P-223P
South Branch Rockaway Creek Tributary A	Panels	224P-228P
South Branch Rockaway Creek Tributary B	Panels	229P-230P
South Fork Third Neshanic River	Panels	231P-232P
Spruce Run	Panels	233P-243P
Stony Brook	Panels	244P-247P
Swan Creek	Panels	248P-249P
Swan Creek Tributary	Panels	250P
Third Neshanic River	Panels	251P-256P
Tributary A	Panels	257P-260P
Trib B to Mulhockaway Creek	Panels	261P-263P
Trib C to Mulhockaway Creek	Panels	264P-265P
Trib D to Mulhockaway Creek	Panels	266P-268P
Trib E to Mulhockaway Creek	Panels	269P-270P
Trib F to Mulhockaway Creek	Panels	271P
Tributary No. 1 to Delaware River	Panels	272P-275P
Tributary No. 1 to Milford Creek	Panels	276P
Walnut Brook	Panels	277P-278P
Wickecheoke Creek	Panels	279P-282P
Willoughby Brook	Panels	283P-290P

Exhibit 2 – Flood Insurance Rate Map Index
Flood Insurance Rate Map

**FLOOD INSURANCE STUDY
HUNTERDON COUNTY, NEW JERSEY
ALL JURISDICTIONS**

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Hunterdon County, including the Boroughs of Bloomsbury, Califon, Flemington, Frenchtown, Glen Gardner, Hampton, High Bridge, Lebanon, Milford, and Stockton; the City of Lambertville; the Town of Clinton; and the Townships of Alexandria, Bethlehem, Clinton, Delaware, East Amwell, Franklin, Holland, Kingwood, Lebanon, Raritan, Readington, Tewksbury, Union, and West Amwell, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS report are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Alexandria, Township of

The hydrologic and hydraulic analyses for the June 6, 2001, revision for the Township of Alexandria represent a revision of the original analyses prepared by the State of New Jersey Department of Environmental Protection (NJDEP) for the Federal Emergency Management Agency (FEMA), under Contract No. H-3959. That work was completed in July 1978. The hydrologic and hydraulic analyses for the original study were conducted by Michael Baker, Jr., Inc., under subcontract with the New Jersey Department of Environmental Protection. Certain analyses for the Delaware River were performed by the Delaware River Basin Commission.

The updated hydrologic and hydraulic analysis for the Delaware River were prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, for FEMA. That work was completed in June 1996 (Reference 1).

Bethlehem, Township of

The hydrologic and hydraulic analyses for the July 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-3959. That work was completed in June, 1980. The hydrologic and hydraulic analyses for that study were conducted by

Anderson-Nichols and Co., Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 2).

Borough of Bloomsbury

The hydrologic and hydraulic analyses for the June 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Insurance Administration, under Contract No. H-3959. That work was completed in May 1980. The hydrologic and hydraulic analysis was conducted by Anderson-Nichols & Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 3).

Borough of Califon

The hydrologic and hydraulic analyses for the February 1981 study were prepared by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection for the Federal Insurance Administration, under Contract No. H-3959. That work was completed in January 1980 (Reference 4).

Town of Clinton

The hydrologic and hydraulic analyses for the December 5, 1996, revision for the Town of Clinton represent a revision of the original analyses prepared by U.S. Department of Agriculture, Soil Conservation Service (SCS), Somerset, New Jersey, for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. IAA-H-4-73. That work was completed in 1976. In the revision dated February 19, 1992, an updated hydraulic analysis for Beaver Brook was prepared by Dewberry & Davis for FEMA. That work was completed in September 1990. In the revision dated December 5, 1996, corrections were made to the FIS and FIRM for the Town of Clinton by Leonard Jackson Associates and Dewberry & Davis for FEMA. These corrections were made to ensure that the FIS and FIRM for the Town of Clinton match the FIS and FIRM for the Township of Clinton and to correct the delineation of the floodplain and floodway boundaries associated with the Spruce Run Reservoir spillway. That work was completed in August 1993. No hydrologic and hydraulic analyses were prepared for the 1996 revision (Reference 5).

Township of Clinton

The hydrologic and hydraulic analyses for the September 1, 1983 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-4546. That work was completed in February 1979. The hydrologic and hydraulic analyses for that study were conducted by Anderson-Nichols & Company under subcontract to the New Jersey Department of Environmental Protection (Reference 6).

Township of Delaware

The hydrologic and hydraulic analyses for the July 20, 1981 study were prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Emergency Management Agency, under Contract No. H-3959. That work was completed in June 1978. The hydrologic and hydraulic analyses for that study were conducted by Michael Baker, Jr., Inc. under subcontract to the New Jersey Department of Environmental Protection (Reference 7).

Township of East Amwell

The hydrologic and hydraulic analyses for the May 4, 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Insurance Administration, under Contract No. H-4546. That work was completed in February 1979. The hydrologic and hydraulic analyses for that study were conducted by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 8). The Neshanic River and Back Brook hydraulic studies were revised by Natural and Technological Hazards Management Company in 2003-2006 under the FEMA Limited Map Maintenance Program contract No. EMN-2003-CO-5006 Task 4. The work was completed in 2006 and incorporated in the countywide FIS for Hunterdon.

Borough of Flemington

The hydrologic and hydraulic analyses for the July 16, 1996, revision for the Borough of Flemington represents a revision of the original analyses prepared by the New Jersey Department of Environmental Protection (NJDEP), Division of Water Resources, Bureau of Floodplain Management for the Federal Insurance Administration (FIA), under Contract No. H-4546. That work was completed in August 1978. In the July 16, 1996 revision, the hydraulic analysis for Walnut Brook was prepared by Leonard Jackson Associates for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-90-R-3127. That work was completed in March 1993. The hydrologic analysis for Walnut Brook and the hydraulic and hydrologic analyses for Bushkill Brook were taken from the FIS prepared for the Township of Raritan (Reference 9). The Walnut Brook hydraulic study was revised again by Natural and Technological Hazards Management Company in 2003-2006 under the FEMA Limited Map Maintenance Program contract No. EMN-2003-CO-5006 Task 4. The work was completed in 2006 and incorporated in the countywide FIS for Hunterdon.

Township of Franklin

Hydrologic and hydraulic analyses for the February 3, 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Insurance Administration, under Contract No. H-4546. This work was completed in February 1979. The hydrologic and hydraulic analyses for this study were conducted by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 10).

Borough of Frenchtown

The hydrologic and hydraulic analyses for the July 19, 2001 revision for the Borough of Frenchtown represents a revision of the original analyses prepared by the State of New Jersey, Department of Environmental Protection (NJDEP), Division of Water Resources, for the Federal Insurance Administration (FIA), under Contract No. H-3959. That work was completed in June 1978. The hydrologic and hydraulic analyses for the original study were conducted by Michael Baker, Jr., Inc., under subcontract to the NJDEP.

In the July 19, 2001 revision, the updated hydrologic and hydraulic analyses for the Delaware River were prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, for FEMA. This work was completed in June 1996 (Reference 11).

Borough of Glen Gardner

The hydrologic and hydraulic analyses for the November 17, 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-3959. That work was completed in January 1980. The hydrologic and hydraulic analyses for that study were conducted by Anderson-Nichols & Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 12).

Borough of Hampton

The hydrologic and hydraulic analyses for the October 1, 1981 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-3959. That work was completed in July 1980. The hydrologic and hydraulic analyses for that study were conducted by Anderson-Nichols and Co., Inc. under subcontract to the New Jersey Department of Environmental Protection (Reference 13).

Borough of High Bridge

Hydrologic and hydraulic analyses for the March 30, 1981 study were conducted by the New Jersey Department of Environmental Protection for the Federal Insurance Administration, under Contract No. H-4546. The work was completed in November 1979. The hydrologic and hydraulic analyses for that study were prepared by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 14).

Township of Holland

The hydrologic and hydraulic analyses for the June 6, 2001 revision for the Township of Holland represents a revision of the original analyses prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration (FIA), under Contract No. H-3959. That work was completed in July 1978. The first revision to the original study was completed on March 16, 1981. The hydrologic and hydraulic analyses for the 1981 FIS were conducted by Michael Baker, Jr., Inc., under subcontract to the New Jersey Department of Environmental Protection.

In the June 6, 2001 revision, the updated hydrologic and hydraulic analyses for the Delaware River were prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, for FEMA, under Contract No. EMW-94-E-4371, Project Order No. 2. This work was completed in June 1996 (Reference 14).

Township of Kingwood

The hydrologic and hydraulic analyses for the May 4, 1981 study were prepared by the State of New Jersey Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration, under Contract No. H-3959. This work was completed in July 1978. The hydrologic and hydraulic analyses for that study were conducted by Michael Baker, Jr., Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 16).

City of Lambertville

The hydrologic and hydraulic analyses for the October 1, 1980 study were prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration, under Contract No. H-3959. That work was completed in May 1978. The hydrologic and hydraulic analyses for that study were conducted by Michael Baker, Jr., Inc. under subcontract to the State of New Jersey, Department of Environmental Protection. Certain hydrologic data for the Delaware River performed by the Delaware River Basin Commission were adopted for use in the study (Reference 17).

Borough of Lebanon

The hydrologic and hydraulic analyses in the August 3, 1981 study represent a revision of the original analyses by the New York District of the U.S. Army Corps of Engineers for the Federal Emergency Management Agency, under Contract No. H-4546. The updated version was prepared by the New Jersey Department of Environmental Protection under agreement with the Federal Emergency Management Agency. This study was completed in January 1979. The hydrologic and hydraulic analyses for the study were conducted by Anderson-Nichols & Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 18).

Township of Lebanon

The hydrologic and hydraulic analyses for the July 5, 1983 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-3959. That work was completed in September 1980. The hydrologic and hydraulic analyses for that study were conducted by Anderson-Nichols and Company under subcontract to the New Jersey Department of Environmental Protection (Reference 19).

Borough of Milford

The hydrologic and hydraulic analyses for the May 18, 1981 study were prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration, under Contract No. H-3959. The work was completed in July 1978. The hydrologic and hydraulic analyses for that study were conducted by Michael Baker, Jr., Inc. under subcontract to the New Jersey Department of Environmental Protection (Reference 20).

Township of Raritan

The hydrologic and hydraulic analyses for the November 15, 1985 study were prepared by URS Company, Inc. for the Federal Emergency Management Agency under Contract No. H-6808. This work, which was completed in February 1982, covered all significant flooding sources in the Township of Raritan (Reference 21).

Township of Readington

The hydrologic and hydraulic analyses for the August 15, 1984 study were prepared by the New Jersey Department of Environmental Protection for the Federal Emergency Management Agency, under Contract NO. H-4546. The work was completed in March 1979. The hydrologic and hydraulic analyses for the study were conducted by Anderson-Nichols & Co. under subcontract to the New Jersey Department of Environmental Protection (Reference 22).

Borough of Stockton

The hydrologic and hydraulic analyses for the June 6, 2001 revision for the Borough of Stockton represent a revision of the previous two analyses. The original analysis was prepared by the U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS) for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. IAA-H- 16-72. An updated study was dated October 15, 1982. The updated version was prepared by the New Jersey Department of Environmental Protection, Division of Water Resources under agreement with the Federal Emergency Management Agency, Contract No. H-3959. This study, which was completed in December 1980, covered all significant flooding sources in the Borough of Stockton. In the June 6, 2001 study, the hydrologic and hydraulic analyses for the Delaware River were prepared by the U.S. Army Corps of Engineers (USACE), Philadelphia District, for FEMA. This work was originally prepared for the Bucks County, Pennsylvania FIS and was completed in June 1996 (Reference 23).

Township of Tewksbury

The hydrologic and hydraulic analyses for the October 15, 1981 study were prepared by the New Jersey Department of Environmental protection for the Federal Emergency management Agency, under Contract No. H-4546. That work was completed in January 1979. The hydrologic and hydraulic analyses for the study were performed by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 24).

Township of Union

The hydrologic and hydraulic analyses for the October 15, 1981 study were prepared by the New Jersey department of Environmental Protection for the Federal Emergency Management Agency, under Contract No. H-4546. That work was completed in March 1980. The hydrologic and hydraulic analyses for the study were performed by Anderson-Nichols and Company, Inc., under subcontract to the New Jersey Department of Environmental Protection (Reference 25).

Township of West Amwell

The hydrologic and hydraulic analyses for the October 1, 1980 study were prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration, under Contract No. H-3959. The work was completed in June 1978. The hydrologic and hydraulic analyses for that study were conducted by Michael Baker, Jr., Inc., under subcontract to the New Jersey Department of Environmental Protection. The analyses for the Delaware River were previously prepared by the Delaware River basin Commission (Reference 26).

September 25, 2009 Countywide FIS

The hydrologic and hydraulic analyses for the flooding sources listed in Table 4 were prepared for FEMA by Natural and Technological Hazards Management, with subcontractor Watershed Concepts, a division of HSMM|AECOM.

This Revision

For this revised countywide FIS, hydrologic and hydraulic analyses for the Delaware River were prepared by T.Y. Lin International for FEMA under Contract No. HSFE02-08-J-0002 P00001. This work was completed in November 2009.

Base map information shown on the FIRM was provided in digital format by the New Jersey Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS). This information was derived from digital orthophotos produced at a scale of 1:2400 (1"=200') with a 1 foot pixel resolution from photography dated 2007-2008.

1.3 Coordination

The community base map selection and the identification of streams requiring detailed study for the original studies were performed in Consultation Coordination Officer (CCO) meetings within each community. The results of the studies were reviewed at the final CCO meetings. All problems raised during the final meeting have been addressed in this study.

The dates of the initial, intermediate, and final CCO meetings held for Hunterdon County, and incorporated communities within its boundaries are shown in Table 1, "Historic Consultation Coordination Officer Meeting Dates".

For the September 25, 2009 FIS, two initial CCO meetings were held on November 21, 2005 and November 29, 2005. The final CCO meetings were held on April 2, 2008. These meetings were attended by representatives of the Study Contractors, the communities, the State of New Jersey, and FEMA. No final CCO meeting was held.

For the May 2, 2012 FIS, an initial CCO meetings was held on October 1, 2010. This meeting was attended by representatives of T.Y. Lin International, RAMPP, communities affected by the Delaware River PMR, the State of New Jersey, and FEMA. No final CCO meeting was held.

A table of Consultation Coordination Officer meeting dates held for previous studies is provided in Table 1.

Table 1 - Historic Consultation Coordination Officer Meeting Dates

<u>Community Name</u>	<u>Initial CCO Date</u>	<u>Final CCO Date</u>
Alexandria, Township of	May 26, 1976 April 19, 1999	March 5, 1980
Bethlehem, Township of	September 1976	January 20, 1981
Bloomsbury, Borough of	September 1976	December 17, 1980
Califon, Borough of	November 3, 1976	June 26, 1980
Clinton, Town of	----- ¹ April 8, 1993	May 27, 1975

¹ Meeting date not provided

Table 1 - Historic Consultation Coordination Officer Meeting Dates

(Continued)

<u>Community Name</u>	<u>Initial CCO Date</u>	<u>Final CCO Date</u>
Clinton, Township of	June 1977	April 21, 1983
Delaware, Township of	May 26, 1976	March 5, 1980
East Amwell, Township of	June 1977	July 16, 1980
Flemington, Borough of	June 7, 1977	April 24, 1979
Franklin, Township of	March 12, 1993 ² ----- ¹	June 23, 1980
Frenchtown, Borough of	May 26, 1976	March 5, 1980
Glen Gardner, Borough of	April 19, 1999 ² September 1976	December 17, 1980
Hampton, Borough of	September 1976	April 27, 1981
High Bridge, Borough of	June 1977	November 5, 1980
Holland, Township of	May 26, 1976	May 5, 1980
Kingwood, Township of	April 19, 1999 ² May 26, 1976	May 11, 2000 March 5, 1980
Lambertville, City of	May 26, 1976	April 30, 1980
Lebanon, Borough of	June 1977	October 29, 1980
Lebanon, Township of	September 1976	January 11, 1983
Milford, Borough of	May 26, 1976	March 5, 1980
Raritan, Township of	June 15, 1979	June 5, 1984
Readington, Township of	June 1977	November 22, 1983
Stockton, Borough of	----- ¹ April 19, 1992	December 3, 1981
Tewksbury, Township of	June 1977	May 13, 1981
Union, Township of	June 1977	May 20, 1981
West Amwell, Township of	May 26, 1976	March 5, 1980

¹ Meeting date not provided

² Notified by letter

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Hunterdon County, New Jersey, including the incorporated communities listed in Section 1.1.

All or portions of the flooding sources listed in Table 2, "Streams Studied by Detailed Methods," were studied by detailed methods. Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM.

Table 2 - Streams Studied by Detailed Methods

<u>Flooding Source</u>	<u>Limits of Revised or New Detailed Study</u>
Alexauken Creek	Entire reach within the Lambertville City and Delaware Township
Assiscong Creek	Portions within Raritan Township
Beaver Brook	Entire reach within Clinton Town; from confluence with South Branch Raritan River to approximately 250 feet upstream of railroad
Brookville Creek	Portions within Delaware Township and Stockton Borough
Bushkill Creek	Portions within Flemington Borough; entire reach within Raritan Township
Capoolong Creek	From approximately 3,920 feet downstream of Quakertown Road to approximately 2,670 feet upstream of Quakertown Road in Franklin Township
Chambers Brook	From downstream corporate limit to approximately 5,490 feet upstream of Coddington Road in Readington Township
Delaware River	Entire reach within Hunterdon County
Harihokake Creek	Entire reach within Alexandria Township and Holland Township
Lamington River Tributary A	Entire reach within Tewksbury Township
Little Nishisakawick Creek	Entire reach within Frenchtown Borough
Lockatong Creek	Entire reach within Kingwood Township

Table 2 - Streams Studied by Detailed Methods
(Continued)

<u>Flooding Source</u>	<u>Limits of Revised or New Detailed Study</u>
Lockatong Creek Tributary No. 1	From confluence with Lockatong Creek to approximately 40 feet upstream of Kingwood Road in Kingwood Township
Lockatong Creek Tributary No. 2	From confluence with Lockatong Creek to approximately 100 feet upstream of Oak Grove Road in Kingwood Township
Milford Creek	Entire reach within Milford Borough; from downstream corporate limit to Spring Garden Road in Holland Township
Muddy Run	Entire reach within Kingwood Township
Mulhockaway Creek	From 1,610 feet downstream of confluence of Tributary B to Gravel Hill Road in Union Township
Musconetcong River	Entire reach within Bethlehem Township, Hampton Borough, Holland Township and Lebanon Township
Nishisakawick Creek	From downstream corporate limit to approximately 420 feet downstream of upstream corporate limit in the Borough of Frenchtown
Pleasant Run	From downstream corporate limit to U.S. Route 202 in Readington Township
Quequacommissaong Creek	From downstream corporate limit to approximately 260 feet upstream of downstream corporate limit in Holland Township
Rockaway Creek	Entire reach within Readington Township and Tewksbury Township
Rockaway Creek Tributary B	From confluence with Rockaway Creek to approximately 3,050 feet upstream of confluence with Rockaway Creek in Tewksbury Township
Rocky Run	From confluence with Spruce Run to approximately 240 feet downstream of Skinner Road in Lebanon Township
Route 202 Tributary	Entire reach within Raritan Township
Sidney Brook	Entire reach within Franklin Township; from downstream corporate limit to approximately 200 feet upstream of railroad in Union Township

Table 2 - Streams Studied by Detailed Methods
(Continued)

<u>Flooding Source</u>	<u>Limits of Revised or New Detailed Study</u>
South Branch Raritan River	Entire reach within Califon Borough, Clinton Town, High Bridge Borough, Lebanon Township; portions within Clinton Township; from downstream corporate limits to approximately 3,830 feet upstream of railroad in Raritan Township
South Branch Raritan River Tributary A	Entire reach within Readington Township
South Branch Rockaway Creek	Entire reach within Clinton Township, Lebanon Borough and Readington Township
South Branch Rockaway Creek Tributary A	From downstream corporate limit to just upstream of U.S. Route 22 in Lebanon Borough
South Branch Rockaway Creek Tributary B	Entire reach within Lebanon Borough
South Fork Third Neshanic River	Entire reach within East Amwell Township; Portions within Delaware Township
Spruce Run	Entire reach within Bethlehem Township, Clinton Town, Glen Gardner Borough, Lebanon Township and Union Township
Stony Brook	From downstream corporate limit to approximately 50 feet upstream of Linvale Road in East Amwell Township
Swan Creek	Entire reach within Lambertville City
Swan Creek Tributary	Entire reach within Lambertville City
Third Neshanic River	Entire reach within Delaware Township and Raritan Township
Tributary A	From confluence with Neshanic River to approximately 50 feet upstream of Manners Road in East Amwell Township
Tributary B to Mulhockaway Creek	Entire reach within Union Township
Tributary C to Mulhockaway Creek	Entire reach within Union Township
Tributary D to Mulhockaway Creek	Entire reach within Union Township

Table 2 - Streams Studied by Detailed Methods
(Continued)

<u>Flooding Source</u>	<u>Limits of Revised or New Detailed Study</u>
Tributary E to Mulhockaway Creek	Entire reach within Union Township
Tributary F to Mulhockaway Creek	Entire reach within Union Township
Tributary No. 1 to Milford Creek	From confluence with Milford Creek to Spring Garden Road in Holland Township
Tributary No. 1 to Delaware River	Entire reach within Holland Township
Wickecheoke Creek	Entire reach within Stockton Borough; from downstream corporate limit to Rosemont-Ringoes Road in Delaware Township
Willoughby Brook	Entire reach within High Bridge Borough; from downstream corporate limit to approximately 70 feet downstream of Buffalo Hollow Road in Lebanon Township

For streams studied by approximate methods, see Table 3, "Streams Studied by Approximate Methods."

Table 3 - Streams Studied by Approximate Methods

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
Alexauken Creek	Portions of West Amwell Township
Alexauken Creek Tributary 1	Entire reach within Delaware Township
Alexauken Creek Tributary 2	Entire reach within Delaware Township
Alexauken Creek Tributary 3	Entire reach within West Amwell Township
Allerton Creek	Entire reach within Clinton Township
Allerton Creek Tributary 1	Entire reach within Clinton Township
Assiscong Creek	Entire reach within Franklin Township; portions of Raritan Township
Back Brook Tributary 1	Entire reach within East Amwell Township
Back Brook Tributary 1A	Entire reach within East Amwell Township

Table 3 - Streams Studied by Approximate Methods
(Continued)

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
Back Brook Tributary 2	Entire reach within East Amwell Township
Beaver Brook	Portions within Clinton Township
Beaver Brook Tributary 1	Portions within Clinton Township
Brookville Creek	Portions within Clinton Township
Bushkill Brook	Portions within Flemington Borough and Raritan Township
Bushkill Brook Tributary 1	Portions within Flemington Borough and Raritan Township
Cakepoulin Creek	Portions within Alexandria Township and Franklin Township
Cakepoulin Creek Tributary 1	Entire reach within Alexandria Township
Capoolong Creek	Entire reach within Franklin Township
Capoolong Creek Tributary 1	Entire reach within Franklin Township and Union Township
Capoolong Creek Tributary 2	Entire reach within Franklin Township
Capoolong Creek Tributary 3	Entire reach within Franklin Township and Union Township
Chambers Brook	Portions within Readington Township
Chambers Brook Tributary 1	Entire reach within Readington Township
Cold Brook	Entire reach within Tewksbury Township
Cramers Creek	Entire reach within Clinton Township
Croton Creek	Entire reach within Delaware Township and Raritan Township
Croton Creek Tributary 1	Entire reach within Franklin Township and Raritan Township
Croton Creek Tributary 2	Entire reach within Franklin Township and Raritan Township
Derry Run	Entire reach within Lebanon Township

Table 3 - Streams Studied by Approximate Methods
(Continued)

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
First Neshanic River	Portions within Raritan Township
Frog Hollow Creek	Entire reach within Califon Borough and Tewksbury Township
Holland Brook Tributary 1	Entire reach within Readington Township
Lamington River Tributary 1	Entire reach within Readington Township
Little Brook	Entire reach within Lebanon Township
Lockatong Creek	Entire reach within Lebanon Township and Delaware Township; portions within Kingwood Township
Lockatong Creek Tributary No. 1	Portions within Kingwood Township
Lockatong Creek Tributary No. 2	Portions within Kingwood Township
Lockatong Creek Tributary No. 3	Entire reach within Franklin Township and Kingwood Township
Lockatong Creek Tributary No. 4	Entire reach within Franklin Township and Kingwood Township
Lockatong Creek Tributary No. 5	Entire reach within Franklin Township
Lockatong Creek Tributary No. 6	Entire reach within Franklin Township
Milford Creek	Portions within Holland Township
Moores Creek	Entire reach within West Amwell Township
Neshanic River Tributary 1	Entire reach within Raritan Township and West Amwell Township
Neshanic River Tributary 1A	Entire reach within East Amwell Township
Neshanic River Tributary 1B	Entire reach within East Amwell Township
Nishisakawick Creek	Entire reach within Alexandria Township; portions within Frenchtown Borough
Peters Brook	Entire reach within West Amwell Township

Table 3 - Streams Studied by Approximate Methods
(Continued)

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
Pleasant Run	Portions within Readington Township
Pleasant Run Tributary 1	Entire reach within Readington Township
Plum Brook	Entire reach within Delaware Township and Raritan Township
Prescott Brook	Entire reach within Clinton Township and Readington Township
Prescott Brook Tributary 1	Entire reach within Readington Township
Prescott Brook Tributary 1A	Entire reach within Clinton Township and Readington Township
Prescott Brook Tributary 2	Entire reach within Clinton Township
Quequacommisacong Creek	Entire reach within Alexandria Township; portions within Holland Township
Rockaway Creek	Portions within Tewksbury Township
Rockaway Creek Tributary 1	Entire reach within Clinton Township and Readington Township
Rockaway Creek Tributary 2	Entire reach within Tewksbury Township
Rockaway Creek Tributary 3	Entire reach within Clinton Township
Rockaway Creek Tributary B	Portions within Tewksbury Township
Rocky Run	Portions within Lebanon Township
South Branch Raritan River	Entire reach within Franklin Township; portions within Clinton Township and Raritan Township
South Branch Raritan River Tributary 1	Entire reach within Readington Township
South Branch Raritan River Tributary 2	Entire reach within Readington Township
South Branch Raritan River Tributary 3	Entire reach within Clinton Township
South Branch Raritan River Tributary 4	Entire reach within Clinton Township

Table 3 - Streams Studied by Approximate Methods
(Continued)

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
South Branch Rockaway Creek Tributary 1	Entire reach within Clinton Township
South Branch Rockaway Creek Tributary 1.0	Entire reach within Clinton Township
South Branch Rockaway Creek Tributary 2	Entire reach within Clinton Township
South Branch Rockaway Creek Tributary 3	Entire reach within Clinton Township
South Branch Rockaway Creek Tributary A	Entire reach within Clinton Township; portions within Lebanon Township
South Fork Third Neshanic River	Entire reach within Raritan Township; portions within Delaware Township and East Amwell Township
South Fork Third Neshanic River Tributary 1	Entire reach within Delaware Township
South Fork Third Neshanic River Tributary 1A	Entire reach within Delaware Township
South Fork Third Neshanic River Tributary 2	Entire reach within Delaware Township
Sidney Brook	Portions within Union Township
Spruce Run	Entire reach within Clinton Township and Lebanon Township; portions within Glen Gardner Borough and Union Township
Stony Brook	Entire reach within East Amwell Township
Stony Brook Tributary 2	Entire reach within East Amwell Township
Stony Brook Tributary 3	Entire reach within East Amwell Township
Swan Creek	Entire reach within West Amwell Township; portions within Lambertville City
Swan Creek Tributary	Entire reach within West Amwell Township; portions within Lambertville City
Tributary A	Portions within East Amwell Township

Table 3 - Streams Studied by Approximate Methods
(Continued)

<u>Flooding Source</u>	<u>Description of Study Reaches</u>
Tributary A Tributary 1	Entire reach within East Amwell Township
Tributary A Tributary 2	Entire reach within East Amwell Township
Tributary A Tributary 3	Entire reach within East Amwell Township
Tributary B to Mulhockaway Creek	Entire reach within Bethlehem Township
Tributary C to Mulhockaway Creek	Entire reach within Bethlehem Township; portions within Union Township
Tributary M6	Entire reach within Bethlehem Township
Tributary M9	Entire reach within Bethlehem Township
Tributary No. 1 to Milford Creek	Portions within Holland Township
Tributary S 7	Entire reach within Lebanon Township
Tributary Sp10	Entire reach within Lebanon Township
Tributary to Harihokake Creek	Entire reach within Alexandria Township
Unnamed Stream 1	Entire reach within East Amwell Township
Walnut Brook	Portions within Raritan Township
Wickecheoke Creek	Entire reach within Kingwood Township; portions within Delaware Township
Wickecheoke Creek Tributary 1	Entire reach within Delaware Township
Wickecheoke Creek Tributary 2	Entire reach within Delaware Township
Wickecheoke Creek Tributary 3	Entire reach within Delaware Township
Wickecheoke Creek Tributary 4	Entire reach within Kingwood Township
Wickecheoke Creek Tributary 5	Entire reach within Delaware Township, Franklin Township and Raritan Township
Willoughby Brook	Portions within Lebanon Township

For streams studied by detailed methods for this study, see Table 4, "Scope of Revision for September 25, 2009 FIS."

Table 4 - Scope of Revision for September 25, 2009 FIS

<u>Flooding Source</u>	<u>Limits of Revised or New Detailed Study</u>
Back Brook	Entire reach within East Amwell Township
First Neshanic River	Entire reach within Raritan Township
Holland Brook	Entire reach within Readington Township
Lamington River	Entire reach within Readington Township and Tewksbury Township
Neshanic River	Entire reach within East Amwell Township and Raritan Township
Second Neshanic River	Entire reach within Raritan Township
South Branch Raritan River	Entire reach within Raritan Township and Readington Township
Third Neshanic River	Entire reach within Raritan Township
Walnut Brook	Entire reach within Flemington Borough; portions within Raritan Township

For the May 2, 2012 Revised Countywide FIS, the Delaware River was studied in its entirety in Hunterdon County.

The September 25, 2009 FIS also incorporates the determinations of letters issued by FEMA resulting in map changes (Letter of Map Revision (LOMR), and Letter of Map Revision Based on Fill (LOMR-F)), as shown in Table 5, "Letters of Map Change."

Table 5 - Letters of Map Change

<u>Community</u>	<u>Case Number</u>	<u>Flooding Source</u>	<u>Letter Date</u>
Tewksbury, Township of	98-02-021P	Tributary A	3/6/1998

No Letters of Map Revision (LOMRs) were incorporated as part of the May 2, 2012 revision.

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction through Hunterdon County.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and representatives of Hunterdon County.

2.2 Community Description

Hunterdon County is located in central New Jersey. Its county seat, Flemington, is located approximately 40 miles southwest of New York City and 22 miles northwest of Trenton, New Jersey. The climate of this region is mostly temperate continental with some moderate maritime influences. This region has an average daily maximum temperature of approximately 64 degrees Fahrenheit (°F), and a daily minimum of approximately 42°F. The average annual precipitation is 45 inches, which is relatively high compared to many sections of North America. Monthly precipitation averages are fairly distributed throughout the year with the most intense rainfall occurring in July and August.

For up to date population estimates, see Table 6, “Population Estimates.”

Table 6 - Population Estimates

<u>Community</u>	<u>Population Estimate¹</u>
Alexandria, Township of	5,089
Bethlehem, Township of	4,008
Bloomsbury, Borough of	881
Claifon, Borough of	1,052
Clinton, Town of	2,605
Clinton, Township of	14,082
Delaware, Township of	4,730
East Amwell, Township of	4,557
Flemington, Borough of	4,267
Franklin, Township of	3,152
Frenchtown, Borough of	1,491
Glen Gardner, Borough of	1,992
Hampton, Borough of	1,658
High Bridge, Borough of	3,763
Holland, Township of	5,310
Kingwood, Township of	4,043
Lambertville, City of	3,808
Lebanon, Borough of	1,830
Lebanon, Township of	6,292
Milford, Borough of	1,219
Raritan, Township of	22,720
Readington, Township of	16,295
Stockton, Borough of	555
Tewksbury, Township of	6,088
Union, Township of	6,352
West Amwell, Township of	2,944

¹ Data obtained from the U. S. Census estimates for 2006 (Reference 27)

Township of Alexandria

The Township of Alexandria is located on the western border of central New Jersey in western Hunterdon County, approximately 30 miles northwest of Trenton. Across the Delaware River to the southwest of Alexandria lie the Pennsylvania Townships of Tinicum and Bridgeton. On the west are the New Jersey communities of the Borough of Milford and the Township of Holland. The Township of Bethlehem, New Jersey, borders Alexandria on the north and east, the Townships of Union and Franklin are on the east, and the Township of Kingwood and the Borough of Frenchtown on the south. Alexandria was originally part of the Township of Amwell, formed in 1708 when the area was part of Burlington County. In 1713, Amwell became part of Hunterdon County; in 1730, the Township of Bethlehem was created and covered most of northwest Hunterdon County. In 1765, the Township of Alexandria was formed from Bethlehem. It was named in honor of James Alexander, the father of Revolutionary hero William Alexander. In 1879, the northwestern section of Alexandria became the Township of Holland (Reference 28). Today, Alexandria has a total land area of 27.1 square miles.

Most of the township lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale. Some of the township is in the Highlands Division of the Appalachian Province, which is characterized by gently rolling to steep uplands underlain by gneiss, quartzite, and limestone rock (Reference 29). Elevations range from 93 feet at the Delaware River to 990 feet in the northern part of the township. The Delaware River, which has a total drainage area of 12,765 square miles, is the major waterway feeding the Delaware Bay (Reference 30).

With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows south along the western border of Alexandria. Its watershed upstream of the township consists primarily of open space, agricultural land and wooded areas away from the main river channels, and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas immediately upstream of Alexandria in New Jersey include Milford and Phillipsburg.

Harihokake Creek rises in north-central Alexandria and flows generally southwest to its confluence with the Delaware River. Harihokake Creek has a drainage area approximately 2 miles wide, extending from the center of Alexandria's northeastern corporate limits southwest through the township to the Delaware River. The watershed also includes a small part of the Township of Holland. Channel elevations increase at an average rate of about 42 feet per mile. Most of its watershed consists of woodlands, open space and agricultural lands with scattered houses. Its only extensive residential development is at Mount Pleasant, near the County Route 519 bridge.

Development in the Township of Alexandria from its earliest days has been primarily residential and agricultural. The only types of business in the township during its early history were those that catered to the local people, such as sawmills, grist mills, oil mills, and distilleries. Today, business in the township consists mostly of small stores and shops, a research farm, and one industrial facility which manufactures fabricated and brazed metal products (Reference 31).

Township of Bethlehem

The Township of Bethlehem occupies 20.6 square miles of Hunterdon County in northwestern New Jersey. It is located 34 miles north of Trenton, New Jersey, 50 miles west of New York City, and 55 miles northeast of Philadelphia, Pennsylvania.

The Township of Bethlehem is bordered by the Boroughs of Glen Garner and Hampton to the northeast; the Townships of Union, Alexandria and Holland to the south; the Borough of Bloomsbury to the west; and the townships of Franklin and Washington in Warren County to the northwest.

Settlers first began to cut farms out of northern Hunterdon County in the early eighteenth century. The Township of Bethlehem was established in 1730 and originally encompassed the northern third of present-day Hunterdon County. The area was predominantly family farms and supported small industries such as iron forges and grist mills. Growth was slow until the latter half of the nineteenth century, when the Central Railroad of New Jersey was built through Bethlehem, bringing people and trade to the small towns. Today Bethlehem is basically a residential town with an agricultural concern (Reference 32).

The principal waterway in Bethlehem is the Musconetcong River, with a drainage area of 158 square miles. Originating in Lake Hopatcong, the Musconetcong loops to the northwest after flowing through Lake Musconetcong and then flows southwest, forming the border of Warren County, until reaching the Delaware River in Riegelsville, New Jersey.

The central region of the Delaware River Basin includes four geological provinces. The Musconetcong River and its tributaries are within the Reading Prong of the New England Upland Subprovince, which is called the Highlands in New Jersey. The area is moderately rugged and characterized by approximately parallel, somewhat irregular ridges and intervening valleys all trending northeast. The ridges, which rise about 500-1,000 feet above the valleys, are formed largely by gneiss and related hard crystalline rocks; the valleys are underlaid by crystalline rocks - principally carbonate rocks and shale. Most of the New England province has been glaciated. In the northeastern part of the Highlands the ridges are blanketed by extensive deposits of glacial till, and the valleys contain thick deposits - largely outwash - which completely mask the bedrock in most places.

Spruce Run is also located in the Highlands physiographic province, an area underlaid by resistant ridges of Pre-Cambrian gneiss and occasional beds of Cambro-Ordovician limestone. The soils in this area are deep, mostly well drained, moderate sloping and rocky.

Borough of Bloomsbury

The Borough of Bloomsbury occupies 0.8 square mile of Hunterdon County in northwestern New Jersey. It is located approximately 34 miles north of Trenton, New Jersey, 50 miles from New York City and 55 miles from the City of Philadelphia. Bloomsbury is bordered by the Township of Bethlehem on the east and south, and by the Townships of Greenwich and Franklin in Warren County on the north and west.

Settlers first began to cut farms out of northern Hunterdon County in the 1730s. Originally part of the Township of Bethlehem, the land that is now Bloomsbury

belonged at that time to Robert Johnston. He owned an iron forge along the Musconetcong River which was in operation until 1799 (Reference 32). Growth was slow up to the latter half of the nineteenth century, when the Central Railroad of New Jersey and the Lehigh Valley Railroad were built through Bloomsbury. The town became a center for commerce, and was separated from the Township of Bethlehem and incorporated as a borough in 1905. Today Bloomsbury is basically a residential town with a small light industrial concern.

The principal waterway in Bloomsbury is the Musconetcong River, with a drainage area of 158 square miles. Originating in Lake Hopatcong, the Musconetcong loops to the northwest after flowing through Lake Musconetcong and then flows southwest to form the border of Warren County, joining the Delaware River in Reigelsville, New Jersey.

The central region of the Delaware River basin includes four geologic provinces. The Musconetcong River and its tributaries are within the Reading prong of the New England Uplands subprovince, which is called the Highlands in New Jersey. The area is moderately rugged and characterized by approximately parallel, somewhat irregular ridges and intervening valleys all trending northeast. The ridges rise 500 to 1,000 feet above the valleys, and are formed largely of gneiss and related hard crystalline rocks. The valleys are underlain by weaker rocks, principally carbonates and shales. Most of the New England province has been glaciated. In the northeastern part of the province, in New Jersey, the ridges are blanketed by extensive deposits of glacial till, and the valleys contain thicker deposits - largely outwash - which completely mask the bedrock in most places.

Borough of Califon

The Borough of Califon is a residential and farming community of approximately 1 square mile. Califon is located in Hunterdon County, New Jersey and is bordered to the north, east, and west by the Township of Lebanon, to the southwest by the Township of Tewksbury. Califon, Califon, originally a part of Lebanon and Tewksbury, became a separate borough in May 1918 (Reference 33).

The land area in the Borough of Califon is 25 percent undeveloped, approximately 40 percent farmland and the remaining 35 percent divided between residential and industrial development (Reference 34).

The principal waterway in Califon is the South Branch Raritan River with a drainage area of 276 square miles. The South Branch Raritan River originates in Budd Lake, flows southwest, and then turns to the east to join North Branch Raritan River near Raritan, New Jersey to form the main stream of the Raritan River.

The Borough of Califon is located in the Highlands physiographic region, an area underlain by resistant ridges of Pre-Cambrian gneiss and occasional beds of Cambro-Ordovician limestone. The soils in this area are deep, mostly well drained, moderately sloping and rocky.

Town of Clinton

The Town of Clinton is located at the confluence of Spruce Run and the South Branch Raritan River, in northern Hunterdon County, in northwestern New Jersey. It is bordered by the Township of Clinton, to the north and east; the Township of Franklin,

to the southwest; and the Township of Union, to the west. This area of New Jersey is still rural in nature. The Town of Clinton has a total land area of 1.34 square miles.

Land use within the upstream watershed is generally agriculture, and much of the land is wooded. The drainage area of the South Branch Raritan River in the Town of Clinton is approximately 111 square miles, forming part of the Raritan River Basin. The South Branch Raritan River flows south and eastward toward the town, where it joins the North Branch Raritan River to form the Raritan River near Somerville, New Jersey. The Raritan River then flows eastward into the Raritan Bay south of New York City.

The South Branch Raritan River upstream of the confluence with Spruce Run has an average width of approximately 100 feet, an average depth of six feet, and an average stream bottom slope of 2.5 feet per thousand.

The floodplain paralleling Halstead Street is built up, but this gives way to grass and then to woodland in the upper reaches. Average floodplain width in this reach is 500 feet. Out of bank flooding in this reach is fairly frequent, but only less frequent events cause damage.

Downstream of Interstate Route 78, the South Branch Raritan River averages 150 feet wide with a channel bottom slope of about two feet per thousand. The channel in this segment averages 4.5 feet deep, with the floodplain averaging 1,000 feet wide. This area floods quite frequently; and consequently, little development has taken place. Between Interstate Route 78 and Spruce Run, the South Branch is fairly well entrenched with an average width of 130 feet and banks of four feet. The average slope along this reach remains two feet per thousand. The Old Clinton Mill Dam is located approximately 300 feet downstream of Spruce Run. Flooding along this reach occurs mainly during the larger storms and is accentuated by numerous road crossings, the mill dam, and previous filling and building in the floodplain.

The floodplain along Spruce Run is largely undeveloped and has a width of approximately 500 feet.

Beaver Brook is a small tributary to the South Branch of the Raritan River with a drainage area of 7.0 square miles and an average floodplain width of 200 feet. In places, the stream and floodplain have been constricted by U.S. Route 22 and its associated business and commercial establishments. Out of bank flooding occurs frequently, but only larger storms produce significant damage. The lower reaches of Beaver Brook are subject to backwater flooding from the South Branch of the Raritan River.

Township of Clinton

The Township of Clinton, primarily a residential community with some light industry, is located in north-central Hunterdon County in northwestern New Jersey. The community is situated 25 miles northwest of New Brunswick, 50 miles west of New York City and 60 miles north of Philadelphia. The township has a land area of approximately 34 square miles. Clinton is bordered by the Townships of Tewksbury and Lebanon and the Borough of High Bridge to the north, the Township of Readington to the south and east, the Townships of Raritan and Franklin to the south, and the Town of Clinton and the Township of Union to the west. The Borough of Lebanon is located entirely within the community, north of Round Valley Reservoir.

The principal waterway in Clinton is the South Branch Raritan River, with a drainage area of approximately 70 square miles. The South Branch Raritan River originates at Budd Lake in the Township of Mount Olive, and flows southwest and then east to join the North Branch Raritan River near Raritan, New Jersey, forming the main stem of the Raritan River. Development within the floodplain of the South Branch Raritan River in the community is residential and agricultural.

Beaver Brook, with a drainage area of approximately 7 square miles at the Town of Clinton-Township of Clinton corporate limits, is a tributary to the South Branch Raritan River. Residential and agricultural development is located in the floodplain of Beaver Brook in the Township of Clinton.

South Branch Rockaway Creek originates in the Township of Clinton and flows east through the Borough of Lebanon, then south to meet Rockaway Creek in the Township of Readington. South Branch Rockaway Creek has a drainage area of approximately 8 square miles at the Township of Readington-Township of Clinton corporate limits. Development within the floodplain of South Branch Rockaway Creek is mostly agricultural with some residential development located near the downstream corporate limits of the township.

Half of the Township of Clinton lies within the Raritan Valley Lowland of the Piedmont Physiographic Province and half is located in the Highlands, an extension of the Reading Prong of the New England Physiographic Province. The lowland area is a low, rolling plain, sloping gently to the southeast, while the highlands consist of flat-topped ridges separated by narrow, deep valleys.

The area is underlain by numerous types of rocks of which the most prominent are the resistant diabase of the Cushetunk Mountain ring dike. The remaining bedrock is composed of highly erodible Brunswick Shale, Kittatinny Limestone, Hardyston Quartzite and Precambrian gneisses. Numerous faults located throughout the community are aligned from northeast to southwest (Reference 35).

Soils in the area are mostly stony, medium textured, poorly to moderately drained silty clay loam on the hillsides, and moderately to excessively drained silt loam in the valleys (Reference 35). Vegetation in the township consists of wooded areas with occasional cultivated areas of corn and soybeans. In the upland areas, broadleaf species of white, black and red oak, as well as white ash, tulip, sweet birch, yellow birch, red maple, beech, hickory and conifer species are found.

Township of Delaware

The Township of Delaware is located on the western border of central New Jersey in southwestern Hunterdon County, approximately 19 miles northwest of Trenton. It is bounded by the Pennsylvania Townships of Solebury and Plumstead on the west across the Delaware River, the New Jersey townships of Kingwood and Franklin on the north, the townships of Raritan and East Amwell on the east, and by the Township of West Amwell and the City of Lambertville on the south.

The Township of Delaware was originally part of the Township of Amwell, which was formed in 1708 when the area was part of Burlington County. In 1713, Amwell became part of Hunterdon County, and in 1838 the township was subdivided to form the townships of Delaware, Raritan, and Amwell. It is believed that Delaware derives its name from the Indian tribe which inhabited the area when the first settlers arrived.

The township has a total land area of 36.6 square miles. The Township of Delaware lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale (Reference 29). Elevations range from 43 feet at the Delaware River to 550 feet in the northern corner of the township.

The Delaware River, with a total drainage area of 12,765 square miles, is the major waterway feeding the Delaware Bay (Reference 30). With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows southerly along the western border of the township. The watershed upstream of the study area consists primarily of open space, agricultural and wooded land away from the main river channels, and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas immediately upstream of the township include Milford, Frenchtown, and Phillipsburg, New Jersey.

Alexauken Creek has its headwaters in the central part of the Township of West Amwell and flows generally northwest to a point just south of the center of Delaware's southern boundary. From this point, it flows southwest to its confluence with the Delaware River. From its mouth upstream to a Conrail bridge, approximately 1,200 feet, the creek forms the boundary between the City of Lambertville to the south and the Township of Delaware to the north. From this bridge, the Conrail tracks form the southern corporate limits of the township, and just south of them Alexauken Creek flows through Lambertville and West Amwell, except for a portion about 3,600 feet long which loops into the Township of Delaware about 3,100 feet upstream of the Conrail bridge. In addition to draining the northwestern portion of West Amwell and the eastern part of East Amwell, Alexauken Creek also drains the southern part of the Township of Delaware. Channel elevations along the part of Alexauken Creek which bounds, meanders into, or is adjacent to the township averages about 24 feet per mile.

Brookville Creek begins in the southwestern part of the Township of Delaware and flows generally southwest to its confluence with the Delaware River, the last 1,900 feet forming the southeastern border between the Borough of Stockton and the Township of Delaware. Brookville Creek drains a small part of the southern portion of the Township of Delaware, and channel elevations increase about 100 feet along the 3,700-foot portion of the stream studied in detail.

Wickecheoke Creek has its headwaters in the Township of Raritan and flows generally southwest, entering the Township of Delaware near its northern corner and continuing on through the township to its confluence with the Delaware River. Approximately the last 2,000 feet of the creek form the northwestern boundary between the Borough of Stockton and the Township of Delaware. The Wickecheoke Creek watershed includes most of the northeastern part of the township. Channel elevations along the creek increase at a rate of about 40 feet per mile.

The Third Neshanic River begins in the eastern part of the township and flows generally southeast. Outside the township, the Third Neshanic River becomes a major tributary to the Neshanic River, which eventually empties into the Raritan River, the major waterway feeding Raritan Bay. The drainage area of the Third Neshanic River includes the east-central part of the Township of Delaware. Channel elevations in the township increase at a rate of about 40 feet per mile.

The watersheds of Alexauken Creek, Brookville Creek, Wickecheoke Creek, and the Third Neshanic River consist mostly of open space, agricultural land, and woodlands, with very little residential development. The only significant development occurs near the mouths of Alexauken Creek in Lambertville and Brookville Creek and Wickecheoke Creek in Stockton.

Development in the township is almost entirely residential and agricultural. Even in its early days, businesses were those that catered to local people, such as sawmills, grist mills, and various small shops.

Today business in the township consists primarily of small shops and stores. There are some industrial facilities, which manufacture chemical and allied products and electrical equipment and supplies (Reference 31).

Township of East Amwell

The Township of East Amwell occupies 27.8 square miles of Hunterdon County in northwestern New Jersey. It is located approximately 20 miles west of New Brunswick, 45 miles southwest of New York City and 50 miles northeast of Philadelphia.

East Amwell is bordered on the southeast by the Township of Hopewell, Mercer County; on the southwest by the Township of West Amwell, Hunterdon County; on the west by the Township of Delaware, Hunterdon County; on the northwest by the Township of Raritan, Hunterdon County; on the northeast by the Township of Hillsborough, Somerset County.

The Township of East Amwell is primarily rural residential. Mixed farming plays an important role in the community and there is no significant industry. Commercial establishments are concentrated in Ringoes, the largest village in the township. There is no significant development in the floodplains although some residential and farm structures would be inundated by major flooding events.

The Township of East Amwell lies entirely within the Piedmont Physiographic Province. The northern part of the township is in the Raritan Valley Lowland region while the southern part of the community lies in the Sourland Mountain region. The northern lowland region is a rolling plain sloping gently southeastward, while the mountain region, though higher and steeper, has relatively flat mountaintops (References 35 and 36).

Elevations in the community range from a high point of approximately 560 feet in the southeast portion of the township near the intersection of Lindbergh Road and South Hill Road to a low point of less than 100 feet where the Neshanic River enters the Township of Hillsborough (Reference 37).

The area is underlain predominantly by Brunswick shale from the Triassic period that is easily eroded by weathering forces and comprises the major parent material of the local soils overlying the bedrock. The remaining bedrock is composed of highly resistant argillite and diabase rock (Reference 37).

Vegetative cover consists mainly of forested areas interspersed with cultivated farmland and pastures. The forested areas consist of broadleaf species of white oak, pin oak, willow, river birch, boxelder, sugar maple, red maple, beech, and basswood along with various conifer species.

Borough of Flemington

The Borough of Flemington is located in the northwest portion of New Jersey in the central portion of Hunterdon County. The total land area contained within the borough limits is 1.1 square miles. Flemington is situated approximately 40 miles southwest of New York City and 22 miles northwest of Trenton, New Jersey.

Walnut Brook, which flows south through the borough, is a tributary of the First Neshanic River. The brook is 3.8 miles in length and has a drainage area of 3.4 square miles. Bushkill Brook, a tributary flowing northeast to the South Branch of the Raritan River, is 2.3 miles in length with a drainage area of 4.6 square miles. The development in the floodplain is basically residential as most of Flemington is rural.

Township of Franklin

The Township of Franklin is located in Hunterdon County in northwestern New Jersey. Franklin is bordered by the Town of Clinton to the north, the Township of Clinton to the northeast, the Township of Raritan to the southeast, the Township of Kingwood to the southwest, the Township of Alexandria to the west, and the Township of Union to the northwest. It is located approximately 9 miles northwest of Flemington, 50 miles west of New York City and 60 miles northeast of Philadelphia. The Township of Franklin covers 23.3 square miles.

The Township of Franklin is primarily agricultural. It has a significant number of farms and several commercial establishments which contribute to the economic base of the community.

Elevations in the community range from 706 feet just southeast of Quakertown to 140 feet at the eastern corporate limits of Franklin along the South Branch Raritan River.

The bedrock of Franklin consists of shale interbedded with sandstone, siltstone, argillites, and conglomerates. Approximately 70 percent of the township is made up of the Lockatong Formation, which is the interfingering of the Stockton Formation to the east and the Brunswick Shale to the west. The northeast corner of Franklin has a thick deposit of border conglomerates (References 35 and 37).

Vegetative cover consists mainly of cultivated farmland and pastures interspersed with forested areas. The forested areas contain broadleaf species of white oak, pin oak, willow, river birch, boxelder, sugar maple, red maple, beech and basswood along with various conifer species.

Capoolong Creek originates in the western corner of Franklin and flows in a generally northeastern direction through Franklin until it meets the South Branch Raritan River. The river has a total fall of about 300 feet, including 78 feet within the 1.2 mile study reach. The total drainage area at the downstream limit of study is 6.03 square miles.

Sidney Brook originates in the Township of Union and flows in a generally southeastern direction through Union and Franklin until it meets the South Branch Raritan River. The total drainage area at the mouth is 5.5 square miles.

The development in the floodplain of both Capoolong Creek and Sidney Brook is primarily residential.

Borough of Frenchtown

The Borough of Frenchtown is located on the western border of central New Jersey in western Hunterdon County, approximately 26 miles northwest of Trenton. It is bounded by the Township of Tinicum across the Delaware River in Pennsylvania on the west, by the Township of Alexandria, New Jersey, on the north and by the Township of Kingwood on the east and south.

Frenchtown, originally known as Alexandria, was first settled by Colonel Thomas Lowrey in 1785. In 1795, the land was purchased by Paul Henri Mallet-Prevost, a refugee of the French Revolution, and the settlement became known as Frenchtown. The community was incorporated as a borough on April 4, 1867 (Thomas F. Gordon, 1973).

Frenchtown lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale (U.S. Dept. of Agriculture, 1974). Elevations range from 94 feet at the Delaware River to 330 feet along the borough's eastern corporate limits. The Delaware River, which has a total drainage area of 12,765 square miles, is the major waterway feeding the Delaware Bay (U.S. Dept. of the Interior, 1960). With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows south along the western border of Frenchtown. Its watershed upstream of Frenchtown consists primarily of open space, agricultural and wooded land away from the main river channels, and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas in New Jersey immediately upstream of Frenchtown include Milford and Phillipsburg.

Nishisakawick Creek has its headwaters in the central part of the Township of Alexandria and flows generally southwest, entering Frenchtown at its northwestern corner and continuing southwest to its confluence with the Delaware River in the southwestern corner of the borough. The channel elevations for Nishisakawick Creek through Frenchtown increase 53 feet over a distance of about 6,700 feet.

Little Nishisakawick Creek has its headwaters in northwestern Kingwood and flows generally west through the southern half of Frenchtown to its confluence with the Delaware River, approximately 200 feet downstream of the mouth of Nishisakawick Creek. Channel elevations for Little Nishisakawick Creek through Frenchtown increased 67 feet over a distance of about 5,100 feet.

The only significant development in both the Nishisakawick Creek and Little Nishisakawick Creek floodplains occurs near their mouths in Frenchtown. Elsewhere, the watersheds contain only scattered residential dwellings among open spaces, agricultural lands, and woodlands. Development in the Borough of Frenchtown is heavy along the Delaware River north of Nishisakawick Creek and consists of a mixture of residential, commercial, and industrial development. In the area between Nishisakawick Creek and Little Nishisakawick Creek, development consists of scattered residential dwellings. South of Little Nishisakawick Creek, what development there is in the borough consists of a few residential dwellings and commercial establishments, all of which are within 1,000 feet of the Delaware River.

Until the 1900s, business in Frenchtown consisted mainly of grist mills, sawmills, and factories for the manufacturing of buggies, wagon wheels, and spokes. Today, the

major industries in Frenchtown include factories for the manufacturing of electronic components, lumber yards, poultry hatcheries, food processing and distribution plants, and a large mail order business (Reference 31).

Borough of Glen Gardner

The Borough of Glen Gardner occupies 1.5 square miles of Hunterdon County in northwestern New Jersey. It is located approximately 34 miles north of Trenton, New Jersey, 50 miles from New York City and 55 miles from Philadelphia. Glen Gardner is bordered by the Township of Lebanon to the north and east, the Borough of Hampton to the northwest and the Township of Bethlehem to the west and south.

Settlers first began to cut farms out of northern Hunterdon County in the early eighteenth century. One of the earliest buildings in the Glen Gardner area was a tavern built around 1760 by John Eveland. The area was predominantly family farms and supporting small industries, such as iron forges and grist mills.

Growth was slow up to the latter half of the nineteenth century, when the Central Railroad for New Jersey was built through the borough, and the Gardner brothers came from New York to establish a picture frame factory. Glen Gardner boomed with these incentives until the end of the century when the Gardners closed their factory and left town.

The borough was separated from the Township of Lebanon and incorporated in 1919. Today, Glen Gardner is basically a residential town with farms in the north and one mining operation in the southeast corner of the borough.

The principal stream in Glen Gardner is Spruce Run, which flows south for 5 miles from its headwaters in the Township of Lebanon to the Spruce Run Reservoir, which empties into the South Branch Raritan River about 0.5 mile below the dam in Clinton. In Glen Gardner the stream is a fairly steep, fast-flowing stream with a narrow floodplain, flowing through the residential and rural parts of the borough.

Tributaries to Spruce Run within the study area are Alpaugh Brook, which flows east into the borough and joins Spruce Run just west of Bells Crossing, and two unnamed tributaries south of Alpaugh Brook.

Along Spruce Run the most extensive development adjacent to the floodplain is along the downstream portions of the stream.

Spruce Run is located in the Highlands physiographic province, an area underlain by resistant ridge of Precambrian gneiss and occasional beds of Cambro-Ordovician limestone. The soils in this area are deep, mostly well-drained, moderate in slope and rocky.

Borough of Hampton

The Borough of Hampton occupies 1.4 square miles of Hunterdon County in northwestern New Jersey. It is located 35 miles north of Trenton, New Jersey, 50 miles west of New York City and 55 miles northwest of Philadelphia, Pennsylvania.

Hampton is bordered on the north by the Township of Lebanon, on the south by the Borough of Glen Gardner and the Township of Bethlehem and on the west by the Township of Washington.

Settlers first began to cut farms out of northern Hunterdon County in the early eighteenth century. The land now in Hampton was originally purchased by John Bowlby of England in the 1740's. The area was predominantly family farms, and supported small industries such as iron forges and grist mills (Reference 39). Growth was slow until the latter half of the nineteenth century when the Central Railroad of New Jersey built through Hampton, establishing storage site in the borough for coal destined for New York City. In 1895, the Borough of Hampton Junction was incorporated; in 1909 the name was changed to Hampton. Today, Hampton is a residential town with an agricultural concern (Reference 39).

The principal waterway in Hampton is the Musconetcong River, with a drainage area of 158 square miles. Originating in Lake Hopatcong, the Musconetcong River loops to the northwest after flowing through Lake Musconetcong, and then flows southwest until reaching the Delaware River in Riegelsville, New Jersey.

The central region of the Delaware River Basin includes four geological provinces. The Musconetcong River and its tributaries are within the Reading Prong of the New England subprovince, which is called the Highlands, in New Jersey. This is an area of moderate relief, characterized by parallel, irregular ridges and intervening valleys trending northeast. The ridges, which rise 500-1,000 feet above the valleys, are composed largely of gneiss and related hard crystalline rocks; the valleys are underlain by marine sediments – principally carbonate rocks and shale. Most of the New England province has been glaciated. In the northeastern part of the Highlands, the ridges are blanketed by extensive deposits of glacial till, and the valleys contain thicker deposits - largely outwash - which completely mask the bedrock in most places.

Borough of High Bridge

The Borough of High Bridge is located in Hunterdon County, New Jersey, 35 miles northwest of New Brunswick, 60 miles west of New York City and 60 miles north of Philadelphia. It occupies approximately 2.30 square miles and is bordered by the Townships of Lebanon to the north and Clinton to the south, east and west.

High Bridge is primarily residential, with small industry encompassing a variety of manufacturing which includes a tool and die plant, a computer component manufacturer and a number of other smaller diversified industries.

The geologic make-up of the borough is entirely Precambrian igneous and metamorphic materials. The primary rocks are granites, granodiorites and gabbroic gneisses. The area has been subjected to stress since Precambrian times as evidenced by faults in the south and southeast portions of the borough.

High Bridge has only two major streams flowing through the borough. The meanders of the streams reflect the underlying bedrock structure, as in the southeast section of the borough where the South Branch Raritan River flows along the fault line (Reference 35).

Vegetative cover consists mainly of wooded areas interspersed with cultivated farmland and pastures. The wooded areas consist of broadleaf species of white pine and oak as well as willow, river birch, boxelder, sugar maple, red maple, beech and basswood along with various conifer species.

Elevations in the community range from about 780 feet just northeast of Super Fine

Road to about 210 feet at the High Bridge - Clinton corporate limits on the South Branch Raritan River.

The principal watercourse in High Bridge is the South Branch Raritan River with a drainage area of approximately 70 square miles. The river originates at Budd Lake in the Township of Mount Olive, flows southwest and then east, joining the North Branch Raritan River near Raritan, New Jersey to, form the main stem of the Raritan River.

Willoughby Brook has its headwaters in the Township of Lebanon and flows southwest until it empties into Spruce Run Reservoir in the Township of Union. The total drainage area at the mouth is 2.44 square miles.

The area adjacent to the floodplains of the South Branch Raritan River consists generally of residential development and small commercial establishments.

Township of Holland

The Township of Holland is located on the western border of central New Jersey in northwestern Hunterdon County, approximately 32 miles northwest of Trenton, New Jersey. Directly across the Delaware River to the west and south lie the Pennsylvania communities of Bridgeton, Nockamixon, Durham, and Riegelsville; the New Jersey Townships of Pohatcong and Bethlehem border Holland on the north; the Township of Alexandria lies to the east and south; and the Borough of Milford borders Holland on the southeast.

Holland, the last township to be formed in Hunterdon County, was created in 1879 when the northwestern section of the Township of Alexandria became a separate entity (Hunterdon County Board of Chosen Freeholders, 1976).

Approximately the southern two-thirds of Holland lie in the Piedmont Plateau region, and the remainder is in the Highlands Division, both of which are part of the Appalachian Province. The Piedmont Plateau, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale. The Highlands Division is characterized by gentle rolling to steep uplands and is underlain by gneiss, quartzite, and limestone rock (U.S. Department of Agriculture, 1974). Elevations range from 95 feet at the Delaware River to 960 feet in the northeastern part of the township.

The Musconetcong River has its headwaters in north-central New Jersey and flows generally southwest to its confluence with the Delaware River opposite Riegelsville, Pennsylvania. The total drainage area at the mouth is approximately 158 square miles. From the mouth upstream for 6.3 miles, the Musconetcong River forms the boundary between the Township of Holland, Hunterdon County, and the Township of Pohatcong, Warren County. Channel elevations along this part of the river increase at an average rate of about 20 feet per mile. Most of its watershed consists of open space, wooded areas, and agricultural lands, with moderate residential and light industrial development near the river's floodplain. Upstream of Holland, the Boroughs of Bloomsbury and Hopatcong are the major centers of development along the river.

Milford Creek begins in the central part of the township and flows generally south into the Borough of Milford, where it empties into the Delaware River. The channel elevations through the township increase at an average rate of 58 feet per mile.

Tributary No. 1 to Milford Creek also begins in the central part of the township and flows southeast to its confluence with Milford Creek. Channel elevations increase about 28 feet along the 1,940-foot length of stream studied in detail.

The watersheds of Milford Creek and Tributary No. 1 to Milford Creek consist of open space, agricultural land, and wooded areas, except for the area near the confluence of the two streams and a small area in the Milford Creek watershed approximately 1.0 mile upstream of the limit of detailed study. In these two areas, there is residential development in the form of lot plans.

Tributary No. 1 to Delaware River begins in the west-central part of Holland and flows generally south to its confluence with the Delaware River. The watershed consists almost totally of undeveloped open areas, woodlands, and agricultural land with only a few residential dwellings. Channel elevations increase at an average rate of about 95 feet per mile.

Development in the township, even from its earliest days, has been primarily residential and agricultural. The only types of business in the township during its early history were those that catered to the local people, such as sawmills, grist mills, and ferries. Today, business consists mostly of small stores and shops. There are several industrial facilities, including a paper production plant and the Holland Power Plant of the New Jersey Power and Light Company (Reference 31).

Township of Kingwood

The Township of Kingwood is located on the western border of central New Jersey in the west - central part of Hunterdon County, approximately 22 miles northwest of Trenton. It is bounded by the Pennsylvania communities of Plumstead and Tinicum on the west and by the New Jersey communities of Frenchtown and Alexandria on the north, Franklin on the east, and Delaware on the south.

The Township of Kingwood was incorporated in 1798 and originally included part of Frenchtown, which was incorporated as a borough in 1867 (Reference 40). Kingwood has a total land area of 35.2 square miles.

The Township of Kingwood lies in the Piedmont Plateau region, which is part of the Appalachian Province, The Piedmont, characterized by nearly level lowlands with occasional ridges and low hills, and is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale (Reference 29). Elevations range from 57 feet at the Delaware River to 570 feet in the south-central part of the township. The Delaware River, with a total drainage area of 12,765 square miles, is the major waterway feeding the Delaware Bay (Reference 30). With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows southward along the western border of the township. The watershed upstream of the study area consists primarily of open space, agricultural and wooded land away from the main river channels, and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas immediately upstream of the township include Milford, Frenchtown, and Phillipsburg, New Jersey.

Lockatong Creek has its headwaters in the southwestern portion of the Township of Franklin and flows generally southwest through the Township of Kingwood, into the Township of Delaware, where it empties into the Delaware River. In addition to

draining southwestern Franklin, Lockatong Creek and its tributaries, including Tributary No. 1, Muddy Run, and Tributary No. 2, drain almost all of the Township of Kingwood. The northwest corner is drained by Nishisakawick Creek, Little Nishisakawick Creek, and Copper Creek. Another area, about 1.0 mile in width along the Delaware River, drains directly into the Delaware. The channel elevations of Lockatong Creek in Kingwood increase at an average rate of about 70 feet per mile from the downstream corporate limits to a point approximately 1,500 feet upstream of the mouth of Tributary No. 1. From this point the channel elevations increase at an average rate of only 7 feet per mile.

Tributary No. 1 begins in the southern part of the Township of Kingwood and flows southwest to its confluence with Lockatong Creek, approximately 1,500 feet upstream of the Byram-Kingwood Road bridge. The entire watershed of Tributary No. 1 lies in the south-central part of Kingwood, Channel elevations increase approximately 30 feet along the 3,500 feet of the stream segment studied in detail.

Muddy Run has its headwaters in the east-central region of the Township of Kingwood, flowing generally southwest to its confluence with Uckatong Creek. The entire watershed of Muddy Run lies in the east central region of the township, and channel elevations increase at an average rate of about 15 feet per mile.

Tributary No. 2 begins in the western portion of the Township of Franklin, flowing generally south to its confluence with Lockatong Creek approximately 1,500 feet upstream of the State Route 12 bridge. Tributary No. 2 drains the extreme western part of the Township of Franklin and the northeastern part of the Township of Kingwood. Channel elevations increase approximately 20 feet along the 8,100 feet of the portion of the stream studied in detail.

The watershed of Lockatong Creek, Tributary No, 1, Muddy Run, and Tributary No. 2 consist primarily of open space, agricultural land, woodlands, and scattered residential areas, with very little development near the floodplains.

Development in the Township of Kingwood is almost entirely residential and agricultural . Even in its early days, the types of business were those that catered to the local people, such as sawmills, grist mills, and various small shops. Today business in the township consists primarily of small shops and stores. There are a few industrial facilities, which manufacture chemical and allied products, fabricated metal products, and paper and allied products (Reference 31).

City of Lambertville

The City of Lambertville is located on the western border of central New Jersey in southwestern Hunterdon County, approximately 14 miles northwest of Trenton. It is bounded on the west by the Delaware River and the Borough of New Hope and the Township of Solebury in Pennsylvania, by the Township of Delaware, New Jersey on the north, and by the Township of West Amwell on the east and south.

Lambertville, which was incorporated on March 1, 1849, became a city in 1872. The city has a total land area of 1.3 square miles.

Lambertville lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont is characterized by nearly level lowlands with occasional ridges and low hills and is underlain by sedimentary rocks comprised mainly of

argillite, sandstone, and shale (Reference 29). Elevations range from 40 feet at the Delaware River to 340 feet in the extreme southeastern corner of the city. The Delaware River, which has a total drainage area of 12,265 square miles, is the major waterway feeding the Delaware Bay (Reference 30). With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows southerly along the western border of Lambertville. Its watershed upstream of Lambertville consists primarily of open, agricultural, and wooded land away from the main river channel and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas immediately upstream of Lambertville in New Jersey include Stockton, Milford, Frenchtown, and Phillipsburg.

Swan Creek, flowing northwest as it enters the city, is joined by Swan Creek Tributary about 1,000 feet inside the city limits and then flows west into the Delaware River. Swan Creek and its tributary drain the southern part of the city. The channel slope of Swan Creek between its mouth and the confluence with its tributary averages about 85 feet per mile. Stream channel elevations from the confluence of Swan Creek and Swan Creek Tributary to the city's corporate limits increase 35 feet for Swan Creek over a distance of about 1,300 feet and 20 feet for the tributary over a distance of about 1,200 feet. Both portions of these streams have steep channel slopes with high velocities. The Swan Creek watershed is highly developed near the creek in Lambertville, with scattered residential development, open spaces, agricultural lands, and woodlands predominant in the upper watershed.

Alexauken Creek, which flows in a westerly direction along the northern boundary of Lambertville, has its headwaters in the Township of East Amwell. Channel elevations on Alexauken Creek along the city boundary increase 15 feet over a distance of about 4,000 feet. The watershed consists primarily of open and agricultural land and woodland, with very little residential development.

Land use in the City of Lambertville is primarily for residential, commercial, and industrial purposes. Around 1872, development consisted of a variety of businesses such as shops, mills, professional services, foundries, restaurants, and hotels. Today, Lambertville has the same diversity of commerce. Some of the industries in Lambertville produce apparel, electrical machinery and supplies, fabricated metal products, food products, furniture, luggage, and publishing services (Reference 31).

Borough of Lebanon

The Borough of Lebanon occupies 1.23 square miles of Hunterdon County in northwestern New Jersey. It is located approximately 30 miles northwest of New Brunswick, 55 miles west of New York City and 60 miles northeast of Philadelphia. Lebanon is bordered by the Township of Clinton on all sides.

The Borough of Lebanon is primarily residential; however, it has a significant number of commercial establishments and several industries which contribute to the economic base of the community.

The major portion of the Borough of Lebanon lies within the Raritan Valley Lowland of the Piedmont physiographic province; the remainder lies in the Highlands, an extension of the Reading Prong of the New England physiographic province. The lowland area is a low, rolling plain, sloping gently to the southeast, and the Highlands consist of flat-topped ridges separated by narrow, deep valleys.

Elevations in the community range from 380 feet at the southwest corporate limits to 200 feet at the eastern corporate limits along South Branch Rockaway Creek.

Vegetative cover consists mainly of wooded areas interspersed with cultivated areas of corn and soybeans. In upland areas, broadleaf species of white, black, and red oak, as well as white ash, tulip, sweetbirch, yellow birch, red maple, beech and hickory are found along with conifer species.

The climate of this region is mostly temperate continental with some moderate maritime influences. Winter climate is controlled by polar continental air masses; summer climate is controlled by tropical air masses moving up over the United States from the Gulf of Mexico.

The principal watercourse in Lebanon is South Branch Rockaway Creek, which originates just upstream of the corporate limits in the Township of Clinton. The creek flows east through Lebanon, then turns south until it meets Rockaway Creek in the Township of Readington. The creek has a total fall of about 200 feet, including 65 feet within the 1.1 mile study reach. The total drainage area at the Lebanon-Clinton line is 5.33 square miles.

Tributary A originates in the Township of Clinton and flows southeast through Lebanon until its confluence with South Branch Rockaway Creek. The total drainage area at the mouth is 3.93 square miles.

Tributaries A1 and B originate in the Township of Clinton just over the Lebanon corporate limits and flow south until their confluences with Tributary A. At this point Tributary B has a total drainage area of 0.24 square mile.

Township of Lebanon

The Township of Lebanon is a rural community with a land area of approximately 32.0 square miles. The township is located in northern Hunterdon County in northwestern New Jersey. Lebanon is situated 35 miles north of Trenton, 45 miles west of New York City and 55 miles north of Philadelphia. The Township of Lebanon is bordered by the Township of Morris to the northeast, the Borough of Califon and Township of Tewksbury to the southeast, the Township of Clinton and Borough of High Bridge to the south, the Townships of Union and Bethlehem to the southwest, the Boroughs of Glen Gardner and Hampton to the west, and the Townships of Mansfield and Washington to the northwest.

The township of Lebanon was founded on October 26, 1731. At that time, Lebanon was a remote farming community producing some iron and limestone. By the early 1900s, the township was becoming a residential community with some small farms. Lebanon grew rapidly due to the Central Railroad of New Jersey and, in 1919, the Borough of Glen Gardner separated from the township. Today, Lebanon is primarily a rapidly growing residential community.

One of the principal waterways in Lebanon is the Musconetcong River, with a drainage area of 158 square miles. The Musconetcong River originates in Lake Hopatcong, loops to the northwest after flowing through Lake Musconetcong and then flows southwest, forming the border of Warren County, to the Delaware River in Riegelsville.

South Branch Raritan River, with a drainage area of 276 square miles, is the other major waterway in the township. The Neshanic River and Drakes Brook are major tributaries to South Branch Raritan River. South Branch Raritan River originates in Budd Lake, flows southwest, and then loops east to join North Branch Raritan River near Raritan, New Jersey.

The central region of the Delaware River basin includes four geological provinces. The Musconetcong River basin, Spruce Run basin and the upstream end of South Branch Raritan River basin are within the Reading Prong of the New England Upland Subprovince, which is called the Highlands in New Jersey. This area is moderately rugged and is characterized by parallel, somewhat irregular, ridges and valleys running northeast. The ridges, rising 500 to 1,000 feet above the valleys, are formed by gneiss and related hard, crystalline rocks. The valleys are underlain by weaker rocks such as carbonate rocks and shale. Most of the New England Province has been glaciated. In the northeastern portion of the community, the ridges are covered by extensive deposits of glacial till, and the valleys contain thicker deposits, mostly outwash, which completely covers the bedrock in most places.

Borough of Milford

The Borough of Milford is located on the western border of central New Jersey in northwestern Hunterdon County, approximately 30 miles northwest of Trenton. It is bounded on the west by the Delaware River, across which lies the Township of Bridgeton, Pennsylvania, and by the New Jersey townships of Alexandria on the south and Holland on the north and east.

The Milford area was first settled in the early 1700s and became the site of a small settlement and a mill. After the mill burned, the settlement took the name Burnt Mills. In 1794, Colonel Thomas Lowrey purchased the area, built a new mill and several houses near the river, and the village became known as Lowreytown. A flour mill and a sawmill were erected in 1803 and the place was called Milford, which later was converted to Milford. Milford, within the limits of the Township of Holland, became a borough on April 15, 1911, and was officially incorporated on March 13, 1925 (Reference 41). Milford has a total land area of 1.3 square miles.

Milford Creek has its headwaters in central Holland and flows generally southeast through the township and into the Borough of Milford, where it empties into the Delaware River. The watershed includes parts of central and south-central Holland and all of Milford, except for the southeastern part of the borough and the area which drains directly into the Delaware River. Channel elevations for Milford Creek increase at an average rate of 32 feet per mile downstream of the confluence with Quequacommissaong Creek. Upstream of the confluence, this rate increases to approximately 60 feet per mile.

Quequacommissaong Creek begins in the eastern part of the Township of Holland and flows generally southward into Milford to its confluence with Milford Creek in the north-central part of the borough. The watershed includes most of east-central Holland and a large part of northwestern Alexandria, which is drained by Quequacommissaong Creek's major tributary, Hakiokake Creek. Channel elevations in the borough increase approximately 20 feet along the 2,730-foot portion of the stream studied in detail.

The watersheds of Milford Creek and Quequacommissaong Creek also consist primarily of open space, agricultural land, woodlands, and scattered residential

dwellings. The only development near the floodplains upstream of Milford occurs at the small communities of Little York, along the Alexandria-Holland border on Hakiwokake Creek, and at Riegel Ridge and Spring Mills in central Holland, along Quequacommisacong Creek. Within the borough, development is heavy along Milford Creek from its confluence with Quequacommisacong Creek downstream to the Bridge Street bridge along Water Street, and along Quequacommisacong Creek, from its mouth upstream approximately 1,000 feet along York Road. Only light development exists in the rest of the floodplains in Milford.

Township of Raritan

The Township of Raritan, Hunterdon County, New Jersey is located in west-central New Jersey and is bordered on the north by the Town of Clinton, on the east by the Townships of Readington and Hillsborough, on the south by the Township of East Amwell, and on the west by the Townships of Franklin and Delaware. The Township of Raritan also completely surrounds the Borough of Flemington.

Raritan was originally formed on February 23, 1838 and has not changed its boundaries since that date. The township was created from approximately one-fourth of the Old Amwell Township purchased from the Indians in 1703 and subsequently divided into Raritan, Delaware, and East and West Amwell.

The early settlers of this area were comprised of a mixture of nationalities including the Dutch, Irish, Scotch, German, French and English. These people arrived on an individual or family basis with no direct aims for colonization and formed Raritan's early complexion as a predominantly agricultural community, Raritan retained its agricultural status until 1940 when housing and some small industry began to develop. Raritan has experienced a slow transition to a predominantly residential area of single homes with a number of farms in the outlying area (Ref. 1 and 2).

The township is divided into two major drainage areas - the hilly northern portion of the township drains into the South Branch Raritan River and its tributaries. The southern, central and western sections, which are generally flatter, drain into the Neshanic River or one of its many branches. The Township of Raritan lies entirely within the Piedmont Physiographic Province. The area is underlain predominately by Brunswick shale from the Triassic period that is easily eroded by weathering forces and comprises the major parent material of the local soils overlying the bedrock. The remaining bedrock is composed of highly resistant argillite and diabase rock. Elevations in the community range from a high point of approximately 625 feet in the northernmost portion of the township to a low point of approximately 100 feet at the township's easternmost border adjacent to the South Branch of the Raritan River.

Township of Readington

The Township of Readington lies in northwestern New Jersey in Hunterdon County. It is located 25 miles northwest of New Brunswick, 50 miles west of New York City and 60 miles northeast of Philadelphia. Readington is bordered by the Township of Tewksbury to the north, the Township of Bedminster to the northeast, the Township of Branchburg to the east, the Township of Hillsborough to the south, the Township of Raritan to the west and the Township of Clinton to the northwest.

The Township of Readington occupies 47.65 square miles of Hunterdon County. The Township of Readington is primarily residential; however, it has a number of

commercial establishments which contribute to the economic base of the community.

The Township of Readington lies within the Raritan Valley Lowland of the Piedmont Physiographic Province. The Lowland area is a low rolling plain, sloping gently southeastward with approximately 92 percent of the elevations under 300 feet and 6 percent between 300 and 500 feet. The elevations in the community range from 720 feet at Cushetunk Mountain to 100 feet in the southeast part of town.

The drainage area for the Lamington River watershed is approximately 53 square miles at the Tewksbury and Readington corporate limits. The river originates in the Township of Mine Hill and flows in a southerly direction to its confluence with the North Branch Raritan River near Burnt Mill in the Township of Bedminster.

Rockaway Creek originates in the southern portion of the Township of Washington in Morris County. From here, it follows a southeasterly direction to its confluence with the Lamington River east of Whitehouse. The drainage area of the watershed is approximately 21.7 square miles at the Tewksbury and Readington corporate limits.

South Branch Rockaway Creek originates upstream of the Township of Clinton corporate limits. It flows easterly through the Township of Lebanon, then flows in a southerly direction until it empties into Rockaway Creek in the Township of Readington. The total drainage area for the study area is 12.6 square miles above its confluence with Rockaway Creek.

Chambers Brook originates at the confluence of two unnamed tributaries in northwestern Readington. It flows in an easterly direction until it empties into the North Branch Raritan River in the Township of Branchburg. The total drainage area of the study area is 5.5 square miles at the corporate limits of Branchburg and Readington.

Holland Brook originates at the confluence of two unnamed tributaries in northwestern Readington. It flows in a southeast direction and empties into the South Branch Raritan River in the Township of Branchburg. The total drainage area of the study area is 8.9 square miles.

Pleasant Run is formed by a series of small tributaries in southwestern Readington. It flows in a southeast direction and empties into the South Branch Raritan River in the Township of Branchburg. The total drainage area of the study area is 7.9 miles at the corporate limits of Branchburg and Readington.

The South Branch Raritan River is the principal watercourse in Readington. It originates at

Budd Lake and flows in a southwest direction from the Township of Mount Olive. From here, it loops easterly and joins the North Branch Raritan River near Raritan, New Jersey to form the main stem of the Raritan River. The South Branch Raritan River has a total drainage basin area of 276 square miles. Of this, 179 square miles lie above the corporate limits of Hillsborough, Branchburg and Readington. The river drops about 55 feet within the 8.7 miles of study.

Tributary A originates at the confluence of two unnamed tributaries in south central Readington and flows in a southerly direction until it empties into the South Branch Raritan River. The total drainage area above the study limit is 2.01 square miles at its confluence with the South Branch Raritan River.

Minor floodplain development has occurred along most of the streams in Readington and consists primarily of residential structures.

Borough of Stockton

The Borough of Stockton is located on the western border of central New Jersey in southwestern Hunterdon County, approximately 20 miles northwest of Trenton, New Jersey. It is bordered on the south by the Township of Solebury across the Delaware River in Bucks County, Pennsylvania, and on the west, north, and east by the Township of Delaware.

The Borough of Stockton was originally part of the Township of Amwell, when the area was part of Burlington County. In 1713, Amwell became part of Hunterdon County, and in 1838 the township was subdivided into the Townships of Delaware, Raritan, and Amwell. The Borough of Stockton was subdivided from the Township of Delaware on April 14, 1898.

The Borough of Stockton lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont is characterized by nearly level lowlands, with occasional ridges and low hills, and is underlain by shale (Reference 29). The relatively flat topography of a river terrace dominates the southern portion of the borough along the Delaware River.

The Delaware River, with a total drainage area of 12,765 square miles, is the major waterway feeding the Delaware Bay. The river flows south from its headwaters in the Catskill Mountains in southeastern New York, and flows along the southern border of the Borough of Stockton. The watershed upstream of the study area consists of primarily open space, agricultural and wooded land away from the main river channels, and areas of highly urbanized development along the river banks.

Brookville Creek begins in the southwestern part of the Township of Delaware and flows generally southwest to its confluence with the Delaware and Raritan Canal. The last 2,500 feet of the stream's distance forms the southeastern corporate limits between the Borough of Stockton and the Township of Delaware.

Wickecheoke Creek has its headwaters in the Township of Raritan and flows generally southwest. Approximately the last 2,000 feet of the creek forms the northwestern corporate limits between the Borough of Stockton and the Township of Delaware.

The watersheds of Brookville Creek and Wickecheoke Creek consist mostly of open space, agricultural land and woodlands, with very little residential development. The only significant development occurs near the confluences of Brookville Creek and Wickecheoke Creek. Development in the borough is almost entirely residential and agricultural. Business within the borough consists primarily of small shops and stores which cater to the local community.

Township of Tewksbury

The Township of Tewksbury occupies approximately 31.8 square miles of Hunterdon County in northwestern New Jersey. It is located 15 miles south of Hackettstown, New Jersey, 50 miles west of New York City and 65 miles northeast of Philadelphia, Pennsylvania.

Tewksbury is bordered by the Township of Lebanon and the Borough of Califon on the west, the Township of Clinton on the southwest, the Township of Readington on the south, the Township of Bedminster on the east and the Township of Washington on the north.

Vegetation consists mainly of wooded areas interspersed with cultivated areas of corn and soybean. In upland areas, broadleaf species of white, black and red oak, white ash, tulip, sweet birch, yellow birch, red maple, beech and hickory are found along with conifer species.

The principal streams in Tewksbury are the Lamington River and Rockaway Creek. The Lamington River flows south to its confluence with the North Branch Raritan River near Burnt Mills in the Township of Bedminster, New Jersey. The river has a fall of about 140 feet within the 6.6 mile study area. The drainage area is approximately 53 square miles at the Tewksbury-Readington corporate limits.

Rockaway Creek originates in the southern part of the Township of Washington and flows southeast to its junction with South Branch Rockaway Creek. It then flows east to its confluence with the Lamington River east of the Town of Whitehouse in the Township of Readington. Rockaway Creek has a fall of about 605 feet within the 11.6 mile study area. The drainage area of the watershed is approximately 21.7 square miles at the Tewksbury-Readington corporate limits.

The South Branch Raritan River originates at Budd Lake in the Township of Mount Olive, New Jersey. It flows southwest and then loops to the east, joining the North Branch Raritan River near Raritan, New Jersey, to form the main stem of the Raritan River.

Tributary A originates in north-central Tewksbury near Fairmount and flows east to its confluence with the Lamington River near Potterville.

Tributary B rises from the junction of two unnamed streams, both flowing south from their origins near Farmersville. Tributary B then flows south to its confluence with Rockaway Creek near Mountainville.

The floodplains of the Lamington River, Rockaway Creek, South Branch Raritan River, Tributary A and Tributary B are largely undeveloped, although there is scattered residential development in all the floodplains.

Township of Union

The Township of Union occupies approximately 20.3 square miles of Hunterdon County in northwestern New Jersey. It is located 60 miles west of New York City and 60 miles northeast of Philadelphia, Pennsylvania. The Township of Union is bordered by the Township of Lebanon on the northeast, the Township of Clinton and the Town of Clinton on the east, the Township of Franklin on the southeast, the Township of Alexandria on the southwest and the Township of Bethlehem on the north.

Union is predominantly a residential community with several scattered commercial establishments. Agriculture plays a minor role in the community.

The Township of Union lies in a geologically complex area. The northernmost section of Union is composed of highly resistant igneous and metamorphic rocks. The greater

portion of the bedrock in the township is composed of limestones, sandstones, shales, argillites and conglomerates deposited as the Highlands were uplifted and the sea retreated to the southeast.

The area is well drained with a fairly high drainage density. In the northern section of Union, the drainage pattern is structure-controlled along the fault areas. The remainder of the township has a dendritic drainage pattern, characterized by tributaries branching in all directions (References 35 and 42).

Vegetative cover consists mainly of wooded areas interspersed with cultivated farm land and pastures. The wooded areas consist of broadleaf species of white and pin oak as well as willow, river birch, boxelder, sugar maple, red maple, beech and basswood along with various conifer species.

The principal streams in Union are Mulhockaway Creek and Tributary A to the South Branch Raritan River. Mulhockaway Creek flows east from a point near the western border of the township to Spruce Run Reservoir. Mulhockaway Creek has a fall of about 236 feet within the 4.3 mile study area. The drainage area of the watershed is approximately 15 square miles at its downstream terminus at Spruce Run Reservoir.

Tributary A to the South Branch Raritan River originates in the south-central section of the Township of Union and flows in a northeast direction until it reaches a pond just east of Jutland. It then flows southeast across the Union-Franklin corporate limits to its confluence with the South Branch Raritan River near Conrail in the Township of Franklin. Tributary A to the South Branch Raritan River has a fall of about 119 feet within the 3.2 mile study area.

Tributaries B and C to Mulhockaway Creek both originate in the southeastern part of the Township of Bethlehem near Charlestown and flow southeast across the Bethlehem-Union corporate limits to their confluences with Mulhockaway Creek near Van Syckel's Corner Road in Union.

Tributary D to Mulhockaway Creek rises in the hills in the southwestern part of the Township of Union. It flows north under Interstate Route 78 near Perryville to its confluence with Mulhockaway Creek south of Van Syckel's Corner Road in Union.

Tributary E to Mulhockaway Creek originates in the west-central portion of the Township of Union. It flows northeast under Interstate Route 78 to its confluence with Tributary D to Mulhockaway Creek.

Tributary F to Mulhockaway Creek originates in the western hills of the Township of Union. It flows northeast under Conrail to its confluence with Mulhockaway Creek just downstream of Baptist Church Road.

Spruce Run originates in the Township of Lebanon. It flows southwest into the Borough of Glen Gardner and then flows southeast across the Glen Gardner corporate limits. It continues southeast and its centerline becomes the Union-Lebanon corporate limits just upstream of its mouth at the northern tip of Spruce Run Reservoir.

The floodplains for all these streams are largely undeveloped, although there is scattered residential development in most of the floodplains.

Township of West Amwell

The Township of West Amwell is located on the western border of central New Jersey in the southern part of Hunterdon County, approximately 10 miles northwest of Trenton. It is bounded by the Pennsylvania communities of New Hope and Solebury on the west, by the New Jersey communities of Lambertville and Delaware on the north, by East Amwell on the north and east, and by Hopewell on the east and south.

West Amwell was originally a part of the Township of Amwell, formed in 1708 when the area was part of Burlington County. The first land owner in the area was John Reading, who named his home Mount Amwell in memory of his original home in England. In 1713, the Township of Amwell became part of Hunterdon County, and on February 27, 1846, the Township of Amwell was divided to form the Townships of East and West Amwell. At that time, the township included Lambertville, which was incorporated on March 1, 1849 (Reference 43). West Amwell has a total land area of 21.8 square miles.

The Township of West Amwell lies in the Piedmont Plateau region, which is part of the Appalachian Province. The Piedmont, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised mainly of argillite, sandstone, and shale (Reference 29).

Alexauken Creek has its headwaters in the central part of the Township of West Amwell and flows generally northwest to a point near the center of the northern corporate limits. From this point it then flows southwest to its confluence with the Delaware River at the northern corporate limits of the City of Lambertville. From the mouth upstream to a Conrail bridge, approximately 1,200 feet, Alexauken Creek forms the boundary between the City of Lambertville to the south and the Township of Delaware to the north. From the Conrail bridge at the downstream corporate limits of West Amwell on Alexauken Creek, approximately the next 2,900 feet of Alexauken Creek form the border between the City of Lambertville to the south and West Amwell to the north. Except for a section of about 3,600 feet, which loops into the Township of Delaware, the remainder of Alexauken Creek flows through the Township of West Amwell.

The Alexauken Creek watershed drains the northwestern portion of West Amwell, as well as the extreme southern part of the Township of Delaware and eastern portions of East Amwell. The channel elevations in Alexauken Creek in the township increase at an average of about 24 feet per mile for the portion of the creek downstream of the State Route 179 bridge. The watershed consists primarily of open space, agricultural land, and woodland with very little residential development.

Development in West Amwell from its earliest days has been primarily residential and agricultural. The only types of business in the township during its early history were those that catered to the local people, such as sawmills, grist mills, and flax seed mills. Today business in the township consists mostly of small stores and shops; a few industrial facilities manufacture fabricated metal products and electrical machinery and supplies (Reference 31).

2.3 Principal Flood Problems

Township of Alexandria

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an

area of major storm paths. Although the most severe floods in the past generally resulted from excessive rainfall, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Floods of major significance on the Delaware River occurred in October 1903, August 1955, and May 1972. The flood of August 1955 was the most devastating event experienced on the Delaware River. This flood, which has approximately a 150-year recurrence interval, was the result of excessive rainfall from three separate storms which hit the area in early August. According to the gage in Flemington, New Jersey, the nearest official recording station, a total of 15.2 inches of rain fell on the area during the period from August 1 to August 18, culminating with Hurricane Diane (Reference 44). There was major damage to communities, roads, and bridges along the Delaware River, but due to the limited development, damage in the Township of Alexandria was fairly light.

The most recent high water on the Delaware River occurred in June 1973. The flood of June 1972, resulting from the rainfall of Tropical Storm Agnes, although producing severe flooding on the Schuylkill River and many other streams in Pennsylvania, did not cause major flooding on the Delaware River (References 45 and 46).

Major flooding near the mouth of Harihokake Creek is primarily a result of backwater from the Delaware River. In the Mount Pleasant area near the County Route 519 bridge, periodic flooding problems, mainly basement and shallow property flooding, do occur. This is due to the residential development along the stream and the constriction created by the bridge. Because of the limited amount of building in the floodplain, flood problems on the remainder of upper Harihokake Creek and other streams in the community have not been extensive in the past, although occasional flash flooding, which causes high channel velocities with resulting scour and erosion, does occur.

Township of Bethlehem

The past history of flooding in Bethlehem indicates that flooding may be experienced during any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by ice and snow melt has occurred. The more extensive floods have occurred mostly in late summer and fall, usually associated with tropical disturbances moving northward along the Atlantic coast.

Flooding along the Musconetcong River in Bethlehem is generally restricted to the "mucklands" which lie in the floodplain area and are used for truck farming. Little damage to structures has been experienced.

The recorded history of flooding in the Musconetcong River Basin near Bethlehem began in 1904. Since then, several major floods have occurred and minor floods have been a common occurrence. Based on peak stages and discharges of USGS gaging station No. 01457000 near Bloomsbury, New Jersey, the dates of the ten major flood events are: October 10, 1903, March 15, 1940, August 11, 1942, November 7, 1951, August 19, 1955, August 3, 1967, April 2, 1970, June 2, 1973, January 9, 1978 and January 25, 1970 (Reference 47).

The recorded gage history of flooding began in 1959 at the Spruce Run Reservoir dam in Clinton, New Jersey (USGS gage No. 01396800). Since that time, a number of major and minor flood peak stage and discharge measurements have been recorded by

this gage. The maximum recorded discharge for this gage is 6,410 cubic feet per second (cfs) which occurred in April 1970. However, the Spruce Run Reservoir moderates these flows making the discharges at the gage unrepresentative of the flows on the main stem.

On August 27-28, 1971, New Jersey was hit by Hurricane Doria rendering New Jersey a natural disaster area. An extensive high water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Borough of Bloomsbury

Past history of flooding in Bloomsbury indicates that flooding may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by ice and snow melt has occurred. The most extensive floods have occurred primarily in late summer and fall, and are usually associated with tropical disturbances moving north along the Atlantic Coast.

The recorded history of flooding in the Musconetcong River basin near Bloomsbury began in 1903. Since then, several major floods have occurred and minor floods have been a common occurrence. Based on peak stages and discharges of UGSS gaging station No. 01457000 near Bloomsbury, the dates of ten major flooding events are as follows: October 10, 1903; March 15, 1940; August 11, 1942; November 7, 1951; August 19, 1955; August 3, 1967; April 2, 1970; June 23, 1972; January 9, 1978 and January 25, 1979.

On August 27 - 28, 1971, New Jersey was hit by Hurricane Doria, rendering the state a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Borough of Califon

The history of flooding in Califon indicates that flooding of varied origin may occur at any time during the year. Flooding in the spring, compounded by ice and snow melt, is more frequent than flooding in the winter months. Extensive floods have occurred in late summer and fall, usually being associated with tropical storms moving north along the Atlantic coast.

Gaging station No. 1396500 near High Bridge has recorded flooding events on South Branch Raritan River since 1918. According to the records developed at gaging station No. 1396500, major floods occurred on February 6, 1896; in February 1902, and on February 2, 1922; March 11, 1936; March 15, 1940; March 11, 1952; April 2, 1970; August 28, 1971; February 5, 1973; December 21, 1973 and January 25, 1979.

On August 27 - 28, 1971, New Jersey was hit by Hurricane Doria, rendering the state a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources. Tropical Storm Doria had a maximum flow of 3,140 cfs at the High Bridge gage. The flood flow in January 1979 was 6,360 c f s, while the flood of record in February 1896 had an estimated flow of 7,560 cfs (Reference 47).

Town of Clinton

The past history of flooding in the Town of Clinton indicates that floods may be experienced in any season of the year; however, the possibility of flooding during the winter months is less. Although most severe floods have been caused by rainfall alone, some spring floods have been compounded by snow melt and moving ice. The major floods in the late summer and fall have been associated with tropical storms moving up the Atlantic coastline.

In August 1955, Hurricane Diane produced the highest precipitation in 57 years on the South Branch Raritan River at Stanton, New Jersey. A winter storm, accompanied by snowmelt in March 1940 produced the highest flows on record for the South Branch at High Bridge, New Jersey. More recently, Tropical Storm Doria in August 1971 produced significant flooding throughout the state.

Township of Clinton

History of flooding in Clinton indicates that, since New Jersey lies within the major storm tracks of North America, flooding may be experienced during any season of the year. The most extensive flooding occurs in the late summer and fall and is usually associated with tropical storms moving north along the Atlantic coast. Flooding during the winter is infrequent; however, spring flooding associated with snowmelt and ice has occurred.

Flooding along the South Branch Raritan River has been recorded since 1918 at USGS gaging station No. 1396500 near High Bridge, New Jersey. Since then, several major floods have occurred and minor flooding has been a common occurrence. Based on peak stages and discharges at this gage, major flooding events occurred as follows: February 6, 1896, October 9, 1903, March 15, 1940, July 19, 1945, November 7, 1951, August 19, 1955, October 14, 1955, April 2, 1970, August 28, 1971 and December 1, 1974. March 15, 1940 was the flood of record at the High Bridge gage with a flow of 5,200 cubic feet per second (cfs). This flood has a recurrence interval of 40 years (Reference 47).

There are no gaging stations located in the Rockaway Creek watershed. Based on gage data from USGS gaging station No. 01399500 on the Lamington River near Pottersville, two miles from the Rockaway Creek watershed, major floods occurred on February 6, 1896, March 15, 1940, August 13, 1955, April 2, 1970 and August 28, 1971. The flood of August 28, 1971, was the flood of record at the Pottersville gage with flows of 2,700 cfs and a recurrence interval of 40 years (Reference 47).

Hurricane Doria affected Clinton from August 27 to August 28, 1971, causing the area to be declared a national disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Hurricane Doria.

Township of Delaware

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths. Although the worst floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Flooding history for the Delaware River is summarized above with the Township of Alexandria. In the Township of Delaware, the small riverside communities of Raven Rock and Brookville were especially hard hit, and property damage was very heavy (Reference 44).

Major flooding near the mouths of Alexauken Creek, Wickecheoke Creek, and Brookville Creek in the Township of Delaware is primarily a result of backwater from the Delaware River. Due to the limited development in their floodplains, flood problems on the upper parts of Alexauken Creek, Brookville Creek, Wickecheoke Creek, the Third Neshanic River, and other streams in the community have not been extensive, although flash flooding, which causes high channel velocities and resultant scour and erosion, does occur occasionally.

Township of East Amwell

The history of flooding in East Amwell indicates that flooding of various origins may be experienced in any season of the year. In the winter months, flooding is infrequent, but in the spring, flooding caused by rain, snowmelt, and ice jams is common. The largest floods usually occur in the late summer and in the fall. These floods are usually caused by tropical storms moving northward along the Atlantic coast.

In East Amwell there have been four major storm events in this century. The dates for these storms are August 9, 1942, July 18, 1945, August 19, 1955, and August 28, 1971. The peak discharge for the August 28, 1971 flood was 15,900 cubic feet per second (cfs) and has been assigned a 100-year recurrence interval (References 47, 48, and 49). The August 9, 1942, July 18, 1945 and August 19, 1955 floods had peak discharges of 9,150 cfs, 10,300 cfs and 8,830 cfs respectively.

Locally, East Amwell has not experienced major damage due to flooding.

Borough of Flemington

Flood problems in the Borough of Flemington are mainly associated with the inadequacy of surface and subsurface drainage systems, which are unable to carry storm flows. Any storm of a few hours duration will cause flooded basements and property damage, such as

caved-in walls and damaged warehouse goods. The principal flood problems along Walnut Brook are caused by the flow backing up behind State Route 12 and running along the embankment.

Township of Franklin

The history of flooding in Franklin indicates that flooding of various origins may be experienced in any season of the year. In the winter months flooding is infrequent, but in the spring flooding caused by rain, snowmelt, and ice jams is common. The largest floods generally occur in the late summer and in the fall. These floods are usually caused by tropical storms moving northward along the Atlantic coast.

The recorded gage history of flooding in the South Branch Raritan River basin began in 1918. Since the beginning of the record ten major flood events have occurred: October 9, 1903; March 15, 1940; July 19, 1945; November 7, 1951; August 19, 1955; October 14, 1955; April 2, 1970; August 28, 1971; December 1, 1974; and January 26, 1979.

January 26, 1979 was the flood of record at the High Bridge gage with a flow of 6,360 cfs which has been assigned a 100-year recurrence interval using a log-Pearson Type III analysis of the gage data (Reference 48).

There is no recorded history of severe flooding similar to that experienced on the South Branch Raritan River for either Capoolong Creek or Sidney Brook.

On August 27-28, 1971, New Jersey was hit by Hurricane Doria causing the President to declare New Jersey a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Borough of Frenchtown

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths generally resulting in excessive rainfall, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Floods of major significance on the Delaware occurred in October 1903, August 1955, and May 1972. The flood of August 1955 was the most devastating event recorded on the Delaware River. This flood, which had approximately a 150-year recurrence interval, occurred on August 19, 1955. In early August, a local storm dumped 2.19 inches of rain in the Flemington, New Jersey, site of the nearest official recording station. A short time later, the remains of Hurricane Connie passed over the area, dropping another 8.25 inches of rain. On August 18, Hurricane Diane dumped 4.75 inches of rain on the area, already completely saturated by the earlier rainfall (The Great Flood Disaster of 1955, 1955). The Delaware River crested at 2 feet above the markings left by the previous "all-time high" flood of October 1903. Damage to businesses and residential dwellings was major, and was estimated at \$320,000. The Trenton Avenue area near the confluence of Nishisakawick Creek with the Delaware River was especially hard hit.

Businesses which suffered major damage included Niece's Lumber Yard, Ken Chickeries, and the Frenchtown Feed Store. The Frenchtown bridge over the Delaware River was battered and left covered with debris, but suffered no significant structural damage.

Major flooding on Nishisakawick Creek and Little Nishisakawick Creek in Frenchtown is primarily a result of backwater from the Delaware River causing overflow in their lower reaches. Upstream of the portions affected by Delaware River backwater, the flooding problems are minimal because of the limited amount of development in the floodplains. However, occasional flash flooding, which causes high channel velocities with resulting scour and erosion, does occur on these streams.

Borough of Glen Gardner

Past history of flooding in Glen Gardner indicates that flooding may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by snowmelt and ice has occurred. The most extensive floods have occurred primarily in late summer and fall, and are usually associated with tropical

disturbances moving north along the Atlantic Coast.

The recorded gage history of flooding began in 1959 at the Spruce Run Reservoir dam in Clinton (USGS gage No. 01396800). Since that time, a number of major and minor flood-peak stage and discharge measurements have been recorded by this gage. The maximum recorded discharge for this gage is 7,410 cubic feet per second (cfs) which occurred in April 1970. However, the Spruce Run Reservoir moderates these flows, making the discharge at the gage unrepresentative of the flows on the main stem.

On August 27 - 28, 1971, New Jersey was hit by Hurricane Doria, rendering New Jersey a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Borough of Hampton

Past history of flooding in the Borough of Hampton indicates that flooding may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by snowmelt and ice has occurred. The most extensive floods have occurred primarily in late summer and fall, and are usually associated with tropical disturbances moving north along the Atlantic Coast.

The recorded history of flooding in the Musconetcong River basin near Bloomsbury, New Jersey began in 1904. Since then, several major floods have occurred and minor floods have been a common occurrence. Based on peak stages and discharges of the USGS gaging station No. 01457000 near Bloomsbury, the dates of ten major flooding events are as follows: October 10, 1903; March 15, 1940; August 11, 1942; November 7, 1951; August 19, 1955; August 3, 1967; April 2, 1970; June 2, 1973; January 9, 1978; and January 25, 1979 (Reference 47).

On August 27-28, 1971, New Jersey was hit by Hurricane Doria, rendering the state a natural disaster area. An extensive high water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Borough of High Bridge

The history of flooding in High Bridge indicates that flooding of various origins may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by snowmelt and ice has occurred. The most extensive floods have occurred primarily in late summer and fall. They are usually associated with tropical disturbances moving northward along the Atlantic Coast.

The recorded gage history of flooding in the South Branch Raritan River basin near High Bridge began in 1918. Since then, several major floods have occurred, with minor floods being a common occurrence. Based on peak stages and discharges of USGS gaging station no. 01396500 near High Bridge, the dates of ten major flooding events within the basin are as follows: October 9, 1903; March 15, 1940; July 19, 1945; November 7, 1951; August 19, 1955; October 14, 1955; April 2, 1970; August 28, 1971; December 1, 1974, and January 26, 1979.

The January 26, 1979, flood was the flood of record at the High Bridge gage with a flow of 7,360 cubic feet per second, which has been assigned a 100-year recurrence interval. On August 27-28, 1971, New Jersey was hit by Tropical Storm Doria, which caused the President to declare New Jersey a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the NJDEP.

Township of Holland

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin lies in an area of major storm paths. Although the most severe floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of snowmelt and moving ice.

Flooding history for the Delaware River is summarized above with the Township of Alexandria. The small communities of Holland and Mt. Joy suffered heavy residential losses. The Holland Power Plant was put out of production on Friday, August 19, when the floodwaters stood waist-deep inside the plant.

Flooding near the mouths of the Musconetcong River and Tributary No. 1 to Delaware River is primarily a result of backwater from the Delaware River. Flooding on the upper portion of the Musconetcong River in the Township of Holland has not been severe in the past, due to the regulatory effect of numerous dams on the river and to the relatively light development within its floodplain. Shallow property flooding has occurred, but has generally been due to debris blockage behind bridges and other obstructions in the floodplain, which create ponding situations. Flooding on the upper portion of Tributary No. 1 to Delaware River is primarily due to the steep stream gradient. Scour and erosion problems and shallow property flooding are the major problems on this portion of the river.

Flooding problems along Milford Creek and Tributary No. 1 to Milford Creek have not been extensive in the past. However, with the development of the Spring Mills and Reigel Ridge areas, erosion and alluvial problems, as well as shallow flooding of residences near the floodplains, have occurred.

Township of Kingwood

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths. Although the worst floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Flooding history for the Delaware River is summarized above with the Township of Alexandria. The Delaware River established high-water marks at heights of 2 feet or more above the previous "all-time high" established by the 1903 flood. All along the Delaware River, major damage was done to communities, roads, and bridges, including the Byram-Point Pleasant bridge, which was completely destroyed. Three island camps in the Delaware River, in or adjacent to the Township of Kingwood, were completely submerged, but more than 600 campers were successfully evacuated by boat and helicopter (Reference 44).

Due to the limited amount of development in their floodplains, flood problems on Lockatong Creek, Tributary No. 1, Muddy Run, Tributary No. 2, and other streams in the community have not been extensive in the past. On streams with steep channel slopes, including the lower portion of Lockatong Creek, flash flooding and the resultant high channel velocities create scour and erosion problems. Flooding problems on the upper part of Lockatong Creek, Tributary No. 1, Muddy Run, and Tributary No. 2 are due to the low, wide floodplains along the relatively flat streams. Flooding in the overbanks can be quite wide, although usually very shallow, and can be greatly increased by ponding behind bridges, culverts, and other obstructions in the floodplain. Due to the limited amount of development along the streams, flooding has generally affected only a small amount of agricultural land.

City of Lambertville

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths. Although the worst floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Floods of major significance on the Delaware River occurred in October 1903, August 1955, and May 1972. The flood of August 1955 was the most devastating event experienced on the Delaware River in recent times.

This flood, which had a recurrence interval of approximately 150 years, caused extensive damage in Lambertville. The Lambertville-New Hope bridge was closed for four weeks after the flood, because of structural weakness and storm debris. This span between Lambertville and New Hope had been destroyed in the 1903 flood, but was rebuilt. Businesses and factories also sustained major damage. Damage in Lambertville from North Main Street to the river totaled over half a million dollars. A few of the businesses which suffered major damage were Belmont Forwarders, Inc., the Lambertville Water Company, the Mercer Paper Tube Company, and Holcombe's Nursery (Reference 44). Many small businesses and residences were flooded.

Major flooding on Alexauken Creek and Swan Creek, in Lambertville, usually results from backwater from the Delaware River causing overflow in their lower reaches. They also occasionally experience flash flooding, which causes high channel velocities and resultant scour and erosion.

Borough of Lebanon

Past history of flooding in Lebanon indicates that flooding may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by snowmelt and ice has occurred. The most extensive floods have occurred primarily in late summer and fall, and are usually associated with tropical disturbances moving north along the Atlantic Coast.

The Rockaway Creek basin has no USGS recording or crest-stage gaging stations. However, it is probable that major floods which have occurred in watersheds with similar climatic and physiographic characteristics would also reflect flooding in the Rockaway Creek watershed. Although the Lamington River basin is larger than the Rockaway Creek basin, it exhibits many similar characteristics and could be used as a

reference for flooding in the Rockaway Creek basin. USGS gaging station No. 01399500, on the Lamington River near Pottersville, is only 2 miles from the Rockaway Creek basin. Based on this gage, which has records from 1896 to the present, five major flooding events in the Rockaway Creek watershed have occurred. These are dated August 28, 1971; March 15,

1940; February 6, 1896; August 13, 1955, and April 2, 1970. The August 28, 1971, flood was the flood of record at the Pottersville gage with a flow of 2,700 cubic feet per second; this has been assigned a 40-year recurrence interval (References 47 and 48). On this date New Jersey was hit by Hurricane Doria, causing the President to declare New Jersey a natural disaster area. An extensive high-water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Township of Lebanon

History of flooding in Lebanon indicates that flooding may be experienced in any season of the year since New Jersey lies within the major storm tracks of North America. Flooding during winter months is less frequent, but spring flooding compounded by snowmelt and ice has occurred. The most extensive floods have occurred primarily in late summer and fall, and are usually associated with tropical disturbances moving north along the Atlantic Coast.

The recorded history of flooding in the Musconetcong River basin near Bloomsbury began in 1904. Since then, several major floods have occurred and minor flooding has been a common occurrence. Ten major flooding events, based on the peak stages and discharges at the USGS gage near Bloomsbury, are as follows: October 10, 1903, March 15, 1940, August 11, 1942, November 7, 1951, August 19, 1955, August 3, 1967, April 2, 1970, June 2, 1973, January 9, 1978 and January 25, 1979 (Reference 47) . The flood of January 25, 1978 has a recurrence interval of approximately 100 years at the Bloomsbury gage.

The recorded history of flooding for South Branch Raritan River near High Bridge began in 1896. Ten major floods, based on the USGS gage (No.1396500) near High Bridge, are as follows: February 6, 1896, February 1902, March 11, 1936, March 15, 1940, March 11, 1952, April 2, 1970, August 28, 1971, February 5, 1973, December 21, 1973, and January 25, 1979 (Reference 47).

On August 27 and 28, 1971, New Jersey was struck by Hurricane Doria which caused the area to be declared a national disaster area. An extensive high-water mark survey was conducted by the State of New Jersey and the USGS following Hurricane Doria.

Township of Milford

Flooding has been a problem along the Delaware River since settlement of the area in the early part of the seventeenth century. The Delaware River Basin is located in an area of major storm paths. Although the most severe floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Floods of major significance on the Delaware River occurred in October 1903, August 1955, and May 1972. The flood of August 1955 was the most devastating event recorded on the Delaware River.

Flooding history for the Delaware River is summarized above with the Township of Alexandria. The Milford bridge, although structurally undamaged, was battered and left covered with debris. Damage to homes, personal property, and commercial establishments was extremely heavy. The Riegel Paper Corporation suffered a loss of about one million dollars and was forced to close for nearly three weeks. Heavy losses were also suffered by the Milford Coal and Lumber Company and Cregar's Feed Mill (Reference 31).

The most recent high water on the Delaware River occurred in June 1973. The flood of June 1972 resulting from Tropical Storm Agnes, although producing severe flooding on the Schuylkill River and many other streams in Pennsylvania, did not cause major flooding on the Delaware River (References 45 and 46). Flooding on Milford Creek near its mouth is primarily the result of backwater from the Delaware River. On the upper portion of Milford Creek and on Quequacommissacong Creek, flooding problems, comprised of mostly basement and shallow property flooding, have occurred but have not been extensive.

Township of Raritan

Although areas in Raritan are subject to fluvial flooding, damages within the township have been minimal. This is primarily due to the fact that the South Branch Raritan River within the township has a well defined channel with a rather limited floodplain. The Neshanic River and its major tributaries have larger less confined floodplains but are predominately occupied by farmland which experiences little or no residual flood damages.

Township of Readington

The past history of flooding in the Township of Readington indicates that flooding may be experienced in any season of the year. Winter flooding is less frequent; however, spring flooding, compounded by snow melt and ice, has occurred. The more extensive floods occur primarily in late summer and fall. These floods are usually associated with tropical disturbances moving northward along the Atlantic Coast.

The recorded gage history of flooding on the Lamington River began in 1922 at USGS gage No. 01399500 near Pottersville. Since that time a number of major and minor floods have occurred as indicated by the peak stages and discharges recorded at the gage. Based on historic accounts ten major flooding events within the Lamington River basin occurred as follows: February 6, 1896; November 17, 1927; March 15, 1940; August 14, 1942; September 1, 1952; August 13, 1955; October 14, 1955; April 2, 1970; August 28, 1971; and May 31, 1972. The August 28, 1971, flood of record at the Pottersville gage had a flow of 2,700 cubic feet per second (cfs) (References 47 and 48). It has been assigned a 40-year recurrence interval using a log-Pearson Type III analysis of the gage data (Reference 49).

The recorded gage history of flooding in the South Branch Raritan River basin at Stanton began in 1904. Several major and minor floods have occurred since that time. Based on peak stages and discharges of USGS gaging station No. 013970000 at Stanton, the dates of five major flooding events within the basin are as follows: March 15, 1940; July 19, 1945; November 7, 1951; August 19, 1955; and October 14, 1955. The flood of August 19, 1955, had a record of 18,000 cfs at the Stanton gage (References 47 and 48). It has been assigned a 100-year recurrence interval using a log-Pearson Type III analysis of the gage data (Reference 49).

On August 27 and 28, 1971, a heavy frontal storm combined with tropical storm Doria which produced the greatest flooding recorded in the area. New Jersey was declared a natural disaster area. The State of New Jersey and the USGS conducted an extensive high water mark survey following Hurricane Doria; these data are on file with the Division of Water Resources.

Borough of Stockton

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths. Although the worst floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of snowmelt and moving ice.

Flooding history for the Delaware River is summarized above with the Township of Alexandria.

Within the Borough of Stockton, the major source of flood damage is the Delaware River which inundates numerous commercial structures and residences in the Bridge and Mill Street areas. Major flooding near the mouths of Wickecheoke Creek and Brookville Creek is primarily the result of backwater from the Delaware River.

Township of Tewksbury

Past history of flooding in Tewksbury indicates that flooding of various origins may be experienced in any season of the year. Flooding during winter months is less frequent, but spring flooding compounded by ice and snow melt has occurred. The more extensive floods have occurred in late summer and early fall, and are usually associated with tropical disturbances moving north along the Atlantic coast.

The recorded gage history of flooding in the area began in 1922 at the gage near Pottersville, New Jersey, on the Lamington River (USGS gage No. 01399500). Since then a number of major and minor floods have been experienced as indicated by peak stages and discharges recorded at the gage. Based on peak stages and discharges at this gage, the dates of ten major flooding events within the Lamington River basin are as follows: February 6, 1896; November 17, 1927; March 15, 1940; August 14, 1942; September 1, 1952; August 13, 1955; October 14, 1955; April 2, 1970; August 28, 1971, and May 31, 1972. The August 28, 1971 flood was the flood of record at the Pottersville gage with a flow of 2,700 cubic feet per second (cfs) and has been assigned a 40-year recurrence interval (References 47 and 48).

The recorded gage history of flooding in the South Branch Raritan River basin near High Bridge, New Jersey, began in 1918. Since then, several major floods have occurred and minor floods have been a common occurrence. Based on peak stages and discharges of USGS gaging station No. 01396500 near High Bridge, and No. 013970000 at Stanton, New Jersey, the dates of ten major flooding events within the basin areas follows: February 6, 1896; October 9, 1903; March 14, 1940; July 19, 1945; November 7, 1951; August 19, 1955; October 14, 1955; April 2, 1970; August 28, 1971 and December 1, 1974. The March 15, 1940 flood was the flood of record at the High Bridge gage with a flow of 5,200 cfs and a 40-year recurrence interval.

On August 27-28, 1971, a heavy frontal storm in combination with tropical storm Doria produced the greatest flooding recorded in the area. This storm rendered New Jersey a

natural disaster area. An extensive high water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Township of Union

Past history of flooding in Union indicates that flooding of various origins may be experienced in any season of the year. Flooding during winter months is less frequent, but spring flooding compounded by ice and snow melt has occurred. The more extensive floods have occurred primarily in late summer and early fall, and are usually associated with tropical disturbances moving north along the Atlantic coast.

All watercourses in the township are in the South Branch Raritan River basin. There are no stream gaging stations within the township, which prevents the determination of a flood-frequency value to be associated with a particular flooding event in Union.

On August 27-28, 1971, New Jersey was hit by Hurricane Doria, rendering the state a natural disaster area. An extensive high water mark survey was conducted jointly by the State of New Jersey and the USGS following Doria; these data are on file with the Division of Water Resources.

Township of West Amwell

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin is located in an area of major storm paths. Although the most severe floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snow melt.

Flooding history for the Delaware River is summarized above with the Township of Alexandria. Major damage was done to communities, roads, and bridges along the Delaware River but, due to limited development, damage in West Amwell was minimal.

Major flooding near the mouth of Alexauken Creek is primarily a result of backwater from the Delaware River. Due to the limited amount of development in the floodplain, flooding problems on the upper parts of Alexauken Creek and other streams in the community have not been extensive in the past, although occasional flash flooding, which causes high channel velocities and resultant scour and erosion, does occur.

Flood Problems for This Revision

No special flood problems were taken into special consideration for this revision.

2.4 Flood Protection Measures

Pre-Countywide Flood Protection Measures

In the pre-countywide FIS studies there were no specific flood control measures listed for any of the communities in Hunterdon County. The following communities stated that water-supply, power, and flood-control reservoirs outside of their particular community help to reduce the probability of damaging floods: the Township of Alexandria, the Township of Delaware, the Borough of Frenchtown, the Township of Holland, the Township of Kingwood, the City of Lambertville, the Borough of Milford,

the Borough of Stockton, and the Township of West Amwell. Table 7, “Regulatory Lakes and Reservoirs Upstream of Hunterdon County Flooding Sources”, lists the major regulatory reservoirs and lakes, the drainage areas they control, and the date storage began for the Delaware River Basin upstream of communities in this report.

Table 7 - Regulatory Lakes and Reservoirs Upstream of Hunterdon County Flooding Sources

<u>Name</u>	<u>Stream</u>	<u>Storage Area (Sq. Mi.)</u>	<u>Storage Began</u>
Lake Wallenpaupak	Wallenpaupack Creek	228.0	November 1925
Prompton Reservoir	West Branch Lackawaxen River	59.6	July 1960
General Edgar Jadwin Reservoir	Dyberry Creek	64.5	October 1959
Francis E. Walter Reservoir	Lehigh River	289.0	February 1961
Beltzville Lake	Pohopoco Creek	96.3	February 1971
Pepactan Reservoir	East Branch Delaware River	371.0	September 1954
Swinging Bridge Reservoir	Mongaup River	118.0	January 1930
Neversink Reservoir	Neversink River	91.8	January 1953
Cannonsville Reservoir	West Branch Delaware River	454.0	September 1963
Penn Forest Reservoir	Wild Creek	16.5	October 1953
Wild Creek Reservoir	Wild Creek	22.2	January 1941
Lake Hopatcong	Musconetcong River	25.6	1828
Toronto Reservoir	Black Lake Creek	23.2	January 1926
Cliff Lake	Black Lake Creek	6.5	January 1939

Flood Protection Measures for This Revision

No special flood protection measures were taken into account for this revision.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent-annual-chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100 year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10); for any 90 year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the communities within Hunterdon County.

3.1.1 Pre-Countywide Analysis

Township of Alexandria

Flood-frequency analyses for Harihokake Creek were done using a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determination of the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Township of Bethlehem

The peak discharges for the selected recurrence intervals along the Musconetcong River from its confluence with the Delaware River upstream to Lake Musconetcong, a distance of 41.5 miles, have been determined by the Floodplain Management Section of the Bureau of Water Control, Division of Water Resources, NJDEP, using a log-Pearson Type III distribution for gages at the Borough of Bloomsbury, New Jersey, Hackettstown, New Jersey, and at the outlet to Lake Hopatcong.

Since gage data were not available for Spruce Run, peak discharges for the selected frequencies were calculated by using the regional relationships developed by Stephen J. Stankowski of the USGS through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey (Reference 50). This report develops discharges based upon the parameters of basin size, channel slope, surface storage, and development within the community.

Borough of Bloomsbury

The floodway design discharges along the Musconetcong River from its mouth at the Delaware River, upstream to Lake Musconetcong, a distance of 41.5 miles, have been

determined by the Floodplain Management Section of the Bureau of Water Control, Division of Water Resources of the NJDEP.

Borough of Califon

For South Branch Raritan River, discharges were computed using a log-Pearson Type III distribution analysis of streamflow records from the USGS gaging station at High Bridge. These values were adjusted with a weighted regional skew and were transferred from High Bridge to Califon by a discharge-drainage area transfer equation using a transfer coefficient of 1.0 (References 49 and 52).

Town of Clinton

The hydrology used for the South Branch of the Raritan River and its tributaries was based on an analysis of three USGS stream gages which monitor the flows in the watershed in the vicinity of the Town of Clinton. These gages are: #3965 on South Branch near High Bridge, #3968 on Spruce Run at Clinton, and #3970 on the South Branch Raritan River at Stanton, New Jersey. A Log-Pearson Type III frequency analysis (Reference 53) was conducted for the gages at Stanton and High Bridge. While the High Bridge gage records were analyzed for all available stream flow data up to and including 1971, the Stanton gage analysis included only the years through 1962. This exception was made to avoid the biasing of the frequency analysis at the Stanton gage due to the completion of the Spruce Run Reservoir the following year. A frequency analysis was not conducted on the Spruce Run gage due to the shortness of the period of record. Data on actual storms, however, was used to determine the relationship of peak times along the gages. All records were supplied by the USGS.

Using the SCS Project Formulation Program (TR-20) (Reference 54), which develops hydrographs and performs reach and reservoir routings, a model was developed to duplicate the historical discharge-frequency relationships at the gages in the watershed for the period preceding the completion of the Spruce Run Reservoir. Rainfall-frequency relationships were obtained from the "Rainfall Frequency Atlas of the United States", (Reference 55). The reservoir characteristics were then inserted in the model, which developed the present day discharges for the 10-, 50-, 100-, and 500-year frequency storms required in this study.

A Flood Hazard Study of the South Branch Raritan River, which includes the Town of Clinton, was published by the State of New Jersey in April 1973 (Reference 56). The Floodway Design Flood in that report approximates the 100-year frequency for the entire length of the South Branch Raritan River. The discharges used were based on a Mean Annual Flood calculation modified by regional curves and skew coefficients, and the discharges used were averaged over long reaches. The Flood Hazard Area Design Flood represents no specific flood frequency. The data base for that study includes stream flow information only through 1961 (Reference 57).

The discharges used in this study were obtained from the TR-20 model and agree with the log-Pearson Type III frequency analysis of the USGS stream gages.

Township of Clinton

For the South Branch Raritan River, values for the 10-, 50-, 100- and 500 year peak discharges were calculated at the USGS gaging station at High Bridge (No. 01396500). A log-Pearson Type III analysis of annual peak flow data was used

(Reference 49).

Since gage data were not available for the remaining streams studied by detailed methods, peak discharges for the selected recurrence intervals were calculated using the regional relationships developed by the USGS in cooperation with the State of New Jersey (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages in New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

Township of Delaware

Seventy years of records at the Trenton gage were used in this analysis. Modification of frequency distributions was made to allow for effects of reservoir regulation.

Flood-frequency values for Alexauken Creek, Brookville Creek, Wickecheoke Creek, and the Third Neshanic River were determined by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determination of the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Township of East Amwell

The peak discharges for the lower section of Stony Brook were estimated by using two methods and then obtaining a weighted average of the two values. In one method, values for the 10-, 50-, 100-, and 500-year peak discharges were calculated using a COE log-Pearson Type III analysis on two gaging station's annual peak flow data. One gage (USGS gage No. 01398000) is on the Neshanic River near Reaville, 0.5 mile upstream of the East Amwell corporate limits and has a record length of 48 years. The other gage (USGS gage No. 01400900) is on Stony Brook near Glenmore and has a record length of 22 years.

The flows calculated for the gages were transposed to specific locations using the following drainage area-discharge formula (Reference 52):

$$Q_1 = Q_2 (A_1/A_2)^T$$

where Q_1 is the discharge at a specific location and A_1 is the drainage area at the point and, Q_2 is the discharge at the gage and A_2 is the drainage area at the gage with T being the transfer exponent.

For the Stony Brook, a value of 0.8 was considered to be representative for the transfer exponent.

In the other method, the peak discharges were calculated using a regional relationship developed by the USGS in conjunction with the NJDEP, Division of Water Resources (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

The drainage area adjusted COE log-Pearson Type III analysis was used to calculate flows for the upper section of Stony Brook. Discharges for the South Fork Third Neshanic River and Tributary A were calculated using Stankowski's regional

regression equations.

Borough of Flemington

For Bushkill Brook, Special Report 38 was used to develop discharges for the 10-, 50-, 100- and 500-year recurrence intervals (Reference 50). Discharges developed for Bushkill Brook were routed through a natural detention area created by an embankment and an undersized culvert carrying the Black River and Western Railroad. Detention of flood flows in this area result in a significant decrease of discharges downstream of the railroad. Stankowski's Method (Special Report 38) is based on a regression analysis of 103 stream gages in the State of New Jersey and is used to estimate peak-flood magnitudes having selected recurrence intervals for drainage basins larger than 1.0 square mile with various degrees of urban or suburban development. Parameters used in this method are basin size, channel slope, surface storage, and population density.

Township of Franklin

Since no gage data was available for Capoolong Creek or Sidney Brook, stream peak discharges for the selected frequencies were calculated from the regional relationships developed by the USGS in cooperation with the State of New Jersey, Department of Environmental Protection, Division of Water Resources (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

Borough of Frenchtown

For the 1981 FIS, flood-frequency values for Nishisakawick Creek and Little Nishisakawick Creek were determined by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas to determine the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Borough of Glen Gardner

No gage data were available for Spruce Run, discharges were calculated using regional relationships developed in Special Report 38 (Reference 50), These relationships were developed through a statistical regression analysis of data collected from over 100 gages a cross the State of New Jersey. This report develops discharges based upon the parameters of basin size, channel slope, surface storage and development within the community, However, a comparison of recorded gage flows with the Special Report 38 results for this and other streams included in the Pohatcong, Musconetcong and South Branch Raritan Basins indicated that the Stankowski equation of t hat report produced consistently high values (References 47 and 48). Therefore, the discharges computed by the Special Report 38 method were weighted versus gage results in this area to produce more consistent results.

Borough of Hampton

The peak discharges for the selected recurrence intervals along the Musconetcong River from its confluence with the Delaware River upstream to Lake Musconetcong, a distance of 41.5 miles, have been determined by the Floodplain Management Section of the Bureau of Floodplain Management, Division of Water Resources, NJDEP, using

a log-Pearson Type III distribution for gages at the Boroughs of Bloomsbury and Hackettstown, New Jersey and at the outlet to Lake Hopatcong.

Borough of High Bridge

Peak discharge values for the South Branch Raritan River were obtained from the Flood Insurance Study (FIS) for the Township of Clinton (Reference 58). These values were derived from a log-Pearson Type III analysis of annual peak flow data from USGS gage no. 01396500, which is located 1,000 feet north of the Borough of High Bridge (Reference 49).

No gage data were available for Willoughby Brook. The peak discharge values for this stream were obtained from the FIS of the Township of Lebanon (Reference 58). They were calculated using the regional relationships developed by Stephen J. Stankowski of the USGS in cooperation with the State of New Jersey (Reference 50). This method is based on data gathered at over 100 gages throughout New Jersey. These relationships account for urban development as well as natural retention created by lakes and swamps. A comparison of recorded gage flows with the Stankowski results for this and other streams included in the Musconetcong River basin indicated that the Stankowski relationships produced consistently high values. Therefore, final discharges computed by the Stankowski method were weighed with local data to produce more consistent results.

Township of Holland

For the 1981 FIS, Flood-frequency analysis procedures developed by the Water Resources Council (WRC) were employed for the Musconetcong River (WRC, 1976). Discharges for the portion of the Musconetcong River studied in detail were computed from a log-Pearson Type III distribution of annual peak discharges adjusted for regional skew at the stream gages at Bloomsbury and Hackettstown, both in New Jersey. Flood-frequency analyses for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to Delaware River were made by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determining the peak discharges for the 10-, 50-, 100-, and 500-year floods (State of New Jersey, 1974).

Township of Kingwood

Flood-frequency values for Lockatong Creek, Tributary No. 1, Muddy Run, and Tributary No. 2 were determined by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determination of the peak discharges for the 100, 50-, 100-, and 500-year floods (Reference 51).

City of Lambertville

Flood-frequency values for Swan Creek, Swan Creek Tributary, and Alexauken Creek were determined by use of a regional regression analysis which considers drainage area, channel slope, surface storage and the extent of impervious areas in determining the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Borough of Lebanon

No gage data were available for South Branch Rockaway Creek or Tributaries A and B. For reaches of South Branch Rockaway Creek and Tributary A, both having drainage areas greater than one square mile, the discharges were calculated using regional relationships developed in Special Report 38 (Reference 50). These relationships were developed through a statistical regression analysis of data collected from over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

For the reach of South Branch Rockaway Creek whose upstream limit has a drainage area less than one square mile, as well as for Tributary B, the discharges were calculated by the Rational Method. This method of calculating peak flow for small watersheds is based on the criterion that for storms of uniform intensity, distributed evenly over the basin, the maximum rate of runoff occurs when the entire basin area is contributing at the outlet. Thus the rate of runoff is equal to a percentage of the rainfall intensity, or:

$$Q_p = ciA, \text{ where}$$

Q_p = rate of runoff in cubic feet per second (cfs)

c = runoff coefficient

i = rainfall intensity (inches per hour) of a storm whose duration is equal to the time of concentration of the drainage area, and

A = area of the watershed (acres)

Peak discharges for Tributary A1 were taken directly from the Type 15 Flood Insurance Study for the Borough of Lebanon (Reference 61). In that study, a log-Pearson Type III method of statistical analysis was performed on discharge-drainage area data from five gaged areas also in the Raritan River basin. This data was then applied to Lebanon by interpolating generalized curves, and a discharge-frequency curve for Lebanon was developed. The standard project flood was estimated by computing the standard Project Rainfall for the drainage area and applying it to the unit hydrograph for Lebanon. The unit hydrograph was developed synthetically by Snyders Method (Reference 62).

Township of Lebanon

For South Branch Raritan River, discharges were determined on the basis of 58 years of record at the USGS gaging station at High Bridge. A log-Pearson Type III distribution analysis using weighted regional skew was applied (References 49 and 52).

Discharges for the Musconetcong River, from its confluence with the Delaware River upstream for a distance of 41.5 miles, have been determined by the NJDEP using a log Pearson Type III distribution for the gages at Bloomsbury, Hackettstown and at the outlet to Lake Hopatcong (Reference 52).

For the remaining streams studied by detailed methods where gage data was unavailable, the peak discharges for the selected recurrence intervals were calculated using the regional relationship developed in USGS Special Report 38 (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

Borough of Milford

Flood-frequency analyses for Milford Creek and Quequacommissacong Creek were made by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas to determine the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Township of Raritan

Special Report 38 was utilized to develop discharges for the 10-, 50-, 100- and 500-year recurrence intervals on Route 202 Tributary, Bushkill Brook and Assiscong Creek (all tributaries of the South Branch Raritan River).

Discharges developed for Bushkill Brook were routed through a natural detention area created by an embankment and an undersized culvert carrying the Black River and Western Railroad. Detention of flood flows in this area result in a significant decrease of discharges downstream of the railroad.

Stankowski's Method (Special Report 38) is based on a regression analysis of 103 stream gages in the State of New Jersey and is used to estimate peak-flood magnitudes having selected recurrence intervals for drainage basins larger than 1.0 square mile with various degrees of urban or suburban development. Parameters used in this method are basin size, channel slope, surface storage, and population density (Reference 50).

Township of Readington

Riverine flood heights for the Lamington River were performed using weighted discharges. These discharges were based on stream gage records and regional regression equations. Values for the 10-, 50-, 100- and 500-year peak discharges were calculated at USGS gage No. 01399500 near Pottersville using a log-Pearson Type III analysis of annual peak flow data. These flows were transposed to specific upstream and downstream locations according to the drainage area - discharge formula:

$$Q_1 / Q_2 = (A_1 / A_2)^T$$

where Q_1 is the discharge at a specific location and A_1 is the drainage area at that point, and Q_2 is the weighted discharge developed at the gage and A_2 is the drainage area at the gage with T being the transfer exponent (Reference 52). For the Lamington River, 0.75 was used as a representative value for the transposition exponent.

Peak discharges for the selected frequencies for the Lamington River were also calculated using regional relationships developed by Stephen J. Stankowski (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

Peak discharge for Rockaway Creek, South Branch Rockaway Creek, Chambers Brook, and Pleasant Run were calculated using regional relationships developed by Stephen J. Stankowski (Reference 50).

Peak discharges for Tributary A were calculated using two methods. For areas with drainage areas of one square mile or more, Stankowski's regional relationships were used. For drainage areas less than one square mile, the rational method was utilized.

Borough of Stockton

Flood-frequency values for Brookville Creek and Wickecheoke Creek were determined by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determination of the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

Township of Tewksbury

To calculate the flood heights for the Lamington River, weighted discharges were used. These discharges were based on stream gage records and regional regression equations. Values for the 10-, 50-, 100- and 500-year peak discharges were calculated at USGS gage No. 01399500 using a log-Pearson Type III analysis of annual peak flow data. Flows calculated for the gage located near Pottersville, New Jersey, were transposed to specific locations according to the drainage area-discharge formula:

$$Q_1 / Q_2 = (A_1 / A_2)^T$$

where Q_1 is the discharge at a specific location, A_1 is the drainage area at that location, Q_2 is the discharge at the gage and A_2 is the drainage area at the gage, with T being the transfer exponent (Reference 52). For the Lamington River a value of 0.75 was considered to be representative for the transfer exponent.

Peak discharges for the selected frequencies for the Lamington River were also calculated using regional relationships developed by Stephen J. Stankowski (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention created by lakes and swamps.

A weighted average of the drainage-area adjusted log-Pearson Type III flood values and the values obtained using Stankowski's regional equation was calculated for selected locations on the Lamington River.

Discharges for the South Branch Raritan River were obtained from the Flood Insurance Study for the adjacent Township of Lebanon (Reference 63).

For the remaining streams studied in detail, all ungaged, peak discharges for the selected frequencies were calculated using Stankowski's regional equation.

Township of Union

No gage data are available for Mulhockaway Creek, Tributaries A through F or Spruce Run. For Mulhockaway Creek and Tributaries A through F stream peak discharges for the selected frequencies were calculated from the regional relationships developed by Stephen J. Stankowski (Reference 50). These relationships were developed through a statistical regression analysis of data collected at over 100 gages across the State of New Jersey. This analysis accounts for urban development as well as natural retention in lakes and swamps. For Spruce Run, a comparison of recorded gage flows with the Stankowski results for this and other streams in the Musconetcong River basin indicated that the Stankowski equation produced consistently higher values. Therefore, discharges that were computed by the Stankowski method were weighted versus gage results in this area to produce more consistent results.

Township of West Amwell

Flood frequency values for Alexauken Creek were determined by use of a regional

regression analysis which considered drainage area, channel slope, surface storage, and the extent of impervious areas in determination of the peak discharges for the 10-, 50-, 100-, and 500-year floods (Reference 50).

3.1.2 September 25, 2009 Countywide Study

For this countywide study, discharges for the 10-, 2-, 1-, and 0.2-percent-annual-chance recurrence intervals were calculated for stream reaches included in new detailed studies, and discharges for the 1-percent-annual-chance recurrence interval were calculated for stream reaches studied by approximate methods.

The flood discharges for the gaged streams of South Branch Raritan River, Neshanic River, Walnut Brook, Back Brook, and Holland Brook, as well as the flood discharges for the ungaged streams of First Neshanic River, Second Neshanic River and Third Neshanic River were determined based on the log-Pearson Type III distribution developed by the USGS. The gages used for this restudy are listed below in Table 8.

Table 8 - Stream Gage Information

<u>Gaged Stream</u>	<u>Gage No.</u>	<u>Location of Gage</u>	<u>Years of Record</u>
Holland Brook	01398107	Readington, NJ	23
Back Brook	01398045	Ringoes, NJ	26
Neshanic River	01398000	Reaville, NJ	74
South Branch Raritan River	01397000	Stanton, NJ	89
Walnut Brook	01397500	Flemington, NJ	68

For the studied gaged streams, ratios of weighted discharges to regression discharges were developed at each stream gaging station location. Discharges at other locations along these streams were then developed by multiplying the regression discharge by these ratios. For the entire length of the South Branch Raritan River, the ratios obtained for the South Branch Raritan River gage located at Stanton (Station No. 01397000) were used. For the entire length of the Neshanic River, the ratios obtained for the Neshanic River gage located at Reaville (Station No. 01398000) were used. For the entire length of Walnut Brook, the ratios obtained for the Walnut Brook gage located at Flemington (Station No. 01397500) were used. For the entire length of Holland Brook, the ratios obtained for the Holland Brook gage located at Readington (Station No. 01398107) were used. For the entire length of Back Brook, the ratios obtained for the Back Brook gage located at Ringoes (Station No. 01398045) were used.

The hydrology for the ungaged streams that were studied, which include First Neshanic River, Second Neshanic River, Third Neshanic River and Back Brook was computed by correlation with the gaged streams that had been restudied. This correlation was based on the similarity and size of the drainage basins. For the First, Second, and Third Neshanic Rivers, the Walnut Brook gage was used for computing the selected Flood Insurance Study discharges.

For the studied ungaged streams, ratios of weighted discharges to regression discharges were developed at each stream gaging station location. Discharges at other locations along these streams were then developed by multiplying the regression discharge by their ratios. For the length of the First Neshanic River between the confluences of the Neshanic River and Walnut Brook, the ratios obtained at the Neshanic River gage located at Reaville (Station No. 01398000) was used, and for the length downstream of its confluence with Walnut Brook, the ratios obtained at the Walnut Brook gage located at Flemington (Station No. 01397500) was used. For the entire length of the Second Neshanic River, the Walnut Brook gage located at Flemington (Station No. 01397500) was used. For the entire length of the Third Neshanic River, the ratios obtained for the Holland Brook gage located at Readington (Station No. 01398107) were used.

For flooding sources studied by approximate methods, regional regression analysis was used to determine the discharges. The analysis was completed in accordance with the USGS report U.S. Geological Survey Water-Resources Investigations Report 94-4002: Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993. (http://water.usgs.gov/software/nff_manual/nj/). For areas where urbanization was likely to affect discharges, impervious area was estimated based on population density. The percentage area covered by lakes and ponds was calculated using a lakes and ponds coverage obtained from the county.

3.1.3 Revised Analysis

For the Delaware River, the USGS developed flood magnitude and frequency values, including 10-, 2-, 1-, and 0.2-percent-annual chance floods, for eight active USGS stream flow gaging stations on the main stem of Delaware River. The eight active gages include stations from Trenton, NJ to Callicoon, NY (Reference 141). This data was developed by USGS in collaboration with USACE Philadelphia District, NJDEP, FEMA Regions II & III and Delaware River Basin Commission (DRBC). The hydrologic analysis was performed in accordance to guidelines published by the Interagency Advisory Committee on Water Data in its Bulletin 17B. This involved the analysis of peak-flow gage data record utilizing the PEAKFQ program. Five additional flow locations were established, between USGS gaging stations, to provide better flow distribution along the main stem. These flow locations are placed in the vicinity of tributaries with significant drainage area contribution. The discharges, including 10-, 2-, 1-, and 0.2-percent-annual chance floods, were estimated per linear-interpolation of a discharge–frequency relationship as a function of drainage area for the eight active USGS gaging stations. In addition, the New Jersey Flood Hazard Area Design Flood (NJFHADF) was computed for the USGS gaging stations and the additional flow locations. The NJFHADF is equal to the 1-percent-annual-chance flood plus an additional 25% in flow, and not to exceed the 0.2-percent-annual-chance flood. NJFHADF boundary is to regulate disturbance to the land and vegetation within flood hazard area of a water body. This regulation is set forth by the State of New Jersey Flood Hazard Area Control Act Rules N.J.A.C. 7:13, and is administered.

A summary of the drainage area-peak discharge relationships for all of the streams studied by detailed methods is shown in Table 9, “Summary of Discharges”.

Table 9 - Summary of Discharges

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Alexauken Creek					
At mouth	14.78	1,830	2,980	3,690	5,800
150 feet downstream of Creek					
Road bridge	7.66	970	1,630	2,040	3,280
Assiscong Creek					
At confluence with South					
Branch Raritan River	3.0	655	1,100	1,380	2,185
Back Brook					
At confluence with Neshanic					
River	11.51	1,940	3,040	3,620	5,250
Downstream of tributary from					
Unionville	10.48	1,800	2,820	3,350	4,870
Upstream of tributary from					
Unionville	5.52	1,080	1,690	2,010	2,910
Downstream of tributary near					
Wertsville Road	4.08	840	1,330	1,580	2,290
Upstream of tributary near					
Wertsville Road	3.35	720	1,130	1,350	1,950
Downstream of tributary from					
Rocktown	2.81	630	990	1,170	1,700
Upstream of tributary from					
Rocktown	2.41	550	870	1,040	1,500
At Old York Road	0.94	260	410	490	710
Beaver Brook					
At the Township of Clinton-					
Town of Clinton corporate limit	7.0	1,200	2,000	2,500	3,700
Just upstream of tributary near					
intersection of Beaver Avenue					
and Highfield Street	4.83	865	1,435	1,795	2,836
Brookville Creek					
At mouth	1.26	320	540	690	1,110
Bushkill Brook					
At confluence with South					
Branch Raritan River	4.3	835	1,185	1,345	1,785
Just upstream of first tributary					
above South Branch Raritan					
River	2.5	570	765	835	1,015
Just upstream of Flemington					
Junction Road	1.6	600	965	1,185	1,785

Table 9 - Summary of Discharges

(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Capoolong Creek					
3,970 feet downstream of Quakertown Road	5.85	123	1,971	2,417	3,642
Just downstream of confluence with tributary near Pittstown	5.85	1,300	2,072	2,541	3,824
Just upstream of confluence with tributary near Pittstown	2.63	738	1,186	1,456	2,193
2,645 feet upstream of Quakertown Road	1.96	593 ¹	961 ¹	1,184 ¹	1,794 ¹
Chambers Brook					
At Branchburg corporate limits	5.5	930	1,495	1,830	2,726
Just upstream of tributary and 500 feet west of County Line Road	3.5	620	1,010	1,240	1,905
At Coddington Road	2.3	420	596	860	1,337
Delaware River					
At USGS Gage 01463500 at Trenton, NJ	6,780	169,000	245,000	280,000 / 350,000 ²	372,000
Downstream of confluence of Tohickon Creek	6,588	168,150	243,301	277,451 / 346,602 ²	366,053
At USGS Gage 01457500 at Riegelsville, NJ	6,328	167,000	241,000	274,000 / 342,000 ²	358,000
First Neshanic River					
At confluence with Neshanic River	5.1	1,740	3,540	4,600	7,930
Just upstream of confluence with Walnut Brook	0.9	615	1,250	1,630	2,800
Harihokake Creek					
At mouth	9.70	1,520	2,500	3,120	4,960
Approximately 125 feet downstream of Gallmeier Road	8.06	1,370	2,270	2,840	4,520
Approximately 3,940 feet downstream of County Route 519	4.38	540	1,410	1,770	2,850
Approximately 1,913 feet upstream of County Route 519	2.00	410	720	910	1,490
Holland Brook					
At mouth	12.40	2,070	3,560	4,420	7,150
Upstream side of Rte. 202	11.30	1,920	3,300	4,110	6,640

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Holland Brook (Continued)					
Gage at Readington-Branchburg corporate limits	9.00	1,600	2,750	3,420	5,530
Upstream of tributary below Readington-Branchburg corporate limits	8.9	1,365	2,173	2,661	4,039
Just upstream of tributary flowing along Readington Road, upstream of Centerville Road bridge	6.50	1,168	1,871	2,295	3,490
Just upstream of tributary near Pineback Road	3.80	1,046	1,681	2,067	3,147
Just upstream of tributary near limit of detailed study	1.60	512	841	1,046	1,612
Lamington River					
At confluence with North Branch Raritan River	99.4	6,560	10,000	12,000	16,500
Upstream of Rockaway Creek	57.8	2,645	4,630	5,690	8,790
Downstream of confluence of Cold Brook	53.12	2,518	4,426	5,549	8,440
Upstream of confluence of Cold Brook	46.88	2,229	3,932	4,848	7,537
Downstream of confluence of tributary at Camp Brady	44.12	2,127	3,754	4,627	7,193
Upstream of confluence of tributary at Camp Brady	42.89	2,079	3,666	4,518	7,024
Downstream of confluence of Herzog Brook in Bedminster	41.77	2,031	3,573	4,400	6,842
Upstream of confluence of Herzog Brook in Bedminster	36.87	1,843	3,237	3,983	6,193
Downstream of confluence of Lamington River Tributary A near Pottersville	36.77	1,835	3,220	3,961	6,159
Upstream of confluence of Lamington River Tributary A near Pottersville	32.97	1,686	2,953	3,631	5,646
Lamington River Tributary A					
At confluence with the Lamington River	3.80	760	1,280	1,620	2,614
Little Nishisakawick Creek					
At mouth	3.42	720	1,200	1,500	2,390

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Lockatong Creek					
At downstream corporate limits (Township of Kingwood)	19.78	1,990	3,270	4,070	6,500
Milford Creek					
At confluence with Delaware River	17.05	2,960	1,690	5,770	5,830
At confluence with Quequacommisacong Creek	4.74	1,160	1,880	2,320	3,580
At downstream corporate limit (Holland)	3.51	900	1,480	1,840	2,870
At confluence of Tributary No. 1 to Milford Creek	1.77	540	900	1,130	1,770
Muddy Run					
At mouth	2.94	390	670	850	1,410
Mulhockaway Creek					
At Spruce Run Reservoir	15.1	2,280	3,690	4,570	7,120
Upstream of confluence of Tributary B to Mulhockaway Creek	11.7	1,915	3,110	3,865	6,030
Upstream of confluence of Tributary D to Mulhockaway Creek	9.4	1,775	2,885	3,580	5,580
Upstream of confluence of Tributary C to Mulhockaway Creek	6.8	1,420	2,330	2,910	4,585
Upstream of confluence of Tributary F to Mulhockaway Creek	3.5	920	1,520	1,900	2,980
Upstream of confluence of tributary near Conrail tunnel	1.7	440	770	985	1,630
Musconetcong River					
At mouth	157.6	3,910	6,600	8,070	12,300
At Mt. Joy Road bridge	156.20	3,880	6,560	8,010	12,230
At Willow Lane bridge	153.90	3,840	6,500	7,930	12,140
At Riegel Paper Company	150.40	3,780	6,420	7,820	12,000
At the downstream corporate limit (Township of Bloomsbury)	143.0	4,010	7,040	8,690	13,630
At the downstream corporate limit (Township of Bethlehem)	143.0	4,010	7,035	8,695	13,625

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Musconetcong River (Continued)					
Upstream of the confluence of Tributary A	137.3	3,710	6,465	7,965	12,415
Upstream of confluence of Sigler Brook	131.0	3,445	5,960	7,450	11,350
Neshanic River					
At Rainbow Hill Road Bridge	51.75	8,540	15,420	19,330	31,290
Downstream of tributary from Wertsville	47.46	8,390	15,150	19,000	30,750
Upstream of tributary from Wertsville	42.59	8,210	14,830	18,590	30,100
Downstream of Back Brook	42.23	8,180	14,800	18,550	30,040
Upstream of Back Brook	30.72	7,690	13,890	17,410	28,190
At downstream corporate limits of Township of Raritan	27.40	7,520	13,570	17,020	27,550
At Gage station 01398000	25.70	7,420	13,400	16,800	27,200
Just upstream of confluence of Third Neshanic River	11.70	4,630	8,360	10,480	16,960
Nishisakawick Creek					
At mouth	10.60	1,600	2,620	3,270	5,170
Quequacommissocong Creek					
At confluence with Milford Creek	11.90	2,040	3,320	4,130	6,490
Pleasant Run					
At Route 202, the upstream limit of detailed study	7.90	1,266	2,023	2,476	3,759
At Readington-Branchburg corporate limits, the downstream limit of detailed study	7.40	1,266	2,023	2,479	3,759
Rockaway Creek					
At confluence with the Lamington River	38.3	5,305	8,120	9,820	14,505
Upstream of South Branch Rockaway Creek	21.7	2,995	4,730	5,805	8,835
At Rockaway Road Bridge near McCrea Mills	16.9	2,665	4,220	5,190	7,920
At first crossing of Rockaway Road	16.86	2,740	4,340	5,340	8,149

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Rockaway Creek (Continued)					
Upstream of confluence of tributary near Potterstown Road	15.34	2,586	4,103	5,040	7,687
Downstream of Rockaway Creek Tributary B near Mountainville	8.64	1,490	2,420	3,000	4,645
Upstream of Rockaway Creek Tributary B near Mountainville	4.20	770	1,280	1,600	2,536
At Saw Mill Road bridge	3.08	550	920	1,160	1,861
At Fairmont Road	1.50	290	510	660	1,111
Rockaway Creek Tributary B					
At confluence with Rockaway Creek	4.44	1,000	1,630	2,030	3,157
Rocky Run					
At downstream corporate limits (Township of Lebanon)	1.90	280	520	660	1,030
Route 202 Tributary					
At confluence with South Branch Raritan River	1.00	205	355	450	735
Second Neshanic River					
At confluence with Neshanic River	6.20	1,950	3,980	5,180	8,920
Just upstream of confluence of 1st tributary above Rte. 202	3.90	1,480	3,010	3,920	6,750
Just upstream of confluence of 2nd tributary above Rte. 202	2.50	1,130	2,310	3,000	5,170
Sidney Brook					
At confluence with South Branch Raritan River	5.51	960	1,560	1,920	2,933
At Pittstown Road	4.76	866	1,408	1,736	2,661
South Branch Raritan River					
At confluence with Neshanic River	190.0	11,200	18,000	21,500	31,400
At downstream corporate limits	178.88	10,400	17,800	20,500	30,600
Upstream of Dam at Rockefellow's Mills	170.5	9,950	16,300	19,700	29,400
At upstream confluence of Spruce Run in Town of Clinton	69.58	3,300	5,400	6,500	9,900

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
South Branch Raritan River (Continued)					
At the confluence of Spruce Run in the Town of Clinton	65.00	3,300	5,400	6,500	9,900
At gaging station near High Bridge	64.9	3,300	5,240	6,230	8,990
At Main Street bridge in Borough of Califon	57.4	3,320	5,240	6,230	8,990
At Main Street bridge in Borough of Califon	57.4	2,930 ¹	4,620 ¹	5,500 ¹	7,930 ¹
At downstream corporate limits (Township of Califon)	54.3	3,160	4,990	5,930	8,550
At upstream corporate limits (Township of Califon)	52	2,930	4,620	5,500	7,930
At downstream corporate limits (Township of Lebanon)	39.7	2,930	4,620	5,500	5,930
South Branch Raritan River Tributary A					
At the Township of Union downstream corporate limit	4.4	900	1,460	1,805	2,775
Upstream of Race Street	2.8	680	1,120	1,385	2,145
At confluence with South Branch Raritan River	2.0	335	575	725	1,175
Just upstream of tributary near Lehigh Valley Railroad	1.5	260	415	530	865
South Branch Rockaway Creek					
At confluence with Rockaway Creek	12.6	1,915	2,996	3,633	5,398
At Cushetunk Dam	11.4	1,919	3,012	3,668	5,471
Downstream of unnamed tributary near Township of Clinton-Township of Readington corporate limits	8.24	1,899	2,984	3,643	5,444
Upstream of unnamed tributary near Township of Clinton-Township of Readington corporate limits	7.05	1,629	2,573	3,150	4,723
Upstream of confluence of Tributary A	1.4	400	650	600	1,150
Upstream of unnamed tributary in Borough of Lebanon, near Borough of Lebanon-Township of Clinton corporate limits	1.38	390	640	790	1,185

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
South Branch Rockaway Creek (Continued)					
Upstream of confluence of unnamed tributary near Sloan's Lane bridge	1.19	334	556	692	1,076
At Borough of Lebanon- Township of Clinton corporate limits	0.93	295	460	600	850
South Branch Rockaway Creek Tributary A					
At confluence with South Branch Rockaway Creek	3.93	995	1,555	1,930	2,955
Upstream of confluence of Tributary B	2.56	780	1,280	1,590	2,460
Upstream face of U.S. Route 22 bridge	2.34	680	1,120	1,400	2,184
South Branch Rockaway Creek Tributary B					
At confluence with South Branch Rockaway Creek Tributary A	0.24	115	170	215	295
At Borough of Lebanon- Township of Clinton corporate limits	0.10	60	85	105	145
South Fork Neshanic River					
At the downstream crossing of Creek Road	4.68	750	1,270	1,610	2,631
At the upstream crossing of Creek Road	4.00	720	1,220	1,540	2,510
Stony Brook					
At downstream corporate limits (Township of East Amwell)	10.92	2,620	3,090	4,070	5,640
Upstream of Tributary from Camp Harmony	7.24	1,450	2,120	2,544	3,846
Downstream of Peters Brook	4.15	1,220	1,787	2,071	2,855
Upstream of Peters Brook	3.25	748	1,095	1,269	1,749
Upstream of Linvale Road	2.08	702	1,028	1,192	1,643
Spruce Run					
At confluence with Spruce Run Reservoir	15.5	1,350	2,360	2,910	4,360
Upstream of confluence of Rocky Run	13.3	1,190	2,080	2,570	3,850

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Spruce Run (Continued)					
At the downstream corporate limit (Township of Bethlehem)	11.7	1,190	2,080	2,570	3,850
Upstream of confluence of unnamed tributary	10.7	990	1,740	2,150	3,240
Upstream of confluence of Alpaugh Brook	9.8	910	1,600	1,980	3,000
Swan Creek					
At the mouth	3.43	480	810	1,000	1,560
Above confluence with Swam Creek Tributary	1.9	250	430	540	8,800
Swan Creek Tributary					
At the mouth	1.31	300	520	660	1,080
Third Neshanic River					
At the confluence with the Neshanic River	10.7	2,710	5,520	7,180	12,370
Upstream of confluence with tributary approx. 0.5 miles downstream of corporate limits	3.2	1,310	2,680	3,480	5,990
At downstream corporate limits (Township of Delaware)	2.92	540	910	1,150	1,860
Tributary A					
At the confluence with Neshanic River	4.87	792	1,337	1,682	2,709
Downstream of Tributary near Welisewitz Road Bridge	4.87	782 ¹	1,320 ¹	1,661 ¹	2,675 ¹
Upstream of Tributary near Welisewitz Road bridge	2.88	549	938	1,187	1,931
Downstream of confluence with Tributary southwest of Furman's Corner	2.55	543	927	1,174	1,908
Upstream of confluence with Tributary southwest of Furman's Corner	1.77	403	696	885	1,449
Downstream of confluence with Tributary near Wertsville	1.48	370	640	815	1,335
Upstream of confluence with Tributary near Wertsville	0.78	207	366	469	778
At Manners Road	0.71	193	342	439	730

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Tributary B to Mulhockaway Creek At confluence with Mulhockaway Creek	3.1	580	990	1,260	2,050
Tributary C to Mulhockaway Creek At confluence with Mulhockaway Creek	1.1	230	415	535	900
Tributary D to Mulhockaway Creek At confluence with Mulhockaway Creek	2.3	320	560	715	1,200
Upstream of confluence of Tributary E to Mulhockaway Creek	1.0	200	325	410	635
Tributary E to Mulhockaway Creek At confluence with Mulhockaway Creek	1.0	120	230	290	445
Tributary F to Mulhockaway Creek At confluence with Mulhockaway Creek	1.3	310	550	710	1,205
Tributary No. 1 At downstream corporate limits (Township of Kingwood)	1.1	200	340	440	730
Tributary No. 2 At mouth	1.85	220	380	490	810
Tributary No. 1 to Delaware River At mouth	1.94	540	910	1,150	1,840
Approximately 1,310 feet upstream of River Road	1.63	500	840	1,060	1,690
Approximately 1,380 feet upstream of Phillips Road	1.14	360	620	790	1,270
Tributary No. 1 to Milford Creek At mouth	1.03	300	510	640	1,030
Walnut Brook Just upstream of Black River & Western Railroad Bridge	3.4	1,360	2,770	3,610	6,220
At downstream corporate limits of Flemington	3.03	1,270	2,590	3,370	5,800

Table 9 - Summary of Discharges
(Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-</u> <u>Percent</u>	<u>2-</u> <u>Percent</u>	<u>1-</u> <u>Percent</u>	<u>0.2-</u> <u>Percent</u>
Wickecheoke Creek At mouth	26.39	3,460	5,500	6,770	10,450
Willoughby Brook At its confluence with Spruce Run Reservoir	2.44	330	600	760	1,180

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data Tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM (Exhibit 2).

The hydraulic analyses for this and all pre-countywide FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

3.2.1 Pre-Countywide Analysis

Each community within Hunterdon County has a previously printed FIS report. The hydraulic analyses described in those reports have been compiled below in this revision.

Township of Alexandria

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the USACE HEC-2 step-backwater computer program (Reference 65). For Harihokake Creek, starting water-surface elevations were estimated at the mouth by the slope/area method outlined in the HEC-2 user's manual (Reference 66).

There is a reach in Harihokake Creek where supercritical flow occurs. This is a rapid flow which is highly turbulent, and usually occurs in steep parts of a stream. Sub-critical flow, the more common type, has a relatively low velocity, as it usually occurs on streams with flatter slopes. The super-critical reach on Harihokake Creek extends from a point approximately 4,000 feet downstream of the County Route 519 bridge to

the end of the detailed study, 3,000 feet upstream of the same bridge. For a distance of approximately 300 feet upstream of the bridge, the flow is sub-critical, due to the backwater effects of the bridge. When this backwater effect ends, the flow again becomes super-critical.

The flow transition between a super-critical and a sub-critical region usually involves turbulence with an accompanying loss of energy. Furthermore, the length of this turbulent transition, called a hydraulic jump, is unpredictable and is different for each flow. It should be noted that hydraulic jumps for small streams usually occur within the channel banks and have little or no effect on the land adjacent to the stream.

According to an accepted engineering analysis involving the velocity and depth of the upstream super-critical section (Reference 74), the hydraulic jumps that occur during the flooding of Harihokake Creek are the undular type which involve relatively small turbulent energy losses and represent somewhat gradual transitions between the super-critical and sub-critical regimes. Therefore, linear assumption between the two flow regimes, as shown on the flood profiles, is a reasonable one.

Township of Bethlehem

Cross sections for the backwater analyses of the Musconetcong River and Spruce Run were obtained from aerial photographs flown in December 1977 at a scale of 1:2400 (Reference 75). The below water sections for the Musconetcong River were obtained from the COE and the State of New Jersey Works Project Administration (WPA) (References 76 and 77). The below water sections for Spruce Run were obtained from field measurements. All bridges, dams and culverts were field checked for elevation data and structural geometry.

In undeveloped reaches, or long reaches between structures, sections were located at regular intervals and changes in valley configuration. At structures, to determine the inability to pass flood flows, cross sections were taken at close intervals up and downstream and used in conjunction with the significant hydraulic features of the structure.

Channel roughness factors (Manning's "n") used in the hydraulic computations, were chosen by engineering judgment and based on field observations of the streams and floodplain areas. The acceptability of all assumed hydraulic factors, cross sections and hydraulic structure data was checked by computations that duplicated historic flood water profiles.

Water surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 78). Where possible, computed water surface elevations were compared with recorded gage data and were in agreement to a tolerance of 0.5 foot (Reference 79). Starting water-surface elevations for the Musconetcong River in Bethlehem were obtained from the Township of Pohatcong Flood Insurance Study (Reference 80). Starting water-surface elevations for Spruce Run were obtained from frequency-elevation data for Spruce Run Reservoir supplied by the NJDEP.

At some locations along studied streams, hydraulic conditions may create a situation of supercritical flow. Because of the inherent instability of such a condition, an assumption of critical depth has been adopted for the backwater analyses of this study.

Borough of Bloomsbury

For the Musconetcong River, water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 78). Cross sections for the backwater analyses of the Musconetcong River were obtained from aerial photographs flown in 1977 at a scale of 1:21,600 (Reference 81). The below-water sections were obtained by field measurement by the COE and the State of New Jersey Works Project Administration (WPA) (References 76 and 77). Cross sections were located at regular intervals and changes in valley configuration. Cross sections at structures were taken at close intervals upstream and downstream in order to determine the ability of those structures to pass flood flows. All bridges, dams and culverts were field-checked to obtain elevation data and structural geometry.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the stream and floodplain areas. The acceptability of all assumed hydraulic factors, cross sections and hydraulic structure data was checked by computations that duplicated historic water profiles.

Starting water-surface elevations for the Musconetcong River were obtained from the Flood Insurance Study for the Township of Bethlehem (Reference 82).

Borough of Califon

Overbank portions of cross sections for the backwater analysis of South Branch Raritan River were obtained from aerial photographs flown in April 1965 (Reference 83). The below water sections were obtained by field measurement. All bridges, dams and culverts were field checked to obtain elevation data and structural geometry.

In undeveloped or long distances between structures, cross sections were located at regular intervals and at changes in valley configuration. Cross sections were taken at close intervals upstream and downstream of structures and were used in conjunction with the significant hydraulic features of the structure.

Starting water-surface elevations were obtained from the Flood Insurance Study for the Township of Lebanon, New Jersey (Reference 63).

Roughness factors (Manning's "n") used in the hydraulic computations were selected using engineering judgment and based on field observations of channels and floodplain areas.

Town of Clinton

Backwater computations in the original study were made using standard SCS computer programs. Bernoulli's Theorem was applied to the total energy head at each cross section; and Manning's formula was used to determine friction losses between cross sections. The revised analysis for Beaver Brook was conducted using the U.S. Army Corps of Engineers HEC-2 step-backwater computer program (Reference 84).

At road crossing structures, water-surface computations were made for open channel flow, pressure flow, weir flow, or a combination of these.

In areas where backwater effects are experienced, the highest elevations, irrespective of

the source of flooding, were used to determine the extent of the flooded zone.

Township of Clinton

The overbank portions of the cross sections for the South Branch Raritan River and South Branch Rockaway Creek were obtained from photogrammetric mapping (References 85 and 86). The below-water sections for the South Branch Raritan River were obtained from cross-sectional data provided by the New York District of the COE (Reference 87). The below-water sections for South Branch Rockaway Creek were obtained from Flood Hazard Report No. 9 (Reference 88). Overbank portions of the cross sections for the backwater analyses of Beaver Brook were obtained from mapping prepared from aerial photographs (Reference 89). The below-water sections were obtained by field measurement in conjunction with the aerial photographs. All bridges, dams and culverts were field checked to obtain elevation data and structural geometry. Along undeveloped portions of the streams where long distances exist between structures, cross sections were taken at close intervals upstream and downstream of structures in order to compute their significant hydraulic characteristics. An access road on Beaver Brook was not considered in the hydraulic analyses since it would not affect the water-surface elevations.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the streams and floodplain areas.

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 78). Water-surface elevations for the portion of the South Branch Raritan River between the USGS gage and the upstream corporate limits were taken from the Flood Insurance Study for the Township of Lebanon (Reference 63).

Starting water-surface elevations for the South Branch Raritan River and Beaver Brook were taken from the Flood Insurance Study for the Town of Clinton (Reference 90). Starting water-surface elevations for South Branch Rockaway Creek were taken from the Flood Insurance Study for the Township of Readington (Reference 91).

Township of Delaware

All cross sections for Alexauken Creek, Brookville Creek, Wickecheoke Creek and the Third Neshanic River were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Alexauken Creek, Brookville Creek, Wickecheoke Creek and the Third Neshanic River were obtained by field surveys.

For Alexauken Creek, Brookville Creek, Wickecheoke Creek, and the Third Neshanic River, starting water-surface elevations were estimated at their mouths by the slope/area method outlined in the COE HEC-2 users manual (Reference 65).

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 66).

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high-water marks where available.

There is a reach on Brookville Creek and on the Third Neshanic River where supercritical flow occurs. This is a rapid flow (high velocity), which is sometimes highly turbulent, and usually occurs in steep parts of a stream. Subcritical flow, the more common type, has a relatively low velocity, as it usually occurs on streams with flatter slopes. The supercritical reach on Brookville Creek extends from a point approximately 1,350 feet upstream of its mouth to a point approximately 3,500 feet upstream of its mouth. The supercritical reach on the Third Neshanic River begins at a point approximately 600 feet downstream of the Sandbrook-Headquarters Road bridge and continues upstream to the end of the detailed study at the Stockton-Flemington Road bridge, a total length of about 1,460 feet.

The flow transition between a supercritical and a subcritical region usually involves turbulence with an accompanying loss of energy. Furthermore, the length of this turbulent transition, called a hydraulic jump, is unpredictable and is different for each flow. It should be noted that hydraulic jumps for small streams usually occur within the channel banks and have little or no effect on the land adjacent to the stream.

According to an accepted engineering analysis known as open channel hydraulics, which involves the velocity and depth of the upstream supercritical sections (Reference 74), the hydraulic jumps that occur during the flooding of Brookville Creek and the Third Neshanic River are the undular type which involve relatively small turbulent energy losses and represent somewhat gradual transitions between the supercritical and subcritical regimes. Therefore, a linear assumption between the two flow regimes, as shown on the flood profiles, is a reasonable one.

Township of East Amwell

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 93).

Starting water-surface elevations for Stony Brook were obtained from the Township of Hopewell Flood Insurance Study (Reference 94). Starting water-surface elevations for the Neshanic River, Tributary A, Back Brook, and the South Fork Third Neshanic River were calculated using the slope/area method.

Overbank portions of cross sections for the backwater analyses of the South Fork Third Neshanic, Back Brook and Tributary A were obtained from mapping prepared from aerial photographs by Geod, Inc. (Reference 95). The below-water sections were obtained by field measurement in conjunction with the aerial photogrammetry.

Overbank portions of cross sections for Stony Brook and the Neshanic River were obtained from mapping prepared from aerial photographs by Quinn and Associates (Reference 96). The below-water sections were obtained by field measurement (Reference 97).

All bridges, dams, and culverts were field-checked to obtain elevation data and structural geometry.

Roughness factors (Manning's "n") used in the hydraulic computations, were chosen by engineering judgment and based on field observations of the channel and floodplain areas.

Borough of Flemington

Cross sections for Walnut Brook were obtained from photogrammetric maps, compiled from aerial photographs (Reference 98). Below-water sections were obtained by field measurement. For Bushkill Brook, channel cross sections and partial overbank cross sections were obtained by field survey. The overbanks were extended using topographic and photogrammetric maps (References 99, 100, and 101). All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry.

Water-surface elevations of floods of the selected recurrence intervals were computed using the U.S. Army Corps of Engineers HEC-2 step-backwater computer program (Reference 102). Starting water-surface elevations were calculated using the slope/area method.

Roughness factors (Manning's "n") used in the hydraulic computations were based upon engineering judgment and field observations of the streams and floodplain areas. A weighted average "n" value was used for bridges with steel decks, concrete abutments, and earthen bottoms. Non-effective flow areas were disregarded by using extremely high "n" values. The acceptability of all assumed hydraulic factors, cross sections, and hydraulic structure data were checked by calibrating computed flood profiles to known historic flood profiles.

Township of Franklin

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 93). Starting water-surface elevations for Capoolong Creek and Sidney Brook were calculated using the slope/area method.

Overbank portions of cross sections for the backwater analyses of both streams were obtained from mapping prepared from aerial photographs (Reference 103). The below-water sections were obtained by field measurement in conjunction with the aerial photogrammetry.

All bridges, dams, and culverts were field checked to obtain elevation data and structural geometry.

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the channel and floodplain areas.

At some locations along the studied streams, hydraulic conditions may create a situation of supercritical flow. Because of the inherent instability of such a condition, an assumption of critical depth has been adopted for the backwater analysis in this study.

Borough of Frenchtown

For the 1981 FIS, all cross sections for Nishisakawick Creek and Little Nishisakawick Creek were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Nishisakawick Creek and Little Nishisakawick Creek were obtained by field survey.

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (USACE, Generalized Computer Program, October 1973). Starting water-surface elevations for Nishisakawick Creek and Little Nishisakawick Creek, starting water-surface elevations were estimated at their mouths by the slopel area method outlined in the USACE HEC-2 users manual (USACE, Users Manual, October 1973).

A summary of the hydraulic analysis methods for the Delaware River can be found above in the summary for the Township of Alexandria.

Borough of Glen Gardner

For Spruce Run, water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 93). Starting water-surface elevations for Spruce Run were obtained from the Spruce Run Reservoir. Overbank portions of cross sections for the backwater analyses of all streams were obtained from maps prepared from aerial photographs flown in 1977 (Reference 104). The below-water sections were obtained by field measurement. All bridges, dams, and culverts were field checked to obtain elevation data and structural geometry. In undeveloped reaches or long reaches between structures, sections were located at regular intervals and at changes in valley configuration. Cross sections were taken at close intervals upstream and downstream of structures to determine their ability to pass flood flows, and used with the significant hydraulic features of the structure.

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the channel and floodplain areas. The acceptability of all assumed hydraulic factors, cross sections, and hydraulic structure data was checked by computations that duplicated historic flood water profiles.

Borough of Hampton

Cross sections for the backwater analyses of the detailed studied stream were obtained from aerial photographs flown in December 1977 at a scale of 1:2,400 (Reference 105). The below water sections for the Musconetcong River were obtained from the COE and the State of New Jersey Works Project Administration (References 76 and 77). All bridges and culverts were field checked to obtain elevation data and structural geometry.

In undeveloped stream segments, or long segments between structures, cross sections were located at regular intervals and changes in valley configuration. Cross sections were taken at close intervals upstream and downstream of structures, and used in conjunction with the significant hydraulic features of the structures, to determine their ability to pass flood flows.

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 78). Starting water-surface elevations for the Musconetcong River were obtained from the Flood Insurance Study for the Township of Bethlehem (Reference 106).

Channel roughness factors (Manning's "n") used in the hydraulic computations, were chosen based on engineering judgment and based on field observations of the stream

and floodplain areas.

Borough of High Bridge

The overbank portions of cross sections on the South Branch Raritan River were obtained from photogrammetric mapping (Reference 107). The below-water sections were obtained from cross-sectional data provided by the New York District of the COE (Reference 108). The overbank portions of cross sections on Willoughby Brook were obtained from mapping prepared by Aerial Data Reduction Associates, Inc. (Reference 109). The below-water sections were obtained by field measurement.

All bridges, dams and culverts were field-checked to obtain elevation data and structural geometry. In undeveloped reaches or long reaches between structures, cross sections were located at regular intervals and changes in valley configuration. Cross sections at structures were taken at close intervals upstream and downstream in order to determine their ability to pass flood flows, and were used in conjunction with the significant hydraulic features of the structure.

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the channel and floodplain areas. Water-surface elevations of floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 93). Starting water-surface elevations for the South Branch Raritan River were obtained from the Township of Clinton FIS (Reference 58). Starting water-surface elevations for Willoughby Brook were obtained from the FIS for the Township of Lebanon.

Township of Holland

1981 FIS

Valley and structure cross-section data for the backwater analysis along the Musconetcong River were obtained by photogrammetric compilation, from field surveys by the USACE and the NJDEP, and from information extracted from Works Progress Administration drawings (Works Progress Administration, 1937).

All cross sections for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to Delaware River were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to Delaware River were obtained by field survey.

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the HEC-2 step-backwater computer program (USACE, Generalized Computer Program, October 1973).

For the Musconetcong River, starting water-surface elevations for all floods were assigned a value of 137.62 feet, which was well below the backwater elevations of all floods on the Delaware River. For Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to Delaware River, starting water-surface elevations were estimated at the mouths by the slope/area method as outlined in the USACE HEC-2 user's manual (USACE, Users Manual, October 1973).

Supercritical flow occurs on most of the studied portion of Tributary No. 1 to Delaware River. This is a rapid flow which is sometimes highly turbulent and usually occurs in steep parts of the stream. Subcritical flow, the more common type, has a relatively low velocity, as it usually occurs on streams with flatter slopes. Except for the reach extending from the mouth to a point approximately 500 feet upstream of the CONRAIL bridge, and for distances of approximately 500 feet upstream of the River Road bridge and the Phillips Road bridge where the backwater effect created by the bridges reduces the velocities to a subcritical flow situation, flows on all of Tributary No. 1 to Delaware River are supercritical.

The flow transition between a supercritical and a subcritical region usually involves turbulence, with an accompanying loss of energy. Furthermore, the length of this turbulent transition, called a hydraulic jump, is unpredictable and is different for each flow. It should be noted that hydraulic jumps for small streams usually occur within the channel banks and have little or no effect on the land adjacent to the stream.

According to an accepted engineering analysis involving the velocity and depth of the upstream supercritical sections (Reference 74), the hydraulic jumps that occur during flooding on Tributary No. 1 to Delaware River are the undular type, which involve relatively small turbulent energy losses and represent somewhat gradual transitions between the supercritical and subcritical regimes. Therefore, a linear assumption between the two flow regimes, as shown on the Flood Profiles, is a reasonable one.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high water marks, where available.

2001 FIS

A summary of the hydraulic analysis methods for the Delaware River can be found above in the summary for the Township of Alexandria.

Township of Kingwood

All cross sections for Locketong Creek, Tributary No. 1, Muddy Run, and Tributary No. 2 were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Locketong Creek, Tributary No. 1, Muddy Run, and Tributary No. 2 were obtained by field surveys.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high-water marks where available.

Starting water-surface elevations were estimated for Locketong Creek at the downstream corporate limits, and for Tributary No. 1, Muddy Run, and Tributary No. 2, at their mouths, by the slope/area method outlined in the COE HEC-2 users manual (Reference 65). Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HE-2 step-backwater computer program (Reference 66).

City of Lambertville

All cross sections for Swan Creek, Swan Creek Tributary, and Alexauken Creek were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for these streams were obtained by field surveys.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high-water marks where available.

For Swan Creek, Swan Creek Tributary, and Alexauken Creek, starting water-surface elevations were estimated by the slope/area method, as outlined in the COE HEC-2 users manual (Reference 65). Water-surface elevations for floods of the selected recurrence intervals were computed through use of the HEC-2 step-backwater computer program (Reference 66).

Borough of Lebanon

For South Branch Rockaway Creek, Tributary A and Tributary B, water surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 93). Starting water-surface elevations for South Branch Rockaway Creek were obtained from the Flood Insurance Study for the Township of Clinton (Reference 58). Starting water-surface elevations for Tributaries A and B were calculated using the slope-area method. Overbank portions of cross sections for the backwater analyses of all streams were obtained from maps prepared from aerial photographs (Reference 112). The below-water sections were obtained by field measurement in conjunction with the aerial photogrammetry. All bridges, dams, and culverts were field checked to obtain elevation data and structural geometry. In undeveloped reaches or long reaches between structures, sections were located at regular intervals and at changes in valley configuration. Cross sections were taken at close intervals upstream and downstream of structures to determine their ability to pass flood flows, and used in conjunction with the significant hydraulic features of the structure.

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the channel and floodplain areas. The acceptability of all assumed hydraulic factors, cross sections, and hydraulic structure data was checked by computations that duplicated historic flood water profiles. At some locations along studied streams, hydraulic conditions may create a situation of supercritical flow. Because of the inherent instability of such a condition, an assumption of critical depth has been adopted for the backwater analyses of this study.

For Tributary A, water-surface elevations of floods of the selected recurrence intervals were taken from the Type 15 Flood Insurance Study (Reference 113). These elevations were computed utilizing the COE Generalized Computer Program "Backwater Any Cross Section" (Reference 114). The computations were verified by comparison with flood marks from Hurricane Doria, and updated to reflect changes in the topography.

Township of Lebanon

Cross sections for the backwater analysis of South Branch Raritan River were obtained from aerial photographs flown in April 1965 (Reference 115). Below-water sections for South Branch Raritan River were obtained by field measurement from the Survey of

Rockaway Creek and South Branch Raritan River (Reference 116). The overbank portions of cross sections were obtained from topographic maps (References 117 and 118). Cross sections for the backwater analysis of the Musconetcong River, Spruce Run, Rocky Run and Willoughby Brook were obtained from aerial photographs flown in December 1977 at a scale of 1:2,400 (Reference 119). The below-water sections for the Musconetcong River were obtained from the COE and the State of New Jersey (References 76 and 77). The below-water sections for Spruce Run, Rocky Run and Willoughby Brook were obtained from field measurements. All bridges, dams and culverts were field surveyed in order to obtain elevation data and structural geometry. In undeveloped areas or where long distances exist between structures, cross sections were located at regular intervals and at changes in valley configuration. Cross sections were located at close intervals upstream and downstream of structures in order to take into account the significant hydraulic features of each structure.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen using engineering judgment and based on field observations of the streams and floodplain areas.

The hydraulic characteristics and water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (References 78 and 65). When possible, computed water-surface elevations were compared with recorded gage data (Reference 47).

For South Branch Raritan River, the starting water-surface elevations were obtained from the Flood Insurance Study for the Township of Clinton (Reference 58). Starting water-surface elevations for the Musconetcong River were obtained from the Flood Insurance Study for the Borough of Hampton (Reference 13). The starting water-surface elevations for Spruce Run and Willoughby Brook were obtained from the frequency-elevation data for Spruce Run Reservoir. For Rocky Run, the starting water-surface elevations were calculated using the slope/area method.

Borough of Milford

All cross sections for Milford Creek and Quequacommissacong Creek were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Milford Creek and Quequacommissacong Creek were obtained by field surveys.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high-water marks where available.

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 65). Starting water-surface elevations were estimated for Milford Creek and Quequacommissacong Creek at their mouths using the slope/area method (Reference 66).

Township of Raritan

For all streams studied in detail, channel cross sections and partial overbank cross sections were obtained through field surveys. The overbanks were extended using topographic maps compiled from aerial photographs at a scale of 1:2400 and 1: 4800

(References 99, 100 and 101). All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment based on field observations of the streams and floodplain areas.

Water-surface profiles were developed using the COE HEC-2 step-backwater computer program (Reference 65). Cross sections were located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of those structures.

Starting water-surface elevations on the Neshanic River were based on results of the flood insurance study completed for the adjacent Township of East Amwell. An investigation of basin peaking characteristics indicated that a peak on peak starting condition with their respective receiving bodies of water would be most appropriate for the First, Second and Third Neshanic Rivers. Starting water-surface elevations for all other streams, with the exception of South Branch Raritan River, which was taken in its entirety from the existing Township of Readington Report, were based on the slope-area method.

Township of Readington

The below-water sections of the Lamington River were obtained from cross sectional data provided by the New York District Corps of Engineers (Reference 120). The overbank portions of cross-sections on the Lamington River were obtained from photogrammetric mapping (References 121 and 122).

The below-water sections of Rockaway Creek, South Branch Rockaway Creek and South Branch Raritan River were obtained by field measurement (Reference 97). The overbank portions of cross-sections were obtained from photogrammetric mapping (References 121 and 122).

For Chambers Brook, Holland Brook, Pleasant Run and Tributary A, the below-water sections were obtained by field measurement by Geed, Inc. The overbank portions of cross-sections for these streams were obtained from mapping prepared by Geod Aerial Mapping Company, Inc. (Reference 123).

All bridges, dams and culverts were field checked to obtain elevation data and structural geometry. In undeveloped reaches, or long reaches between structures, sections were located at regular intervals and at changes in valley configuration. Cross-sections were located at close intervals upstream and downstream of a structure in order to determine their ability to pass flood flows. These were used in conjunction with the significant hydraulic features of the structures.

Channel roughness factors (Manning's "n") used in the hydraulic computations, were chosen by engineering judgment and by field observations of the streams and floodplain areas.

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step backwater computer (Reference 78). Starting water-surface elevations for Lamington River, Chambers Brook, Holland Brook and Pleasant Run were taken from the Branchburg Flood Insurance Study (Reference 124).

For Rockaway Creek and Tributary A, the starting water-surface elevations were calculated by a normal depth analysis. Starting-water surface elevations for South Branch Rockaway Creek were taken from the Rockaway Creek profile. Further, the starting water-surface elevations for the South Branch Raritan River were obtained from the Township of Hillsborough Flood Insurance Study (Reference 125).

Borough of Stockton

1982 FIS

All cross sections for Brookville Creek and Wickecheoke Creek were obtained by photogrammetric methods and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridges and culverts were field surveyed to obtain structural geometry.

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (Reference 65). Brookville Creek and Wickecheoke Creek starting water-surface elevations were estimated at their mouths by the slope/area method outlined in the USACE HEC-2 user's manual (Reference 66).

There is a reach on Brookville Creek where supercritical flow occurs. This is a rapid flow (high velocity), which is sometimes highly turbulent, and usually occurs in steep parts of a stream. Subcritical flow, the more common type, has a relatively low velocity as it usually occurs on streams with flatter slopes. The supercritical reach on Brookville Creek extends from a point approximately 1,350 feet upstream of its mouth upstream to the corporate limits.

The flow transition between a supercritical and a subcritical region usually involves turbulence with an accompanying loss of energy. Furthermore, the length of this turbulent transition, called a hydraulic jump, is unpredictable and is different for each flow. It should be noted that hydraulic jumps for small streams usually occur within the channel banks and have little or no effect on the land adjacent to the stream.

According to an accepted engineering analysis known as open channel hydraulics, which involves the velocity and depth of the upstream supercritical sections, the hydraulic jumps that occur during the flooding of Brookville Creek are the undular type which involve relatively small turbulent energy losses and represent somewhat gradual transitions between the supercritical and subcritical regimes (Reference 74). Therefore, a linear assumption between the two flow regimes, as shown on the flood profiles, is a reasonable one.

Township of Tewksbury

The below-water sections of the Lamington River were obtained from cross sectional data provided by the New York District of the COE (Reference 126). The overbank portions of cross sections on the Lamington River were obtained from topographic maps prepared from aerial photographs (Reference 85).

The below-water sections of Rockaway Creek and the South Branch Raritan River were obtained by field measurement (Reference 116). The overbank portions of cross sections were obtained from topographic maps (References 85 and 118).

The overbank portions of cross sections on Tributary A and Tributary B were obtained from mapping prepared by Geod Aerial Mapping, Inc. (Reference 127). The below-water sections were obtained by field measurement by Geod, Inc.

All bridges, dams and culverts were field checked to obtain elevation data and structural geometry. In undeveloped stream segments, or long segments between structures, cross sections were located at regular intervals and at changes in valley configuration. At structures, to determine their ability to pass flood flows, cross sections were taken at close intervals upstream and downstream of the structure, and were used in conjunction with the significant hydraulic features of the structure.

Roughness factors (Manning's "n") used in the hydraulic computations were based on engineering judgment and field observations of the channel and overbank areas.

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 78). Starting water surface elevations for the Lamington River and Rockaway Creek were obtained from the Flood Insurance Study for the Township of Readington (Reference 91). Starting water surface elevations for the South Branch Raritan River were obtained from the Flood Insurance Study for the Borough of Califon (Reference 128). Starting water-surface elevations for Tributary A and Tributary B were calculated using the slope-area method.

Township of Union

The overbank portions of cross sections on Mulhockaway Creek and Tributaries A through F were obtained from mapping prepared by Geod Aerial Mapping, Inc. (Reference 129). The below-water sections were obtained by field measurement by Geod, Inc.

The below-water sections of Spruce Run were obtained by field measurement by Anderson Nichols and Co. Inc. The overbank portions of cross sections were obtained from topographic maps compiled from aerial photographs prepared by Aerial Data Reduction Associates, Inc. (Reference 130). All bridges, dams and culverts were field checked to obtain elevation data and structural geometry.

In undeveloped stream segments, or long segments between structures, cross sections were located at regular intervals and at changes in valley configuration. At structures, cross sections were taken at close intervals up and downstream of the structure, and used in conjunction with the significant hydraulic features of the structure.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen based on engineering judgment and field observations of the channel and floodplain areas.

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 78). Starting water-surface elevations for Mulhockaway Creek and Spruce Run were obtained from the frequency-elevation data for Spruce Run Reservoir supplied by the NJDEP; starting water-surface elevations for Tributary A to the South Branch Raritan River were obtained from the Flood Insurance Study for the Township of Franklin (Reference 131). Starting water-surface elevations for Tributaries B, C, D, E and F to Mulhockaway Creek were calculated using the slope-area method.

At some locations along detailed studied streams, hydraulic conditions may create a situation of supercritical flow. Because of the inherent instability of such a condition, an assumption of critical depth has been adopted for the backwater analyses of this study.

Township of West Amwell

All cross sections for Alexauken Creek were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Alexauken Creek were obtained by field surveys.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the floodplain areas, by comparison with high-water marks where available, and, for the Delaware River from previous studies by the COE (References 133 and 134).

For Alexauken Creek, starting water-surface elevations were estimated at the mouth by the slope/area method as outlined in the HEC-2 users manual (Reference 66). Water-surface elevations for floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 65).

3.2.2 September 25, 2009 Countywide Study

The techniques and tools utilized to perform the hydraulic analyses in this FIS study meet FEMA's adopted standards. No individual community criteria were incorporated within this study.

Cross-sections for Back Brook, Holland Brook, Neshanic River, First Neshanic River, Second Neshanic River, Third Neshanic River, South Branch Raritan River and Walnut Brook were determined from topographic maps with underwater portions obtained from field surveys. Information for bridges and dams were obtained from field survey data. Starting water-surface elevations for both the gaged and ungaged study streams were determined by using the slope/area method. The USACE HEC-RAS computer program was used to compute water-surface elevations of floods of the selected recurrence intervals.

Water surface profiles were produced for the 10-, 2-, 1-, and 0.2-percent-annual-chance storms for detailed study streams and for the 1-percent-annual chance storm for the approximate studies.

Locations of selected cross sections used in hydraulic analysis of each stream are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM (Exhibit 2).

At some locations along study streams, hydraulic conditions may create a situation of supercritical flow. Because of the inherent instability of such a condition, an assumption of critical flow has been adopted for the backwater analyses.

The hydraulic analyses for this FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if the hydraulic structures remain unobstructed, operate properly, and do not fail.

Channel roughness factors (Manning’s “n”) used in the hydraulic computations were chosen by engineering judgment and field inspection of the stream and floodplain areas. For Back Brook, Holland Brook, Neshanic River, South Branch Raritan River and Walnut Brook, an “n” value of 0.015 was used for concrete structures and a weighted average “n” value was used for bridges with steel decks, concrete abutments and earthen bottoms. Non-effective flow areas were disregarded by using extremely high “n” values. The acceptability of all assumed hydraulic factors, cross-sections, and hydraulic structure data were checked by calibrating computed flood profiles to known historic flood profiles.

3.2.3 Revised Analysis

For the Delaware River, cross sections were obtained from two-foot contour data developed from Light Detection and Ranging (LiDAR) data collected in spring 2008 with two-foot contour accuracy. Below-water sections were obtained by field surveys. All bridges, wing dams, and miscellaneous structures were field surveyed to obtain elevation data and structural geometry. As-built drawings provided by Delaware River Joint Toll Bridge Commission were utilized to supplement survey data where needed. Water-surface elevations for floods of the selected recurrence intervals, including the NJFHADF, were computed through use of the USACE HEC-RAS 4.0 step-backwater computer program (Reference 141). The HEC-RAS model was calibrated to the recorded high water mark elevations from the flood event of April 2005 (Reference 145). The Manning’s “n” values were adjusted within reasonable parameters so that the computed water surface elevations generally matched the recorded high water marks. Comparisons were made with high water mark elevations collected for floods of August 1955 and June 2006. The results were within acceptable limits.

The Delaware River remains under tidal influence downstream from its mouth to approximately 600 feet downstream of U.S. Route 1 in Trenton, NJ. Starting water-surface elevations were set per tidal conditions established in Bucks County FIS (Reference 135) and per NJDEP Delineation of Floodway & Flood Hazard Area Maps for the City of Trenton (Reference 136).

Table 10, “Manning’s ‘n’ Values”, provides a listing of roughness coefficients used in the detailed models done for the countywide study.

Table 10 - Manning's "n" Values

<u>Flooding Source</u>	<u>Roughness Coefficients</u>	
	<u>Channel</u>	<u>Overbanks</u>
Alexauken Creek (Delaware)	0.045	0.110
Alexauken Creek (Lambertville)	0.045	0.110
Alexauken Creek (West Amwell)	0.045	0.110
Assiscong Creek	0.020 - 0.050	0.025 - 0.130
Back Brook	0.025 - 0.045	0.035 - 0.110
Beaver Brook (Clinton TWP)	0.035 - 0.050	0.045 - 0.070
Beaver Brook (Clinton)	0.030	0.016 - 0.060
Brookville Creek (Delaware)	0.025 - 0.035	0.110 - 0.120

Table 10 - Manning's "n" Values
(Continued)

<u>Flooding Source</u>	<u>Roughness Coefficients</u>	
	<u>Channel</u>	<u>Overbanks</u>
Brookville Creek (Stockton)	0.025 - 0.035	0.110 - 0.120
Bushkill Creek (Flemington)	0.030 - 0.045	0.045 - 0.100
Bushkill Creek (Raritan)	0.030 - 0.045	0.045 - 0.100
Capoolong Creek	0.050	0.060 - 0.070
Chambers Brook	0.030 - 0.035	0.040 - 0.080
Delaware River	0.020 - 0.100	0.035 - 0.100
First Neshanic River	0.030 - 0.035	0.020 - 0.100
Harihokake Creek (Alexandria)	0.030 - 0.050	0.080 - 0.100
Holland Brook	0.035 - 0.060	0.070 - 0.950
Lamington River (Readington)	0.024 - 0.038	0.040 - 0.080
Lamington River (Tewksbury)	0.038 - 0.040	0.060 - 0.085
Lamington River Tributary A	0.040 - 0.045	0.070 - 0.090
Little Nishisakawick Creek	0.045 - 0.055	0.100
Lokatong Creek	0.035 - 0.050	0.120
Lokatong Creek Tributary No. 1	0.045 - 0.055	0.110 - 0.120
Lokatong Creek Tributary No. 2	0.040 - 0.050	0.100 - 0.120
Milford Creek (Holland)	0.030 - 0.050	0.120
Milford Creek (Milford)	0.500	0.120
Muddy Run	0.020 - 0.040	0.080 - 0.100
Mulhockaway Creek	0.025 - 0.040	0.060 - 0.090
Musconetcong River (Bethlehem)	0.030 - 0.040	0.060 - 0.095
Musconetcong River (Bloomsbury)	0.035	0.060 - 0.090
Musconetcong River (Hampton)	0.030 - 0.040	0.060 - 0.095
Musconetcong River (Holland)	0.035	0.090
Musconetcong River (Lebanon)	0.030 - 0.055	0.060 - 0.095
Neshanic River (East Amwell)	0.025 - 0.040	0.070 - 0.100
Neshanic River (Raritan)	0.025 - 0.075	0.070 - 0.101
Nishisakawick Creek	0.045	0.100
Pleasant Run	0.035 - 0.040	0.050 - 0.070
Quequacommissacong Creek (Milford)	0.030 - 0.055	0.120
Rockaway Creek (Readington)	0.025 - 0.045	0.050 - 0.100
Rockaway Creek (Tewksbury)	0.05 - 0.045	0.050 - 0.120
Rockaway Creek Tributary B	0.045	0.060 - 0.085
Rocky Run	0.035 - 0.055	0.050 - 0.090
Route 202 Tributary	0.018 - 0.053	0.055 - 0.100
Second Neshanic River	0.022 - 0.040	0.070 - 0.150
Sidney Brook (Franklin)	0.030 - 0.045	0.060 - 0.075
South Branch Raritan River (Califon)	0.045	0.070 - 0.100
South Branch Raritan River (Clinton TWP)	0.028 - 0.060	0.040 - 0.090
South Branch Raritan River (High Bridge)	0.030 - 0.060	0.040 - 0.100
South Branch Raritan River (Lebanon)	0.045 - 0.060	0.060 - 0.100

Table 10 - Manning's "n" Values
(Continued)

<u>Flooding Source</u>	<u>Roughness Coefficients</u>	
	<u>Channel</u>	<u>Overbanks</u>
South Branch Raritan River (Raritan)	0.030 - 0.040	0.060 - 0.080
South Branch Raritan River (Raritan)	0.025 - 0.035	0.050 - 0.080
South Branch Raritan River (Readington)	0.030 - 0.040	0.035 - 0.080
South Branch Raritan River (Readington)	0.025 - 0.036	0.050 - 0.081
South Branch Raritan River (Tewksbury)	0.045	0.060 - 0.100
South Branch Raritan River Tributary A	0.035	0.050 - 0.090
South Branch Raritan River Tributary A	0.030 - 0.045	0.050 - 0.075
South Branch Rockaway Creek (Clinton)	0.015 - 0.040	0.060 - 0.090
South Branch Rockaway Creek (Lebanon)	0.030 - 0.040	0.060 - 0.090
South Branch Rockaway Creek (Readington)	0.030 - 0.040	0.060 - 0.090
South Branch Rockaway Creek Tributary A	0.040 - 0.045	0.060 - 0.110
South Branch Rockaway Creek Tributary B	0.040 - 0.045	0.060 - 0.110
South Fork Third Neshanic River (Delaware)	0.030 - 0.050	0.090 - 0.120
South Fork Third Neshanic River (East)	0.040 - 0.050	0.060 - 0.100
Spruce Run (Bethlehem)	0.040 - 0.050	0.070 - 0.090
Spruce Run (Glen Gardner)	0.040 - 0.050	0.040 - 0.095
Spruce Run (Lebanon)	0.040 - 0.050	0.060 - 0.090
Spruce Run (Union)	0.040 - 0.050	0.060 - 0.090
Stony Brook	0.055	0.120
Swan Creek	0.060 - 0.070	0.100 - 0.150
Swan Creek Tributary	0.070	0.150
Third Neshanic River (Delaware)	0.030 - 0.050	0.090 - 0.120
Third Neshanic River (Raritan)	0.035 - 0.040	0.045 - 0.110
Tributary A	0.035 - 0.045	0.060 - 0.085
Tributary B to Mulhockaway Creek	0.040	0.060 - 0.0800
Tributary C to Mulhockaway Creek	0.035 - 0.040	0.060 - 0.070
Tributary D to Mulhockaway Creek	0.040	0.070 - 0.090
Tributary E to Mulhockaway Creek	0.035 - 0.040	0.085
Tributary F to Mulhockaway Creek	0.030 - 0.040	0.065 - 0.070
Tributary No. 1 to Milford Creek	0.045	0.100
Tributary No.1 to Delaware River	0.025 - 0.045	0.080 - 0.100
Walnut Brook	0.022 - 0.040	0.035 - 0.100
Wickecheoke Creek (Delaware)	0.035 - 0.045	0.090 - 0.130
Wickecheoke Creek (Stockton)	0.035 - 0.045	0.090 - 0.130
Willoughby Brook (High Bridge)	0.030 - 0.040	0.055 - 0.090
Willoughby Brook (Lebanon)	0.030 - 0.055	0.045 - 0.090

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the North American Vertical Datum of 1988 (NAVD), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. Some of the data used in this revision were taken from the prior effective FIS reports and FIRMs and adjusted to NAVD88. The datum conversion factor from NGVD29 to NAVD88 in Hunterdon County is negative 0.8 feet.

For additional information regarding conversion between the NGVD and NAVD, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services,
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3243

Qualifying benchmarks within a given jurisdiction that are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Benchmarks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g.; mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation well (e.g.; concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g.; concrete monument below frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g.; concrete monument above frost line, or steel witness post)

In addition to NSRS benchmarks, the FIRM may also show vertical control monuments established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for benchmarks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their Web site at www.ngs.noaa.gov.

It is important to note that temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control.