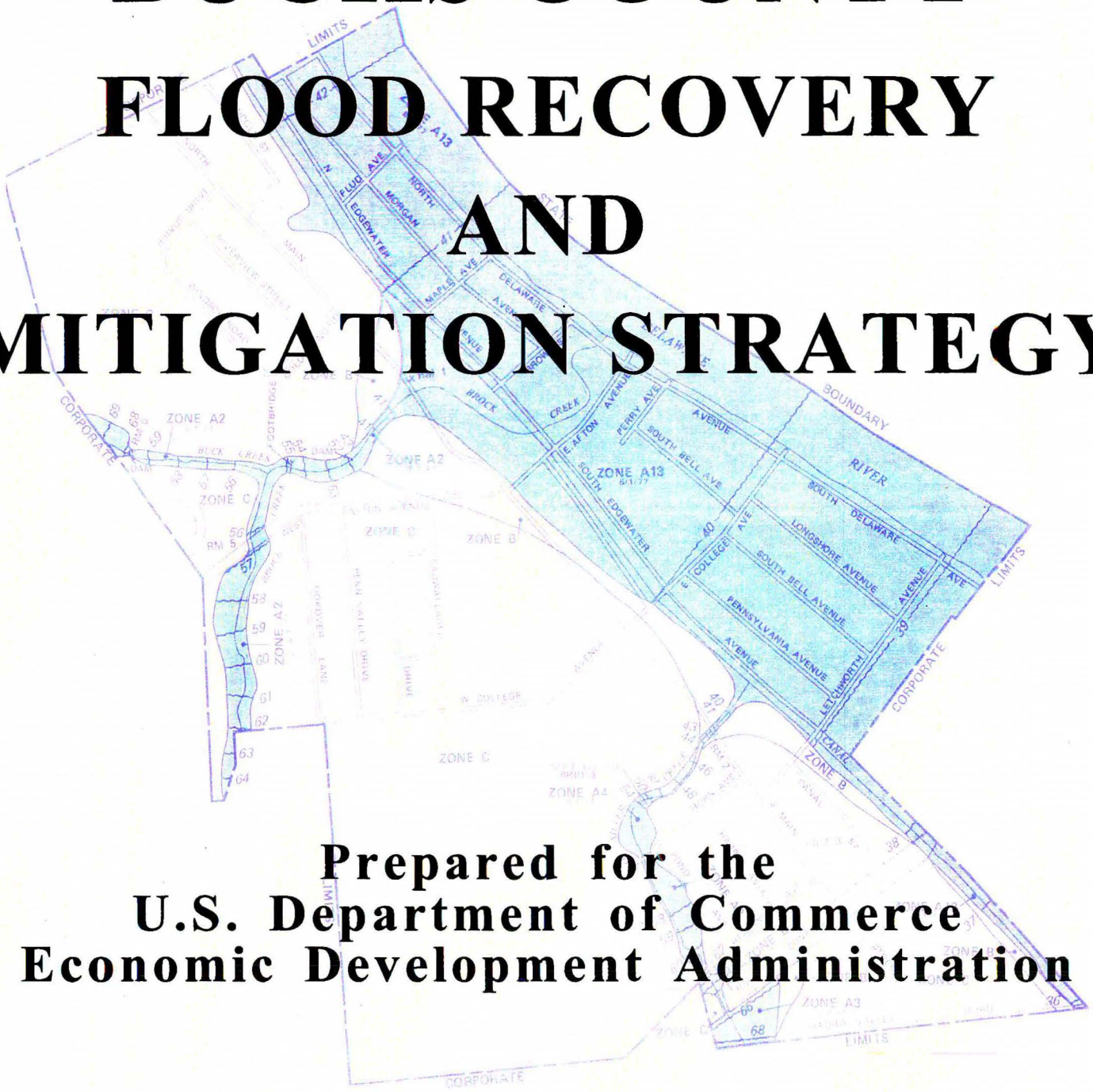
BUCKS COUNTY FLOOD RECOVERY AND MITIGATION STRATEGY



Prepared for the
U.S. Department of Commerce
Economic Development Administration

Prepared by the
Delaware Valley Regional Planning Commission

BUCKS COUNTY
FLOOD RECOVERY
AND
MITIGATION STRATEGY

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SEPTEMBER 1998

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

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ABSTRACT

This report provides a flood recovery and mitigation strategy for those flood prone communities in Bucks County. As an element of a flood mitigation plan for eastern Pennsylvania, which is coordinated by the Economic Development Council of Northeastern Pennsylvania under a grant from the Economic Development Administration, this study describes both structural and non-structural flood proofing alternatives. The study also provides an analysis of the impact of development on two local watersheds within Bucks County.

For More Information Contact:

Delaware Valley Regional Planning Commission
Regional Planning Division
The Bourse Building
111 South Independence Mall East
Philadelphia, PA 19106-2515
(215) 592-1800
Fax: (215) 592-9125
website: http://www.dvrpc.org

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EXECUTIVE SUMMARY

Floods have caused a greater loss of life and property, and have devastated more families and communities in the United States than all other natural hazards combined. In both January and June of 1996, the residents of Bucks County, Pennsylvania found out first hand about the devastating effect of floods. A January thaw coupled with excessive rain and melting snow caused the Delaware River and Neshaminy Creek to crest well above flood stage. In June, a strong cluster of thunderstorms dumped more than nine inches of rain in less than five hours on lower Bucks County. The resulting flash floods caused two deaths and damaged numerous structures, producing millions of dollars in damages. The purpose of this study is to explore the development conditions that contributed to the severity of the 1996 floods and develop a flood recovery and mitigation strategy for Bucks County.

Although these flood events were triggered by an abnormality in weather conditions, the floods were exacerbated by floodplain development and the growing amount of impervious coverage. These urbanized conditions prevent water from traveling its normal course and cause an increase in flood frequency and velocity. As the central and lower portions of Bucks County continue to develop, the channelization of small creeks coupled with increased stormwater runoff and lack of adequate stormwater control, will cause more frequent and severe flood events. In addition, past efforts to reduce flood losses by controlling floodwaters rather than encouraging people to avoid flood hazard areas may have added to the damage totals.

Once flood damage has occurred, a variety of federal, state, local and nonprofit agencies and programs are set in motion to aid residents with the recovery effort. Assistance can range from covering insured losses under the National Flood Insurance Program to establishing Red Cross shelters and providing food and counseling. Due to the 1996 floods, more than 300 people used the Red Cross for assistance in Bucks County. Moreover, the Small Business Administration (SBA) provided 357 loans totaling more than $8.5 million in flood-related assistance.

Limiting flood damage may be accomplished through a variety of nonstructural and structural measures. Nonstructural measures are comprised of two components: those that modify flood prone property and those strategies that persuade people not to build in areas that are likely to be flooded. These include zoning and planning, tax incentives, flood insurance programs, stream corridor restoration, acquisition and relocation of structures and other measures.

The primary nonstructural means of limiting flood damage is to prohibit development within flood prone areas or to require development within the floodplain to adhere to certain guidelines. The Pennsylvania Flood Plain Management Act and the Delaware River Basin Commission (DRBC) Floodplain Regulations provide for limited control of floodplain development. In Pennsylvania, local governments make their own land use decisions and therefore have the direct responsibility for floodplain management. Within the Bucks County portion of Sub-Basin 2, 94% of the communities have ordinance language that regulates development within the 100-year floodplain. However, only 36% of Sub-Basin 2 municipalities regulate development in the flood

fringe area, and 46% provide floodplain mapping.

Structural measures involve control of floodwaters and include levees, floodwalls, dams, channels, stormwater drainage systems and other public works that manage stormwater runoff. Structural approaches have been widely used throughout Bucks County by the U.S. Army Corps of Engineers (Corps), Pennsylvania Department of Environmental Protection (DEP) and Bucks County. Examples include a series of flood control dams along the Neshaminy Creek, a levee along the Delaware River in Morrisville Borough and widespread stormwater control systems in the urbanized portion of the county.

In Bucks County and throughout the Commonwealth, effective floodplain management will require cooperation among all levels of government and the public to share in the responsibility of managing flood risk. The *Bucks County Flood Recovery and Mitigation Strategy* identifies a variety of specific policies and recommended actions for improving floodplain management and limiting the potential damage caused by floods.

Major Recommended Actions include:

- *Municipalities should seek to further reduce potential flood damage by adopting and enforcing more stringent regulations controlling development within the 100-year floodplain and flood fringe areas.*

- *Federal Emergency Management Agency (FEMA) should provide updated Flood Insurance Rate Maps to communities in order to recognize recent flooding trends. Further, detailed inventories and maps should be created to identify specific areas and structures at risk of flooding. Funding should be provided to complete flood stage forecast maps for the Neshaminy Creek as well as updated maps for the Delaware River.*

- *Bucks County Emergency Management Agency (EMA) and Pennsylvania Emergency Management Agency (PEMA) should conduct a public outreach campaign to better educate the public living in and around flood prone areas regarding the risks associated with purchasing homes in the floodplain and flood prone areas. Increased outreach is also needed to train municipal officials how to make land use decisions that will not negatively impact the floodplain.*

- *The National Weather Service, DRBC, and Bucks County EMA should coordinate efforts to establish a single source of emergency flood information for the public which should provide flood warnings,and identify evacuation routes and relief options.*

- *Pennsylvania Department of Community and Economic Development (DCED), Bucks County, and flood prone municipalities should promote the acquisition of flood prone areas for community parks and recreational open space.*

CHAPTER 1

BUCKS COUNTY FLOODS: JANUARY & JUNE 1996

THE STUDY AREA

The intent of this project is to minimize or mitigate future flood damage along the Delaware River Basin in eastern Pennsylvania. The Delaware Valley Regional Planning Commission (DVRPC) joined with the Economic Development Council of Northeastern Pennsylvania, the Lehigh Valley Joint Planning Commission and the Northern Tier Regional Planning and Development Commission under a grant from the Economic Development Administration at the U.S. Department of Commerce to focus on those areas affected by recent flooding and to develop recommendations to mitigate against future damages.

Since flooding and subsequent flood damage is a direct result of sub-basin and watershed development, runoff management and existing flood control, the study areas were coordinated by sub-basin under the *Pennsylvania State Water Plan of 1983.* As such, DVRPC has undertaken a study of the Bucks County portion of Sub-Basin 2 which includes the drainage entering the Delaware River between the Lehigh River and the Poquessing Creek (Figure 1). These watersheds include Tohickon, Cooks, Tinicum and Neshaminy creeks, in addition to numerous other small drainages along the Delaware River.

FLOOD EVENTS

During the past 50 years, major floods have occurred in Bucks County eleven times, with the most recent flood events occurring in 1996 (Figure 2). According to the Bucks County Emergency Management Agency (EMA), Bucks County faces minor flooding approximately three times a year. There are two areas of potential flooding hazards in Bucks County. Flooding can occur along small creeks, including the Neshaminy Creek and along the Delaware River. Flooding generally occurs during spring, when winter weather has abated causing a rapid snowmelt, but may also occur during the winter due to ice jams or during the period of severe summer weather which causes flash floods.

ICE JAMS

Ice jamming is a potential flooding cause along Bucks County creeks and rivers. During winter, large snowstorms may leave Bucks County with a deep snow cover and frozen creeks and rivers. If heavy rains and unusually mild temperatures move into the region, while snow and ice are present, ice jam flooding can result. Ice jam flooding occurs when warm temperatures and heavy rain cause a rapid snow melt. This causes frozen rivers to swell. The rising water breaks the ice layer into large chunks, which float downstream and often pile up near narrow passages or obstructions, such as bridges and dams. The ensuing ice jam often forces water to overflow the river banks causing floods. The ice jam may also release suddenly causing rapid increases in downstream river stages.

On January 19, 1996, heavy rains, mild temperatures and a rapid snowmelt resulted in serious flooding along the Delaware River in Bucks County (Table 1). The Delaware River Basin Commission reported that flows on the Delaware River were the highest in more than 40 years. Flooding along the Bucks County portion of the Delaware River began in Bridgeton Township around Upper Black Eddy and proceeded south producing floods in New Hope Borough, Upper Makefield Township and Yardley Borough.

Table 1: Examples of Flooding in January 1996

Bridgeton Township	Upper Black Eddy between Delaware Canal and Delaware River from Bridge Lane to the Tinicum Township line
New Hope Borough	Between Delaware Canal and Delaware River from Parry Street to Dock Street
Upper Makefield Township	Along Delaware Canal from the intersection of the canal with River Road to Bailey Court
Yardley Borough	Between Delaware Canal and Delaware River from Fuld Avenue to the railroad bridge

Source: Bucks County Emergency Management Agency.

The National Weather Service (NWS) issued its first flood watch at 3:50 p.m. on January 18, warning of shifting ice, small stream flooding, excessive rain and melting snow. Flood warnings were issued on both January 19 and 20. The Delaware River crested at Trenton, NJ, across the river from Morrisville Borough, at 22.2 feet on January 21, 1996, as predicted by NWS. This was 2.2 feet above the official flood stage of 20 feet. As the floodwaters surged downstream, an ice jam in the Delaware River near the Delaware Water Gap in Monroe County broke up, causing rapid rises in water levels downstream (Table 2). Water levels exceeded the flood stage by nearly seven feet in Riegelsville Borough and over five feet in Yardley Borough.

Table 2: Flood Stage Report: January 19-21, 1996

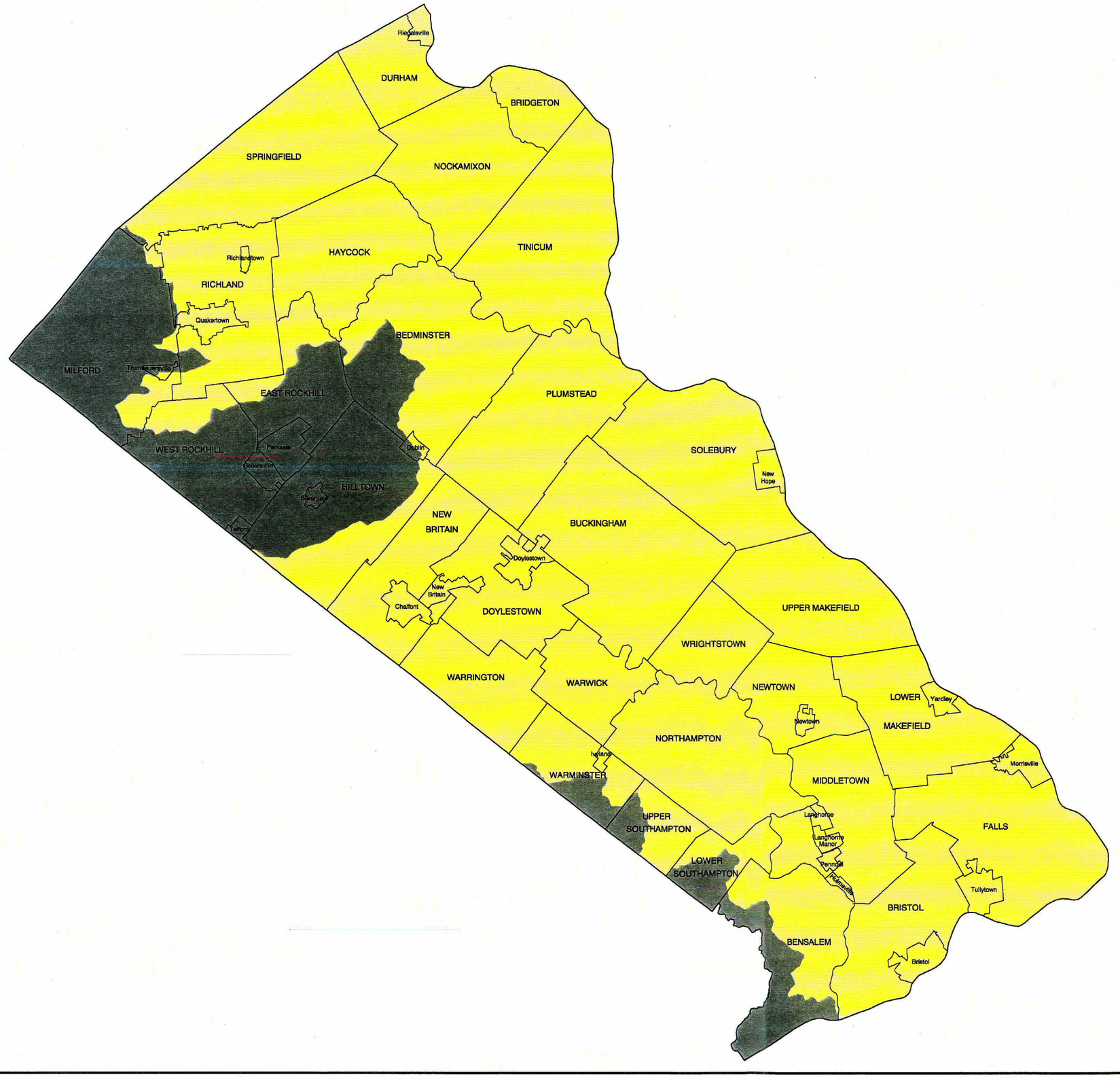
Location	Flood Stage	Crest	Date	Time
Delaware River				
Riegelsville	22 ft.	28.72 ft.	Jan. 20	6:15 p.m.
New Hope-Lambertville	13 ft.	15.34 ft.	Jan. 20	11:00 p.m.
Washington Crossing	18 ft.	18.45 ft.	Jan. 21	12:00 a.m.
Trenton, NJ	20 ft.	22.19 ft.	Jan. 21	1:30 a.m.
Neshaminy Creek				
Langhorne	9 ft.	14.98 ft.	Jan. 21	1:00 a.m.

Source: National Weather Service.

Figure 1.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

SUB-BASIN 2 STUDY AREA



Study Area

Area Outside Study

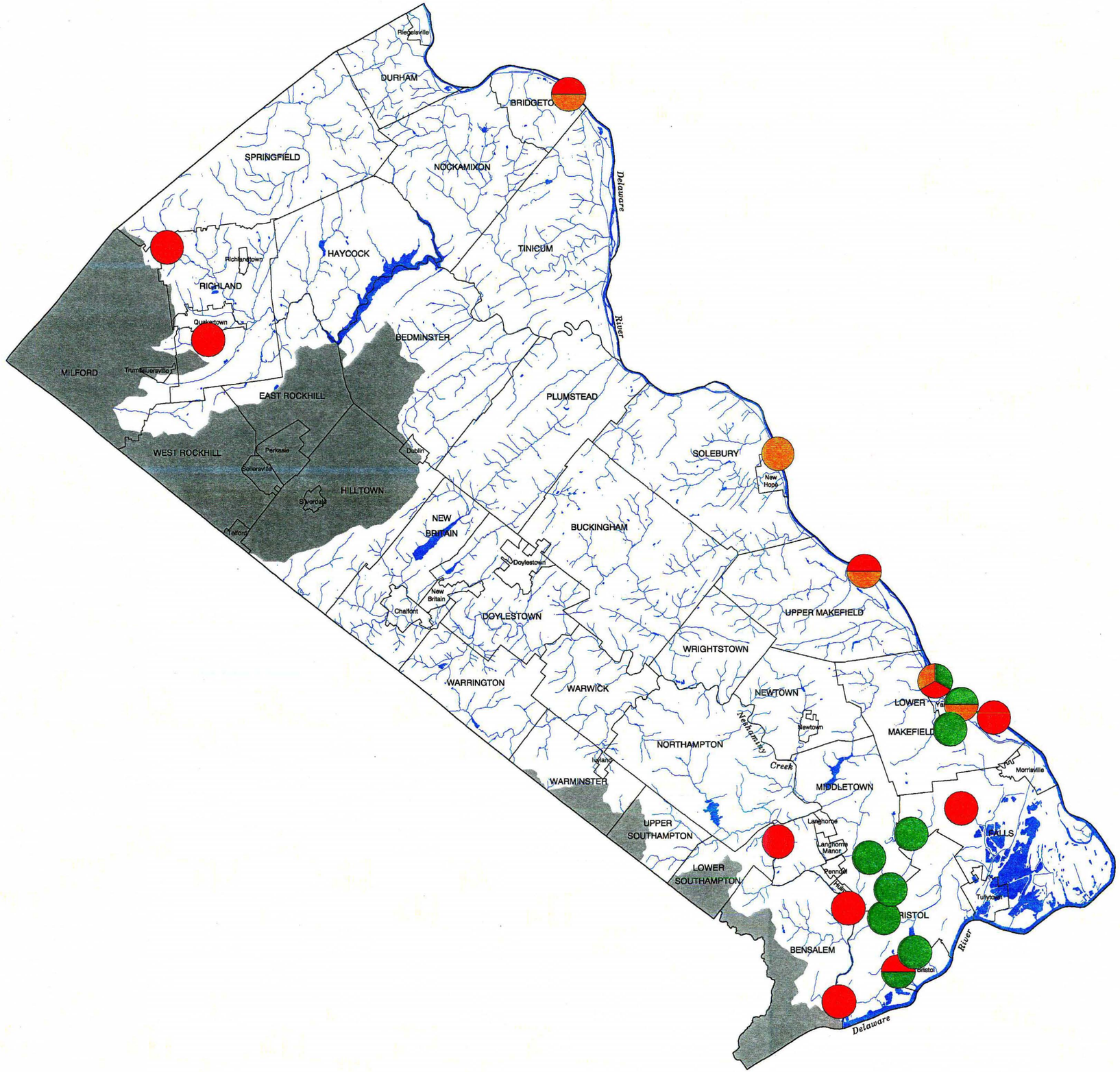
0 2 4 6
Miles

Delaware Valley Regional Planning Commission
June, 1998

Figure 2.

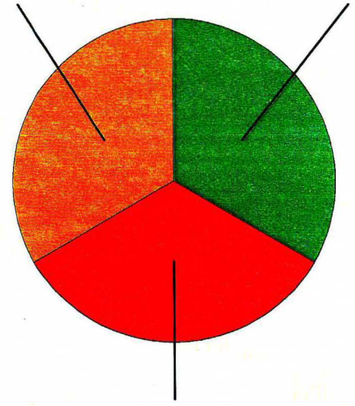
FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

FLOOD LOCATIONS



January 1996 Flood

June 1996 Flood



Frequently Flooded Areas

Area Outside Study

Source: Bucks County Emergency Management Agency

0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

FLASH FLOODS

Substantial development throughout Bucks County and location of homes and businesses in the floodplain has made many communities prone to flash floods. A substantial rainfall, in conjunction with a large amount of impervious surface, such as parking lots, driveways and rooftops, may produce runoff that cannot be handled by the existing stormwater control system. The runoff inundates local creeks, storm drains and retention ponds forcing water onto roads and driveways and occasionally into homes and businesses. Flash floods occur quickly and the floodwater can travel at a high rate of speed destroying everything in its path.

The flash floods that occurred in Lower Bucks County in June 1996 were due to an extremely large amount of rainfall in a short period of time. A small but strong cluster of thunderstorms dumped more than nine inches of rain in a 30 square mile area in less than five hours. The axis of the heaviest rainfall ran from just northeast of Langhorne, Pennsylvania to Ewing, New Jersey (Table 3).

The first flash flood warning came from the National Weather Service (NWS) in Mount Holly, New Jersey at 6:07 p.m. Another warning came at 8:15 p.m. and a third at 10:15 p.m. Each warning cautioned residents about severe street flooding and rapid rises in the Neshaminy Creek area. Some rainfall reports from Bucks County were: Neshaminy Falls (5.0"), Richboro (4.1"), Southampton (3.3"), Yardley (6.1") and a volunteer spotter for NBC-TV measured approximately 9.0" at Langhorne.

Table 3: Examples of Flooding in June 1996

Yardley Borough	Between Delaware Canal and Delaware River from Fuld Avenue to the railroad bridge; along Brock, Buck and Silver creeks
Lower Makefield Township	Along Silver Creek between Wienman Way and Lakeview Drive
Falls Township	Along Queen Anne Creek from Olds Boulevard to Stanford Road
Middletown Township	Along Mill Creek and Highland Park Drive in Levittown from Hollow Road to Trenton Road; along Mill Creek from New Rodgers Road to Trenton Road; along Mill Creek from Frosty Hollow Road to New Falls Road
Bristol Township	Along Bath Road and Laurel Drive from David Drive to Glenrich Avenue
Bristol Borough	Area between Bristol Pike and Garden Street from Fourth Avenue to Lake Street (into Silver Lake Park); along Otter Creek in the vicinity of Bristol Pike

Source: Bucks County Emergency Management Agency.

According to the Bucks County EMA, the heaviest damages from the flooding in June 1996 were primarily concentrated in seven communities: Bensalem, Bristol, Falls and Middletown townships, and Bristol, Penndel and Yardley boroughs (Table 4). There were 661 residences that suffered some level of flood damage. More than 200 residences were affected by the floods but remained habitable, however 62 residences suffered major damage and three homes were destroyed. Yardley Borough was the most affected community with 260 residences suffering from flood-related damages. Of those residences affected in this area, 65% did not have flood insurance. Low income property owners accounted for 80% of those affected in Bristol Borough. In addition to the residential damage, more than 65 business in the Lower Bucks County area were affected.

Table 4: Damage Assessments for the June 1996 Flood

Single Family Homes

Municipality	Homes		Habitability				Status	Insurance	Income	Business
	Primary	Secondary	Affected but still Habitable	Minor	Major	Destroyed	% Own	% Insured	% Low Income	No.
Bensalem Township	38	0	24	14	0	0	100	0	10	1
Bristol Borough	0	0	0	24	2	0	60	0	80	30
Bristol Township	116	0	40	69	7	0	80	0	30	5
Falls Township	19	0	9	10	0	0	100	25	0	0
Middletown Township	0	0	58	45	27	1	100	85	20	11
Yardley Borough	0	0	22	141	16	2	80	65	15	20

Apartments/Condominiums

Falls Township	22	0	0	22	0	0	0	0	0	0
Penndel Borough	0	0	49	0	0	0	0	0	0	0
Yardley Borough	0	0	13	56	10	0	0	0	0	0
TOTAL	**195**	**0**	**215**	**381**	**62**	**3**				**67**

Source: Bucks County Emergency Management Agency.

CHAPTER 2

THE 100-YEAR FLOODPLAIN

Bucks County is located in the Central Delaware River Basin (Sub-Basin 2), as identified in the *Pennsylvania State Water Plan of 1983.* Sub-Basin 2 includes portions of Berks, Bucks, Carbon, Lackawana, Luzerne, Monroe, Montgomery, Northampton, Schuylkill and Wayne counties. Drainage in Sub-Basin 2 covers more than 1,900 square miles or approximately 30% of the Pennsylvania portion of the Delaware River Basin. In Bucks County, this includes the drainage entering the Delaware River from the Lehigh River to the Poquessing Creek.

The Bucks County segment of the central Delaware River Basin contains two sub-basins: the Delaware River and the Neshaminy Creek. Within these sub-basins are 43 watersheds encompassing portions of 50 municipalities (Figure 3). The watersheds include Cooks, Neshaminy, Tinicum and Tohickon Creeks in addition to numerous small drainages along the Delaware River. Much of Sub-Basin 2 in Bucks County is still used for agriculture, however the lower portion of the county is heavily urbanized. Manufacturing, primarily the steel and chemical industries, have concentrated in this area. Another significant center of urbanization has developed along the western Neshaminy Creek Watershed. Development here is primarily residential and comprises acres of impervious cover, such as roads, driveways, cul-de-sacs.

An important component in the development of Sub-Basin 2 has been the location of the 100-year floodplain, which is delineated based on the 100-year flood. The 100-year flood, is based upon the flow of water in a stream or river that has a 1-in-100, or 1% chance of being equaled or exceeded each year. Once a stream's flow in a 100-year flood has been estimated, the elevation of the surrounding land enables hydrologists to determine where flood water would go and to what depth. The area which becomes flooded is the 100-year floodplain (Figure 4).

The Bucks County 100-year floodplain, also referred to as the flood hazard area, comprises 28,076 acres and is home to more than 14,000 people (Table 5). According to the Bucks County EMA, Tinicum Township has the largest 100-year floodplain at 5377 acres which accounts for 28% of the total land area in the Township. Bristol Township has 1,300 residents living in the 2,688 acre 100-year floodplain, while Northampton Township has a 100-year floodplain comprising almost 1,700 acres. The most populous 100-year floodplain, with approximately 2,600 residents, is located in Lower Southampton Township.

Although the sizes of their floodplains are relatively small, those municipalities most affected by the 1996 floods contain some of the most populous floodplains in Bucks County. Bristol, Middletown and Upper Makefield townships and Yardley Borough collectively contain 2,628 residents who live within the 100-year floodplain.

Table 5: Bucks County Municipalities Located in Sub-Basin 2 Flood Hazard Areas*

Municipality	Size of Flood Hazard Area (acres)*	1990 Population in Flood Hazard Area
Bedminster Township	960.0	188
Bensalem Township	736.0	124
Bridgeton Township	624.0	375
Bristol Borough	374.4	333
Bristol Township	2,688.0	1,300
Buckingham Township	640.0	236
Chalfont Borough	320.0	100
Doylestown Borough	121.6	57
Doylestown Township	1,216.0	250
Dublin Borough	NA	NA
Durham Township	608.0	200
East Rockhill Township	480.0	362
Falls Township	N/A	200
Haycock Township	704.0	92
Hilltown Township	172.8	32
Hulmeville Borough	213.1	185
Ivyland Borough	NA	NA
Langhorne Borough	12.8	0
Langhorne Manor Borough	38.4	0
Lower Makefield Township	934.4	557
Lower Southampton Township	174.1	2,607
Middletown Township	96.0	238
Milford Township	358.4	103
Morrisville Borough	92.2	19
New Britain Borough	28.2	15
New Britain Township	998.4	300
New Hope Borough	225.9	280
Newtown Borough	3.2	0
Newtown Township	960.6	120
Nockamixon Township	409.6	140
Northampton Township	1,689.6	585
Penndel Borough	NA	NA
Plumstead Township	172.8	97
Quakertown Borough	160.0	300
Richland Township	1,657.6	195
Richlandtown Borough	NA	NA
Riegelsville Borough	199.0	800
Solebury Township	526.1	150
Springfield Township	1,043.2	0
Tinicum Township	5,376.6	600
Trumbauersville Borough	NA	NA
Tullytown Borough	576.0	112
Upper Makefield Township	500.0	290
Upper Southampton Township	38.4	500
Warminster Township	0.6	600
Warrington Township	320.0	560
Warwick Township	857.6	140
West Rockhill Township	217.6	70
Wrightstown Township	320.0	15
Yardley Borough	230.4	800
TOTAL	**28,075.6**	**14,227**

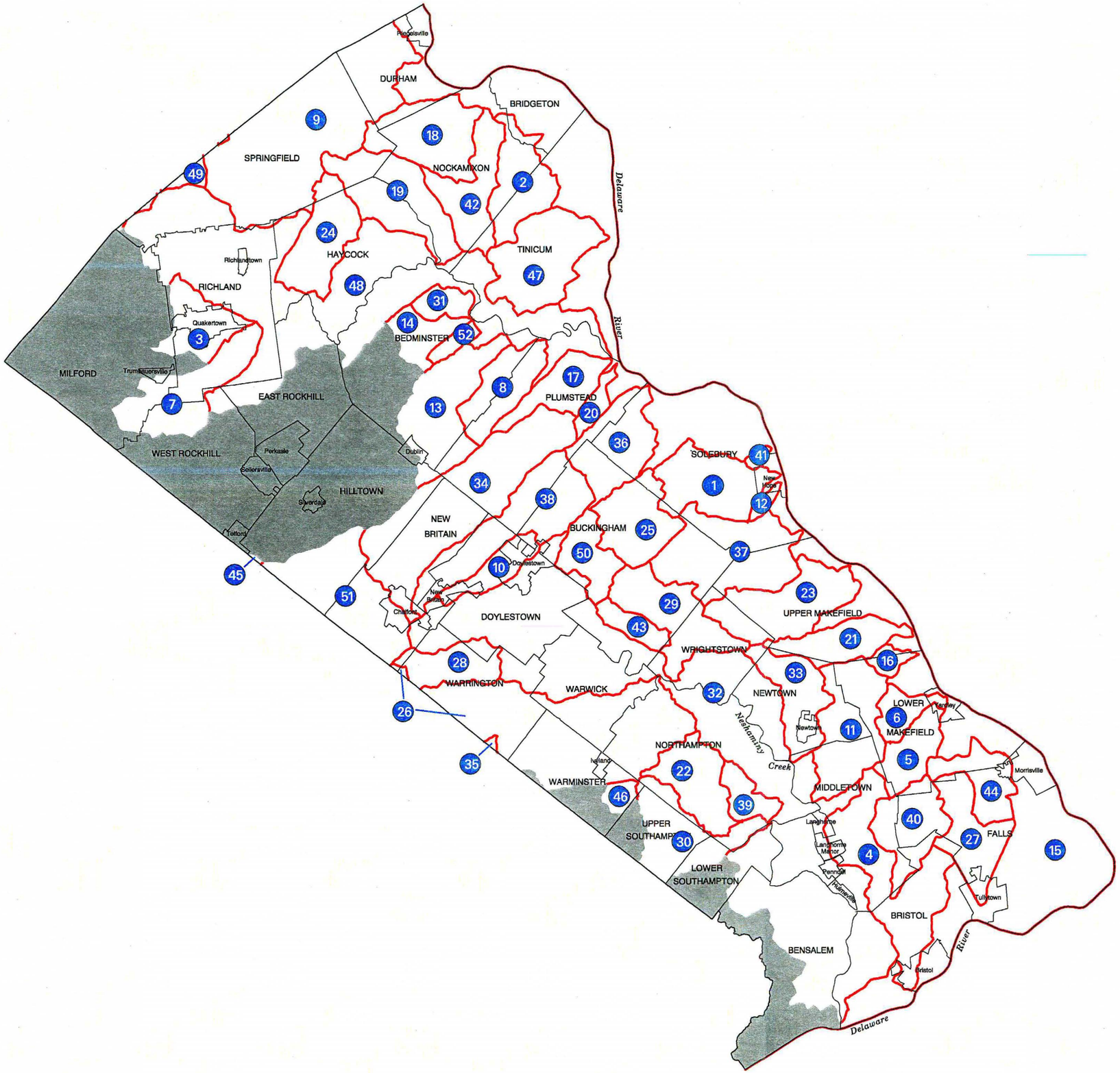
* same area as 100-year floodplain.

Source: Bucks County Emergency Management Agency.

Figure 3.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

WATERSHEDS



1	Aquetong Creek	27	Martins Creek
2	Beaver Creek	28	Mill Creek (1)
3	Beaver Run	29	Mill Creek (2)
4	Black Ditch and Mill Creeks	30	Mill Creek (3)
5	Brock Creek	31	Mink Run
6	Buck Creek	32	Neshaminy Creek
7	Butter and Morgan Creeks	33	Newtown Creek
8	Cabin Run	34	North Branch Neshaminy Creek
9	Cooks Creek	35	Park Creek
10	Cooks Run	36	Paunnacussing Creek
11	Core Creek	37	Pidcock Creek
12	Dark Hollow Run	38	Pine Run (1)
13	Deep Run	39	Pine Run (2)
14	Deer Run	40	Queen Anne Creek
15	Delaware River	41	Rabbit Run
16	Dyers Creek	42	Rapp Creek
17	Gaddes Run	43	Robin Run
18	Gallows Run	44	Rock Run
19	Haycock Creek	45	Skippack Creek
20	Hickory Creek	46	Southampton Creek
21	Houghs Creek	47	Tinicum Creek
22	Ironworks Creek	48	Tohickon Creek
23	Jericho Creek	49	Tumble Brook
24	Kimples Creek	50	Watson Creek
25	Lahaska Creek	51	West Branch Neshaminy Creek
26	Little Neshaminy Creek	52	Wolf Run

Watershed Boundary

Area Outside Study

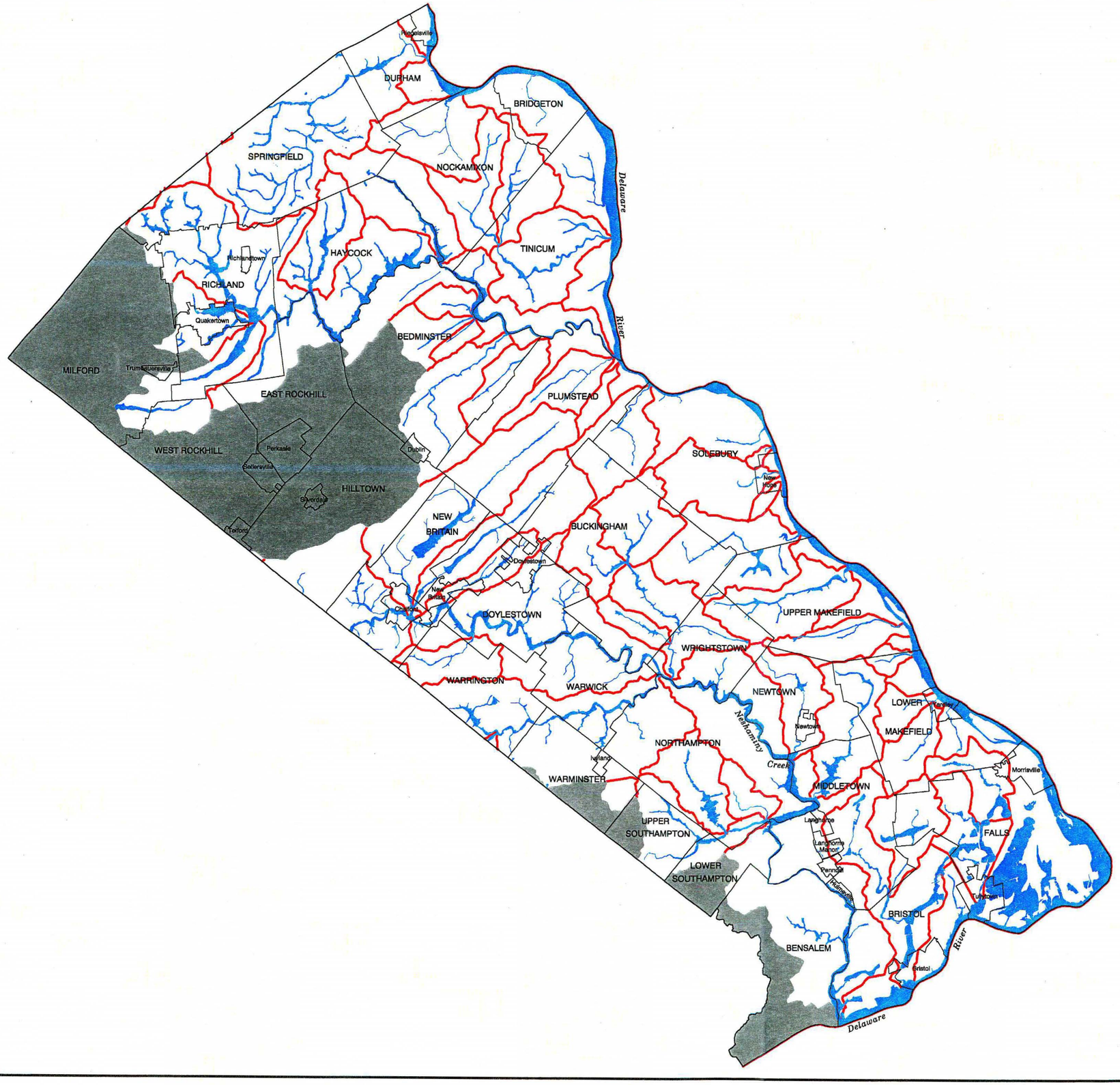
0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

Figure 4.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

100 - YEAR FLOODPLAIN



FEMA 100-Year Floodplain

Watershed Boundary

Area Outside Study

0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

The population of those Bucks County municipalities located in Sub-Basin 2 increased 7%, from 526,263 in 1990 to 563,135 in 1996 (Table 6). Some of the largest population percent gains occurred in the central portion of the County with increases in Warwick (+40.1%), Buckingham (+39.7%), Doylestown Township (+20.8), Warrington (+18.8%) and New Britain Township(+15.6). Within lower Bucks County, Lower Makefield experienced a 24.0% growth increase from 25,083 in 1990 to 31,095 in 1996. Even those lower Bucks County communities ravaged by the 1996 floods followed this trend, as Bristol Township (+0.1), Middletown (+4.7) and Yardley (+1.6) all experienced population increases (Figure 5).

Table 6: Percent Change in Sub-Basin 2 Population (1990-1996)

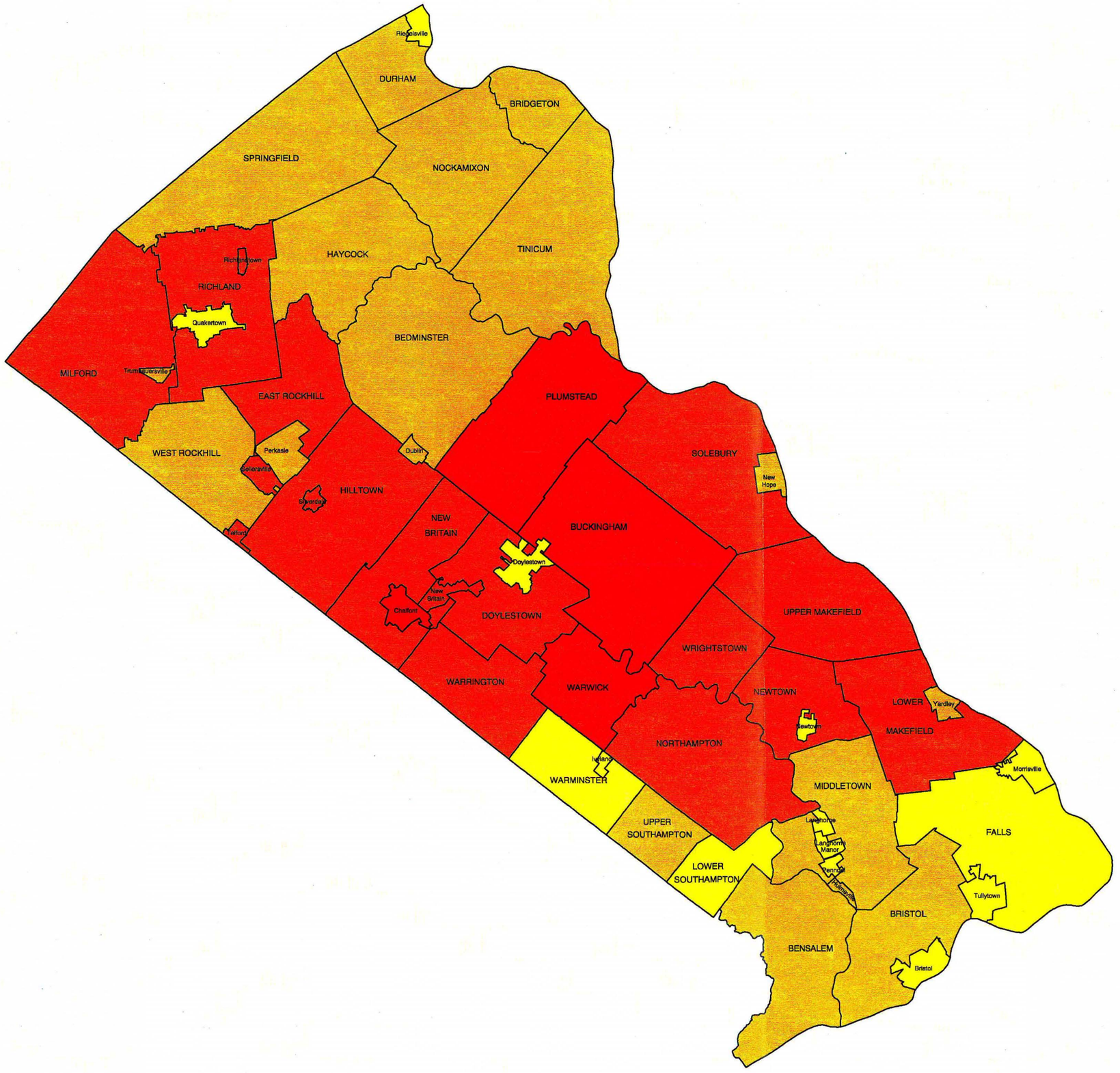
Municipality	1990 Population	1996 Population*	% Change 1990-1996
Bedminster Township	4,602	4,706	2.3
Bensalem Township	56,788	57,611	1.5
Bridgeton Township	1,378	1,421	3.1
Bristol Borough	10,405	10,198	-2.0
Bristol Township	57,129	57,689	1.0
Buckingham Township	9,364	13,080	39.7
Chalfont Borough	3,069	4,006	30.5
Doylestown Borough	8,575	8,431	-1.7
Doylestown Township	14,510	17,523	20.8
Dublin Borough	1,985	2,016	1.6
Durham Township	1,209	1,247	3.1
East Rockhill Township	3,753	4,677	24.6
Falls Township	35,047	34,851	-0.6
Haycock Township	2,165	2,260	4.4
Hilltown Township	10,582	11,516	8.8
Hulmeville Borough	916	926	1.1
Ivyland Borough	490	487	-0.6
Langhorne Borough	1,361	1,328	-2.4
Langhorne Manor Borough	807	789	-2.2
Lower Makefield Township	25,083	31,095	24.0
Lower Southampton Township	19,860	19,789	-0.4
Middletown Township	43,063	45,105	4.7
Milford Township	7,360	8,028	9.1
Morrisville Borough	9,765	9,530	-2.4
New Britain Borough	2,174	2,333	7.3
New Britain Township	9,099	10,521	15.6
New Hope Borough	1,400	1,413	0.9
Newtown Borough	2,565	2,509	-2.2
Newtown Township	13,685	16,384	19.7
Nockamixon Township	3,329	3,429	3.0
Northampton Township	35,406	38,583	9.0
Penndel Borough	2,703	2,699	-0.2
Plumstead Township	6,289	8,932	42.0
Quakertown Borough	8,982	8,975	-0.1
Richland Township	8,560	9,458	10.5
Richlandtown Borough	1,195	1,328	11.1
Riegelsville Borough	912	892	-2.2
Solebury Township	5,998	6,815	13.6
Springfield Township	5,177	5,296	2.3
Tinicum Township	4,167	4,328	3.9
Trumbauersville Borough	894	894	0.0
Tullytown Borough	2,289	2,257	-1.4
Upper Makefield Township	5,949	6,556	10.2
Upper Southampton Township	16,076	16,153	0.5
Warminster Township	32,832	32,811	-0.1
Warrington Township	12,169	14,452	18.8
Warwick Township	5,915	8,287	40.1
West Rockhill Township	4,518	4,613	2.1
Wrightstown Township	2,426	2,584	6.5
Yardley Borough	2,288	2,324	1.6
TOTAL	**526,263**	**563,135**	**7.0**

* U.S. Census estimates
Source: U.S. Census.

Figure 5.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

POPULATION CHANGE 1990 - 1996



- Less Than 0%
- 0%- 5%
- 5% - 25%
- More Than 25%

Source: U.S. Census

0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

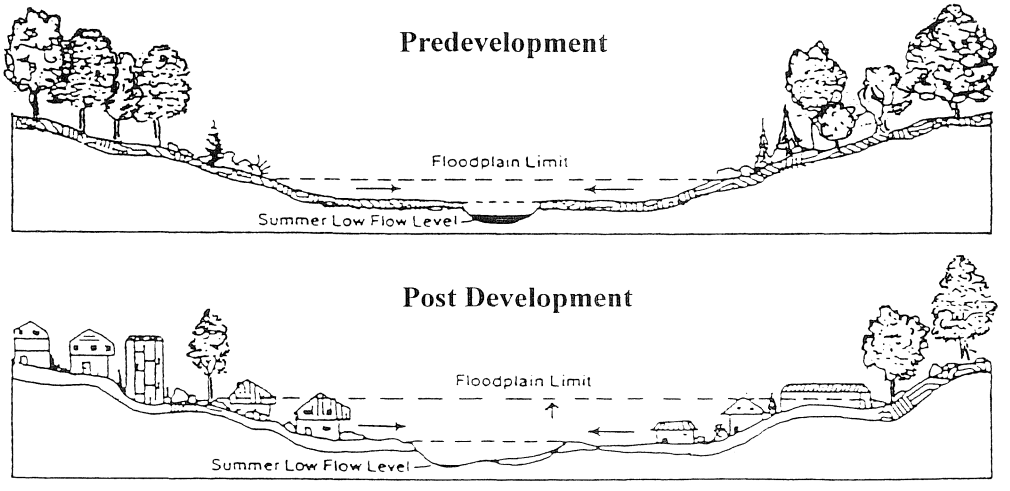
CHAPTER 3

LAND USE AND IMPERVIOUS COVERAGE

Urbanization trends, such as the construction of buildings and the paving of sidewalks and streets, increases both the speed and amount of stormwater runoff. Water that would usually soak into soils after a rainfall is unable to penetrate paved streets and parking lots. Instead, the water simply runs off rooftops, driveways, streets and parking lots, picking up speed as it travels. In addition to flood-related impacts, increased runoff due to impervious cover can cause changes in hydrology, habitat structure, water quality and biodiversity of aquatic systems. Other types of impervious surfaces include patios, sidewalks and compacted soil.

An undeveloped stream corridor and its floodplain exhibit narrow and low flooding levels (Figure 6). The 100-year floodplain generally extends along the flat stream buffer area while flood heights remain low. A healthy summer low flow level in the stream is evident. After development, the increase in runoff rates shifts the elevation of the 100-year floodplain upward, which may place more property, structures and lives at risk. The floodplain following urbanization becomes wider and flood heights increase significantly. In addition, increased runoff causes erosion and sediment build up in the stream bed constricting the summer low flow level.

Figure 6: The Stream and Its Floodplain, Before and After Development



Source: Center for Watershed Protection

BUCKS COUNTY LAND USE

Land use in Bucks County can be characterized by urban, suburban and rural patterns (Figure 7). In lower Bucks County, single-family and multi-family residential land uses are widespread. Non-residential land uses, such as commercial, manufacturing, transportation and utilities, add to the urban features of lower Bucks County. The suburbanized central Bucks County region comprises agriculture interspersed between single-family residential developments. Higher density commercial and multi-family developments are situated along corridors or concentrated in areas like Doylestown and Newtown. The upper Bucks County region continues to maintain a rural atmosphere with a majority of this area in agriculture and wooded land uses.

Most zoning codes set the maximum density for an area based on dwelling units, or rooftops. For example, in a given area, no more than one single family home can be located on each acre of land. The relative share of impervious coverage can vary in the same zoning category. The Center for Watershed Protection in Silver Spring, Maryland estimates that impervious areas associated with medium density single family homes can range from 25% to nearly 69%, depending on the layout of streets and parking. The Center also approximates that 65% of all impervious coverage is devoted to the car including driveways, streets, parking lots, turnarounds and cul-de-sacs. It is estimated by the Center that the amount of impervious coverage in most urbanized landscapes has increased 50% since 1950. The Center calculates that each person generates approximately one-half acre of impervious coverage in the urban landscape.

A breakdown of the total impervious coverage by the four residential street design components, reveals that streets typically account for approximately one-half of the total impervious coverage of the components (Figure 8). Driveways comprise more than 30% of the total impervious cover, while sidewalks (13.6%) and turnarounds (6.8%) also contribute to an increase in runoff.

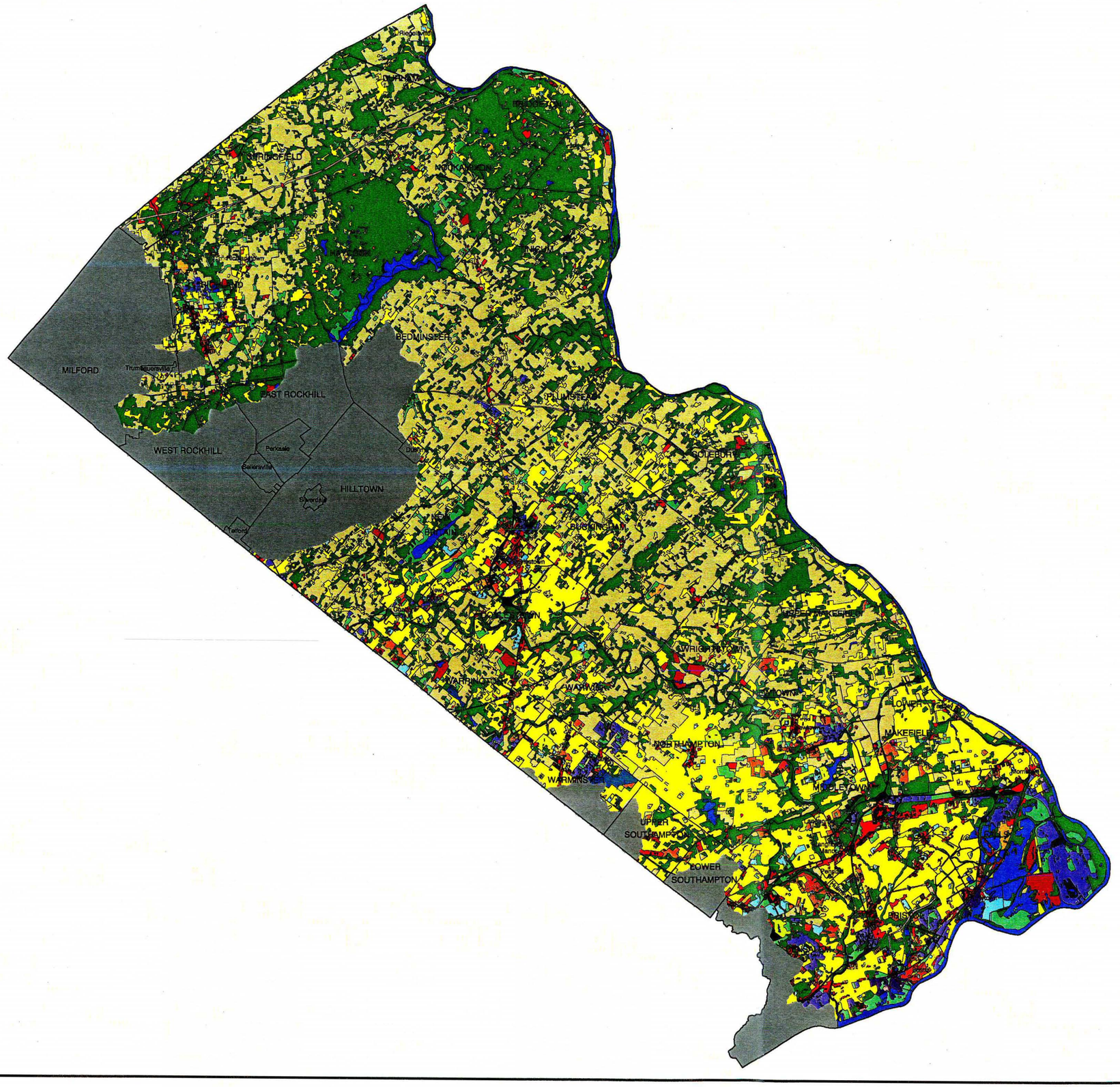


Figure 7.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

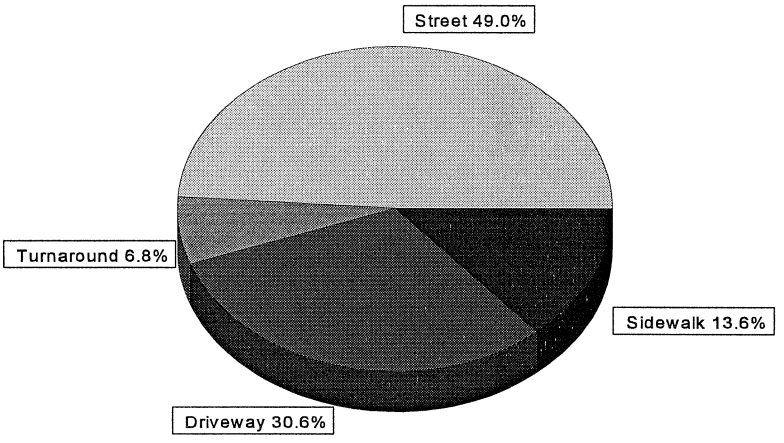
LAND USE

- Single Family (detached)
- Multi-Family
- Row Homes
- Mobile Homes
- Manufacturing
- Heavy Manufacturing
- Transportation
- Utilities
- Commercial / Services
- Community Services
- Military
- Recreation
- Agriculture
- Mining
- Vacant
- Wooded
- Water
- Area Outside Study

0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

Figure 8: Percent of Total Impervious Cover by the Four Residential Street Design Components



Source: Center for Watershed Protection.

The impacts of impervious coverage on stormwater runoff include increasing runoff velocity and reducing water quality. According to the Texas Water Resources Institute, the most significant impact is the increase in the amount of total runoff (Table 7). Based upon an average slope, the percent of stormwater runoff from an asphalt road is 73% while concrete roof permits 75% of the rainfall to runoff. Conversely, only 37% of rainfall runs off a park or landscaped area that is less than 50% covered with grass. A park or landscaped area that is more than 75% grass-covered, captures 71% of the rainfall, allowing only 29% to runoff.

Table 7: Impact of Impervious Cover on Runoff

Type of Surface	% of Rainfall Runoff Based on Average Slopes
Concrete Roof	75%
Asphalt Road	73%
Landscape/Park (<50% covered with grass)	37%
Landscape/Park (50%-75% covered with grass)	33%
Landscape/Park (>75% covered with grass)	29%

Source: Texas Water Resources Institute.

Traditional zoning has strongly emphasized and regulated rooftops and has largely ignored impervious cover created for cars such as streets, parking lots and driveways. The rooftop component is primarily fixed in the density of zoning, such as allowing the maximum number of dwelling units, or rooftops in a particular area. A community may be zoned to permit no more than one single family home on one acre of land. By utilizing this planning tool, density zoning only considers the number of rooftops while neglecting the car component of imperviousness. The creation of roads, parking lots and driveways, which constitute a larger share of impervious cover, is generally not explicitly considered in the zoning process. While the issue of stormwater management may be addressed in the subdivision phase, these regulations often only consider the conveyance of stormwater off the project site, and may not consider the larger regional impacts of increased flooding caused by the increase in impervious cover.

Impervious surface control should be a key element of site planning in all urbanizing watersheds. Since many zoning and subdivision ordinances provide for the maximum number of buildings permitted on a site, it may be difficult to alleviate the impacts associated with rooftops or drivways. However, communities may be better suited to impact impervious cover by regulating roadways and parking areas. For example, reducing road widths is one of the best opportunities for reducing imperviousness in residential areas. Prohibiting parking on residential streets may allow for narrower paved rights-of-way and a reduction in the percentage of impervious cover. In commercial and industrial areas the primary focus should be on the reduction of impervious parking areas. A viable consideration for many areas involves pervious alternatives to traditional impervious surfaces and include various mixes of asphalt with larger pore spaces such as sand, gravel or turf. Compacted soils also function to prohibit water from permeating the ground, so careful consideration must be made when replacing asphalt parking with an area of compacted soil.

CHAPTER 4

A DEVELOPMENT COMPARISON

As with many suburban counties, Bucks County has experienced a majority of its growth within the past 30 years as farmland and forested areas have been replaced by strip malls and sprawling residential developments. Development in central Bucks County contains acres of impervious elements which have increased the amounts of stormwater runoff, in addition to increasing the frequency and intensity of flood events in the lower portion of the county. In order to better understand these development patterns, a comparison of two areas in Bucks County was undertaken. Aerial photographs taken in 1965 and 1995 allow for an important visual comparison between 30 years of suburban development.

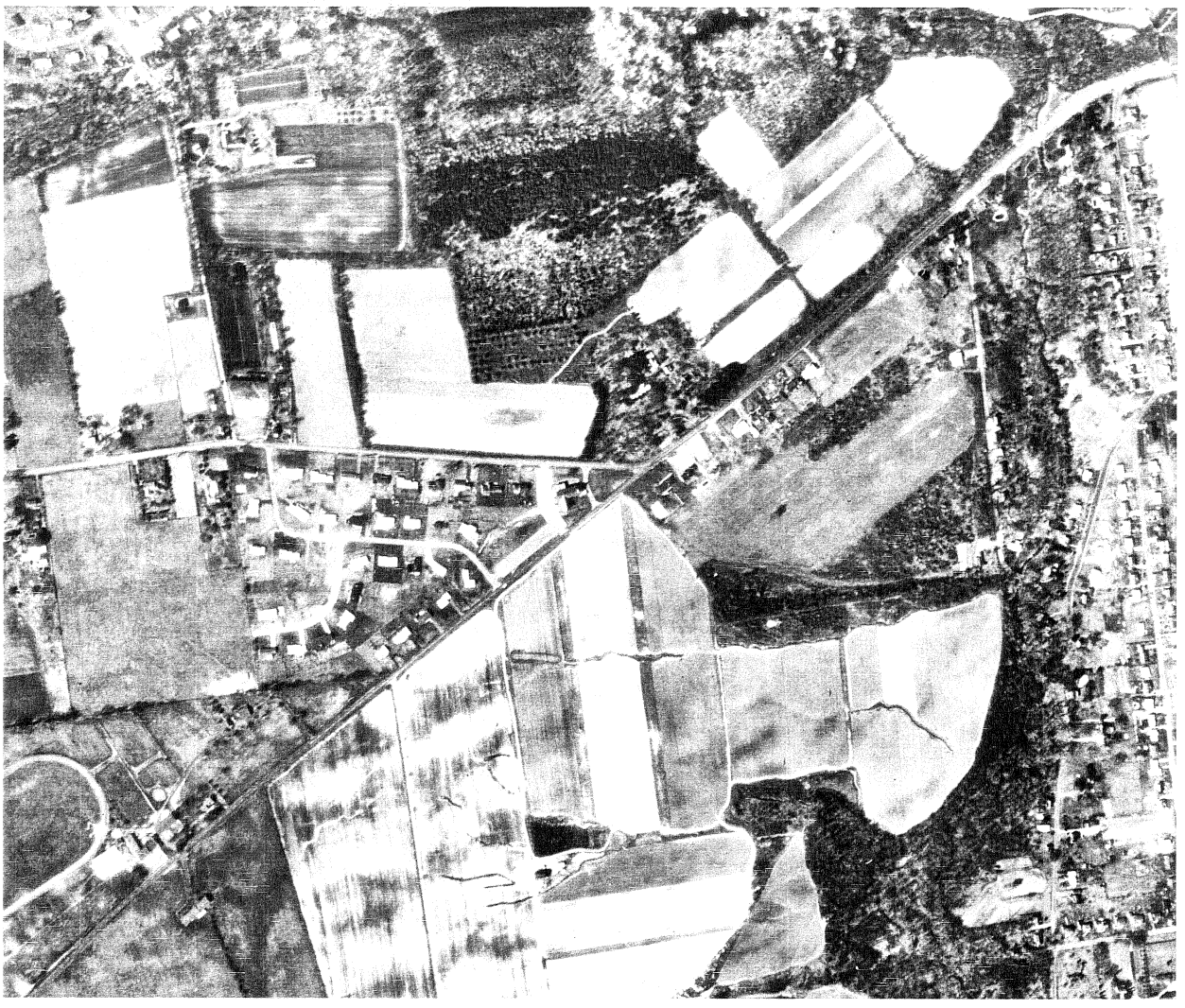
The development of the Buck and Brock Creek watershed in Lower Makefield Township and Yardley Borough was analyzed to illustrate how development has altered the landscape in Yardley. Development patterns in the central portion of the Neshaminy Creek watershed encompassing Newtown and Northampton townships was analyzed to show how widespread development has become in central Bucks County. Development in this portion of the county has been identified as a cause of flooding along the lower reaches of the Neshaminy Creek.

The Buck and Brock creeks drain the developed portions of Lower Makefield Township and Yardley Borough into the Delaware River. The confluence of these waterways, in Yardley, has commonly been the scene of flood events, including the floods in January and June 1996. Development in Lower Makefield, which is one of the fastest growing communities in Pennsylvania, has severely affected its downstream neighbor. Further, despite its dense development, Yardley continues to grow which may further exacerbate the inability of storm drains to handle runoff from residential areas in the watersheds.

Encompassing a drainage area of more than 150,000 acres, the Neshaminy Creek watershed includes 31 municipalities in Bucks and Montgomery counties. The headwaters of the Neshaminy begin in the rural areas of Upper Bucks County, flow south through areas of recent suburbanization and drain the urban municipalities of Lower Bucks County before emptying into the Delaware River at Neshaminy State Park.

Flooding and stormwater runoff have long been of concern in the Neshaminy Creek watershed. Historically, the watershed was largely rural in character, with relatively few urban features in the upper watershed. Recent suburbanization in central Bucks County has contributed to flood events in lower Bucks County. One area of central Bucks County that has undergone this transition is situated along the banks of the Neshaminy Creek in Newtown and Northampton townships.

Figure 9: Buck and Brock Creek Watersheds, 1965



In 1965, the Buck and Brock Creek watersheds comprised primarily the urbanized portions of Yardley, in addition to the suburban and agricultural mix in Lower Makefield (Figure 9). Early examples of impervious cover consisted primarily of roads and to a minimal extent rooftops. The principal residential areas in 1965 were located in Yardley and to a lesser extent certain portions of Lower Makefield. Land adjacent to the Delaware River and the Pennsylvania Canal was the most heavily developed, however, residential development began to spread into the eastern portions of Lower Makefield. Commercial and industrial developments were sparsely located throughout the Buck and Brock Creek watersheds.

Since the watersheds were still primarily agricultural in nature, the impacts associated with impervious coverage were not prevalent. Flooding in Yardley and Lower Makefield was not exacerbated by impervious coverage-induced runoff. Although an abundance of agricultural lands existed, flooding occurred due to deforestation of this area for agricultural purposes.

Figure 10: Buck and Brock Creek Watersheds, 1995

A stark contrast to the aerial photographs of 1965, the Buck and Brock Creek watersheds in 1995 contain heavily developed residential areas (Figure 10). These developments are situated between both creeks along Newtown-Yardley Road (Route 332) and Langhorne-Yardley Road.

The amount of impervious cover was almost nonexistent in 1965; however, as this photograph shows, the percentage of rooftops, driveways, cul-de-sacs, sidewalks and roads has increased substantially. As a result, flooding along the Buck and Brock creeks and the Pennsylvania Canal has increased in frequency.

Figure 11: Neshaminy Creek at Newtown and Northampton, 1965

In 1965, the land adjacent to the Neshaminy Creek in this area contained little evidence of impervious coverage. Aside from a few scattered farmhouses and the roads leading to them, the amount of rooftops, streets and parking lots was sparse (Figure 11). Agricultural land and forested areas provided the main landscape feature, as was also evident throughout most of the upper Neshaminy Creek watershed.

Flood damage along the Neshaminy Creek occurred as a result of habitation of the floodplain. Many properties impacted by floods were situated within the natural floodplain of the creek. Although this reach has not had a history of flood damage, the developed portions of Newtown Borough on the Newtown Creek, immediately north of this area, have been impacted by flooding induced by impervious coverage. In fact, as a result of a major flood event in 1955 in which portions of Newtown Borough were flooded, the Bucks and Montgomery County Conservation Districts and the Commissioners of Bucks and Montgomery Counties, in cooperation with the U.S. Department of Agriculture proposed the development of a network of ten flood control structures in the entire Neshaminy Creek Basin. To date, eight flood control devices have been constructed.

Figure 12: Neshaminy Creek at Newtown and Northampton, 1995

Wide-scale residential and transportation-related development are characteristic of the area today (Figure 12). No less than six residential developments with hundreds of houses have been constructed along the banks of the Neshaminy in the past 30 years. In addition, the construction of the Newtown Bypass (Route 413) has added acres of impervious highway cover. This development, coupled with the extensive development that has occurred throughout Central Bucks County, has intensified many flood events in the lower portion of the County. Currently, a debate rages between these two sections of Bucks County regarding the proposed construction of the Dark Hollow Dam.

The impervious coverage most commonly found between Newtown and Northampton is in the form of streets, rooftops and cul-de-sacs. During heavy rains, the drainage ways that lead from the residential developments to the creek are often inundated with runoff, which causes creek levels to quickly rise and increases the velocity of the creek's flow. These impacts all come to a crescendo somewhere downstream.

CHAPTER 5

FLOOD RECOVERY ASSISTANCE PROGRAMS

The Bucks County floods of January and June 1996 resulted in two deaths and caused widespread devastation, millions of dollars in damages, destroying numerous homes and businesses. In response to the overwhelming needs of Lower Bucks County's residents, a variety of post flood recovery efforts were undertaken. Federal, state, local and nonprofit agencies established assistance centers and set in motion the process to financially assist county residents with the recovery effort (Appendix A).

NATIONAL FLOOD INSURANCE PROGRAM

Federal flood insurance was first made available in 1968 through the enactment of the National Flood Insurance Act. Prior to this program, affordable private flood insurance was generally not available. Under the National Flood Insurance Program (NFIP), federally subsidized flood insurance is made available to owners of flood-prone property in participating communities. Coverage is available both for the structure (up to $185,000 for a single family home) and its contents (up to $60,000).

The purpose of flood insurance is to enable individuals and state and local governments to purchase insurance against losses from physical damage or the loss of buildings and their contents caused by floods or flood-related erosion. As part of the NFIP, Flood Insurance Rate Maps (FIRM) are provided by FEMA and contain information concerning the elevation of flooding during a 100-year flood event. Flood insurance is available for all structures in a participating community whether the structures are in or out of the floodplain. This coverage is also available to manufactured homes that are anchored to permanent foundations.

Flood insurance is provided at a reasonable rate, backed by the federal government to participating communities and is administered by the Federal Insurance Administration (FIA). Communities participating in the NFIP are required to adopt certain minimum floodplain standards, including restrictions on new development in the floodway, elevation standards and subdivision regulations that minimize exposure to flood hazards. Since these activities can have a great impact on the insurance premium base, flood damages, flood insurance claims and federal disaster assistance payments, the FIA implemented the Community Rating System (CRS).

The CRS rewards those communities, through lower insurance rates (a reduction of up to 45% is possible), that are doing more than the minimum NFIP requirements to prevent or reduce flood losses. The system provides an incentive for communities to initiate new flood protection activities. Any community within full compliance with the rules and regulations of the NFIP may apply for a CRS classification. The CRS identifies creditable activities under four categories: public information, mapping and regulations, flood damage reduction and preparedness. The CRS assigns points to a community based upon how well an activity advances the goals of the CRS. As of July 1996, the NFIP revised its CRS planning credit criteria to reflect the extent to which a community followed a proper planning process comprising ten steps:

organization, public participation, coordination, hazard assessment, problem assessment, goal setting, review alternatives, preparation of action plan, adoption of plan and implementation, evaluation and revision of the plan.

Although participation in the NFIP is voluntary, strong incentives exist. The 1973 Flood Disaster Protection Act mandated flood insurance for all federally backed mortgages, such as VA and FHA mortgages and loans and mortgages obtained through federally insured and regulated financial institutions. Further, disaster assistance grants are not available to local governments not participating in the NFIP. Community participation in the NFIP has been high, with approximately 19,000 municipalities participating nationwide (as of 1995).

Table 8: National Flood Insurance Program Claim Report for Bucks County (January 1996 flood)

Municipality	# of Claims	Building Payment	Contents Payment
Bridgeton Township	17	$189,825	$34,762
Bristol Township	6	$11,919	$0
Falls Township	8	$21,965	$0
Lower Makefield Township	10	$67,401	$4,888
Middletown Township	19	$118,168	$35,386
Upper Makefield Township	29	$776,138	$197,265
Yardley Borough	52	$745,712	$63,903
TOTAL	**141**	**$1,931,128**	**$336,204**

Source: Federal Emergency Management Agency.

After the January 1996 ice-induced floods in Bucks County, 141 separate loss claim were filed under the NFIP (Table 8). More than $1.9 million was paid on building or structural claims and approximately $336,000 was paid on claims for damaged contents. A majority of the claims filed originated from those communities located along the Delaware River such as Bridgeton, Lower Makefield and Upper Makefield townships and in Yardley Borough.

A significant element of the NFIP is Section 1362, the Flooded Properties Purchase Program. Under this program, FEMA offers to buy out owners of damaged property by paying the difference between the fair market value of the property (structure and land) and the allowable insurance claim. The community must agree to participate in the program, must be willing to accept the land and must prepare a plan for its use which ensures that it will never be developed in the future. Eligible properties must have federal flood insurance and must meet one of several damage criteria such as severity or frequency of damage.

In addition to the NFIP, the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act provided greater emphasis and financial support for mitigation activities. Under the Stafford Act, two major forms of disaster assistance are available through FEMA: Individual and Family Grants (IFG) and public assistance.

FEMA's IFG program provides grants up to $10,000 to individuals and families to cover disaster-related expenses like home repairs not covered by insurance and personal belongings. The public assistance component of the program provides grants to states and municipalities, generally at a 75%-25% federal cost share, to cover the cost of damages to public facilities. Eligible projects include repair and replacement of roads, bridges, sewer and water systems and recreational facilities. Communities not participating in the NFIP are not eligible for public assistance funds.

The Stafford Act's Hazard Mitigation Grants Program (HMGP) provides federal matching funds (up to 75% for FEMA-approved projects) for state and local projects that identify and implement measures to reduce the severity of floods. The grants administered under the HMGP are linked to disaster declarations and are limited to 10% of the federal share of the public assistance funds made available.

AMERICAN RED CROSS

The American Red Cross was instrumental in the immediate post-flood recovery efforts for both the January and June 1996 floods in Bucks County. Red Cross chapters from Levittown and Philadelphia delivered a variety of post disaster services to the residents of Bucks County. A temporary assistance center was established in the Bristol Township Municipal Center in response to the June 12, 1996 flood event, while an assistance center was established in Yardley Borough after the January 19, 1996 ice-induced flood.

Individual and family assistance, which was administered by the Red Cross, included help with groceries, clothes, rent, emergency home repairs, transportation, household items, tools and medicines. The Red Cross also helped those needing long-term recovery assistance by providing longer-term shelter and food for those displaced by the floods. The physical and emotional needs of those affected by the floods tended to be met through the Red Cross' first aid, health and mental health assistance service. The Red Cross also assisted in paying for certain medical needs such as prescriptions, medical supplies and emergency medical treatment. The Red Cross offered information and helped to educate residents on the emotional impacts and how to cope with the flood disaster.

According to the Philadelphia Chapter of the American Red Cross, 105 people used the Red Cross for assistance in response to the January 1996 flood event and 55 families totaling 210 people came to the Red Cross for assistance after the June 1996 event.

SMALL BUSINESS ADMINISTRATION

The Small Business Administration (SBA) provides disaster loans for nonfarm, private sector disaster losses. SBA disaster loans are a critical component of post disaster economic

stimulation, helping to entice employment and stabilize tax bases. Disaster loans from SBA assist homeowners, renters, businesses of all sizes and nonprofit organizations to fund rebuilding. This is the only SBA program that provides funding for entities other than small businesses.

By providing disaster assistance in the form of loans which are repaid to the U.S. Treasury, the SBA disaster loan program helps reduce Federal disaster costs compared to other forms of assistance, such as grants. Repairs to uninsured damages are affordable due to the low interest rates (approximately 4%) and long terms available (up to 30 years). By providing assistance in the form of loans rather than grants, the SBA avoids creating an incentive for property owners to underinsure against risk. The appropriate flood insurance is required to obtain disaster loan funds, thereby reducing the need for future assistance.

Three types of disaster loans are authorized by the SBA. Home Disaster Loans are available to homeowners or renters to repair or replace disaster damages to primary residence real estate (up to $200,000) or personal property (up to $40,000). Business Physical Disaster Loans (up to $1.5 million) are a primary source of funding to repair or replace disaster damages owned by the business including real estate, machinery and equipment, inventory and supplies. Businesses and nonprofit organizations of any size are eligible. Economic Injury Disaster Loans provide working capital (up to $1.5 million) until normal operations resume after a disaster. This assistance is available only to those businesses with no credit available elsewhere - if the business and its owners cannot provide for their own recovery from non-government sources. Economic Injury Disaster Loans are restricted to small businesses.

The SBA was an integral component to the recovery efforts after both the January and June 1996 floods in Bucks County. Flooding in January necessitated the approval of 105 loans totaling more than $1.5 million by the SBA, 73% of which went towards home repairs (Table 9). In June, SBA approved 252 loans for $7.2 million, 64% of which went toward home repairs (Table 10).

Table 9: SBA Disaster Loans in Bucks County (January 1996 flood)

Type of Loan	Number of Loans	Amount ($)
Home Disaster Loans	81	$1,101,500
Business Physical Disaster Loans	14	$254,500
Economic Injury Disaster Loans	10	$147,500
Total	**105**	**$1,503,500**

Source: Small Business Administration (Dallas, TX).

Table 10: SBA Disaster Loans in Bucks County (June 1996 flood)

Type of Loan	Number of Loans	Amount ($)
Home Disaster Loans	230	$4,617,800
Business Physical Disaster Loans	16	$2,329,300
Economic Injury Disaster Loans	6	$278,700
Total	**252**	**$7,225,800**

Source: Small Business Administration (Niagara Falls, NY).

PENNSYLVANIA EMERGENCY MANAGEMENT AGENCY

In 1978, the Pennsylvania Emergency Management Services Code (Act 323) established the Pennsylvania Emergency Management Agency (PEMA) to oversee civil defense and disaster preparedness, operations and recovery. PEMA ensures that state and county emergency management operations and plans are in compliance with federal and state regulations. In a partnership with the Federal Emergency Management Agency (FEMA), PEMA supervises state government disaster recovery activities when federal aid is authorized under a Presidential disaster or emergency declaration.

PEMA has a variety of roles and responsibilities related to disaster recovery and mitigation including:

- Coordination of a statewide emergency management program including assistance in development of county and local organizations;
- Maintenance and operation of facilities required for effective direction and control of state, county and local emergency efforts;
- Development of emergency operations plan and procedures for state, county and local emergency management forces regarding the mitigation of and recovery from natural disasters;
- Supply state, county and local agencies and officials and the general public with precautionary notices, watches and warnings relating to actual and potential disasters and to provide a flow of official information and instructions to the general public before, during and after an emergency;
- Training of state, county and local personnel in the principles, techniques, and skills of emergency operations; and
- Administration of several federal aid programs for emergency management and disaster relief.

As a result of the flooding in January 1996, Bucks County was declared a major disaster zone by federal officials and funds and resources for the recovery effort were allocated in a timely fashion. PEMA authorized almost $80,000 to Bucks County municipalities for a variety of recovery measures under FEMA's Public Assistance Program. The federal government, through FEMA, paid more than $295,000 to flood-ravaged municipalities in Bucks County. The request

by many Bucks County communities for state and federal public disaster assistance after the June 1996 floods was not approved since the June flood was not as widespread and Bucks County was not designated a major federal disaster zone.

CHAPTER 6

REGULATION OF FLOODPLAIN DEVELOPMENT

The primary nonstructural means of limiting flood damage is to prohibit development within flood prone areas or to require development in the floodplain to adhere to certain guidelines to limit flood dangers. A host of guidelines and standards exist at the federal, state and local levels, but the most potent measures are local zoning and subdivision ordinances. Local floodplain regulations are required by federal and state legislation to comply with at least the minimum standards set forth at the federal and state levels. In fact, property owners may purchase flood insurance only if the municipality within which the property is located participates in the NFIP. This means that the community must adopt and enforce local land development regulations which at least minimally meet the NFIP requirements.

PENNSYLVANIA FLOOD PLAIN MANAGEMENT ACT

The Pennsylvania Flood Plain Management Act of 1978 (Act 166) gives the Department of Community and Economic Development (DCED), formerly known as the Department of Community Affairs, responsibility of administering 166 to the Commonwealth's municipalities. The policies and purpose of Act 166 include:

- Encouraging planning and development in floodplains which are consistent with sound land use practices;
- Protecting people and property in floodplains from the dangers and damage of floodwaters and from materials carried by such dangers;
- Authorizing a comprehensive and coordinated program of floodplain management, based upon the NFIP, designed to preserve and restore streams and floodplains;
- Assisting municipalities in qualifying for the NFIP;
- Providing for and encouraging local administration and management of floodplains; and
- Minimizing the expenditure of public and private funds for flood control projects and for relief, rescue and recovery efforts.

Under the administration of the DCED, municipalities identified by the Federal Insurance Administration (FIA) as having flood prone areas are required to participate in the NFIP. Flood prone municipalities are required to incorporate ordinance elements which meet DCED standards regarding "development which may endanger human life" (DCED Regulations Section 38.7) and "special permit activities" (DCED Regulations Section 38.6). Expenses relating to the preparation, enactment, administration and enforcement needed to comply with the NFIP and Act 166 are reimbursed to these municipalities.

Act 166 gives limited control of floodplain development to the state, however the authority to regulate floodplain development resides at the municipal level. Act 166 was crafted to promote and enhance the local regulatory role while minimizing the role of the Commonwealth.

DRBC FLOODPLAIN REGULATIONS

The Delaware River Basin Commission (DRBC) is an interstate body that joins the federal government with Delaware, New Jersey, New York and Pennsylvania in river basin planning and regulations. DRBC programs include flood control, regulatory review, water quality and supply issues, regional planning, drought management and recreation.

In 1976, the flood plain regulations for the non-tidal portions of the Delaware River and its tributaries were adopted by the DRBC. These floodplain standards were designed as minimum compliance measures to be followed by local governments in instituting their floodplain regulation ordinances. One important DRBC regulation states: "Any project substantially encroaching upon the 100-year flood plain of the Delaware River or its tributaries shall not conflict with standards of flood plain use as approved by the Commission to safeguard the public health, safety and property, or standards of water quality. Neither shall such project conflict with applicable flood plain zoning ordinances or other land use regulations duly established by state or local government agencies."

A variety of uses are prohibited in the floodway including structures for human or animal occupancy; depositing solid waste, spoil, or fill; and storage or disposal of hazardous materials. Within the floodway, the DRBC permits uses such as agriculture, industrial/commercial (e.g. loading areas, parking lots and airport landing strips), recreational uses, lawns and gardens. Generally, most uses are permitted within the flood fringe area provide they are floodproofed at least one foot above the 100-year flood elevation. According to the standards, a residential dwelling can be located within the flood fringe only if the first floor is above the 100-year flood elevation. In practice, the DRBC applies its floodplain regulations to specific classes of projects subject to review including one or more structures covering a total land area in excess of 50,000 square feet, projects in excess of 25 units and development of land within the floodplain to mine, manufacture, process or store potentially hazardous materials.

A structure which was lawful before the adoption of the DRBC flood plain regulations, but which is currently not in conformity is subject to a variety of conditions. The structure may not be expanded, except to incorporate flood proofing measures that do not raise the level of the 100-year flood. A non-conforming structure in the floodway which is destroyed or damaged to the extent of 50% or more of its current market value, may not be restored or improved. The DRBC does not review subdivisions or individual dwelling units.

LOCAL FLOODPLAIN DEVELOPMENT REGULATIONS

In Pennsylvania, local governments make their own land use decisions and therefore have the direct responsibility for floodplain management. These decisions generally reflect a balance between the need for economic development against the safety risk to the public. However, in the case of development in flood prone areas, the ideal balance does not always occur. Constant changes to hydrology coupled with outdated and/or inaccurate FIRM maps may provide decision makers with incorrect data upon which land use decisions are made.

Human uses of land increase flood risks in two ways. First, the filling of wetlands, dredging or channelization of rivers and urban development anywhere in a watershed increase the velocity

and force with which rainfall flows across the land and into creeks and rivers. Second, the intensive use of floodplains for agriculture, transportation and residential development exposes more property to damage from flooding.

Municipal regulations in the floodplain and its environs serve a variety of purposes. First, they regulate uses, activities and development in and around the floodplain which may contribute to increases in flood heights, velocities and frequencies. Second, the regulations restrict certain uses and activities from locating in areas subject to flooding. Third, the regulations require those uses and activities that do occur in flood prone areas to be protected against flooding and flood damage. Fourth, they protect individuals from buying lands and structures which may be unsuited for their intended purposes because of potential flood hazards.

Municipal Regulations in Bucks County

In 1993, the Bucks County Planning Commission undertook an assessment of the implementation strategies outlined in the County's Natural Resources Plan. This analysis focused upon the extent of municipal implementation regarding a variety of elements including floodplain regulation. Municipal surveys conducted as a part of the County's assessment revealed that 94% of those municipalities located within Sub-Basin 2 have ordinance language (zoning, subdivision/land development, or stand alone ordinances) that regulates development within the 100-year floodplain. Within the flood fringe area, which includes lands adjacent to the floodplain, development is limited by only 36% of the Sub-Basin communities. Floodplain mapping is provided by 46% of these municipalities. Every Sub-Basin 2 community has filed a Floodplain Emergency Plan with the Bucks County Emergency Management Agency.

Table 11: Floodplain Regulations by Municipality (Sub-Basin 2)

Municipality	Regulate Development in 100-year Floodplain	Limit Development in 100-year Flood Fringe	Floodplain Mapping	Floodplain Emergency Plan**
Bedminster Twp.	X	X	X	X
Bensalem Twp.	X		X	X
Bridgeton Twp.	X		X	X
Bristol Bor.	X	X	X	X
Bristol Twp.	X	X		X
Buckingham Twp.	X	X	X	X
Chalfont Bor.	X	X		X
Doylestown Bor.	X			X
Doylestown Twp.	X	X	X	X
Dublin Bor.				X
Durham Twp.	X	X		X
East Rockhill Twp.	X		X	X
Falls Twp.	X			X
Haycock Twp.	X			X
Hilltown Twp.	X		X	X
Hulmeville Bor.	X	X		X
Ivyland Bor.	X			X
Langhorne Bor.	X		X	X
Langhorne Manor Bor.	X			X
L. Makefield Twp.	X			X
L. Southampton Twp.	X			X
Middletown Twp.	X		X	X
Milford Twp.	X			X
Morrisville Bor.	X	X		X
New Britain Bor.	X	X		X
New Britain Twp.	X		X	X
New Hope Bor.	X			X
Newtown Bor.	X		X	X
Newtown Twp.	X		X	X
Nockamixon Twp.	X			X
Northampton Twp.	X		X	X
Penndel Bor.				X
Plumstead Twp.	X	X	X	X
Quakertown Bor.	X	X	X	X
Richland Twp.	X			X
Richlandtown Bor.				X
Riegelsville Bor.	X	X	X	X
Solebury Twp.	X	X	X	X
Springfield Twp.	X			X
Tinicum Twp.	X	X*	X	X
Trumbauersville Bor.	X			X
Tullytown Bor.	X	X	X	X
U. Makefield Twp.	X		X	X
U. Southampton Twp.	X		X	X
Warminster Twp.	X			X
Warrington Twp.	X			X
Warwick Twp.	X	X	X	X
West Rockhill Twp.	X	X	X	X
Wrightstown Twp.	X		X	X
Yardley Bor.	X	X	X	X

*maximum intrusion into flood fringe is 10% of first 10 acres of any lot and 5% of all acres in excess of 10 acres.
**kept on file with Bucks County Emergency Management Agency.
Source: Bucks County Planning Commission.

The following section provides an overview of a selective sample of municipalities within Sub-Basin 2 that have zoning or subdivision/land development ordinances that address floodplain development regulations. These municipalities provide a cross-section of rural, suburban and urban development and the associated flooding regulatory provisions.

Bensalem Township

In Bensalem Township, "no structure shall be located, relocated, constructed, reconstructed, enlarged, substantially improved, or structurally altered within the floodplain (Section 303)." The Township's Zoning Ordinance regulates this development in order to prevent loss, ensure safety, protect commerce and prevent necessary expenditures of public funds due to flooding. The floodplain areas in Bensalem are considered an overlay zone and serve to supplement existing zoning provisions. When conflicts arise, the most restrictive zoning codes shall apply, however, floodplain requirements must always be met.

Within the Bensalem Township floodplains a variety of uses are permitted: agriculture, public and private recreation not requiring permanent or temporary structures, docks, piers, wharfs, bridges and yards. In accordance with the DCED and Act 166, the Township prohibits hospitals, nursing homes, jails and mobile homes within the floodplain. For those structures or uses existing within the floodplain, the Zoning Ordinance prohibits any expansion. However, the Township's Zoning Hearing Board may consider granting a variance based on a number of criteria including: potential effects of any proposed expansion or enlargement on flood heights is fully offset by accompanying improvements; any modifications shall not exceed 50% of the structures' market value; the lowest floor (including basement) must be elevated to at least 1.5 feet above the 100-year flood elevation; and any improvements must be dry floodproofed. The Zoning Hearing Board will not grant a variance that would cause any increase in the 100-year flood elevation.

A series of floodplain maps, created in 1977 and 1978, delineate those areas within the 100-year floodplain. Flood Hazard Maps are provided for Bensalem lands adjacent to the Delaware River and the Mill, Neshaminy and Poquessing creeks. The Zoning Ordinance of Bensalem does not contain language that relates to potential development within the flood fringe area.

Bridgeton Township

Unlike most municipal floodplain regulations reviewed for this report, the Zoning Ordinance of Bridgeton Township utilizes the location and extent of alluvial soils in conjunction with federal flood maps to identify potential flood hazard areas. Bridgeton uses the FEMA maps to delineate the location of the 100-year flood elevation, however soil maps from the Bucks County Soil Survey (from the U.S. Department of Agriculture) serve to identify Alluvial Soil Areas. The areas delineated as Alluvial Soils which are not found in a segment of waterway or drainageway that is a part of the 100-year floodplain, are regulated as being within the 100-year floodplain for purposes of regulating any proposed structure that may inhibit floodwaters or increase fill within the floodplain.

Floodplains in Bridgeton Township are recognized as overlay zones that supplement the general zoning district regulations. Permitted uses are nature preserves and publicly-owned recreation,

golf courses, picnic grounds, boat launches, swimming areas, trails, pervious parking areas, yards, crop farming, plant nurseries and necessary utilities. By specifically mentioning pervious parking areas, which are those areas that allow stormwater to infiltrate the ground rather than running off, Bridgeton recognizes the important effect that limiting the amount of impervious coverage can have in decreasing the probability of runoff-induced flooding.

In the flood fringe area, which is the area adjacent to the 100-year floodplain, Bridgeton Township prohibits the construction of any new principal buildings. Any other buildings that may be permitted within the flood fringe zone must be fully floodproofed.

Bristol Township

The Subdivision and Land Development Ordinance of Bristol Township describes one of its general intents as to "secure safety from, fire, flood and other disturbances." The ordinance requires a map depicting the proposed location of development in relation to the floodplain and must include 100-year flood elevations, floodplain boundaries, proposed lots and sites, fills, flood or erosion protection facilities, along with any special deed restrictions. If a proposed development is to be located partially or completely within the floodplain, the plan map must include the structural and nonstructural techniques to be utilized to avoid flood damages, such as elevation of roads and structures and siting of utilities. Bristol Township's ordinance describes the types of storm drainage systems to be utilized within the township. These include catch basins, detention basins, silt traps and the design of cartways to minimize runoff. The ordinance states that only ditches and other open drainageways that can be both planted and mowed effectively are permitted. Further, Bristol Township desires that runoff generated from impervious surfaces not overflow onto adjacent lands.

The Zoning Ordinance of Bristol Township contains an extensive section concerning land uses and floodplain zones. Bristol's floodplain districts are based upon the 100-year flood delineations conducted in the township in 1978 and are overlays to the Official Zoning Map. Floodplain districts comprise three areas: floodway district, flood fringe district and approximated floodplain district. Within each area, certain land uses are either permitted or prohibited. For example, the floodway district is the area of the floodplain that must be capable of carrying the waters of the 100-year flood without increasing the floodwater elevation more than one foot. Agriculture, recreation and accessory residential uses, such as yards and gardens, are permitted land uses in the floodway district. Conditional uses, such as utilities, docks and storage of certain materials and equipment, may be permitted in the floodway district with approval by the Township Board of Commissioners. In the floodway district the following uses are prohibited: hospitals, jails, nursing homes, mobile home parks and subdivisions and production or storage of potentially hazardous or radioactive materials.

The Zoning Ordinance also contains requirements for structures to be constructed in the floodplain district. In the floodfringe district, structures must be elevated or designed to remain dry up to at least 1½ feet above the level of the 100-year flood. Moreover, Bristol Township requires that these structures employ the dry flood proofing standards set forth by the U.S. Army Corps of Engineers.

Middletown Township

The Natural Resource Protection and Open Space Standards contained in Middletown Township's Zoning Ordinance serve to regulate and protect that natural resource value of floodplains and floodplain soils. The 100-year floodplain is used to delineate potential flooded areas. Where the 100-year floodplain has not been delineated, floodplain soils must be used to establish the floodplain. Middletown Township does not limit development within the flood fringe area.

Land uses permitted within the Middletown Township floodplain are agriculture, forestry, gardening and nurseries, parks, outlets for public and private sewage treatment plants, utility easements, water intakes and quarrying. These uses, if located within the floodway portion of the floodplain, must offset potential increases to flood heights through accompanying stream improvements. Activities prohibited within the floodplain include hospitals, nursing homes, jails and manufactured homes.

In addition to permitted floodplain land uses, Middletown may also permit reclamation of land from the floodplain for inclusion in lot area or base site area. The Zoning Ordinance states: "Land within a tract or site may be reclaimed from the floodplain classification by means of reducing area drained through diversion of surface run-off, retention and controlled release of run-off water, expansion of storage capacity of existing floodways, channel relocation of streams in drainageways, grading, terracing, placement of fill where permitted or other accepted and sound site improvement techniques." Floodplain reclamation is permitted provided that the rate of runoff and erosion are not increased, the frequency and extent of flooding are not increased and the proposed changes do not effect the riparian rights of landowners downstream.

Yardley Borough

The Zoning Code of Yardley Borough contains floodplain performance standards that serve to prevent community loss and impairment as a result of flooding. A disclaimer within the Code warns that large floods may occur on rare occasions and that flood heights may be increased by man-made or natural causes, such as ice jams and bridge openings restricted by debris. The Code further notes that lands outside the floodplain district may not be free from flooding or flood damage.

As in other Bucks County municipalities, the floodplains of Yardley are treated as an overlay to the underlying zoning districts. Land uses permitted in the floodplain consist of agriculture, public and private recreation, yards, gardens, pervious parking and loading areas and airport landing strips. Special exceptions are needed for utilities, streets, bridges and railroads. Land uses specifically prohibited include hospitals, nursing homes, jails and mobile or manufactured homes.

In addition to floodplain regulation, the Zoning Code of Yardley Borough regulates land uses along the Delaware Canal State Park. The purpose of the Canal Enhancement Area is to preserve the natural, scenic and historical values of the canal environment. Components of the Canal Enhancement Area include the towpath, canal and all state-owned adjacent lands, aqueducts and drainage channels. The following uses are not permitted in the Canal Enhancement Area: drive-

through facilities, car wash, vehicle service station, body shop, or repair garage, vehicle sales or repair, adult entertainment or bookstore, junkyards and solid waste disposal or transfer facilities, including recycling centers.

The Canal Area is also regulated by a variety of lot and setback regulations such as requiring a 60 foot setback from the center line of the canal for all new principal buildings. Lot and setback regulations in Yardley Borough also apply to minor surface waters such as Brock and Silver Creeks. The Code requires that no building, off-street parking, or storage area be located within 50 feet of the center line of these minor surface waters.

In addition to land use and subdivision regulations, building construction and property maintenance codes can be an effective municipal floodplain management tool. These codes are used to establish minimum standards for safety regarding life, health and property. The codes' effectiveness rely upon coordination with zoning ordinances and other municipal development regulations. The building code functions to regulate new construction, in addition to expansions, alterations or repairs to existing structures. Within floodprone areas, building codes regulate structural elevations, materials, drainage and flood control devices.

The five municipalities analyzed all have somewhat similar zoning or land development ordinances concerning floodplain development. All contain language specific to what uses are permitted and prohibited within the 100-year floodplain, and most permitted and prohibited uses are universal in these five communities. However, there are differences. Bridgeton has identified Alluvial Soil Areas, which are located adjacent to the FEMA-identified 100-year floodplain. These areas are incorporated into the 100-year floodplain and are regulated as such. Bristol Township has identified a flood fringe district, adjacent to the 100-year flood, which is regulated by specific design and elevation requirements. Floodplain performance standards are an integral component to Yardley's zoning code, as they require that specific standards be met in order to occupy the floodplain.

This analysis revealed that the 100-year floodplain is used as an overlay to existing zoning provisions. Generally, development is permitted within the floodplain provided that there is no increase to the 100-year flood. A more stringent approach may be necessary to ensure that the cycle of build-flood-rebuild is broken. Regulations and their subsequent enforcement can be crafted to allow for floodplain development conditioned upon the total floodproofing of the structures. Other flood mitigation techniques may be incorporated into local regulations that may allow municipalities to focus energy and funds elsewhere rather than on post-flood rescue and recovery.

CHAPTER 7

FLOOD MITIGATION MEASURES

Historically, the Army Corps of Engineers, the Commonwealth of Pennsylvania and Bucks County have tried to curb escalating flood damages by constructing dams, levees and floodwalls, or by enlarging or straightening stream channels. Although these flood control structures generally lessened the damage to existing floodplain development, they also resulted in more extensive development occurring within the floodplain. The potential for damage was increased as more people located within the floodplain.

There are two ways to mitigate flooding: structural and nonstructural measures. Structural measures involve controlling floodwaters and include levees, floodwalls, dams, channels, stormwater drainage systems and other public works that manage stormwater runoff. Structural approaches have been widely used throughout Bucks County. Examples include a series of flood control dams along the Neshaminy Creek, a levee along the Delaware River in Morrisville Borough and widespread stormwater control systems in the urbanized portion of the county.

Nonstructural measures are comprised of two components: those that modify the flood prone property; and those strategies that persuade people not to build in areas that are likely to be flooded. These include zoning and planning, tax incentives, flood insurance programs, acquisition and relocation of structures and stream corridor restoration.

STRUCTURAL MEASURES

Levees

Levees are raised mounds of earth that are usually constructed parallel to the waterway. They are constructed of compacted fill and depending upon the suitability of local soil, may be one of the least expensive flood proofing measures. These embankments serve to keep rising flood waters from overflowing by being constructed higher than the highest flooding level. In shallow flooding areas a small levee, called a berm is commonly constructed.

Levees get their strength from their mass. A typical levee has three horizontal feet from the center point for each vertical foot, so at least six feet of ground is needed for each foot in height. Levees have the advantage of being compatible with the surrounding landscape since they are easy to shape. Grasses and other light vegetation are generally planted on an earthen levee to prevent erosion and provide esthetic enhancement.

The National Flood Proofing Committee of the U.S. Army Corps of Engineers holds that although levees may be economically and aesthetically attractive, they have a number of drawbacks that may make them impractical for many flood proofing situations. Levees have the potential to impede the natural flow of water in a floodplain, possibly resulting in increased flooding elsewhere. The pressure of impeded floodwaters may breach the levee sending a great

deal of swiftly moving water into a concentrated area.

An example of a levee in Bucks County is located along the Delaware River in Morrisville Borough. Water elevations in the Delaware River along this reach can vary by as much as 20 feet above low water during times of prolonged rain or melting snow. The levee is 3,960 feet long and is sited from the Calhoun Street Bridge at its northernmost point to the Lower Free Bridge at its southernmost point. Made of earth and stone, the embankment rises more than 16 feet from the base elevation at Williamson Park located west of the levee. Stairways leading to the top of the levee permit pedestrian access along the length of the embankment.

The Morrisville levee was constructed by the Commonwealth of Pennsylvania in 1930 as a result of extensive flooding in the Borough's central area earlier in the century. In 1964, the Borough and the Commonwealth entered into an agreement whereby the levee became the property and responsibility of the Borough. Recently, the levee has begun to yield to the forces of the Delaware River. Cracked concrete, silt accumulation, missing rip rap, soil erosion and vegetation growth have all taken their toll on the levee.

Costs associated with levee or berm construction can vary. Minimal expenses are expected when a homeowner regrades a yard or uses local fill to construct a small berm. Levee costs may range from $20,000 to protect a small amount of property to millions of dollars, depending upon the size, location, complexity of the project and the materials used.

Floodwalls

In some instances there may be insufficient space to provide flood protection by the use of structures such as earthen levees. In these cases, concrete or steel floodwalls may be recommended. Floodwalls differ from levees since they are constructed of stronger materials, are thinner, take less space and generally require less maintenance. Floodwalls require piles to support the weight of the wall and the lateral pressure of the water. The piles function as an interior foundation that allows for wall stability when flood water pressure is applied. The height of the floodwall is usually greater than the structures which they protect.

Site selection for floodwalls is dependant upon the type of flooding expected at that location. Fast moving flood waters create a tremendous pressure against the floodwall and can erode and undermine the floodwall at its footing causing a failure.

Floodwalls are often constructed along road sides and around residential neighborhoods. Though they serve a protective and practical purpose, floodwalls have been used to aesthetically enhance neighborhoods. Various surface finishes and illustrative images are used to provide a decorative appearance.

Floodwall expenses estimated by the Corps' National Flood Proofing Committee may range from $20,000 to millions of dollars, depending upon the size and complexity of the structure and the materials used.

Flood Gates

The design of levees and floodwalls may contain provisions for crossing the structures by both vehicles and pedestrians. This access is accomplished by leaving openings for sidewalks, roads and driveways. Flood gates, or closures, act to close the openings in levees and floodwalls and prevent flood water from entering. In some cases flood gates are permanently attached to the flood protection structure using hinges so they can remain open when there is no flood threat. They may be portable and slipped into place when a flood threatens.

Flood gates are generally considered a flood control option only if a flooding situation provides sufficient warning time to close or install the gate. All gates are designed to be manually operated, since a loss of power is likely in the case of a severe storm. The Orleans Levee District in Louisiana successfully utilized its flood gates around the New Orleans lakefront during Hurricane Andrew.

Locally, the Pennsylvania Department of Environmental Protection (DEP), Bureau of State Parks operates a series of debris gates along the Delaware Canal towpath. During periods of excessive rain, the gates are opened to allow potential floodwater to flow from the canal, through a stream and into the Delaware River. The debris gates are located along a majority of the canal with a proposal to add an additional gate at the Brock Creek Aqueduct in Yardley Borough.

Dams

Dams are another way of preventing flooding. Dams often have multiple purposes such as water supply, hydroelectric power, recreation and flood control. Dams control the rate at which water flows through them. Flood control dams called impoundment dams hold flood water and release it gradually so as to only allow a certain amount to flow from the dam, thus controlling the potential flooding.

As a result of the severe cycle of flooding in the 1950s, the Bucks and Montgomery County Conservation Districts, the Commissioners from Bucks and Montgomery counties and the U.S. Department of Agriculture's Soil Conservation Service, proposed the creation of a network of ten flood control structures in the Neshaminy Creek Basin. A network of ten dams, eight single-purpose flood control structures and two multi-purpose impoundments were planned. To date, eight of these impoundments have been constructed (Figure 13).

Almost 57 square miles are affected by the Neshaminy Creek flood control structures - primarily in the Lower Mainstem. These communities, Parkland, Hulmeville, Newportville and Croydon, have witnessed reduced levels of runoff due to these devices. According to the Bucks County Planning Commission, the eight structures have reduced flood levels in the lower basin by almost two feet.

Existing Flood Control Structures in the Neshaminy Creek Basin

PA 611: Warrington Dam, completed in 1976, is located on the Little Neshaminy Creek, about 1.5 miles northwest of the intersection of County Line Road and SR 611 in Warrington Township. The maximum height of the dam is 45 feet and the dam contains 2,156 acre-feet of total storage capacity; 182 acre-feet of which is reserved for sediment storage. The maximum floodwater pool is 179 acres with a drainage area of 10.9 acres. Presently, Warrington Dam contains a permanent pool of 26 acres.

PA 612: Robin Run Dam, completed in 1971, is located about 5.5 miles southeast of Doylestown Borough on the Robin Run, between Swamp and Forest Grove Roads in Buckingham Township. The dam has a drainage area of 1.87 square miles, contains 327 acre-feet of storage capacity for floodwater and 99 acre-feet of storage capacity for sediment. The top of dam elevation is at 228.7 feet with a permanent pool of 8 acres and a maximum floodwater pool at 42 acres.

PA 615: This structure is located on the West Branch of the Neshaminy Creek in New Britain Township. The dam is 34 feet high and controls 3.39 square miles of drainage area. While there is no permanent pool, floodwater periodically covers up to 86 acres. This dam provides 714 acre-feet for floodwater storage and 63 acre-feet for sediment storage. The top of dam elevation is 292.2 feet with the maximum water surface elevation at 287.5 feet.

PA 616: Pine Run is a single-purpose flood control dam with a permanent pool of approximately 39 acres (Pine Run Reservoir). The permanent pool can increase its capacity up to 242 acres during maximum flooding periods. The dam, completed in 1974, is located in Doylestown Township and has a total drainage area of 9.89 acres. The dam's sediment storage is 128 acre-feet with floodwater storage at 2,116 acre-feet. The top of dam elevation is at 287.6 feet with the maximum height of the dam at 30 feet.

PA 617: This flood control structure is known as either Lake Galena or Peace Valley Reservoir. It is the largest impoundment in the Neshaminy Creek Basin with a drainage area of 15.8 square miles. The dam's sediment storage capacity is 366 acre-feet and its floodwater capacity of 3,463.1 acre-feet. The dam is located at the confluence of the North Branch of the Neshaminy Creek with the Main Stem of the creek in New Britain Township. Completed in 1974, the permanent pool reservoir is a multi-purpose lake with a normal area of 365 acres and high water area of 482 acres. The dam is the centerpiece of the county's Peace Valley Park and offers important recreational, water supply and flood control benefits. The top of dam elevation is 343 feet with the maximum height of the dam at 67 feet.

PA 620: This dam is known as Lake Luxembourg or Core Creek Dam. It is located on Core Creek about 0.6 miles upstream of the intersection of Core Creek and SR 413 between the Boroughs of Newtown and Langhorne. The drainage area of this multi-purpose structure is 9.57 square miles. The dam has a sediment storage capacity of 260.7 acre-feet and a flood storage capacity of 2,056 acre-feet. The top of dam elevation is 118 feet with the maximum height of the dam at 47 feet. The dam's normal permanent pool is 150 acres and its high water pool at 332 acres. The dam is a major feature in Core Creek Park, a vital county recreational facility.

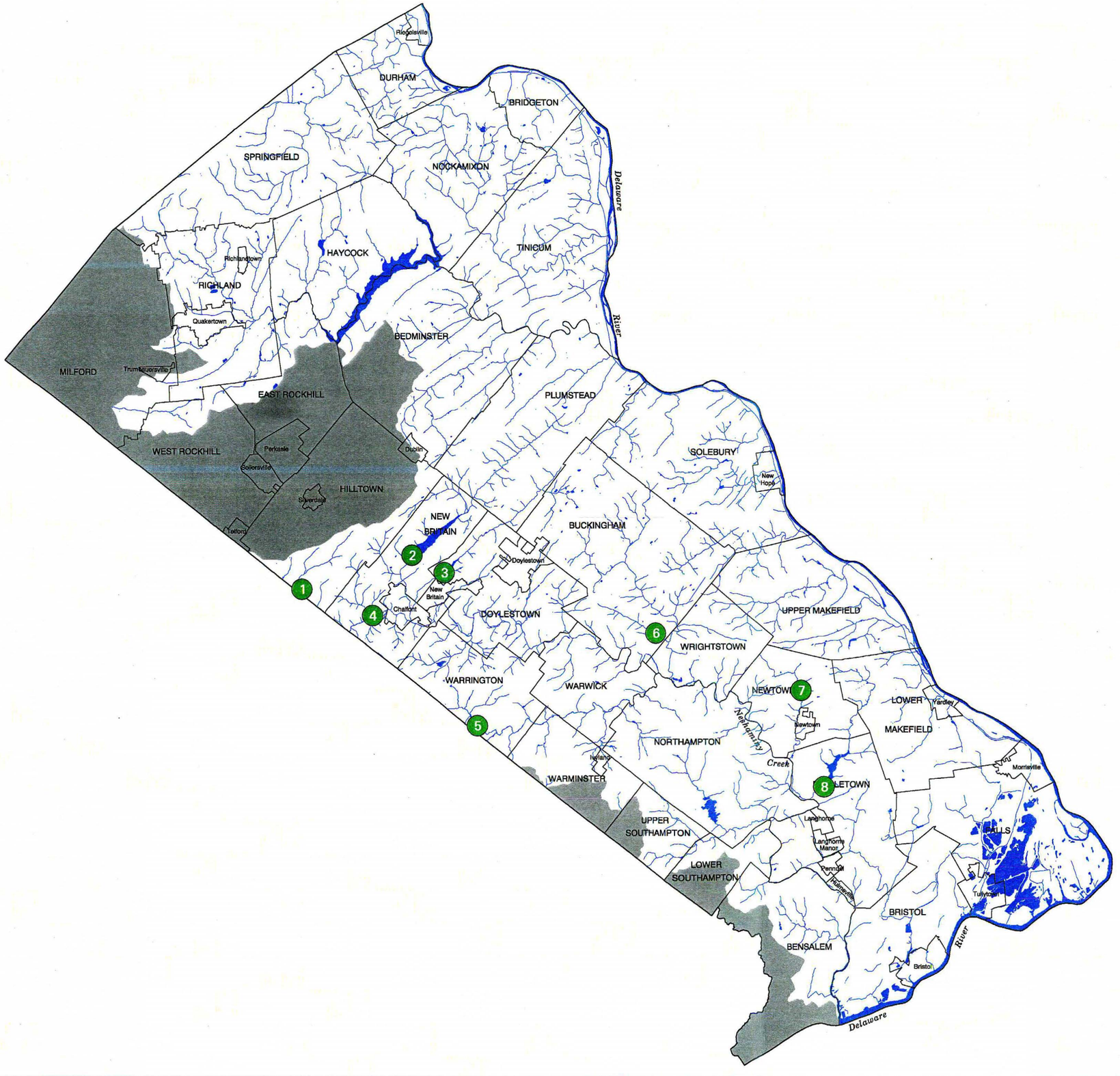
PA 621: This dam is located on Newtown Creek in Newtown Township. The 43-foot high structure controls runoff from 3.04 square miles, provides 679 acre-feet for floodwater storage and allows 69 acre-feet for sediment storage. The dam has a permanent pool of approximately 11 acres, which increases up to a maximum of 82 acres during flood events. The top of dam elevation is at 239.6 feet.

PA 625: This dry dam is located on a tributary of the West Branch of the Neshaminy Creek in Hilltown Township. The structure is 41 feet high and controls the drainage of 2.8 square miles. The dam's flood pool storage provides 508 acre-feet of floodwater storage and 46 acre-feet for sediment storage.

Figure 13.

FLOOD RECOVERY AND MITIGATION STRATEGY BUCKS COUNTY, PA

EXISTING FLOOD CONTROL STRUCTURES



1. West Branch Neshaminy Dry Dam (PA 625)
2. Peace Valley Reservior (PA 617)
3. Pine Run Dam (PA 616)
4. West Branch Neshaminy Dam (PA 615)
5. Warrington Dam (PA 611)
6. Robin Run Dam (PA 612)
7. Newtown Creek Dam (PA 621)
8. Core Creek Dam (PA 620)

Area Outside Study

Source: Bucks County Planning Commission

0 2 4 6 Miles

Delaware Valley Regional Planning Commission
June, 1998

Retention Basins
Retention basins are impoundment areas generally containing a permanent pool of water. They are made by construction and embankment, or the excavation of a pit for the purpose of temporarily storing stormwater. Retained stormwater is held in the basin and slowly released into storm drains or allowed to infiltrate into the ground. Retention basins have historically not kept pace with development in Lower Bucks County, and those communities with retention basins, usually do not have the means to provide consistent maintenance.

Channelization
Channelization is the modification of a waterway channel by straightening, clearing, deepening, widening, or lining with concrete or rip rap. Waterways tend to overflow at river bends, so removing these bends through channelization may reduce local flooding. Channelization functions by speeding the passage of water through a flood prone area.

Along the Delaware Canal, the DEP routinely removes gravel from the canal bed to increase the rate of flow within the canal. The DEP has proposed to begin dredging portions of the canal around Yardley Borough to reduce potential flood hazards.

Ditches and Swales
Ditches and swales are used to control flooding by conveying stormwater runoff from impervious areas to areas designed to hold the water until it can percolate into the ground. In some cases, the ditches and swales can act as retention devices by capturing the runoff and holding it until the water can infiltrate the soil. These controls are gently sloped from the area of imperviousness down to the bottom of the ditch. Generally, ditches and swales are vegetated to further assist with slowing and capturing runoff.

NONSTRUCTURAL MEASURES
Nonstructural methods for dealing with floods are intended to reduce damages from encroaching floodwater by focusing on the condistions at the floodplain property. These include acquiring and/or relocating a structure; elevating a structure; changing existing land use, subdivision regulations and building codes to minimize flood hazards; and preparing emergency plans and measures, such as sandbagging and flood proofing structures. The National Flood Proofing Committee of the U.S. Army Corps of Engineers defines flood proofing as "any combination of changes or adjustments incorporated in the design, construction, or alteration of individual buildings or properties that will reduce flood damages." Unlike a structural approach, the site remains subject to flooding. It is the building or the area adjacent to it that is modified to prevent or minimize flood damage.

Acquisition/Relocation
This is the preferred technique for flood hazard mitigation as it is the most dependable way to floodproof. However, in the short term this can also be the most expensive method for both the property owner and jurisdictional entity. This procedure involves acquiring and relocating flood prone structures outside of the floodplain. Relocating a structure out of the floodplain is appropriate if the structure is in an area where flood hazards are such that continued occupation is unsafe. It is also an option for property owners who want to be free from the damages, fear and

worry associated with flooding. Most acquisition/relocation projects are voluntary agreements between the property owner and a governmental or non-profit entity. Removing structures from the floodplain safeguards they will not be damaged during flood events and eliminates the hazards or risks of flooding to life and property. Removing these structures also reduces the chance of water pollution by removing potentially hazardous material from the floodplain. Another benefit of acquisition and relocation is the creation of open space. Once the structure has been relocated the floodplain is generally preserved as open space or park land.

The Missouri Buyout Program

In 1993 the Midwest was hit by record-breaking floods that caused millions of dollars in damage. Of the nine Midwestern states affected, Missouri was hit hardest by the floods. In fact, Missouri has experienced thirteen presidential flood declarations in the past 25 years. As a result, Missouri initiated the Missouri Buyout Program in 1993. The primary goal of this voluntary program is to alleviate future flood-related problems for both homeowners, emergency managers and taxpayers. This $100 million program is used to demolish flood prone properties due to health and safety reasons. Once the properties are cleared, the publicly-owned land may then be used for open space purposes more consistent with the threat of repeat flooding.

The Missouri Buyout Program was first tested during the May 1995 flood. More than 50% of the 5,500 targeted properties statewide had been purchased in the buyout program since 1993 and therefore, many properties were unaffected by the 1995 flood event. Another example of the effectiveness of the buyout lies at the confluence of the Mississippi and Missouri rivers in St. Charles County, Missouri. The number of potentially occupied parcels of property in the 100-year floodplain purchased under the buyout program in St Charles County stands at 1,374. This includes more than 560 single family residences and three mobile home parks containing over 800 foundation pads. Missouri's State Emergency Management Agency has estimated that the occupancy rate in those parks was 84% at the time of the 1993 flood. Residents in these repeatedly flooded parks were among the neediest from the standpoint of disaster assistance.

The May 1995 rains caused the third worst flood on record in the state. However, 1,000 families, comprising approximately 2,500 people were out of harm's way as a result of the buyout program in St. Charles County alone. The State Emergency Management Agency estimates that at least 95% of the properties bought out since 1993 would have flooded again in the 1995 disaster. These repetitive loss properties have been removed from harm's way and from the federal disaster fund. No additional disaster assistance was granted to these 1,374 properties, no claims will be paid by the National Flood Insurance Program on the buyout properties and the local communities gain open space and recreational lands in perpetuity.

St. Louis County Relocation Grants

In addition to the state-run buyout program, St. Louis County has initiated a relocation program which utilizes funds from Community Development Block Grants (CDBG). The county used the funds to offer special one-time relocation grants in the amount of $5,000 to eligible property-owners in St. Louis County. The goals of the program were to place flood victims into safe and sanitary housing as quickly as possible and to give flood victims the incentive and the capital to move out of the floodplain.

St. Louis County designed specific criteria for the relocation grant program. Eligible applicants had to own and reside in St. Louis County property that had received at least 50% damage or were situated in the designated buyout area. Once eligibility was established, owner-occupants were required to permanently relocate outside the 100-year floodplain, either through the purchase of a new home or by signing a one year rental agreement. Owner-occupants were required to sign a certificate of eligibility and a demolition permit for the flooded property. Owners of seasonal property and empty lots, as well as those owner-occupants who relocated within the 100-year floodplain, were not eligible. The St. Louis County Floodplain Management Program successfully assisted 169 families in relocating, of which 97% relocated outside the 100-year floodplain.

Abington Township Buyout/Relocation

On September 8, 1996, a record deluge inundated residential areas of Abington, Springfield and Upper Moreland townships, Montgomery County, Pennsylvania forcing more than 200 families from their homes and causing millions of dollars in property damage. The Roslyn neighborhood, in Abington Township, was the most affected as 14 homes were damaged when the Sandy Run Creek overflowed. Each home was located in the 100-year floodplain.

As a result of the flood, FEMA approved $1.3 million in hazard mitigation funds to acquire 11 flood prone houses and to elevate another. In addition, the U.S. Department of Housing and Urban Development (HUD) agreed to acquire three more houses. Montgomery County approved a $95,373 grant to assist Abington in purchasing the property. The voluntary program will pay homeowners pre-flood fair-market values. However, those homeowners who do not participate in the relocation program and fail to flood proof their homes, will be ineligible for future FEMA assistance. The flood prone properties will become a park.

Elevation

One structural remedy in flood prone areas involves raising the structure in place so that the lowest floor is above the flood level for which flood proofing protection is needed. This is the best method for protecting a structure from surface flooding, short of removing it from the floodplain. Generally, the structure is jacked up and either a new foundation is built underneath or the structure is placed upon pilings which elevate it above the flood level. This allows floodwaters to flow under the structure causing little or no damage. Many communities have building codes for new and substantially improved structures located in the floodplain that require elevation.

According to the National Flood Proofing Committee of the U.S. Army Corps of Engineers, costs associated with elevating a structure in the floodplain vary between $8,000 to $50,000, depending primarily upon the type of structure.

In 1997, FEMA published a final rule establishing a new flood insurance rate zone, known as the flood control restoration zone or Zone AR, to delineate special flood hazard areas on FIRMs. This new designation covers areas for which a flood protection system is being restored and reduces flood insurance costs and elevation requirements for properties that will be exposed to an increased flood risk during restoration.

Dry/Wet Flood Proofing

Dry flood proofing entails sealing a structure to ensure that floodwaters cannot get inside. All areas below the flood protection level are sealed with waterproofing compounds, impermeable sheeting, or other materials. Openings, such as doors, windows, sewer lines and vents are protected by shields made of sandbags or removable closures to prevent the passage of floodwater. Shields are commonly used when flooding is imminent. The Committee does not recommend dry flood proofing for structures with a crawl space or basement, because these types of buildings are susceptible to underseepage and can be lifted off their foundations. Costs associated with dry flood proofing range from $100 for sandbags to more than $20,000 for greater alterations to the structure design.

A technique commonly employed during dry flood proofing is the use of sandbags. The Orleans Levee District in Louisiana considers the sandbag to be the prime instrument in working to control water in a flooding situation. A sandbag weighs 40 pounds and provides one square foot of surface. The District maintains a reserve of more than 22,000 sandbags.

In some instances, water pressure upon a structure can cause watertight walls and floors to crack, buckle, or break. One alternative to dry flood proofing is to allow the floodwaters to enter the structure while removing or protecting everything that could be damaged. Interior flooding serves to counteract the water forces on the outside of the building, thus reducing the potential for structural damage. This is known as wet flood proofing and is commonly used in basements, garages and accessory buildings. For wet flood proofing to be successful, the property owner must have sufficient warning time to temporarily remove items from the floodable area. This method may not work in areas subject to flash floods. The Committee estimates that in one hour a property owner can accomplish wet flood proofing simply by moving valuables out of the floodable area. Costs can range from general clean-up costs, to $3,000 for relocating a furnace or water heater, to as high as $20,000 to rebuild the floodable area with water-resistant materials and to relocate all utilities.

Flood proofing costs can vary depending upon the structure's condition, the flood proofing technique employed and other site-specific issues such as soil, slope and potential flooding levels (Table 12). The National Flood Proofing Committee of the U.S. Army Corps of Engineers has estimated flood proofing costs for a variety of methods to be used as an initial planning estimate.

Table 12: Estimated Flood Proofing Costs

	Elevation
Wood frame building on piles, posts or piers	$26/square foot
Wood frame building on foundation walls	$19/square foot
Brick building	$32/square foot

These costs include foundation, extending utilities and miscellaneous items, such as sidewalks and driveways. They do not include the cost of fill or landscaping.

Slab-on-grade building	$30/square foot

The unit cost includes foundation, extending utilities and miscellaneous items, such as sidewalks and driveways. It does not include the cost of fill or landscaping. The unit cost is based upon a 2-foot raise. Add $1 per square

foot for each additional foot raise up to eight feet.

Fill (includes hauling and compacting)	$10/cubic yard
Landscaping (no trees, bushes, or flowers)	$5/square yard

Relocation

Moving building	
(complex buildings being moved several miles)	$10/square foot
(simple wood frame building being moved a few hundred feet)	$5/square foot

Additional costs for this measure may include: appropriate elevation cost listed above, fill, lot, landscaping, and relevant indirect costs.

Floodwalls and Levees

Floodwall	
(two feet above ground level)	$77/linear foot
(four feet above ground level)	$113/linear foot
(six feet above ground level)	$160/linear foot
Levee	
(two feet above ground level)	$34/linear foot
(four feet above ground level)	$63/linear foot
(six feet above ground level)	$105 linear foot

Levee costs include landscaping.

Estimated additional costs for floodwalls and levees:

Interior drainage	$3,800 lump sum
Flood gates/closures	$66/square foot
Rip rap	$28/cubic yard
Sidewalk	$9/linear foot
Driveway	
(Asphalt)	$6/square yard
(Concrete)	$16/square yard

Dry Flood Proofing

Sprayed-on-cement (1/8 inch)	$3/square foot
Asphalt (2 coats below grade)	$1/square foot
Periphery drainage	$28/linear foot
Plumbing check valve (6")	$600 lump sum
Pump (submersible sump)	$500 lump sum
Flood shields	
(Metal)	$66/square foot
(Wood)	$21/square foot

Source: U.S. Army Corps of Engineers, National Flood Proofing Committee, 1993.

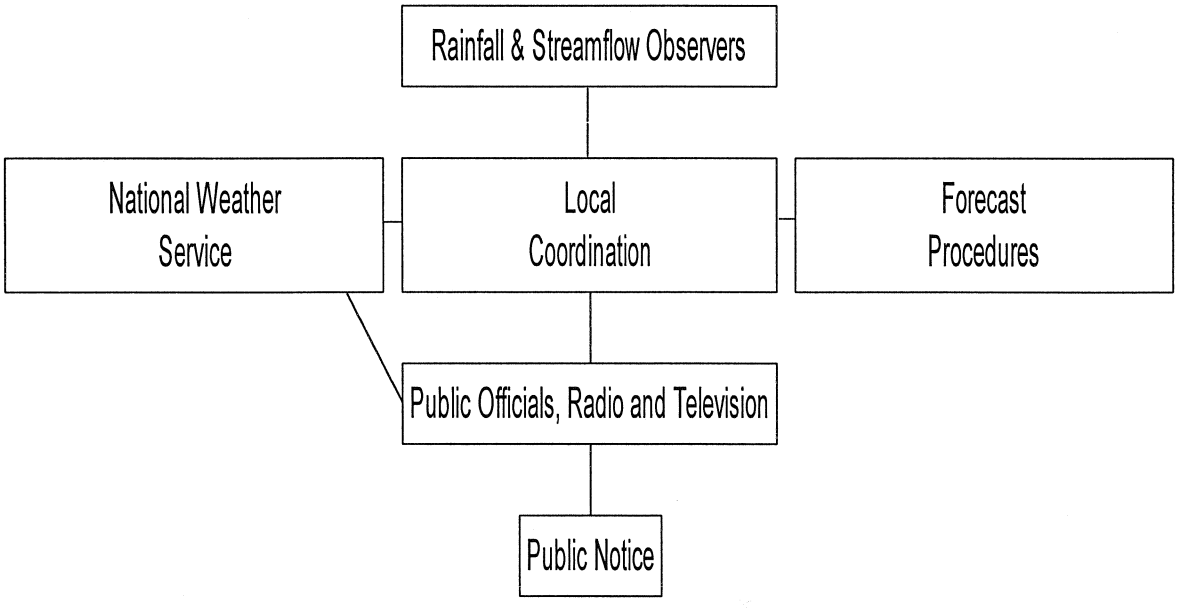
Flood Forecasting/Warning

Historically, local flood warnings were based upon simple tables that related storm rainfall quantities to specific stage heights. These oversimplified tables were effective in providing additional lead-times and produced some reduction in flood damages and loss of life. Many of these manual systems still exist today in portions of the U.S., especially in small communities.

A relatively recent technique to deal with floods is flood forecasting, which entails providing local residents threatened with flooding ample time to flood proof or evacuate. Development of the Local Flood Warning Systems (LFWS) occurred in the early 1970s by the National Weather Service (NWS). Presently, there are more than 400 LFWSs in the U.S. primarily in communities that are prone to flash floods.

At many points, particularly along larger creeks and rivers, daily forecasts of river stages are routinely prepared. These forecasts aid federal, state and local agencies in activities such as navigation and water management. Forecasts for water temperatures, ice formation and breakup, snowmelt and runoff are prepared at selected sites. Most flood forecast data for the Neshaminy Creek and Delaware River in Bucks County are provided by the Middle Atlantic River Forecast Center in State College, PA. The flood data include forecasts of height and time of flood crest, when the creek is expected to overflow its banks and when it will recede. These flood forecasts are sent to the NWS office in Mount Holly, NJ, which then may issue flood watches and/or warnings through Weather Radio operated by the National Oceanic and Atmospheric Administration (NOAA), the Weather Channel and local radio and television (Figure 14).

Figure 14: Structure of a Typical Flood Warning System



Source: National Oceanic and Atmospheric Administration.

In addition, the NWS operates a flood warning sensor at Neshaminy Falls on the Neshaminy Creek which activates an alarm at the NWS Mount Holly office when the flood stage is reached.

Crest forecasts can be made a few hours in advance for communities on creeks draining small areas, but it can be two or more days in advance for downstream sites on large rivers.

There are two types of LFWSs: manual systems and automated systems.

Manual Systems

Manual LFWSs are inexpensive and easy to operate. This system consists of a local data collection system, a community flood coordinator, an easy-to-use flood forecast procedure, a communication network to distribute warnings and a response plan. Data collection is generally undertaken by volunteer observers who collect rainfall and creek/river stage data through inexpensive plastic rain gauges. This data is applied to a forecast procedure consisting of tables, graphs and charts that use an index for flood potential to estimate a flood forecast.

Automated Systems

An automated LFWS is comprised of sensors that report environmental conditions to a computer. Automatic rainfall gauges report rainfall data each time a tipping bucket tips. This is known as event-type rainfall sampling. For river stages, every time a stage of a preselected increment is measured, a new river stage value is transmitted from the sensor to a base station. Automated system operation may vary from a simple flash flood alarm gauge that audibly announces imminent flooding to a continuous computerized analysis of precipitation and streamflow and a hydrologic model to predict flood levels.

A flash flood alarm system consists of a water-level sensor connected to an audible and/or visible alarm device generally located at a community agency with 24-hour operation. Water levels exceeding one or more preset levels triggers the alarm. The sensor is situated at a sufficient distance upstream of a community to provide adequate lead-time to issue a flood warning. Rain gauges can also be located upstream of a community and preset with alarms that signal when a predetermined flood-causing rainfall amount has been reached.

Once a manual or automated system indicates potential flooding, many prepatory activities occur. Eventually these lead to local action. For instance, when NWS river stage data from Trenton, NJ indicates an 18 foot level in the Delaware River, Route 32 in Yardley is closed. Based upon historic river stage information, local authorities have the ability to secure certain flood prone areas, provided they receive the data in a timely fashion.

Flood Stage Forecast Mapping

A local flood warning system modified for Sub-Basin 2 by the Delaware River Basin Commission and the U.S. Army Corps of Engineers uses maps to predict flooding severity along the Delaware River from Trenton to Belvidere. The River Stage Forecast Maps (RSFM) predict where inundation will occur based upon NWS river stage forecasts and upon existing local conditions, such as flood control devices and elevation. Each RSFM contains a Flood Area Chart that corresponds to the predicted flooding areas based upon the forecasted flood stage. The RSFM allows the homeowner to locate a house in a specific flood area. Based upon the Flood Area Chart, it can be seen that a forecasted stage greater than a certain amount will flood the area in which the home is located.

The Natural Hazards Research and Applications Information Center of the University of Colorado at Boulder states the U.S. is currently spending more than $4 billion to modernize the National Weather Service, including improvement to its river and flood program. However, flood forecasting has little value unless those who receive the warnings are prepared to act promptly and efficiently. According to the Center, flood forecasting requires three elements in order to be successful: the technical aspects where information is generated; the distribution of information; and the choices that are made by those who utilize this information.

Riparian Buffers

There are a host of biological, physical and aesthetic benefits to riparian buffers. However, a significant function of buffers is their ability to provide effective flood control insurance. Buffers are relatively large, flat and vegetated areas located between the waterway and the structure being protected. Buffers act to control flooding in two ways. First, they provide a critical right-of-way for creeks and rivers during large floods and storms. This right-of-way disseminates flood waters so the water can be absorbed by the buffer vegetation. Second, buffers can slow the rate at which stormwater runoff reaches a waterway and can reduce the likelihood of flooding by slowing the runoff and absorbing the water.

The Center for Watershed Protection recommends that the width of buffers in urbanized areas range from 20-200 feet on each side of the waterway. All land in the 100-year floodplain should be delineated within the buffer. The Center has also undertaken extensive research into the economic implications of a variety of watershed enhancement techniques including establishing buffers. For example, housing prices in Colorado were found to be 32% higher if they were located next to a buffer. Nationally, the Center found that buffers were thought to have a positive or neutral impact on adjacent property owners in 32 out of 39 communities surveyed. When buffers contain the entire 100-year floodplain, they are a cost-effective form of flood control for both communities and individual property owners. The Center notes that a national study of ten programs that diverted development away from flood prone areas found that land adjacent to the floodplain buffer had increased in value by an average or more than $10,000 per acre.

U.S. ARMY CORPS OF ENGINEERS

In instances when the nature of a disaster exceeds the capabilities of state and local interest, the Corps of Engineers can provide a variety of flood response and post flood response activities to state and local governments. The Corps has four primary programs that can be utilized for flood recovery and mitigation assistance: Disaster Preparedness, Emergency Operations, Rehabilitation and Advance Measures.

Disaster Preparedness Program

Under the Disaster Preparedness Program, the Corps reviews numerous flood-related issues such as emergency management organization, planning, maintenance and equipment. Subsequently, the Corps provides training and supplies to ensure adequate flood control can be undertaken. Inspections of non-federal flood control structures are also provided under this program.

Emergency Operations Program
The Emergency Operations Program is used to supplement state and local emergency efforts in saving lives and protecting improved property (e.g. public facilities/services and residential/commercial developments). Assistance to individual homeowners and businesses, including agricultural lands, is not permitted. Two responses have been established under this program: flood response and post flood response. Assistance associated with the Emergency Operations Program flood response include search and rescue operations, technical advice and assistance, emergency repair to levees and other flood control projects and flood control materials (e.g. sandbags, lumber and rip rap). If the Corps is not actively participating in fighting a flood, federal supplies may be provided only if state and local resources have been or will be exhausted.

Post flood response assistance must be required immediately and is limited to major flood or coastal storm disasters resulting in life-threatening or property-damaging situations. Post flood activities may only be provided for a maximum of 10 days from the date of receipt of the governor's written request for assistance. In addition, the Corps requires that local entities provide all necessary lands, easements and rights-of-way to the Corps; consider the Corps free of damages due to the authorized work; and operate and maintain the emergency work or remove temporary work constructed by the Corps. The types of post flood response assistance are furnish technical advice; clearance of drainage channels, bridge openings, or structures blocked by debris; clearance of blockages of critical water supply intakes and sewer outfalls; debris removal necessary to reopen vital transportation routes; temporary restoration of critical public services or facilities; and identify hazard mitigation opportunities.

Rehabilitation Program
The Corps of Engineers' Rehabilitation Program concerns the rehabilitation of flood control structures damaged or destroyed by floods to its pre-disaster condition. Requests for rehabilitation assistance must be for a non-federal, publicly sponsored flood control project. The proposed rehabilitation must have a favorable benefit-cost ratio and the project will be cost shared at 80% federal and 20% from the local sponsor.

Advance Measures Program
Advance measures prior to flooding consists of those activities performed to protect against loss of life and damage to improved property from flooding. There must be an imminent threat of flooding present before advance measures can be considered and the threat must be of a nature that if action is not taken immediately, damages will be incurred. This threat must be established by the National Weather Service or by Corps determinations of unusual flooding from adverse conditions. A written request from the governor is required. Advance measure assistance involves strengthening of federal and non-federal flood control structures, construction of temporary levees, channel clearance and dredging and relieving the threat of flooding from possible dam failures by dewatering the impoundment, controlled breaching, or strengthening of the structure.

The Corps also provides a variety of floodplain management services to state and local governments and to other non-federal public agencies. The Corps provides general technical

services which involve the physical analyses of natural and cultural floodplain resources in conjunction with an interpretation of flood events. General planning guidance is another service offered by the Corps which provides assistance and guidance on all aspects of floodplain management planning including the potential impacts of watershed-based land use changes on the physical, environmental and economic conditions of the floodplain.

The Corps' Division and District offices provide assistance to states and local governments in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources. This program is funded annually by Congress and any study must be cost shared on a 50% federal - 50% non-federal basis. The planning assistance may encompass studies concerning dam safety and failure, flood damage reduction, floodplain management and flood warning and evacuation.

OTHER FEDERAL AGENCIES

Other federal agencies have programs which are related to flood mitigation and floodplain management activities. Most prominent are the U.S. Geological Survey (USGS), the Natural Resources Conservation Service (NRCS), the National Park Service (NPS) and the Environmental Protection Agency (EPA).

The USGS has the responsibility to collect surface water data, which is the primary hydrology source used to define the floodplain and is depicted on the Flood Insurance Rate Maps (FIRMs). The USGS also continuously monitors and revises the surface water data at its more than 7,000 continuous-recording stations nationwide.

The NRCS, an agency of the U.S. Department of Agriculture, is involved with structural and non-structural measures as a way of reducing flood damages in watersheds that are less than 250,000 acres. Many of the thousands of units managed by the NPS are located in floodplains and are constantly subject to the forces associated with floods. To minimize losses, the NPS has implemented policies on floodplains and dam safety in addition to the use of local flood warning and response systems.

The NRCS is involved with watershed planning and has developed programs that assist state and local governments in considering flood mitigation alternatives. Similarly, the NPS utilizes the watershed approach to facilitate solutions to reducing flood damage. EPA has a limited regulatory function in floodplain management due to its involvement in water quality and stormwater runoff. EPA works with state and local governments to provide guidance and training in water supply planning.

CHAPTER 8

POLICIES FOR FLOODPLAIN MANAGEMENT

In Bucks County and throughout the Commonwealth, effective floodplain management will require cooperation among all levels of government and the public to share in the responsibility of managing flood risk. Agencies at the federal level need to strengthen their programs with adequate funding in those areas where the federal government continues to have a role. Moreover, state and local governments must formulate a consistent floodplain policy which provides adequate protection from unchecked development in floodplains while remaining in accord with local land use control.

The *Bucks County Flood Recovery and Mitigation Strategy* concludes with twelve specific policies and recommendations for improving floodplain management in Bucks County.

1. FEMA should provide updated FIRMs to communities in order to recognize recent flooding trends.

Detailed inventories and maps should be created to identify specific areas and structures at risk of flooding. Higher state flood elevation requirements should be implemented by FEMA because the minimum elevation criteria does not take into account the effects of future development on the 100-year elevation. Moreover, the minimum elevation criteria does not provide a buffer to accommodate for inaccurate floodplain maps or future changes in hydrology.

2. PEMA and flood prone communities should combine their respective resources and create a recent inventory of flood prone lands in order to assist FEMA in updating its ability to manage flood risks and rate flood insurance.

While FEMA does prepare and distribute FIRMs, some FIRMs for Bucks County's Sub-Basin 2 communities are more than 20 years old, resulting in significant gaps in mapping recently established flood prone areas. Further, new technologies in floodplain mapping, such as digital elevation modeling and mapping should be considered.

3. Bucks County Planning Commission, Bucks County Conservation District and DCED should conduct outreach to train municipal officials in flood prone communities how to make land use decisions that will not have a negative impact upon the floodplain and flood fringe area.

Most land use decisions in the floodplain are made without regard for their potential downstream impacts. This awareness is especially important when considering land uses that contain large amounts of impervious cover. Impervious surface reduction and mitigation should be a key element of land use planning in commonly flooded areas.

4. Municipalities should seek to further reduce potential flood damage by adopting and enforcing more stringent regulations controlling development within the 100-year floodplain and flood fringe areas.

Since 100-year floodplain delineations are not static, municipalities should revise development regulations concerning the floodplain to contain specific elements that control development such as requiring set backs, elevations, or buffers.

5. FEMA, DEP and Bucks County EMA should provide more technical assistance to municipalities, as many communities do not have the technical staff or expertise to accomplish assessments of potential flood hazards.

Communities that develop on the fringes of floodplains are required under FEMA's NFIP regulations to monitor the impacts of their development to the base flood elevation. This is done to ensure that the allowable one foot increase in the flood elevation is not exceeded after development has occurred. The NFIP also requires those flood fringe communities to evaluate both the upstream and downstream impacts of their proposed developments to adjacent communities so as to minimize any effects and not to place them out of compliance with NFIP regulations.

6. FEMA, Bucks County EMA and the Bucks County Board of Realtors should increase public outreach to inform residents about the risks associated with purchasing homes in floodplains and in other flood prone areas.

Frequently, residents in communities subject to flooding are unaware of the risk connected to living in the floodplain or flood fringe area.

7. Bucks County Planning Commission should coordinate local development decisions, building codes, floodproofing and flood control to ensure successful floodplain management throughout the watersheds of Bucks County.

Floodplain regulations typically stop at municipal boundaries, which have little or no relationship to floodwater movement. The municipalities in Sub-Basin 2 must work in concert to develop watershed-wide strategies to lessen the effects of land use decisions that have eliminated natural flood control functions.

8. Bucks County Planning Commission and the Bucks County Chamber of Commerce should assist those flood prone municipalities in creating floodplain-friendly economic development strategies.

By not allowing any development to occur in the floodplain, some communities may lose the potential financial benefits of this development. A host of taxes and ancillary fees may not be realized if floodplain development is prohibited. Instead, municipal officials can extend tax or development credits to developers who develop within the floodplain while preserving the natural functions of floodplains. This permits the community to retain the value of the floodplain

while reaping some of the financial benefits associated with development.

9. Bucks County Conservation District should assist flood prone communities to retain, and where necessary, restore the effective flood flow conveyance and flood water storage capacities of floodplains.

Rivers and floodplains not only provide for flood water conveyance and storage, but they also maintain the continuity of the river corridor and associated wildlife habitats.

10. The National Weather Service, DRBC, and Bucks County EMA should coordinate efforts to establish a single source of emergency flood information for the public which should provide flood warnings and identify evacuation routes and relief options.

During the January 1996 flood along the Delaware River, rumors of "dam breaks" and "walls of water" echoed throughout the Delaware River basin. The flood warning system tends to break down at the municipal level when there are too many unofficial information sources. Each community should establish an individual to distribute official information.

11. Bucks County Conservation District and DCED should promote the acquisition of flood prone areas for community parks and recreational open space.

Floodplains need not be wasted land and can function as valuable assets to a community. Municipalities can develop floodplains to serve as passive parks, playing fields, trails and nature areas. Moreover, public and private conservation organizations can acquire flood prone areas for recreation and open space.

12. FEMA, DEP and DCED should develop funding assistance programs for home and business owners wishing to floodproof their structures.

Most funding for flooding impacts is allocated after the fact. Funding for floodprooofing made available prior to a flood may enable government to break the flood-recover-flood cycle. As a preventative rather than reactionary measure, owners of structures located in flood prone areas may be able to limit or abate potential flood damages altogether.

13. PEMA and Bucks County EMA should assist Morrisville Borough to acquire the funding necessary to repair the Morrisville Flood Levee.

The Morrisville Flood Levee, which was constructed in 1930, provides vital flood protection for Morrisville Borough. The levee has undergone a constant deterioration from the tidal forces of the Delaware River, floods and ice floes which have caused cracks, silt accumulation, missing rip rap, erosion and growth of vegetation.

14. DEP should add an additional debris gate at the Brock Creek Aqueduct along the Delaware Canal Towpath in Yardley Borough and undertake routine dredging of the canal. Automated gates should also be considered.

The network of debris gates along the Delaware Canal Towpath are designed to provide flood relief during periods of excessive rainfall. Yardley Borough has experienced severe flooding along the Delaware Canal and an additional gate may provide much need flood relief during periods of excessive rainfall. An increase in the amount of sedimentation has contributed to the potential flood hazards in and around Yardley Borough.

15. DEP and the Neshaminy Watershed Steering Committee should continue to explore the potential outcomes of both constructing the Dark Hollow Dam and providing alternatives to the dam.

As one of the remaining two proposed flood control structures in the Neshaminy Creek Basin, the proposed construction of the Dark Hollow Dam has provided a great deal of debate. The construction of the dam and its alternatives should continue to be analyzed. Further, input from residents in central and lower Bucks County should be included in the process.

16. FEMA and DEP should provide assistance to help communities take advantage of the Community Rating System.

An important component on the NFIP, the rating system could provide local flood insurance discounts and build toward responsible floodplain management.

APPENDIX A

DISASTER ASSISTANCE FOR HOMEOWNERS, RENTERS AND BUSINESS OWNERS

Disaster Assistance for Homeowners, Renters and Business Owners

Program	Agency	Assistance	Eligibility	Criteria
Emergency Assistance	American Red Cross	Emergency food, clothing, shelter and medical assistance	Available to individuals and families with disaster-related emergency needs	Makes referrals to church groups and other voluntary agencies
Disaster Housing Assistance	FEMA	Provides grants for temporary housing or for emergency repairs needed to make a residence livable until more permanent repairs can be made	Available to homeowners and renters whose permanent homes are uninhabitable because of the disaster Homeowners Renters	Housing Assistance grants supplement and insurance coverage an individual might have; grants made to homeowners who can return to their homes by making minimal repairs Homeowners with more substantial property damage may qualify for short-term rental assistance grants; extensions may be granted on a case-by-case basis Renters may qualify for short-term rental assistance; extensions may be granted on a case-by-case basis
Individual and Family Grant Program	FEMA (administered by PEMA)	Grants to meet serious disaster-related needs and necessary expenses not covered by insurance or other federal, state, or voluntary agencies	Persons with serious unmet needs who do not qualify for SBA disaster loans	Maximum grant of up to $12,900 depending on family composition and needs; grants average $2,000
Home/Personal Property Disaster Loans	SBA	Low-interest loans for restoring or replacing uninsured or underinsured disaster-damaged real and personal property	Individuals located in counties included in Presidential declared disasters	Loans limited to amount of uninsured SBA-verified losses
Business Disaster Loans (replacement) and Economic Injury Disaster Loans	SBA	Loans for the repair or replacement of destroyed or damaged business facilities, inventory, machinery, or equipment not covered by insurance	Businesses located counties included in Presidential declared disasters; small businesses located in declared and contiguous counties	Loans limited to $1.5 million
Crisis Counseling	State Mental Health Agencies	Immediate and regular services to meet mental health needs of those affected by a major disaster; includes screening, diagnostics and counseling techniques, outreach, education services and public information	Supplemental funding to state programs to meet mental health needs of those affected in the disaster areas	Regular services are provided for up to nine months after the declaration

Program	Agency	Assistance	Eligibility	Criteria
Tax Assistance	IRS, State Department of Revenue	Expedited federal tax deductions for casualty losses to home, personal property, or household goods; assistance and information on state income tax returns	Individuals and families with disaster-related losses totaling more than 10% of adjusted gross income	Under certain circumstances a taxpayer may file an amended return during the year of the disaster or for previous years and obtain a tax refund in a matter of weeks
Disaster Unemployment Assistance	FEMA (administered by Employment Security Agency)	Weekly benefits available to individuals out of work as a direct result of the disaster	All individuals out of work as a direct result of the disaster, includes self-employed persons, farm owners and others not covered under regular unemployment insurance	Available for a maximum of 26 weeks; proof of income required
Farm Assistance	Farmers Home Administration	Emergency loans for physical or production losses; grants for certain agricultural damage	Farmers who were operating and managing a farm at the time of the disaster	Loans limited to the amount necessary to compensate for actual losses to essential property and/or production
Insurance Information	State Insurance Commissioner, American Insurance Association, FEMA, NFIP	Assistance and/or counseling regarding ways to obtain copies of lost policies, file claims and expedite settlements	Individuals and families with disaster-related losses	
Legal Assistance	FEMA, Young Lawyers Division of ABA	Free legal service for low-income disaster victims	Individuals and families with disaster-related legal issues	Addresses issues such as replacing legal documents, transferring titles, contracting problems, will probates, insurance problems and certain landlord-related problems
Social Security Benefits	SSA	Assistance expediting delivery of Social Security checks delayed by the disaster; assistance in applying for Social Security disability and survivor benefits	Individuals eligible for Social Security	
Veteran's Benefits	Department of Veteran's Affairs	Assistance with information about benefits, pensions, insurance settlements and VA mortgages	Veterans	
Consumer Services	State Department of Consumer Affairs	Counseling on consumer problems such as product shortages, price gouging and disreputable business practices		

Program	Agency	Assistance	Eligibility	Criteria
Aging Services	State agency responsible for services	Services to the elderly such as meals, home care and transportation	Individuals age 60 and over	

Source: Pennsylvania Emergency Management Agency, adapted from FEMA, January 1996.

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