APPENDIX B

Lambertville, New Jersey

BACKGROUND

Lambertville is a City in Hunterdon County, New Jersey, United States. As of the United States 2000 Census, the city population was 3,868. Lambertville is located at 40°22′4″N, 74°56′34″W (40.367881, -74.942860). The city borders Delaware Township and West Amwell Township. The city has a total area of 1.2 square miles (3.2 km²), of which, 1.1 square miles (2.9 km²) of it is land and 0.1 square miles (0.3 km²) of it (9.60%) is water.

Lambertville is located on the Delaware River in the southwestern portion of Hunterdon County. Since the 1800s, Lambertville, due to its proximity to the canal and the (now defunct) railroad, became a factory town. However, today the factories are closed and the town has maintained some of its 18th and 19th century flavor remains -- particularly in its houses, many of which have been restored. The town has become a tourist destination, with many shops, galleries, restaurants, and B&Bs.

The City of Lambertville has highly developed the area in the river's floodplain with 20% of the Town's property value situated in the 100-year floodplain, totaling $147M. Swan Creek flows northwest as it enters the city and joins the Swan Creek Tributary about 1,000 feet inside the city limits then flows west into the Delaware River. Swan Creek drains the southern part of the city. Both portions of these streams have steep channels with high velocities. The Alexauken Creek has its headwaters in the central part of West Amwell Township and flows generally west along the northern border of Lambertville to the Delaware River. From its mouth upstream to a Conrail bridge, 1,200 feet, the creek forms the boundary between the City of Lambertville and Delaware Township.

PROBLEM IDENTIFICATION

Riverine flooding occurs along the Delaware River west of the Delaware and Raritan Canal. The Canal is elevated over the normal level of the river and is adjacent to a railroad track. The canal and railroad acts as a levee through the City, so from the treatment plant to Alexauken Creek there isn't overtopping from the Delaware River until waters rise higher than the100-year flood. There exist two areas where these earthworks passes over creeks. Backup in water from the Delaware River prevents the creek waters from flowing out of the City resulting in backwater flooding along the Swan Creek (+3 mi^2 drainage area) and Alexauken Creek (15 mi^2 drainage area). A 1999 flood event, from Hurrican Floyd, was a Swan Creek only event, the Delaware River did not cause a problem. Nearby, Ely Creek, (0.7 mi^2 drainage area) flows between Alexauken and Swan Creeks, and goes behind businesses and homes, also floods.

The municipality experienced major flooding events in September 2004, April 2005 and June 2006, resulting in millions of dollars of damage. The flooding of 2005 was 6" higher than the other two flooding events. The highest event in 2005 was estimated to be

a 75 year flood event by the town's municipal engineer, but elsewhere was close to a 100 year event.

Flash flooding has occurred in the vicinity of the Elementary School along North Main Street. Additionally, flash flooding has been associated with hillside runoff. In both instances the hazards, vulnerability and potential mitigation measures have been studied by the City and selected mitigation measures have been funded or are scheduled in the next year or two. In the past the area of the School has received additional drainage structures that has mitigated the problem to a great extent, but has not eliminated it. Flooding in this area has an impact to the school and the adjacent roadway that impairs commerce and limits accessibility of the fire company equipment during times of flooding.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D, provided flood information from prior storm events. Lambertville damages for the 1955 event were $131,000 residential, $465,000 commercial, $295,000 industrial, $194,000 emergency costs, when coupled with other damages totaled $1,165,000,000 (1955 dollars) and would be between nine and ten times that amount in current dollars.

A partial file was recovered providing some information from a small flood control study done by the Corps in 1976-77. The information was principally hydraulic/hydrologic in nature involving tributary streams rather than the Delaware River itself. No report was found and the study was thought to have been terminated due to limited flood damages reported from a 1970 storm event and a termination of national program funding in 1978-79 by Congress.

The August 1984 Delaware River Basin Report listed 360 residences, 70 commercial properties, 7 industries and 13 other structures in the 500 year floodplain (also referred to a the Standard Project Flood SPF). There were 133 structures in the 100-year floodplain and 235 in the 1955 flood of record floodplain. That report provided information on the damages expected based on the level of development in 1983 from different flooding events: $1,000 for the 10-year event, $3,557,000 for the 50-year event, $10,168,000 for the 100-year event, $16,214,000 for a repeat of the 1955 flood of record, and $27,956 for the 500-year event. A consolidated Average Annual Damages was estimated at $285,000 in March 1983 dollars.

The August 1984 Delaware River Basin Report evaluated some flood reduction measures available to the City. Two new levees were evaluated, one on each side of Swan Creek. The total linear footage was 5,000 feet and would have had an initial cost of $10,140,000 in March 1983 dollars. Average annual costs were $918,000 and average annual benefits were $275,000 with a BCR of 0.30 to 1. Flood proofing was also evaluated. Of the 450 structures in the floodplain 45% needed no protection, 194 needed flood proofing, 10 needed individual floodwalls, 39 needed elevation, and 4 buyouts. The Benefit cost ratio for this low stage flood reduction as 0.65 to 1.

The National Park Service prepared in 1999 a National Wild and Scenic Study Report for the Lower Delaware River. That plan recommended that several river segments, including Segments G and H be designated as recreational within the Wild and Scenic River System. There is a 2,750 foot gap between these two designated segments which includes a portion of Lambertville 1000 feet north and 1,750 feet south of the Route 202 Bridge of the Delaware River. The Lower Delaware River Wild and Scenic River was made law in October 2000. Section 7(a) of the Wild and Scenic Rivers Act prohibits federal authorization of any water resources project or assistance by loan, grant, license or construction of any water resource project that would have an adverse impact on the values for which the river is designated. The boundary of this designation extends one-quarter mile inland from the ordinary high water mark. The 2,750 foot gap is not totally exclusionary in nature since the Wild and Scenic Designation also requires an evaluation of construction outside a wild and scenic designated river segment which could adversely affect a portion within a designated segment.

"Recreational" river areas -- Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. Regardless of classification, each designated river is administered with the goal of nondegradation and enhancement of the values which caused it to be designated.

An October 2004 *Technical Report of the Interagency Wild and Scenic Rivers Coordinating Council titled Wild &* Scenic Rivers Act: Section 7 provides additional guidance. A determination is required when a project is proposed by a federal agency or it requires some type of federal assistance such as a permit, license, grant or loan. Unlike new FERC-licensed projects, which are prohibited if they are "on or directly affecting" a designated river, other proposed federally assisted water resources projects are prohibited only if they would have a "direct and adverse effect" on the values for which a river was added to the National System. Examples of projects that would likely be subject to this standard include, but are not limited to: dams; water diversion projects; fisheries habitat and watershed restoration/enhancement projects; bridge and other roadway construction /reconstruction projects; bank stabilization projects; channelization projects; levee construction; recreation facilities such as boat ramps and fishing piers; and, activities that require a Section 404 permit from the Army Corps of Engineers. The determination is made in consultation with state and federal agencies as part of the environmental assessment/impact statement process. Depending on the nature of the proposed construction and the degree of effect on the river's values and defined in the original study and management plan, the proposal can be approved, modified, conditioned, or denied.

The Hazard Mitigation Plan for the City of Lambertville, New Jersey (July 2006 draft) was the result of a collaborative effort and represents comprehensive disaster mitigation planning through evaluation and understanding of potential hazard risks, vulnerabilities to those risks, capabilities to manage those risk and selection of actions to achieve Lambertville's goals of a safer, sustainable community. This plan has been constructed

to address the three highest vulnerability that the Community has to natural hazards, with flooding being the highest. The low lying, relatively flat topography and poor drainage characteristics of the majority of the land within the city boundaries combine to expose the City of Lambertville to a high potential to be flooded. When heavy rainfall and a high river discharge combine, low lying areas adjacent to streams and rivers become inundated. However, flood risks also arises from one or more of the following: sewer backup; drainage system backup; dam breaches; and storm water runoff problems. There are three significant drainage areas in City of Lambertville. These include the Swan and Alexauken Creeks and the Delaware River that forms the western boundary of the City. In the City of Lambertville several types of flooding have been observed to occur and include overbank flooding as a result of excessive water levels in the Delaware River inundating areas normally dry; backwater flooding where the higher level of the water in the Delaware causes backup or reverse flow in small streams and drainage piping structures; and backwater flooding due to high main-stem levels prohibiting discharge of the small creeks and drainage piping structures. As part of hazard mitigation, Lambertville wants to ensure that existing structures specifically targeting repetitive loss structures that are in the floodplain are resistant to flood related damage. To do this it would consider:

- Voluntary Acquisition or relocation for structures that are repetitively flooded or have high flood depths;
- Dry floodproofing for buildings on sound slab foundations that are subject to less than 27" of flooding.
- Elevating a building when flood depths are less than 10 feet and have low velocity (less than 5ft/sec).
- Conduct an assessment of all structures (60+/- structures in 100-year floodplain in City) in the 100-year floodplain and obtain flood depths, foundation type, historic nature of property, etc. to determine the best flood protection measure that will keep the character of the structure intact. Project costs and benefits will be considered when projects are prioritized.
- Protect critical facilities in the 100-year flood plain.

A field inspection was conducted on 23 January 2007 by Corps of Engineers staff and local representatives. There are approximately 42 homes and businesses which have repetitive losses when the flooding occurs, with two having severe repetitive losses. Overflow of Swan Creek occurs on the city side and floods approx. 60 properties, coming into basements and 1st floors. When Alexauken creek floods it backflows through the storm drainage system thus flooding area homes (primarily basements) and a commercial business (CVS). The houses on Lambert Lane are flooded by the River and have water coming into the basements and 1st floor; there are historic homes in this area ranging from $500-$600K, with a total value of $10-15M. Other impacted properties in the area range from $279K-$429K. During storm event of 2006 there were 400-500 evacuees; one death occurred when a person got too close to Swan Creek and was sucked in.

Lambertville is looking at all alternatives to try to better the situation, though the town does not want to force people to have their homes bought out. The city now has its own gauge with USGS doing maintenance; National Weather Service does the forecasting.

Municipal officials are looking at means to notify the public, possibly a reverse 911(comparable to what the county has now) and an AM radio station with a 30 mile radius area for coverage to warn people. They're working with residents to get homes raised (2 property owners have/are already raised theirs). Owners along the River would probably sell, but location makes selling price unacceptable.

According to DRBC, based upon a comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 64 repetitive loss properties (payments totaling $3,348,860) with 2 severe repetitive losses (payments totaling $$171,728) . This does not include damages from noninsured properties. These are clustered at 3 locations.
NRCS has completed a Preliminary Flood Damage and Mitigation Report on Swan Creek. Considerable information was developed on flood damages and structures damaged by flooding. A preliminary evaluation was done for the following alternatives:

- Modification of Water Supply Reservoir for Flood Control
- Floodwall
- Flood Gate and Pump (lift) Station
- Nonstructural Measures
- Combined Flood Gate and Pump (lift) Station and Nonstructural Measures

The study recommended further study with the combined plan favored.

Lambertville is thinking about pursuing the floodgate and lift (pumping) station so the creek could be closed before Delaware River flood waters come down from the north. The pumping station would have to handle both Swan Creek flood waters and canal overflow. Calculation of the downstream impact of keeping the Swan Creek backflow in the Delaware River is not part of the project, nor was there a price estimate. This project would not protect from a 100 year event and the FIRM maps would need to stay the same and people would still need to buy flood insurance.

The municipality is trying to obtain State funding for Ely Creek and for the storm sewer backflooding on the Alexauken. The municipality is thinking about putting a slide gate and small pump on Ely Creek. They are considering treating Alexauken Creek the same as Swan Creek, but the watershed is much larger (estimated as 15 square miles by the town officials), so the approach may not work. As with Swan Creek, neither of these projects would be designed for the 100 year flood.

ALTERNATIVE EVALUATION

DELAWARE RIVER

- STRUCTURAL AND NON-STRUCTURAL FLOOD CONTROL MEASURES
  With the overtopping of the banks of the Delaware River not occurring until greater than a 100 year flood, neither structural nor non-structural flood protection measures are justified. Stream backup will be evaluated separately under each specific waterbody.

SWAN CREEK

- STRUCTURAL FLOOD CONTROL MEASURES

    - A new levee-floodwall system is not possible due to the high real estate and construction costs. The proposal by NRCS which would construct a Flood Gate and Pump (lift) Station appear viable and should be pursued.

    - A full Channel Modification as such is not viable; deepening or widening Swan Creek would at most cause only a few feet of flood stage reduction at high fiscal and ecological cost. An updating of the stream hydraulics will determine if limited modifications could result in measurable stage differences. There has been no report of debris being a problem.

The construction of any structural plan must take into consideration the potential for an adverse determination which will be strongly influenced by the exact nature and specific design. While the Delaware River in the vicinity of Swan Creek is not designated as Wild and Scenic, construction could adversely impact the recreational condition of the river segments either up or downstream. Early coordination with the National Park Service should be initiated as soon as possible.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

    - The prior 1984 evaluation of nonstructural flood control measures demonstrate sufficient viability of non-structural measures to be considered. For structures where raising or buyout are not obviously feasible, other floodproofing measures need to be given greater emphasis.

    - Lambertville desires improved mapping in order to know what the river elevation reading means for the municipality in terms of area flooded (the modeling being done for the Susquehenna River is the kind they are interested in). The City has stated its desire for a "reverse" 911 type system. There exists an existing company named, reverse 911, which can utilize GIS flood mapping such as the Corps is developing coupled with a river forecast, as operated by the Weather Service and USGS, as the basis for such a system. They would also like to have an AM radio station that could be updated from a cell phone.

ALEXAUKEN CREEK

- STRUCTURAL AND NON-STRUCTURAL FLOOD CONTROL MEASURES The prior evaluation for Swan Creek is also appropriate here.

ELY CREEK

- STRUCTURAL AND NON-STRUCTURAL FLOOD CONTROL MEASURES With a drainage area of about half the 1.5 square mile minimum for Corps participation, there can be no Federal flood project, as such. The placement of a flap gate and pump appears to be the most practical solution. The time and cost of project evaluation for a Federal project, even if the drainage criteria were not an issue, would likely be prohibitive.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D,
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
Lambertville Flood Insurance Study, April 1988
The National Park Service 1999 National Wild and Scenic Study Report for the Lower Delaware River.
Hazard Mitigation Plan, City of Lambertville, July 2006
Swan Creek Watershed, Preliminary Flood Damage and Mitigation Report USDA Natural Resources Conservation Service January 2007.
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, 2006

Stockton, New Jersey

BACKGROUND

Stockton is a Borough in Hunterdon County, New Jersey. Stockton is located at 40°24′24″N, 74°58′39″W (40.406701, -74.977546). According to the United States Census Bureau, the borough has a total area of 1.6 km² (0.6 mi²). 1.4 km² (0.6 mi²) of it is land and 0.2 km² (0.1 mi²) of it (10.00%) is water. The Borough population was 560 in 2000 census, and there were 246 households, and 148 families residing in the borough. There were 258 housing units. Stockton doesn't have an historic district, per se. However, everything within 300' of the 170 year old D&R Canal is affected by its historic designation (essentially, from Route 29 to the Delaware River).

Besides the Delaware River, there are two streams in Stockton; Brookville Creek and Wickecheoke Creek. Brookville Creek begins in the southwestern part of the Township of Delaware and flows generally southwest to its confluence with the D&R Canal. The last 2,500 feet of the stream forms the southeastern corporate limits between the Borough of Stockton and the Township of Delaware. Wickecheoke Creek has its headwaters in the Township of Raritan and flows generally southwest. Approximately the last 2,000 feet of the Creek forms the northwestern corporate limits between the Borough of Stockton and the Township of Delaware.

PROBLEM IDENTIFICATION

Flooding in 2004 was minimal while flooding in 2005 and 2006 were much more significant. These flooding events were caused by rain events, especially in New York State. Approximately two days after New York State was hit with torrential rain, flooding occurred in Stockton. Flooding occurs traditionally along Mill Street, and along Route 29 in the communities of Brookville and Prallsville Mill. Flooding of the Delaware River also leads to flooding of the canal, which in turn, floods the adjacent portion of the Boro. The September 2004 flood only affected one residence in Stockton. However, during the April 2005 flood, the canal wall breached south of Mill Street and north of town (just south of the Prallsville Mill). The canal wall was also breached during the June 2006 at the south end of Mill Street and during the 1955 flood event.

Although the levee can adequately hold in the canal water, the outer wall tends to fail against pressure from the Delaware River. This occurred during the 2005 and 2006 storms. The canal has been repaired, since the recent storm events, to the pre-existing wall elevations.

Flooding that occurs near the mouths of Wickecheoke Creek and Brookville Creek is primarily the result of backwater from the Delaware River.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from the storm of record. Stockton had 69 residential, 12 commercial, 5 service and 1 public properties damaged by the 1955 event. Damages for the 1955 event were $84,000 physical residential, $157,000 other damages (business, utilities, crops), and $11,000 emergency/highway costs for a total of $257,000 (1955 dollars) which would equate to nearly ten times that amount in current dollars.

The August 1984 Delaware River Basin Report listed 108 residences, 22 commercial properties, 1 service property, 2 public and 1 historic property in the 500 year floodplain (also referred to a the Standard Project Flood SPF). There were 64 structures in the 100-year floodplain. That report provided information on the damages expected based on the level of development in 1983 from different flooding events: $24,000 for the 10-year event, $559,000 for the 50-year event, $1,270,000 for the 100-year event, $2,240,000 for a repeat of the 1955 flood of record, and $2,991,000 for the 500-year event. Consolidated Average Annual Damages were estimated at $55,800 in March 1983 dollars.

In the August 1984 Delaware River Basin Report a 2,900 foot levee was designed; it had an initial cost of over $6,600,000 in 1983 dollars (double in 2007 dollars) and a benefit to cost ratio of 0.07 to 1 making it highly uneconomical. Flood proofing was also evaluated and found even less economically viable with 54 structures susceptible to flooding from a 500 year event. The Benefit to Cost ratio for flooding was 0.02 to 1 (or 2¢ reduction in flood damages for every $1 spent).

According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 12 repetitive loss properties (payments totaling $775,042) with 1 severe repetitive loss (payments totaling $154,507) . This does not include damages from noninsured properties. These repetitive losses were clustered at Mill along the Delaware River and 8 individual locations.

A field inspection was conducted on 23 January 2007 by Corps of Engineers staff and local representatives. The NJ Water Supply Authority is responsible for maintenance of the canal, including repair of breaches. This portion of the D&R Canal is a feeder branch to the main canal, which NJWSA uses to supply water to other parts of New Jersey. Stockton OEM notifies those residents in danger of flooding by going door-to-door. During the 2005 and 2006 events 37 basements were pumped out, approximately 77 homes (121 people) were evacuated, and flooding filled basements and affected some first floors. The April 2005 flood caused foundation damage to four properties and required structural evaluations. Thirty seven properties experience repetitive flooding. The sanitary sewer system was inundated in 2005 and 2006; the pumping station succumbed. (Sewage is normally pumped to Lambertville for treatment.). Emergency services located on Mill Street have gotten flooded. The historic value of properties and blocks could preclude structure elevation.

NJWSA has repaired both the 2005 and 2006 canal wall breaches to pre-existing heights. Each repair cost NJWSA about $500K, of which the 2006 repairs were partially reimbursed by FEMA.

NJWSA has contracted with French & Parello Associates to prepare an overall assessment report for the canal embankment in Stockton. This August 1996 Visual Inspection Report on the Delaware and Raritan Feeder Canal Western Embankment evaluated the condition of the canal between the Prallsville Lock (Station 155+00) to Railroad Crossing (Station 280+00) a distance of 5300 feet which is generally in Stockton. It found that the Western Embankment (that between the Delaware River and the canal) was generally found to be in poor overall condition and in need of significant repair. A review of plan drawings from that report shows that the Western Embankment is marginally overtopped by the 50 year flood event at many locations while at others the 50 year flood is barely contained. The left bank canal wall (that away from the river) is several feet lower in some locations, not even the height of the 10-year flood event.

ALTERNATIVE EVALUATION

- STRUCTURAL FLOOD CONTROL MEASURES

    - A full Channel Modification of the Delaware River as such is not viable; deepening the Delaware River would at most cause only a few feet of flood stage reduction at high fiscal and ecological cost.
    - A separate levee-floodwall was evaluated in 1984 with an extremely low benefit to cost ratio. A comparison of past and present site conditions would indicate this would remain a poor choice, primarily due to the high cost of real estate and construction.
    - The use of the canal structure as a levee is a major problem because of the structural instability of the canal in this area. Until improvements to the canal can be made, consideration of this option is not practical.
    - Additional waste gates for canal overflow need to be considered. Construction of several wastegates north of the Borough could provide some measurable flood reduction potential in the near term without great expense.
    - The relatively high structure density along Mill Street may justify some structural solution. Construction of a 3’ ringwall system around repetitive damaged structures needs to be evaluated. The clustering of several repetitive claims along Mill and Bridge Streets would make an evaluation of a ring levee/floodwall of a few feet in height around each cluster something to consider. A similar ringwall-levee or floodproofing of the sewer pumping station should also be evaluated.

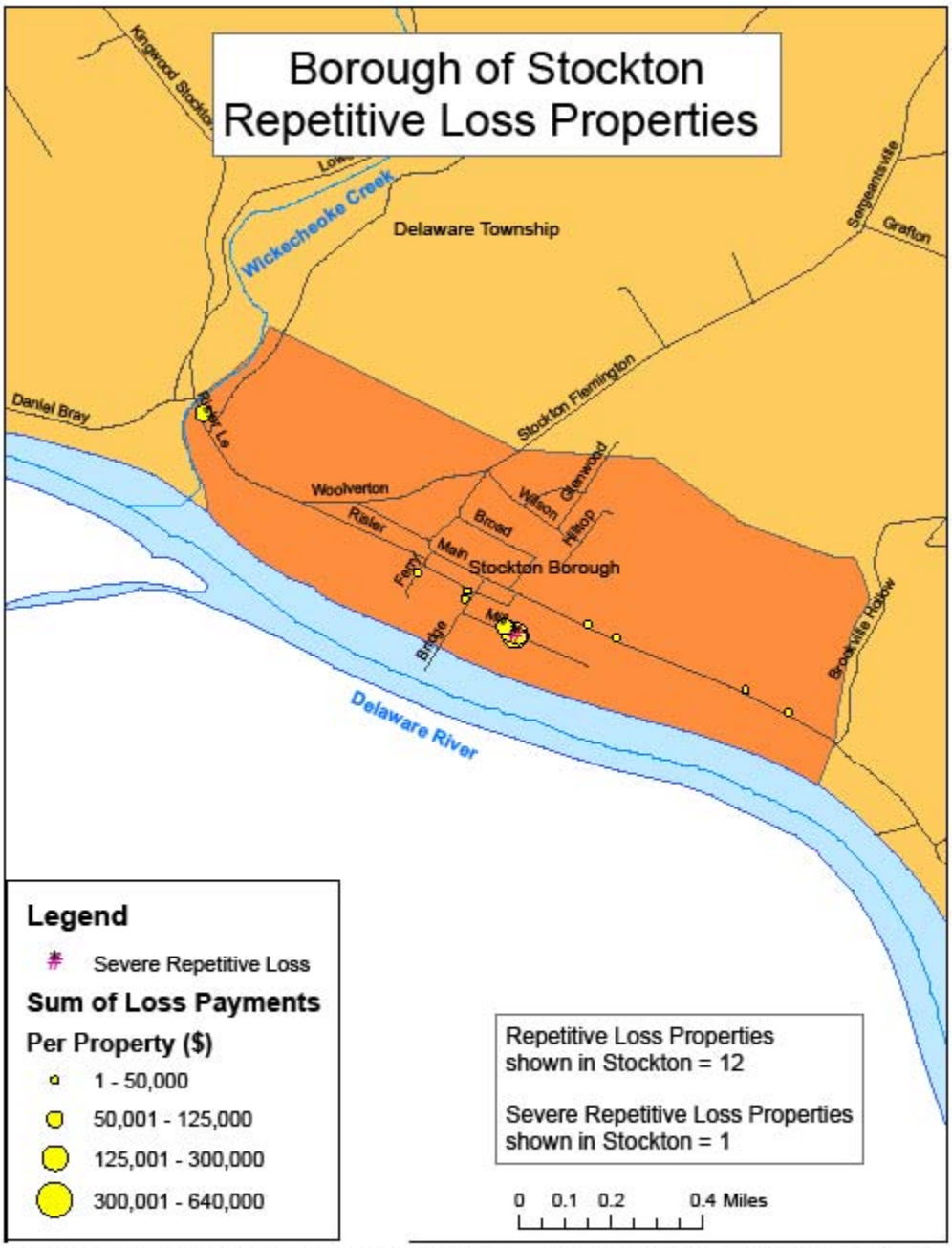
- NONSTRUCTURAL FLOOD CONTROL MEASURES

    - An improved flood warning (whether reverse 911, etc.) might be a significant non-structural measure; the current method of OEM having to go door-to-door has its limits, especially if a flooding event from a levee breach occurs during the night (as has happened historically and fortunately did not result in a loss of life).

    - The prior 1984 evaluation of nonstructural flood control measures makes the likelihood of large scale non-structural measures unlikely. The raising of two structures by their private owners shows that at a minimum an individual structural evaluation of the 13 repetitive damaged properties needs to be conducted. Floodproofing of the Emergency Services Building on Mill Street should be a priority; it will likely be included as a priority in the upcoming County Hazard Mitigation Plan and as such may get some priority in receiving a Hazard Mitigation grant from FEMA

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
August 1996 Visual Inspection Report on the Delaware and Raritan Feeder Canal Western Embankment by French & Parello Associates



Source: Federal Emergency Management Agency (FEMA). A property is considered a repetitive loss property when there are 2 or more losses reported which were paid more than $1,000 for each loss. The 2 losses must be within 10 years of each other and be at least 10 days apart. Losses from 01/01/1978 - 08/31/06 that are closed are considered.

Prepared by Delaware River Basin Commission Staff, October 2006. Draft, subject to change.

BELVIDERE, NEW JERSEY

BACKGROUND

Belvidere is a town in west-central Warren County, New Jersey. The town borders Oxford Township to the north, south and east and the Delaware River to its west. It is the county seat of Warren County. Belvidere is located at 40°49′42″N, 75°4′35″W (40.828299, -75.076496). The town has a total area of 3.5 km² (1.4 mi²). 3.4 km² (1.3 mi²) of it is land and 0.1 km² (0.04 mi²) of it (1.48%) is water. As of the 2000 Census there were 2,771 people, 1,088 households, and 716 families residing in the town. While portions of the Delaware are designated as Wild and Scenic, no portion of the Delaware River at Belvidere is so designated.

PROBLEM IDENTIFICATION

Belvidere has been subjected to flooding from all three of its water bodies. Flooding on the Delaware River also causes backwater along the Pequest River and Pophandusing Creek. Most of the Pequest floodplain is developed by residential and commercial structures. The Pophandusing Creek is located in the southern portion of town and is more reactive to shorter duration, high intensity events.

Flooding in Belvidere is of varied origin and may be experienced any time of year. Flooding during the winter is less frequent, but flooding compounded by snowmelt and ice has occurred.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from prior storm events. Belvidere had 58 residential, 20 commercial and 0 industrial properties inundated during the 1955 flood event. Damages in 1958 dollars at Belvidere from this event were $167,000 for the Delaware River and $215,000 on the Pequest. Damages from earlier events were not able to be broken down. In today's dollars this would be between nine and ten times that amount.

The October 1966 Report titled Extent and Frequency of Floods on Delaware River in the Vicinity of Belvidere, NJ by George M. Farlekas of the USGS developed information relative to the extent, depth, and frequency of flooding. The estimated reoccurrence of the 1955 was over 150 years, while the 1942 was a 5 year event. The areal extent of flooding from both was delineated. The flooding from the Delaware River from the 1942 event only extended to the lower dam, while the 1955 event flooded not only up the Pequest for an additional 1,500 feet but also flooded inland along virtually all of DePue Street. There was no documentation on the level of damages or the cause of flooding except in general terms.

A Reconnaissance Report on the Flood Control Problem, Town of Belvidere, Warren County, New Jersey was completed by the Corps of Engineers in October 1971. It

recommended further study based on a cursory evaluation (7 pages of text) determining that a plan to protect residents from Pequest flooding was economically justified with a BCR of 1.6 to 1. The October 1971 study referenced a 1963 study by McCrosby-Seelye, Associated Consultants, which included a plan to protect the town from flooding as part of urban renewal. This plan called for:

- Channel excavation, removal of two check dams, and the construction of dikes but concluded that the cost of dikes was too expensive to be economical.

The April 1973 Flood Control and the Delaware River by Laurie Burt and Leo M. Eisel, PH.D. evaluated 8 flood damage centers along the Delaware River including Belvidere. Its purpose was to provide updated flood damage data and evaluate flood reduction strategies. It estimated that a maximum of 104 residences and 20 commercial structures were at that time potentially located within the 150 year floodplain representing the 1955 flood of record. Of these residential structures 54 were not reported flooded by the 1955 event; this could have been the result of topographic inaccuracies, or structures built elevated above the natural ground by even a foot or two. This document reported that a winter 1970 storm on the Pequest alone caused flooding damage to 75-85 homes and 25 businesses, about the same as the 1955 flood of record.

The September 1983 Floodplain Management Study Pequest River Watershed by the Soil Conservation Service identified and delineated flood hazard areas along the stream corridors of the Pequest. Within Belvidere, it was reported that a seven-foot-high dam downstream of the railroad bridge near the mouth of the Pequest River (which still exists) creates a backwater about 5' at the 10-year event and 2' at the 100-year flood. A second dam upstream of Market Street (also still exists) creates a backwater about 4' at the 10-year event and 2' at the 100-year flood. Belvidere's flooding is a result of three factors: one, there is a high concentration of residential and commercial dwellings along the river; two, Beaver Brook (located 2 1/3 miles upstream) substantially increases the peak flow rate which when combined with one causes the water to flow out of bank onto Water Street near Howell; and three, the lower section of the town is subject to flooding from the Delaware River (which can extend all the way up the Pequest to the second dam in the vicinity of Market Street (1/3 mile from the mouth).

A Pre-Authorization Planning Report and Plan of Work, titled "Lower Pequest River Watershed, Warren County, New Jersey" was completed by the United States Department of Agriculture, Soil Conservation Service (now known as the Natural Resource Conservation Service (NRCS)) in April 1985. This report was prepared in part to evaluate various methods to reduce flooding along the Lower Pequest River, specifically in the Town of Belvidere. Two of the alternatives pertain to the removal of one or more of the existing dams mentioned above and were both determined to be economically justified at that time. A subsequent April 1987 evaluation done by SCS/NRCS found that as a result of a more detailed hydraulic analysis, the flood stages (elevation associated with a given flood event) were somewhat lower than earlier computed and that groundwater induced flooding of basements was not reduced to the degree assumed. In addition, a detailed structure by structure economic inventory found

that, in large part to property owner's initiative, basement flooding was less than half of that assumed in using nationwide standard damage curves developed by the National Flood Insurance Administration. As a result of these two refinements, removal of one or both dams recommended in the 1985 report could no longer be economically justified.

The August 1984 Delaware River Basin Report listed 151 residences, 38 commercial properties, and 2 services in the 500 year floodplain (also referred to a the Standard Project Flood SPF) and 75 structures in the 100-year floodplain. That report provided information on the damages expected based on the level of development in 1983 from different flooding events. Those damages are as follows: $0 damages for the 10-year event, $150,000 for the 50-year event, $782,000 for the 100-year event, $2,112,000 for a repeat of the 1955 flood of record, and $6,406,000 for the 500-year event. Consolidated Average Annual Damages were estimated at $40,000 in March 1983.

The August 1984 Delaware River Basin Report evaluated flooding along the Delaware River including the Pequest.

- At Belvidere it evaluated two levees, on either side of the Pequest. This alternative produced $31,000 Average Annual Benefits vs. Average Annual Costs of $770,00) for a Benefit to Cost ratio of 0.04 to 1.
- Belvidere was also evaluated for nonstructural flood measures. 191 structures were located within the floodplain, with 83 percent requiring protection. The Benefit to Cost ratio of providing this level of protection was 0.13 to 1 (AAB $24,000 to AAC $180,00 at 1984 price levels).

Results of a field inspection conducted on 24 January 2007 by Corps of Engineers staff and local representatives. When the Delaware reaches 16', it backs up into the Pequest River. Water in the Pequest then goes up storm drains and causes flooding. Later, the water also overtops the Pequest and causes additional flooding. The Delaware River has not overtopped its banks in this area since 1955. The Pequest floods parts of Wall Street, Water Street, Front Street and DePue Street. On the southern side of the Pequest, water from the Delaware River also comes up a municipal boat ramp and further contributes to the flooding.

There are two existing run of river type dams within Belvidere on the Pequest River. The lower dam was recently purchased by the State of New Jersey with Green Acres funding and is currently operated by the NJDEP, Division of Fish & Wildlife. Local residents report siltation within the Pequest, notably behind and downstream of the lower Dam. Local residents also report a rise in the Delaware River bed at the confluence of the Pequest and Delaware River. Since the first of the three floods, an island has begun forming on the south side of the Water Street bridge.

On the southern edge of Belvidere the Delaware River floodwaters back up the Pophandusing Brook, and also scour out the river bank. Flooding occurs on DePue Street and Mansfield Road. Just upstream from the confluence of the river and the brook, the Pophandusing flows in an "S" shaped meander that is constrained by a culvert thru a railroad embankment and by the end of DePue Street. The brook shows signs of

attempting to realign itself; there is significant erosion along its banks. Some local residents have deposited boulders on portions of the embankment in an attempt to keep the brook's alignment from encroaching on DePue Street. Portions of one driveway have already been lost due to bank erosion. Some basements in Belvidere have dirt floors and experience inundation by ground water.

Belvidere uses reverse 911 to warn people about impending flooding. They then go door-to-door to try to get people to evacuate. The majority of the residents don't want to evacuate, especially those who get only basement flooding. With adequate warning of an imminent flood, many people move exposed contents to higher locations in the structures (see prior NRCS evaluation). Municipal representatives have encouraged residents to raise their utilities above flood levels, evacuate when instructed to do so, and seal basements from groundwater.

Municipal Officials have stated that during a major storm event, approximately 55 homes have been flooded, 22 get flooded about 3'-5' in the first floor, the rest get flooded only in the basements. Property values of the homes are approximately $250K-$350K. Impacted owners are interested in relocating and several "for sale" signs were visible during the site visit. Two houses that incurred 1st floor damage have been sold. Town officials report that the market value of homes has dropped since the recent set of storm events. The damage for each event was approximately $50K-$75K for 1st floor flooding. No deaths have occurred as a result of flooding.

According to FEMA, based upon **a** comparative analysis of the National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 31 repetitive loss properties (payments totaling $1,411,393) with 3 severe repetitive losses (payments totaling $440,229) . This does not include damages from noninsured properties. These losses are primarily clustered along the Pequest in the vicinity of the Market Street Dam (Water and South Water Streets) or along DePue Street.

ALTERNATIVE EVALUATION

PEQUEST

- STRUCTURAL FLOOD CONTROL MEASURES

The Municipality would like the following measures evaluated: (1)dredging the Pequest- if dredging could be designed to direct floodwaters onto the undeveloped State property on the south side of the river, rather than the developed properties on the north side. (2) removal of the downstream dam on the Pequest to help with the backwater problem they seem to experience from the Delaware River by helping the Pequest carry floodwater more efficiently, thereby reducing property damage. (3) Channelization to make the Pequest wider and/or deeper. (4) Flap gates on the storm drains that are carrying floodwaters in the wrong direction. (5)Local officials would prefer not to have buyouts of

flooded properties because there would be a loss of tax ratables. (6) Some homeowners are interested in elevation of their homes.

- A levee-floodwall system was considered previously.
- Channel Modification as such is not viable. No constrictions exist whose removal would likely measurably reduce flood stages. Debris blockage has not been reported as a problem in prior reports nor in correspondence with local officials.
- Local Detention is not viable since no vacant land is available & minimal stage reduction could result. Upstream dams were investigated in the past but economic viability is highly unlikely. Offline detention basins should be reviewed.
- FlapGates/Stormwater Outlets are definitely needed and would be effective both for Delaware Backup as well as fluvial flooding from the Pequest.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

  - Basement floodproofing/sealants, raising/protection of utilities, dry floodproofing/individual levees are all measures that could be viable.

POPHANDUSING CREEK

- STRUCTURAL FLOOD CONTROL MEASURES
  - FlapGates/Stormwater Outlets are definitely needed and would be effective both for Delaware Backup as well as fluvial flooding from the Pophandusing Creek. A flapgate on the railroad embankment may also be warranted.
  - No other structural solutions are viable based on the relatively low level of damages.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
  - A review of nonstructural flood control measures is warranted.

MAINSTEM DELAWARE RIVER

- STRUCTURAL FLOOD CONTROL MEASURES
  - With river flooding not occurring until a flood exceeds the 100 year event, no structural solution is economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
  - No nonstructural solution is economically justified but any nonstructural plan for either the Pequest or the Pophandusing Creek would have the added benefit of protecting from Delaware River Flooding.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D, 1962
Report titled Extent and Frequency of Floods on Delaware River in the Vicinity of Belvidere, NJ by George M. Farlekas of the USGS October 1966
Flood Control and the Delaware River by Laurie Burt and Leo M. Eisel, PH.D. April 1973
A Reconnaissance Report on the Flood Control Problem, Town of Belvidere, Warren County, New Jersey, Corps of Engineers in October 1971
The September 1983 Floodplain Management Study Pequest River Watershed by the Soil Conservation Service
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
A Pre-Authorization Planning Report and Plan of Work, titled "Lower Pequest River Watershed, Warren County, New Jersey", USDA SCS (now NRCS) April 1985.
Design Manual fro Retrofitting Flood-prone Residential Structures FEMA 114, Sep 1986

YARDLEY, PENNSYLVANIA

BACKGROUND

The small community of Yardley Borough is bordered by the Delaware River and Trenton, NJ on the east and by Lower Makefield Township on the north, west, and south. Yardley is located at 40°14′29″N, 74°50′11″W (40.241508, -74.836325). The population was 2,498 at the 2000 census. Surrounding Lower Makefield Township (often colloquially paired with Yardley) had a population of 32,681. According to the United States Census Bureau, the borough has a total area of 2.6 km² (1.0 mi²). 2.4 km² (0.9 mi²) of it is land and 0.3 km² (0.1 mi²) of it (9.90%) is water. While portions of the Delaware are designated as Wild and Scenic, no portion of the Delaware River at Yardley is so designated.

As of the census of 2000, there were 2,498 people, 1,170 households, and 649 families residing in the borough. The population density was 1,048.4/km² (2,729.0/mi²) and there were 1,209 housing units. The Borough's population has remained stable, while growth in surrounding Lower Makefield Township has nearly doubled the Township's population's size since 1980.

PROBLEM IDENTIFICATION

Yardley has been subjected to flooding from four sources. Flooding from the Delaware River can come from fluvial flood stages or as occurred in 1996 from ice jams. Floodwaters also enter the Borough from the Delaware Canal which parallels the Delaware River with the distance between the canal and the river varying from 650 to 1,500 feet. Flooding from the Delaware Canal was considered a major problem in the 1955 flood and resulted in the addition of an overflow weir where the Delaware Canal crosses over Brock Creek.

The Delaware Canal just below lock 8 at New Hope is only a few feet above the banks of the Delaware River and even minor flooding, such as occurred on April 1-2, 1993, can cause river waters flowing into the Canal. Heavy local rainfall also causes runoff into the canal; runoff from I-95 just North of Yardley has also been reported as a problem. The West Trenton Railroad embankment restricts flows in the lower portion of the Borough and even minor river stages (above 17') at the Trenton USGS Gauge causes water to backup culverts under River Road and flood homes nearby.

Two tributary streams have also been a source of flooding. In June 12, 1996 over 9 inches of rain from a local thunderstorm fell in 4 hours overflowing the banks of local streams, Silver Creek (also called Bock Creek) begins south of Yardley and flows through a 10 acre lake and flows into the Delaware Canal. Brock Creeks originates west of Yardley and has a 6.01 square mile drainage area (including 2.38 sq. mile Buck Creek) and flows under the Delaware Canal. A concrete aqueduct carries the canal over this creek and any excess flows in the canal are designed to overtop a weir and spill into Brock Creek.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from earlier storm events. Yardley had 223 residential, 26 commercial and no industrial properties inundated in the 1955 storm of record. Damages in 1955 dollars at Yardley from this event were estimated at $3,200,000. In today's dollars damages would nine or ten times the 1955 reported amount.

The 1955 flood event at Yardley was compounded by debris buildup at the Yarley-Wilburtha Bridge causing as much as a 2-3 foot higher crest before the bridge was swept downstream. It was not rebuilt.

The April 1973 Flood Control and the Delaware River Report by Laurie Burt and Leo M. Eisel, PH.D. evaluated 8 flood damage centers along the Delaware River including Yardley. Its purpose was to provide updated flood damage data and evaluate flood reduction strategies in opposition to Tocks Island. At Yardley it reported that estimated damages from a return of the 1955 in 1972 would involve estimated residential damages of $444,000, commercial damages of $641,000, and industrial damages of $319,000, for a total of $1,403,000 which would convert to $5,600,000 in 2007 dollars.

The July 1983 State Water Plan, prepared by PADER (now PADEP) includes combined flood information on Yardley, Lower and Upper Makefield Townships. Average Annual Damages (AAD) of $198,700 (1976 price level) were reported which converts to an AAD of $ 630,000 (2007 price level) for all three municipalities. It was determined that structural projects were not feasible due to scattered damages. However, PADER did recommend nonstructural measures including Flood Plain Regulation, Flood Insurance, Flood Proofing and Flood Forecasting.

The August 1984 Delaware River Basin Report evaluated flooding along the Delaware River including Bock and Brock Creeks and the Delaware Canal.

- A comparison of structures damaged in 1955 and potentially damaged in 1981 for a repeat of that storm showed an increase in number of structures. Residential Structures increased from 223 in 1955 to 272 in 1981 and Commercial Structures increased from 26 in 1955 to 27 in 1981. The Amount of damages from a single event was also reported as follows.

March 1983 Dollars and Conditions ($000)				
10 yr	50 yr	10 yr	1955	500 yr
156	3,942	8,308	11,509	15,696

- The report evaluated two levees above and below Brock Creek ($379,000 Average Annual Benefits vs. Average Annual Costs of $2,668,000) for a Benefit to Cost ratio of 0.14 to 1.
- Yardley was also evaluated for nonstructural flood measures. Of the 328 structures in the floodplain, 63% required no protection from the 35 year flood event, 24% needed floodproofing or floodwalls, 12% needed elevating and 1% required buyouts. The Benefit to Cost ratio of providing this level of protection was 0.66 to 1 (AAB $97,400 to AAC $148,300 at 1984 price levels). Floodproofing to a higher level of protection would have much higher costs and a lower amount of benefits.

A Preliminary Investigation, Flood Control Study (Section 205) Report was completed by the Corps of Engineers in July 1999. That study followed the June 1996 storm. An initial screening for several locations was conducted but neither costs nor benefits were quantified:

- North Main Street Bridge at Brock Creek Brock Creek overflowed its banks from the storm of June 1996 and flooded the Friends Meetinghouse and several residences downstream. The bridge was not thought to be a cause of flooding; channel capacity and the affect of the aqueduct backwater were likely causes of the limited flooding. A structural solution was not recommended due to the limited dollar damages.
- Yardleyville Square Shopping Center Located adjacent to Brock Creek near the confluence with Buck Creek, floodwaters did not reach the shops but were limited to the parking lot. A structural solution was not recommended.
- Brock Creek at Delaware Canal A concrete aqueduct carries the Delaware Canal over Brock Creek with the June 1996 flood. The size of the opening is inadequate for a 100+ year flood. When the aqueduct is eventually replaced, the opening should be enlarged.
- Silver Creek at Delaware Canal This stream discharges directly into the Delaware Canal and has caused towpath failure due to the stormwaters' velocity. An overflow pipe to divert excess water to the Delaware River plus strengthening the canal by construction of a wall to prevent a repeat of the scour should both be considered further.

- Non-Structural Measures were recommended for further consideration.

Flooding from the Delaware River was not evaluated at that time. Further investigation was not undertaken since the Borough of Yardley was unable to fund its share of the continuing portion of study.

A study by PADEP, Bureau of Waterways Engineering, completed in May 2001, a Hydraulic Study of Silver Creek, Brock Creek, and the Delaware Canal in the Borough of Yardley. It computed peak discharges comparing 7 hydrologic methods.

Two Hazard Mitigation Grant Program Joint State –Federal Applications were prepared for Yardley in late 2006. The first was for construction of two additional 48-inch diameter relief gates at the Delaware Canal-Brock Creek Aqueduct. Costing $1,500,000, it would add the single existing relief gate and was to relieve a 100-year localized storm event. The second is a stormsewer relief project along Lechworth Ave. at an estimated cost of $415,000 which would collect runoff at low points protecting the 100 adjacent property owners.

Flood Control Measure Report for The Township of Lower Makefield, Bucks County, PA prepared by Schoor Depalma in October 13, 2007 provides some information concerning flooding in the vicinity of the Conrail railroad embankment. This embankment acts as a dam and lets only water through the Delaware Canal and towpath opening.

According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 143 repetitive loss properties (payments totaling $13,967,309) with 29 severe repetitive losses (payments totaling $5,495,912). This does not include damages from noninsured properties.

ALTERNATIVE EVALUATION

BUCK AND BROCK CREEKS

- STRUCTURAL FLOOD CONTROL MEASURES

    - Local Detention was re-evaluated by Lower Makefield Township and the Borough of Yardley after the June 1996 storm. Nearly half the detention basins did not retain stormwater as anticipated from a greater-than a 100-year storm event. Outlet controls have been modified to insure adequate retention from subsequent storms.
    - Brock Creek Streambed modification was proposed for evaluation in the 1999 Corps Flood Evaluation. Removal of debris (clearing & snagging) that has accumulated in the streambed in the vicinity of the aqueduct (upstream, downstream, and under aqueduct) should become a regular part of Borough maintenance activities. Deepening of the streambed to

increase flow capacity for Brock Creek under the Canal may be a viable short term solution but deepening alone may be inadequate to handle excess flow in Brock Creek because (1) silting would occur over time, (2) rock exists in the streambed, limiting the degree of channel deepening.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - Flood Proofing. Need to investigate the feasibility of utilizing flood proofing techniques for residential properties in the vicinity of Brock Creek at the Canal. Focus on properties that were affected by past flooding.

DELAWARE CANAL

- STRUCTURAL FLOOD CONTROL MEASURES
    - Repair Aqueduct: Some repair needs to be made to existing aqueduct structure. Remove spalled concrete and repair cracked sections as necessary. Increase capacity of overflow from Canal into Brock Creek, as the Borough has proposed in its Hazard Mitigation Grant Application. Remove excess silt & debris from creek bed in vicinity of aqueduct, especially upstream side—to provide unobstructed flow of Brock Creek under canal.
    - Replace Aqueduct: Minimal flood control benefits are thought to occur from removal of old aqueduct and replacement with new structure. Should consider increasing the width of opening for flow of Brock Creek under Canal when aqueduct eventually replaced.
    - Increase Number of Wastegates: The Borough's request for additional relief gates at the canal aqueduct over Brock Creek needs to be implemented since higher river flows do enter the canal upstream just below New Hope and historic gates within the canal to restrict high flows from traveling down the canal have been removed long ago. Additional weirs or overflows need to be considered as well both upstream of Yardley and in the vicinity of Lock 5.
    - During the recent floods, the Delaware Canal overtopped the towpath in several places, contributing to the flooding in Yardley and Lower Makefield. Raising the grade and stability of the towpath in low areas would reduce the amount of water gathering in the drainage ditch that runs parallel to the canal and reduce the likelihood of canal breaching or overflowing at improper locations.
    - Delaware Canal at Silver Creek. Stabilize the Canal bank opposite Silver Creek. Determine the most appropriate material/method or combination (rip-rap, geotextile, gabion, etc.). Past dredging project has provided a reconstructed bank but without any stabilization.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

- Flood proofing techniques used to protect the residential properties from Delaware River floodwater will have coincidental benefits from flows overtopping the Canal.

MAINSTEM DELAWARE RIVER

- STRUCTURAL FLOOD CONTROL MEASURES

  - A levee-floodwall system along the Delaware River was previously found to be a poor economical investment. The area between River Road and the banks of the Delaware River has sufficient area for construction of a levee/floodwall. A temporary floodwall, typically 3-4 foot high could be (if placed upon a 2 foot high permanent base) a 4 foot high levee with a 2 foot freeboard. With River Road beginning to flood at elevation 20'+/- this would provide protection against a 50-60 year flood event. The need to provide over a mile of temporary floodwall in about 24-30 hours, even with the structures bought and stored nearby, would probably be beyond the ability of the Borough's personnel to fully put in place. This could be rectified by utilizing a combination of permanent and temporary floodwalls. While this levee variation may not be economically justified, sufficient viability exists to warrant further investigation. Stacking of the temporary floodwalls may increase the level of protection but construction within a 24 hour period is unlikely.
  - Channel Modification is not viable. No constrictions exist whose removal would likely reduce flood stages. There would be limited stage reduction with high economic & environmental cost from deepening river channel. There are no dams on Delaware River in vicinity of Yardley whose removal could alter stage flows.
  - Local Detention for River caused flooding is not viable. No sizable vacant land is available & minimal stage reduction could result.
  - FlapGates/Stormwater Outlets are a critical component of any flood control project. The community between the Canal and the Delaware River centering on College and Lechworth Avenues is especially low-lying with river flooding known to occur before River Road is overtopped. In addition to flap gates a series of pumps for interior drainage would be needed.
  - Conrail Railroad Embankment- The embankment restricts flows and ways to reduce this impediment needs to be studied. One option being discussed is a bypass either to a channel directly into the Delaware River or into a detention basin created at Macclesfield Park in Lower Makefield.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

  - The 1984 Corps evaluation of floodproofing found sufficient economic viability (BCR = 0.66) that these series of options needed to be re-evaluated in more detail. Flood proofing techniques include levees, flood

walls, elevation, relocation, closures & sealants. Flood proofing functions fall into three general categories: (1) construction of barriers to prevent floodwater from entering the property, (2) elevation or relocation of the structure above the flood hazard, (3) alteration of the structure and relocation of the contents to minimize flood damage. The ability for staged implementation is a significant positive factor.

- Flood warning should also be re-evaluated.
- Wetland/ Floodplain Restoration is not viable in itself with limited unoccupied former floodplain.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, 1962, Appendix D, 1962
April 1973 Flood Control and the Delaware River Report (Environmental Defense Fund) by Laurie Burt and Leo M. Eisel, PH.D
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
July 1983 State Water Plan, prepared by PADER
A Preliminary Investigation, Flood Control Study (Section 205) Report was completed by the Corps of Engineers in July 1999.
A Hydraulic Study of Silver Creek, Brock Creek, and the Delaware Canal by PADER, Bureau of Waterways Engineering May 2001
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, October 2006
Flood Control Measure Report for The Township of Lower Makefield, Bucks County, PA prepared by Schoor Depalma October 13,2007.

NEW HOPE, PENNSYLVANIA

BACKGROUND

New Hope, formerly Coryell's Ferry, is a borough in Bucks County, Pennsylvania, and is located at 40°21′37″N, 74°57′26″W (40.360312, -74.957203).
According to the United States Census Bureau, the borough has a total area of 1.4 square miles (3.7 km²), of which, 1.3 square miles (3.3 km²) of it is land and 0.2 square miles (0.4 km²) of it (11.19%) is water. Much of this is the Delaware River. The population was 2,252 at the 2000 census.

The borough is located at the confluence of the Delaware River and Ingham Creek sometimes called Aquetong Creek, which begins in Solebury Township at Ingham Springs, the most productive spring in Southeastern Pennsylvania, about two miles from its mouth. The name "Aquetong" comes from a local Indian word meaning "place of the pine trees," a reference to the pine forest that the creek runs through at the beginning of its route. Near its end, the creek forms a scenic millpond and waterfall near the Bucks County Playhouse, a former mill powered by the flow of water. The Delaware River Joint Toll Bridge Commission operates two bridges over the Delaware River between New Hope, Pennsylvania and Lambertville, New Jersey. One is a free, two-lane bridge between the two towns, the other, which carries U.S. Highway 202, is a modern toll bridge.

The primary industry of New Hope is tourism. On weekends the streets are crowded with tourists visiting the many restaurants, antique shops and art galleries, or just strolling along the river and the Delaware Division of the Pennsylvania Canal.

PROBLEM IDENTIFICATION

Of the three water bodies within the boundaries of New Hope; the Delaware River, the Aquetong Creek and the Delaware Canal, it appears that the Delaware River is the primary source of flooding and has been a continual problem since settlement of the area. Although the worst flooding generally results from excessive rainfall alone, flooding in the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Based on a comparison of flood maps and aerial photos it does not appear that the last mile of Aquetong Creek, which lies within the boundaries of New Hope Borough, is a significant threat to the residents of New Hope due to the limited structural occupation along the creek’s floodplains.

The Delaware Canal also does not appear to cause a separate flooding problem but rather is affected directly by overbank floodwaters from the Delaware River.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from earlier storm events. New Hope had 146 residential, few commercial and industrial properties inundated in the 1955 storm of record. Damages in 1955 dollars from this event were estimated at $1,500,000. In today's dollars damages would be nine or ten times the 1955 amount.

The April 1973 Flood Control and the Delaware River Report by Laurie Burt and Leo M. Eisel, PH.D. evaluated 8 flood damage centers along the Delaware River including New Hope. Its purpose was to provide updated flood damage data and evaluate flood reduction strategies in opposition to Tocks Island. At New Hope it reported that estimated damages from the 1955 storm of record were as follows: residential damages of $444,000 to 146 residential structures, commercial damages of $641,000, and industrial of $319,000, for a total of $1,403,000 which would convert to $6 million in 2007 dollars. In 1972 that report estimated a total of 117 structures remained in the floodplain valued at $3.1 million.

The July 1983 State Water Plan, prepared by PADER (now PADEP), includes flood information on New Hope. In their analysis, PADEP analyzes a levee and estimates Total Average Annual Damages (AAD) of $54,300 (1976 price level), Average Annual Costs (AAC) of $46,000 and Average Annual Benefits (AAB) of $31,000 for a BCR of .67 Recommended alternatives were nonstructural measures including Flood Plain Regulation, Flood Insurance, Flood Proofing and Flood Forecasting.

The August 1984 Delaware River Basin Report evaluated flooding along the Delaware River and developed a comparison of structures damaged in 1955 and structures potentially damaged in 1981 for a repeat of that storm. The report showed a decrease in the number of residential and an increase in commercial structures. residential structures decreased from 146 in 1955 to 105 in 1981 while commercial structures increased from 0 in 1955 to 109 in 1981. The Amount of damages from a single event was also reported as follows.

March 1983 Dollars and Conditions ($000)

10 yr	50 yr	100yr	1955	500 yr
67	2,589	5,929	10,932	18,424

The report evaluated two levees/floodwalls above and below Aquetong Creek totaling 6,600 feet with a first cost of $11,400,000. The report estimated $214,000 Average Annual Benefits vs. Average Annual Costs of $1,018,000 for a Benefit to Cost ratio of 0.20 to 1.

New Hope was also evaluated for nonstructural flood measures. Of the 278 structures in the 22 year floodplain, 93% required no protection from that 22 year flood event, 5% needed floodproofing or floodwalls, 2% needed elevating and none required buyouts. The Benefit to Cost ratio of providing this level of protection was 1.95 to 1 (AAB $66,200 to

AAC $33.89 at 1984 price levels). Floodproofing to a higher level of protection would have much higher costs and a lesser amount of relative benefits.

Aquetong Creek Coldwater Heritage Plan Jan 2007, done by F. X. Browne for Trout Unlimited reported that Solebury Township, within which most of the 7.5 square mile watershed is located, has a stringent stormwater ordinances. It now requires no net increase in discharge into streams which is more restrictive than NPDES Phase 2 stormwater regulations in Pennsylvania.

According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 88 repetitive loss properties (payments totaling $3,895,035). This does not include damages from noninsured properties.

ALTERNATIVE EVALUATION

AQUETONG CREEK

- STRUCTURAL FLOOD CONTROL MEASURES
    - Local Detention criteria has been strengthened by Solebury Township which restricts new development from any increase in offsite drainage flow increase and is inspecting all existing detention basins to insure proper operation and maintenance. Further action for New Hope is not required.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - Flood Proofing. Need to investigate the feasibility of utilizing flood proofing techniques for residential properties along the stream.

DELAWARE CANAL

- STRUCTURAL FLOOD CONTROL MEASURES
    - No improvements are envisioned that could measurably affect flooding in New Hope. A proposed stop gate repair on the canal near Center Bridge, which is included in the 1987 Canal Master Plan may provide limited benefits if locks upcanal of New Hope cannot now completely stop flows.
    - Downstream of Lock 11 there was a former lock that allowed canal boats to enter the Delaware River. The lock mechanism and a canal stop gate are reported as not functional and this may be contributing to downriver canal storm flows and subsequent flooding.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - No separate action appears viable.

MAINSTEM DELAWARE RIVER

- STRUCTURAL FLOOD CONTROL MEASURES

    - A levee-floodwall system along the Delaware River was previously found to be a poor economical investment. The area south of Aquetong Creek had a sufficient BCR of 0.66 to 1 to justify a reanalysis. Rather than a permanent levee/floodwall which would isolate the community, a temporary floodwall coupled with a permanent base and some permanent floodwalls should be investigated. The amount of permanent vs. temporary would to a large degree be determined by the type of temporary structure chosen and the time the Borough could erect the temporary floodwall.
    - Channel Modification is not viable. No constrictions exist whose removal would likely reduce flood stages. There would be limited stage reduction with high economic & environmental cost from deepening river channel. The one dam on Delaware River in vicinity of New Hope would at most affect the flood stage by 1 or 2 feet.
    - Local Detention for River caused flooding is not viable. No sizable vacant land is available & minimal stage reduction could result.
    - FlapGates/Stormwater Outlets are a critical component of any flood control project and several pipe extensions need to be implemented. A review of recent flooding should be undertaken to determine if backup of the stormwater system which appears to be a major contribution for minor flood events would benefit from the addition of either permanent or temporary pumping stations.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

    - The 1984 Corps evaluation of floodproofing found sufficient economic viability (BCR = 1.95) even for a relatively low level of protection (22-year event) that these series of options needed to be re-evaluated in more detail. Flood proofing techniques include levees, flood walls, elevation, relocation, closures & sealants. Flood proofing functions fall into three general categories: (1) construction of barriers to prevent floodwater from entering the property, (2) elevation or relocation of the structure above the flood hazard, (3) alteration of the structure and relocation of the contents to minimize flood damage. The ability for staged implementation is a significant positive factor.
    - Flood warning should also be re-evaluated. An emergency telephone system in Bucks County is currently operational.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, 1962, Appendix D, 1962
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
April 1973 Flood Control and the Delaware River Report (Environmental Defense Fund) by Laurie Burt and Leo M. Eisel, PH.D
July 1983 State Water Plan, prepared by PADER
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, October 2006.
Aquetong Creek Coldwater Heritage Plan Jan 2007, F. X. Browne for Trout Unlimited

EASTON, PENNSYLVANIA

BACKGROUND

Easton is a city in Northampton County, in the eastern region of Pennsylvania. It is also the county seat of Northampton County. The population was 26,263 at the 2000 census. The city is split up into four primary sections: Historic Downtown, the West Ward, the South Side and College Hill. Historic Downtown is a low-lying area surrounded by hills, lying south of the Bushkill Creek, north of the Lehigh River, to the west of the Delaware River and continues west to Sixth Street. The West Ward lies between Sixth and Fifteenth Streets; the South Side lies south of the Lehigh River; and College Hill is home of Lafayette College.

Easton is located at 40°41′18″N, 75°12′59″W (40.688248, -75.216458).
According to the United States Census Bureau, the city has a total area of 12.0 km² (4.7 mi²). 11.0 km² (4.3 mi²) of it is land and 1.0 km² (0.4 mi²) of it (8.39%) is water including Bushkill Creek and the Lehigh and Delaware Rivers. While portions of the Delaware are designated as Wild and Scenic, no portion of the Delaware River at Easton is so designated.

PROBLEM IDENTIFICATION

Easton has been the subjected to flooding from all three of its water bodies. Flooding from high Delaware River flood stages also causes backup into the Bushkill and Lehigh.

For the Lehigh River, a majority of flood damage has been eliminated by the cooperation of two Corps of Engineers' reservoirs (F. E. Walter and Beltzville). Backup from high Delaware River flows can still be expected to cause significant damages.

For Bushkill Creek more than half the flooding is a result of Delaware River backup but one can not ignore flooding from rainfall upstream overflowing the Bushkill.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from earlier storm events. Easton had 237 residential, 119 commercial and 12 industrial properties inundated in the 1955 storm of record. Damages in 1955 dollars at Easton from this event were estimated at $5,000,000 for the Delaware River, $300,000 for the Lehigh, and $35,000 on the Bushkill. Damages from earlier events were not able to be broken down. In today's dollars damages would be nine or ten times the 1955 amount.

The April 1973 Flood Control and the Delaware River Report by Laurie Burt and Leo M. Eisel, PH.D. evaluated 8 flood damage centers along the Delaware River including Easton. Its purpose was to provide updated flood damage data and evaluate flood reduction strategies in opposition to Tocks Island. At Easton it reported the elimination of over 150 residences, nearly 100 commercial properties, and 9 industrial properties as part

of the Riverside Drive Redevelopment Project which created Scott Park in Easton. Non-structural measures (floodproofing and floodwarning) were proposed strategies for damage reduction for the remaining structures. It also reported a PADER proposed dam along the Bushkill, 14 miles north of Easton which would have reduced flood damage along the Bushkill; it was however, never built. See discussion Belfast/Jacobsberg Reservoir that follows.

The Bushkill was also investigated in October/November 1967 in response to a request by Congressman Rooney. Bushkill Park was visited and flood damage information obtained. According to local interests, the primary cause of damages was debris blockage from an old bridge on the Bushkill. Information was provided to local interests on the Corps' Continuing Authority Program but a request for a study was never received. As part of that investigation, PA Department of Forests and Waters, (PADEP Predecessor) was contacted concerning a Jacobsburg Project. That recreation reservoir was first reported in the Comprehensive Study of the Delaware River Basin H.D. 522 as Belfast Dam (Wg-5), one of 39 small flood control projects but was not pursued further due to a lack of local interest. This 523 acre reservoir would have reduced average annual flood damages from $86,800 in 1955 dollars ($800,000 today) to $52,800 (also 1955 dollars which can be updated to a current $500,000 dollars). This Belfast/Jacobsberg Reservoir had in 1955 a computed BCR of 2.6 to 1 based primarily on recreation. This reservoir site was subsequently acquired by Pennsylvania and was developed as a State Park without a Reservoir due to local opposition to a reservoir. The Pennsylvania staffer contacted as part of the October/November 1967 Coordination also mentioned that the Soil Conservation Service was investigating the Bushkill for flood control reservoirs at that time but locations were too expensive to implement. NRCS (SCS's new nane) was contacted as part of this flood evaluation and had no documentation other than a database which indicated insufficient economic benefits were found to justify its constructing a reservoir on the Bushkill.

The July 1983 State Water Plan, prepared by PADER (now PADEP) includes combined flood information on Easton and West Easton. This damage center includes flooding from both the Lehigh and Delaware River (and presumably Bushkill Creek) reporting a 77% reduction in Natural Annual Damages Due to Existing Projects (F.E. Walter and Beltzville) with residual Average Annual Damages (AAD) of $241,600 (1976 price level) which converts to an AAD of $770,000 (2007 price level).

- Flood Damage Reduction Solution Alternatives listed a levee (AAD Prevented $140,100 at a Average Annual Cost (AAC) of $182,900 making the project not Economically Justified. (Location details absent).
- Recommended were nonstructural measures including Flood Plain Regulation, Flood Insurance, Flood Proofing and Flood Forecasting.

The August 1984 Delaware River Basin Report evaluated flooding along the Delaware River including the Bushkill.

- At Easton it evaluated a levee ($129,600 Average Annual Benefits vs. Average Annual Costs of $2,100,000) for a Benefit to Cost ratio of 0.06 to 1.

- Easton was also evaluated for nonstructural flood measures. Of the 260 structures in the floodplain, 78% required no protection from the 50 year flood event, 12% needed floodproofing or floodwalls, 10% needed elevating and none required buyouts. The Benefit to Cost ratio of providing this level of protection was 0.64 to 1 (AAB $98,700 to AAC $152,900 at 1984 price levels).

The May 1990 Lehigh River Flood Warning Study proposed a separate flood warning/preparedness system for the Lehigh Basin as an interim flood control measure. It was never implemented in large part due to the inability of a non-Federal sponsor to guarantee operation and maintenance of additional stream gauges. Economics were based upon surveys conducted for the F.E. Walter Modification General Design Memorandum. Benefits were to come from a reduction in content damages.

The December 1992 Lehigh River Basin, Reconnaissance Study evaluated flooding on the Lehigh River and Tributaries. AAD in Easton from Lehigh River damages was reported as $55,000 and $123,000 in West Easton ($87,000 and $195,000 in current dollars) based on detailed economic surveys from the F.E. Walter Modification General Design Memorandum. Flood damage reduction started at the ten year event and peaked in the 50-80 year flood range. Damages were primarily commercial with some industrial and little residential.

- A fifteen foot sheetpile wall of 3,450 feet along the Lehigh was evaluated. It would not have provided any flood protection to Downtown Easton since it tied into high ground 4000 feet upstream of the Third Street Bridge.

Easton was also included in the Lehigh Valley Hazard Mitigation Plan, July 2006. This report lists flooding as the number one disaster of Lehigh and Northampton Counties. Of the 21 declared disasters since 1955 in these two counties, 14 were from flooding. Easton had the highest number of both claims and payments from flood insurance in the Lehigh Valley from the September 2004, the April 2005, and the June 2006 storms. This Hazard Mitigation Plan lists 176 parcels with structures and 173 parcels without structures within the outline of the 100 year floodplain. This does not mean all these structures get flooded since structure specific elevations were lacking. Of the 176 parcels with structures, 76 were residential, 31 commercial, 26 industrial, 15 office, 7 utility, and 20 public. Total market value was estimated at $336,112,000. There were 4 public utilities and 1 school within the floodplain with an estimated market value of $140,320,000. There were 10 Hazard Mitigation Flooding Projects listed for Easton.

Proposed Hazard Mitigation Projects – City of Easton

BUSHKILL CREEK

- Relocate City Services Center - currently in Bushkill Creek flood area (currently) City Services Center - 500 Bushkill Drive
- Flooding from confluence of Bushkill Creek and Delaware River 100 block of Bushkill Drive

- Homes, businesses flood from Bushkill Creek and Delaware River North Delaware Drive at Bushkill Drive
- Structural enhancements/design modification to floodproof bridge Pearl and Bushkill St.

LEHIGH RIVER

- Properties impacted by Lehigh River Buttonwood between Raspberry and 14th St.
- Properties impacted by Lehigh River Winter St. in area of Raspberry and 14th.
- Relocate/elevate homes located in flood area 14th Street at Lehigh Drive
- Relocate/elevate homes located in flood area Lynn St.
- Relocate/elevate homes located in flood area Raspberry St. at Lehigh Drive area.

DELAWARE RIVER

- Park floods from Delaware River Eddyside Park - North Delaware Drive SR611

According to FEMA, based upon **a** comparative analysis of the National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 30 repetitive loss properties with total payments of $4,793,574 with 1 severe repetitive loss with a payment of $83,848. This does not include damages from noninsured properties.

ALTERNATIVE EVALUATION

BUSHKILL CREEK

- STRUCTURAL FLOOD CONTROL MEASURES

    - A levee-floodwall system is possible for protecting Delaware River flows from backing up the Bushkill. A roadway over the creek 0.1 miles above the mouth could, with a Flapgate added, provide about a 50 year level of protection. NJ Barriers placed along the bridge shoulder and approaches could also possibly increase the level of protection but would still have less than a 100 year level of protection. Portable pumps need to be investigated as part of this effort.
    - Channel Modification as such is not viable as a stand alone system. No constrictions exist whose removal would likely measurably reduce flood stages. A review of potential debris blockage would be warranted based upon the 1967 field investigation and limited channel modification may be warranted in conjunction with than effort. A debris structure typically consists of a series of piles placed across a stream at an angle at a location where debris could collect, have sufficient open space not to cause upstream flood damages by ponding, and have easy access for heavy equipment to remove the debris after a storm.
    - Local Detention is not viable here. No sizable vacant land is available & minimal stage reduction could result. Upstream dams were investigated in the past but economic viability is highly unlikely.

- FlapGates/Stormwater Outlets may possibly be viable. Limited information available but stormwater backup likely. Need to contact the City of Easton to obtain more details.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

  - Review of River Stage Forecast Map (1990) would appear to indicate majority of 57 structures within 50 year floodplain are within Bushkill Creek. Based on 1984 Basin Study sufficient benefits (57 structures with BCR of 0.64 to evaluate further. Of these none required buyouts, 31 benefitted from raising and 26 from floodproofing.
  - County Hazard Mitigation Plans list two locations within Bushkill for non-structural measures.
  - Flood warning should also be re-evaluated
  - Wetland/ Floodplain Restoration is not viable in itself with limited unoccupied former floodplain.

Figure 1: Black Mill Apartments on Bushkill Drive in the City of Easton, September 2004. Photograph by City of Easton.

MAINSTEM DELAWARE RIVER

- STRUCTURAL FLOOD CONTROL MEASURES

    - A levee-floodwall system along the Delaware River was previously found to be a poor economical investment and should not be evaluated further.
    - Channel Modification is not viable. No constrictions exist whose removal would likely reduce flood stages. There would be limited stage reduction with high economic & environmental cost from deepening river channel. There are no dams on Delaware River in vicinity of Easton whose removal could alter stage flows.
    - Local Detention is not viable. No sizable vacant land is available & minimal stage reduction could result.
    - FlapGates/Stormwater Outlets may be viable. Limited information available but stormwater backup likely. Need to contact the City of Easton.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

    - Review of River Stage Forecast Map (1990) indicates majority of 57 structures within 50 year floodplain are within Bushkill Creek. As part of an evaluation of Bushkill Creek those structures affronting the Delaware should be concurrently evaluated.
    - Flood warning should also be re-evaluated.
    - Wetland/ Floodplain Restoration is not viable in itself with limited unoccupied former floodplain.

Flooding at the junction of the Delaware and Lehigh Rivers

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, 1962, Appendix D
April 1973 Flood Control and the Delaware River Report (Environmental Defense Fund) by Laurie Burt and Leo M. Eisel, PH.D
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
May 1990 Lehigh River Flood Warning Study
December 1992 Lehigh River Basin, Reconnaissance Study
River Stage Forecast Map Delaware River – Reach 4 Sheet 24 Northampton & Warren Counties 1993
Easton Intermodal Transportation Center/Riverwalk Project Environmental Assessment
Lehigh Valley Hazard Mitigation Plan, July 2006.
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, October 2006

UPPER MAKEFIELD, PENNSYLVANIA

BACKGROUND

Upper Makefield Township is a township in Bucks County, Pennsylvania. According to the United States Census Bureau, the township has a total area of 21.5 square miles (55.8 km²), of which, 20.9 square miles (54.2 km²) of it is land and 0.6 square miles (1.6 km²) of it (2.88%) is water. As of the census of 2000, there were 7,180 people, 2,512 households, and 2,105 families residing in the township. There were 2,598 housing units. The average household size was 2.86 and the average family size was 3.13. The median income for a household in the township was $102,759, and the median income for a family was $114,064.

PROBLEM IDENTIFICATION

Flooding has been a continual problem along the Delaware River here since settlement of the area. Although the worst flooding generally results from excessive rainfall alone, flooding in the Delaware River in early spring can be even more severe because of moving ice and snowmelt. The Delaware Canal does not appear to cause a separate flooding problem but rather is affected directly by overbank floodwaters from the Delaware River.

Stormwater management has also become an issue in the township. Within the township, Hough's Creek (5.9 sh. Mi) and Jericho Creek (9.63 sq. Mi.) have repeatedly flooded and caused major impact to properties along their banks, primarily erosional in nature.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D provided flood information from earlier storm events. Damages in 1955 dollars from this event were estimated at $394,000 residential, $50,000 commercial, $35,000 public and $85,000 highway, for a total, including miscellaneous of $590,000. In today's dollars damages would be nine or ten times the 1955 amount.

The July 1983 State Water Plan, prepared by PADER (now PADEP) did not include separate damages for Upper Makefield but consolidated damages with Yardley and Lower Makefield. Damages were reported as scattered and local flood protection was not feasible.

The August 1984 Delaware River Basin Report evaluated flooding along the Delaware River and developed a comparison of damages and number of structures for different storm levels.

March 1983 Dollars and Conditions ($000)
And number of structures

	10 yr	50 yr	100yr	1955	500 yr
$ Damages	260	1,702	3,728	8,134	15,565
# Structures	1/	1/	116	246	304

1/ Not listed

At Upper Makefield, local protection (i.e levees/floodwalls) were not evaluated. Upper Makefield was evaluated for nonstructural flood measures. Of the 304 structures in the 22 year floodplain, 91% required no protection from that 22 year flood event, 7% needed floodproofing or floodwalls, 2% needed elevating and none required buyouts. The Benefit to Cost ratio of providing this level of protection was 0.87 to 1 (AAB $29,800 to AAC $34,200 at 1984 price levels). Floodproofing to a higher level of protection would have much higher costs and a lesser amount of relative benefits.

A Plan to Preserve Upper Makefield Township's Farmland & Open Space report dated June 1998 provides some description of watersheds in the Township but limited information on flooding.

The National Park Service prepared, in 1999, a National Wild and Scenic Study Report for the Lower Delaware River. That plan recommended that several river segments, including Segment I containing Upper Makefield, above Washington's Crossing, be designated as recreational within the Wild and Scenic River System. It was made law in October 2000. Section 7(a) of the Wild and Scenic Rivers Act prohibits federal authorization of any water resources project or assistance by loan, grant, license or construction of any water resource project that would have an adverse impact on the values for which the river is designated. The boundary of this designation extends one-quarter mile inland from the ordinary high water mark.

"Recreational" river areas -- Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. Regardless of classification, each designated river is administered with the goal of nondegradation and enhancement of the values which caused it to be designated.

Section 7 of an October 2004 Technical Report of the Interagency Wild and Scenic Rivers Coordinating Council titled Wild & Scenic Rivers Act provides additional guidance. A determination is required when a project is proposed by a federal agency or it requires some type of federal assistance such as a permit, license, grant or loan. Unlike new FERC-licensed projects, which are prohibited if they are "on or directly affecting" a designated river, other proposed federally assisted water resources projects are prohibited only if they would have a "direct and adverse effect" on the values for which a river was added to the National System. Examples of projects that would likely be subject to this standard include, but are not limited to: dams; water diversion projects; fisheries habitat

and watershed restoration/enhancement projects; bridge and other roadway construction /reconstruction projects; bank stabilization projects; channelization projects; levee construction; recreation facilities such as boat ramps and fishing piers; and, activities that require a Section 404 permit from the Army Corps of Engineers. The determination is made in consultation with state and federal agencies as part of the environmental assessment/impact statement process. Depending on the nature of the proposed construction and the degree of effect on the river's values and defined in the original study and management plan, the proposal can be approved, modified, conditioned, or denied.

According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 58 repetitive loss properties (payments totaling $8,701,479) which was the 6th highest municipality in the basin and 17 severe repetitive losses (payments totaling $4,504,390) which was third highest in the basin. This does not include damages from noninsured properties.

Upper Makefield Township prepared a binder titled Delaware River Flooding Data and Effects on Upper Makefield Township dated June 15, 2007.

- Chapter 1 provides general information including a map of the 100 year flood area. That map shows 6 flood damage clusters with 2 above Washington Crossing (30 and 21 damaged homes) with a 6 home cluster at Washington Crossing and 3 clusters south of Washington Crossing with 6, 17, and 4 homes damaged respectively). Also included is a fact sheet that states that flood stage in this area begins when the Trenton gauge shows 20'. Flooding begins to have a major impact at 21' while Delaware Canal begins to fill with water at 18" flood stage. Route 32 is completely impassible at the 18ft level north of Route 532. It also indicates that 17 homes have been elevated and a FEMA grant for 13 more has been applied for.
- Chapter 2 provides information that the Township requires elevation to be 1.5 feet above the 100 foot flood elevation and hydraulic information on flood stage elevation. There is considerable information concerning the Delaware Shores Community which had the largest number of residences flooded in the township. Of the 31 properties, 16 get flooded by the 25 year event and all would be flooded by the flood of record. The April 2005 flood damaged 21 homes (even with 4 being floodproofed) at the 100 year flood level.

- Chapter 3 includes information on the number of homes flooded June 29, 2006 (74).

ALTERNATIVE EVALUATION

HOUGH'S CREEK

- STRUCTURAL FLOOD CONTROL MEASURES
    - Based on the limited data available, erosion rather than flooding appears to be the primary problem from storm events. A DEP Stream Improvements Program grant appears to be the best option for municipal assistance.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - Need to investigate the feasibility of utilizing flood proofing techniques for residential properties along the stream.

JERICHO CREEK

- STRUCTURAL FLOOD CONTROL MEASURES
    - Based on the limited data available, erosion rather than flooding appears to be the primary problem from storm events. A DEP Stream Improvements Program grant appears to be the best option for municipal assistance.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - Need to investigate the feasibility of utilizing flood proofing techniques for residential properties along the stream.

DELAWARE CANAL

- STRUCTURAL FLOOD CONTROL MEASURES
    - Downstream of Lock 11 in Upper Makefield there was a former lock that allowed canal boats to enter the Delaware River. The lock mechanism and a canal stop gate are reported as not functional and this may be contributing to downriver canal storm flows and subsequent flooding. While no report of canal induced flooding in Upper Makefield has been noted, replacement of the stopgate may at least help flooding in Lower Makefield and Yardley.

- NONSTRUCTURAL FLOOD CONTROL MEASURES
    - No separate action appears viable.

MAINSTEM DELAWARE RIVER

- STRUCTURAL FLOOD CONTROL MEASURES

    - A levee-floodwall system along the Delaware River was not previously investigated. With the damages clustered at 6 locations the use of ring levees around these damage locations needs to be evaluated. Rather than a permanent levee/floodwall which would isolate the community and be determined contrary (at least north of Washing Crossing) to the federal Wild and Scenic River Designation, a temporary floodwall coupled with a permanent base and some permanent floodwalls should be investigated. The amount of permanent vs. temporary would to a large degree be determined by the type of temporary structure chosen and the time the municipality could erect the temporary floodwall. How acceptable even a temporary floodwall would be to the Wild and Recreational designation is unknown.
    - Channel Modification is not viable. No constrictions exist whose removal would likely reduce flood stages. There would be limited stage reduction with high economic & environmental cost from deepening river channel.
    - Local Detention for River caused flooding is not viable. No sizable vacant land is available & minimal stage reduction could result.
    - FlapGates/Stormwater Outlets are a critical component of any flood control project and several pipe extensions need to be implemented. A review of recent flooding should be undertaken to determine if backup of the stormwater system which appears to be a major contribution for minor flood events would benefit from the addition of either permanent or temporary pumping stations.
    - The construction of any structural plan must take into consideration the potential for an adverse determination which will be strongly influenced by the exact nature and specific design. Early coordination with the National Park Service should be initiated as soon as possible.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

    - The 1984 Corps' evaluation of floodproofing found sufficient economic viability (BCR = 0.87) that these series of options need to be re-evaluated in more detail. Flood proofing techniques include: levees, flood walls, elevation, relocation, closures & sealants. Flood proofing functions fall into three general categories: (1) construction of barriers to prevent floodwater from entering the property, (2) elevation or relocation of the structure above the flood hazard, (3) alteration of the structure and relocation of the contents to minimize flood damage. The ability for staged implementation is a significant positive factor.
    - Flood warning should also be re-evaluated. An emergency telephone system in Bucks County is currently operational.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, 1962, Appendix D, 1962
Delaware River Basin Study Final Report and Technical Appendices 1984 (2 volumes)
July 1983 State Water Plan, prepared by PADER
Plan to Preserve e Upper Makefield Township's Farmland & Open Space June 1998
The National Park Service 1999 National Wild and Scenic Study Report for the Lower Delaware River. 1999
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, October 2006.
Delaware River Flooding Data & Effects on Upper Makefield Twp. June 15, 2007

COLCHESTER, NEW YORK

BACKGROUND

Colchester is a township in the State of New York. It is approximately 137.4 square miles with a population of 2,042 in the 2000 Census. It has 1,587 houses (837 occupied: 670 owner occupied, 167 renter occupied). Estimated median house/condo value in 2005: $92,900 (it was $73,500 in 2000). The town includes the village of Downsville and the hamlet of Corbett and Shinoppe on the East Branch Delaware River and the hamlets of Cook Falls, and Horton on the Beaverkill.

There are two major waterway systems in the Township. The Beaverkill is a 48 mile stream with the lower 14 miles in Delaware County. There are two clusters of damage centers on the Beaverkill with the lower one in Colchester at the Horton-Cooks Falls Area. They are residential communities where the mouths of small streams enter the Beaverkill. For Horton, its Horton Brook while for Cooks Falls its Cooks Brook. For the East Branch Delaware River, the New York City Pepacton Reservoir is dominant, with this 15 mile long reservoir located just upstream of Downsville. It is also where Downs Brook and Wilson Hollow Brook flow into the East Branch.

PROBLEM IDENTIFICATION

The following description of historic flooding of Downsville comes from a summary of a 1975 interview of the Colchester Town Supervisor. On May 21, 1942 Downsville saw major flooding with the Downs Brook destroyed and major flooding of Main Street. Downs Brook also flooded in August 1952 with water overflowing its banks below the bridge and flooding lower Main Street. In 1952 the Pepacton Dam spillway overflowed with houses on River Street flooded. Ice jams on the East Branch caused flooding in 1964 and again in 1965. The 1973 storm caused Downs Brook to overflow into Main Street.

There is record form the Corps' Cold Region Research Lab of several ice jams occurring at Cooks Falls along the Beaverkill.

Flooding at Horton-Cooks Falls area is caused by a combination of factors. Besides the tributary streams of Horton Brook, Russell Brook, Horse Brook, and Cooks Brook overflowing, the Beaverkill leaves it banks.

Besides Hurricanes and Tropical Storms, localized summer storms in the region are especially damaging as was the case with the June 19-20 2006 event, just the latest of events. The flash flood occurred June 19-20 after this area, along the Delaware and Sullivan counties border, received 6-8 inches of torrential rain in a matter of hours. During the flash flooding which ensued, one bridge was destroyed and several others sustained significant damage. A seven-mile stretch of Holiday Brook Road was also washed away. Dozens of homes were ripped from their foundations, 14 were inaccessible, and an additional 160 were without utilities.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D, provided little flood information from prior storm events. Damages from the 1955 storm was only provided for the East Branch and Beaverkill Watersheds and not individual communities.

The April 1981 Survey Feasibility Report, Flood Control and Flood Plain Management for the Tributaries to the Delaware River New York and its backup evaluated Colchester in detail. It identified flood damage locations and developed detailed evaluations of 10 locations including one at Downsville. Information on flood damages at locations in Colchester are as follows:

SUMMARY OF DAMAGE SURVEY INFORMATION

Damage Center	Sub-Basin	Flood of Event	Total Damages (Nov 80 $)	Total Damages (2007 $)
Cooks Falls	Beaver Kill	31 March 51	$23,200	$55,000
Horton	Beaver Kill	29 June 1973	$12,100	$29,000
Shinhoppe	East Branch	26 Nov 50	$66,500	$158,000
Downsville	East Branch	29 June 73	$209,000	$496,000
Corbert	East Branch	26 Nov 50	$25,800	$61,000

- For Downsville a 4 foot high levee (3 foot freeboard) and floodwall (including closure structure for Main Street) along Downs Brook was evaluated to protect residential and commercial property to the 100-year elevation. The initial cost was $1,080,000, with the AAC of $85,300 and AAB of $18,000 providing a BRC of 0.2.
- Backup can be found in a June 1980 Downsville Flood Control Analysis Summary. That report provides details on the design of the levee and floodwall as well as hydraulic computations. Based on the amount of historic flooding noted (4-6' of flood stage from the flood of record) coupled with the absence of damages computed at the 25 year flood event, the stage-damage curve and the levee-floodwall height need to be revisited. Use of a sheet pile wall rather than a traditional levee-floodwall would also reduce costs.

The Delaware River Basin Ice Jams Study of 1985 did not indicate that within Colchester Township there were major problem areas for ice jams.

The 1996 Upper Delaware River Watershed, New York Expedited Reconnaissance Study did not mention Colchester. The Plan of Study did include Downsville as one flood damage location to be studied in detail. A survey of flooding damages of residential and commercial buildings and infrastructure was to be conducted along roughly 4,200' of Downs Brook, 1,000' of the East Branch Delaware River, 3,000' of Wilson Hollow Brook, and 1,000' of Tub Mill Brook

The 2006 Delaware County Hazard Mitigation Plan (Draft) provides more current levels of flood damages. Colchester was reported as having 108 buildings (106 residences)

exposed to the 100 year flood event with a total value of $19.7 million and expected damages of $2.6 million ($1.6 Building Structure and $1.0 Building Contents). For the residential properties this translates to $15,400 structural damages per structure and $9,600 contents damage per structure. With an average value of $92,900, this means a 16% structural damage per event converts to, on average, a first floor flooding of about 1-2 foot. For a 500 year event, the number of structures exposed only increases to 117 (115 residential) with projected damages of $2.3 million building structure and 1.2 million contents. It should be noted that these damages are based on FEMA damage curves that show somewhat lower structural damages and higher content damages. Two hundred of the 2,042 citizens live within the 100 year flood zone and and 250 live within the 500 year flood flood zone areas. No specific project proposals were included in that draft document.

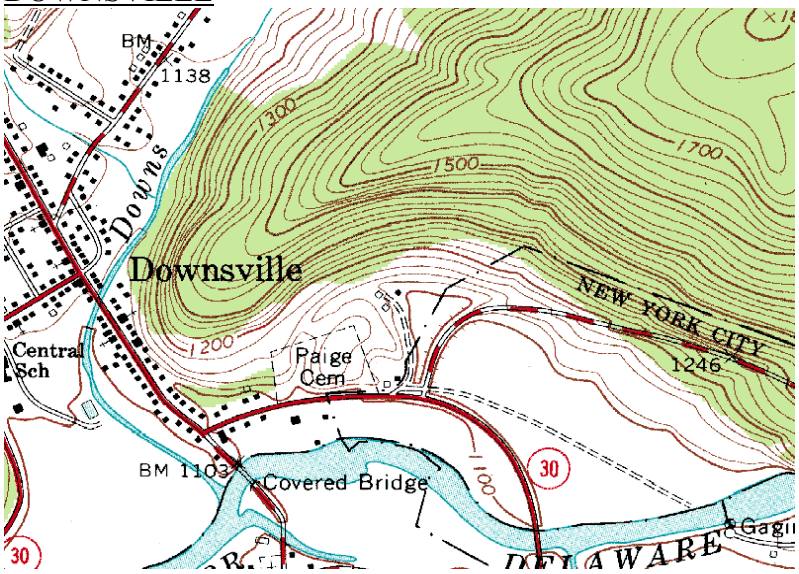
According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 22 repetitive loss properties (payments totaling $931,265) with no severe repetitive losses. This does not include damages from noninsured properties.

The September 2007 East Branch Delaware River Stream Corridor Management Plan recommends a need for an early flood warning system along the East Branch in Colchester.

A May 3, 2007 Press Release by Senator Clinton reports a Hazard Mitigation Project for the voluntary acquisition and demolition of a total of thirty-three (33) residential properties in the Towns of Hancock, Walton, Middletown and Colchester and the Villages of Walton, Sidney, and Deposit. The majority of these properties are located within designated Special Flood Hazard Areas of the Delaware or Susquehanna Rivers and tributaries. Each property identified in the application has incurred substantial damages or was destroyed as a result of flooding that occurred during the last week of June 2006. The number of properties in Colchester were not specified but were located in the Hamlet of Shinoppe on Island Road.

ALTERNATIVE EVALUATION

DOWNSVILLE



Historic Flooding Village of Downsville

0 0.1 0.2 0.3 0.4 0.5 mi

Flooding along Downs Brook was historically caused by constriction of flow at the Main Street Bridge and by inadequate channel capacity along the brook downstream of Main Street**.** Flooding on the East Branch Delaware River is now generally controlled by the upstream Pepacton Reservoir. The historic flood of record on June 1973 caused approximately $20,000 at that time ($80,000 in 2007 dollars). Structural solutions for this level of damage could not be economically justified. Teleford Hollow causes some minor residential flooding on the outskirts of Downsville. A June 1973 (historic flood of record) was less than a foot out of banks. No Federal project appears warranted.

STRUCTURAL FLOOD CONTROL MEASURES

- Downsville was previously analyzed in the 1970's by the Corps for a levee/floodwall with minor channel widening along Downs Brook paralleling Main Street The 1,400 earthen levee having a height of 4 feet above the streambed and a top width of 6 feet would prevent damages to the 100 year storm event. The cost was estimated at $1,010,000 (January 1980 dollars) which can be adjusted to a current cost of about $2,600,000 (2007 dollars). One home would need to be relocated. The average benefits in 1970's were $15,800 with a benefit-to-cost ratio of 0.3. A re-evaluation based upon updated flood stage computations plus a possible switch from a standard levee-floodwall to a sheet pile one needs to be evaluated

- A moderate channel modification of Downs Brook might be justified. High flow diversion might also be possible. The 1970's Corps levee-floodwall design noted above included channel modification and an evaluation should be conducted to evaluate the possibility of isolated shoaling or a channel restriction being the prime

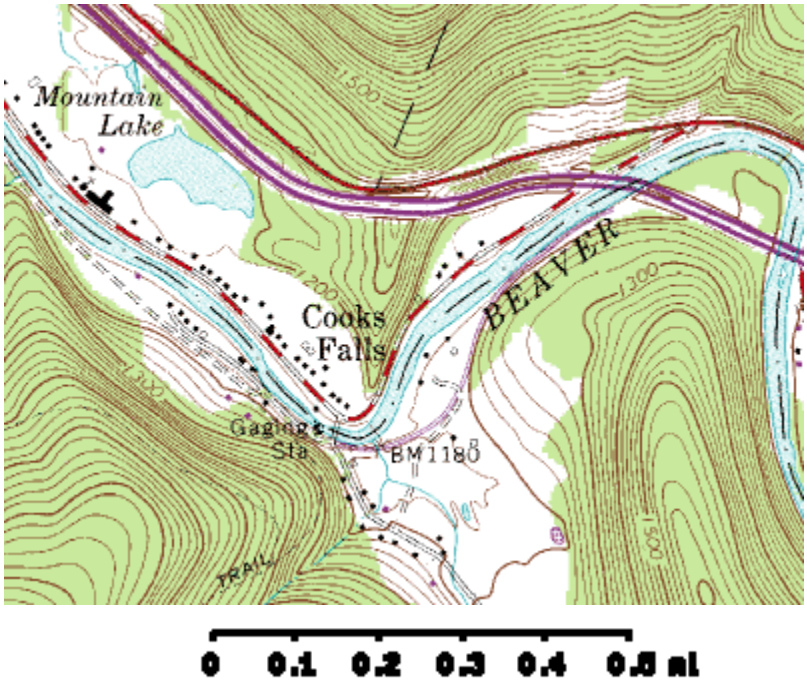
flooding issue. Also stream/bank ecosystem restoration could restore the natural channel thereby improving stream flow capacity and should be investigated.

- Detention basins in the Downs Brook Watershed would not be economically justified based on the combined high construction and mitigation costs coupled with the need for multiple structures from the several tributaries just upstream.

NONSTRUCTURAL FLOOD CONTROL MEASURES

- Nonstructural measures appear to be the most viable alternative but a detailed analysis would depend on the specific structural considerations of each home as well as updated flood stages. Structural raising as well as dry floodproofing would be likely options. Benefits would occur from a reduction in damages from all three sources of flooding.

HAMLET OF COOKS FALLS



The previous flood of record at Cooks Falls occurred in March 31, 1951 as a result of the Beaver Kill overflowing its banks by less than a foot. Damage to homes was reportedly limited to basement flooding coupled with road damages. The historic flood of record caused approximately $15,000 in 1973 dollars ($ 63,000 in 2007 dollars). A few ice jam events were also found in a Cold Regions Research Lab database without details.

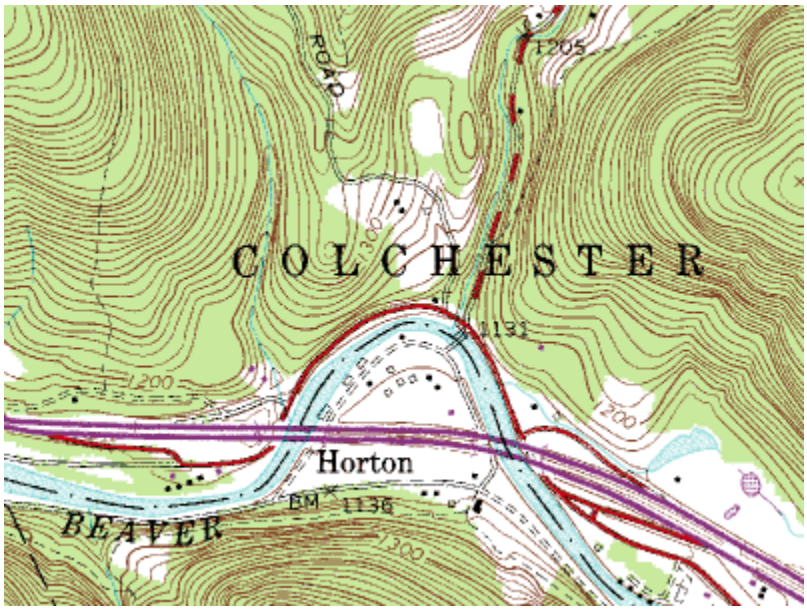
- STRUCTURAL FLOOD CONTROL MEASURES

  The level of damages precludes finding a structural measure from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted especially since it would prevent damages from the two causes of flooding (fluvial and ice jams) .

HAMLET OF HORTON



Flooding in Horton was historically caused by overtopping of the banks of both Horton Brook and Dry Brook which join to become Horton Brook before entering the Beaver Kill. The Beaver Kill caused no historic problems and actual damages from the tributaries have historically been minimal. A review of current aerial photos found no significant recent development.

- STRUCTURAL FLOOD CONTROL MEASURES

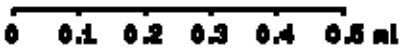
  The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted.

HAMLET OF SHINOPPLE

Hamlet of Shinopple



There is no record of historic flood damage at the Hamlet of Shinopple. The 2006 flood caused considerable residential flooding and several homes were reported to be part of a County Hazard Mitigation Project (Buyout).

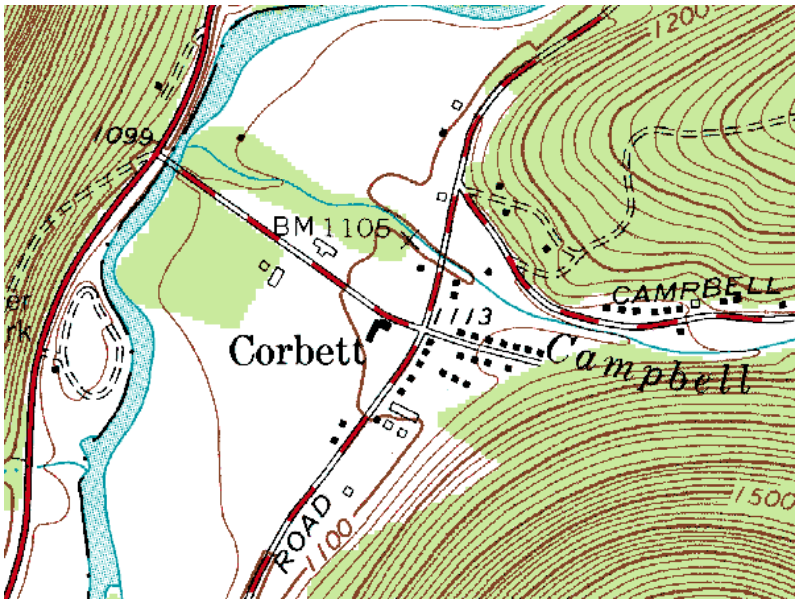
- STRUCTURAL FLOOD CONTROL MEASURES

  The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted. Evaluation of buyouts should be considered.

HAMLET OF CORBETT



Hamlet of Corbett

The previous historic flood of record at Corbertt occurred in 1950 as a result of Campbell Brook overflowing its banks by about 3 feet. Damage to homes was reported as being limited to lawns and basement flooding coupled with road damages. This flood caused approximately $16,000 in 1973 dollars ($66,000 in 2007 dollars).

- STRUCTURAL FLOOD CONTROL MEASURES

  The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted.

1/ PUBLISHED REFERENCES

Comprehensive Study of the Delaware River Basin H.D. 522, 1962
April 1981 Survey Feasibility Report, Flood Control and Flood Plain Management for the Tributaries to the Delaware River New York
Delaware River Basin Ice Jams Study 1985
Flood Insurance Study, Town of Colchester, New York 1987
Upper Delaware River Watershed, New York Expedited Reconnaissance 1996
Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, DRBC, October 2006
Delaware County, NY Hazard Mitigation Plan
East Branch Delaware River Stream Corridor Management Plan, Sept 2007

ROCKLAND, NEW YORK

BACKGROUND

Rockland is a township in New York with a total area of 95.2 sq mi, 94.3 sq mi. of it is land and 1.0 sq mi. of it is water. Population in year 2000 was 3,913. Estimated population in July 2006: was 3,940. There were 2,475 houses (1,560 occupied: 1,097 owner occupied, 463 renter occupied). There are 12 hamlets of varying sizes within Rockland, with Livingston Manor being the largest with 3.1 square miles and a population of 1,355 in the year 2000. The three hamlets of Livingston Manor, Lew Beach and Roscoe form the "Golden Triangle of Fly Fishing" and encompass the world famous Beaverkill and Willowemoc Rivers.

PROBLEM IDENTIFICATION

The 1993 FEMA Flood Insurance Study describes the Willowemoc Creek as the major source of flooding in the Township. The areas most frequently flooded are located in Livingston Manor. During the winter and spring months, ice jams occasionally cause basement flooding along the Little Beaver Kill, immediately upstream of Livingston Manor, and along Pleasant Street. The most notable location of ice jams are at the Main Street Bridge over the Little Beaver Kill in Livingston Manor. The hamlets of Roscoe and Rockland are subject to periodic flooding due to overbank flooding of Willowemoc Creek and the Beaver Kill. Ice jams are also the cause of occasional flooding on Yorktown Road along the Willowemoc near Roscoe.

The town has indicated the belief that flooding in Livingston Manor can not be completely prevented. The town does not want a structural flood damage reduction project that adversely impacts the natural values of the area, citing the concrete channels and floodwalls of a nearby project as an example.

PRIOR REPORTS

The Comprehensive Study of the Delaware River Basin H.D. 522, Appendix D, dated 1960 provided flood information from prior storm events. The November 1950 flood event, which was the prior storm of record for this location caused the following number of properties to be inundated:

Major Damage Centers November 1950 Storm

	No. of Properties Inundated		
	Residential	Commercial	Industrial
Rockland	30	0	0
Roscoe	12	17	3
Livingston Manor	69	30	1

A September 1967 Corps of Engineers Report (20 pages) titled Beaver Kill, Rockland New York evaluated a Flood Skimming Project. It evaluated flood control benefits to the villages of Rockland and Roscoe from construction of a flood skimming project (dam) proposed by the Board of Water Supply, City of New York. The benefits from flood reduction to about 1/3rd of the Township of Rockland would occur by New York City constructing a structure which would transfer all greater than normal flows into City reservoirs. Basement flooding from seepage was reported at the 2 year event even when flood flows remained within streambanks.

Based on the large floodplain, most out of bank flooding was limited at a 15 year event or greater to a foot or two depth. Damages at a 5 year event were only $3,500 while those for a 10 year were $9,500, with a 20 year event escalating to $120,000.

A USGS Open File Report done in 1969 on the Flood of July 27-28, 1969 in Southeastern New York by Bernard Dunn and F. Luman Robinson stated that this flood, which exceeded all stream flows since the gauge was established in 1937, was greater than a 100-year event and damaged about 20 residences, campgrounds, the sewage treatment plant and a motel in Livingston Manor.

An August 1970 Reconnaissance Report of the Flood Control Problem, Livingston Manor and Roscoe – Rockland, Rockland Town, Sullivan County, N.Y. looked at flooding from the Willowemoc Creek from its confluence with the BeaverKill at Roscoe to a point two miles upstream of Livingston Manor as well as portions of the hamlets of Rockland and Roscoe lying adjacent to the BeaverKill. That report listed damages as:

Flood Damages Town of Rockland

Community	Damages 1969 Flood	Average Annual Damages
Livingston Manor	$509,000	$104,000
Roscoe-Rockland	$37,000	$4,4000

The preliminary plan of improvement for Livingston Manor which had a first cost of $1,460,000 included a system of levees, channel relocation and a flume and wall structure. It would have reduced minor flooding to once every twenty years. BCR =1.3 to 1. No other plans or locations were detailed.

A December 1975 COE Plan of Study from the Tributaries of the Delaware River in New York State identified 25 residences, a school, and almost 30 businesses damaged in the July 1969 flood at Livingston Manor. For Roscoe, flooding due to overbank flooding of both the Willowemoc Creek and Beaverkill affected 20 homes, the municipal garage, and a motel. In Rockland flooding damaged about 10 residences bordering the Beaverkill.

A 1976 Economic Damage Assessment by the Justin & Courtney, Inc, for the COE identified four major damage areas in the Township. A description of each follows:

- Lewbeack – Historic flooding of the BeaverKill has caused agricultural flooding as well as some basement flooding. Shin Creek backs up at its only bridge crossing and

causes primarily commercial damages. Stage damage curve showed a 1.5' flood stage above the top of bank for the flood of record from both streams.

- Livingston Manor– Historic flooding of the Little Beaver Kill caused a majority of the flooding, affecting both residential and commercial districts. A major cause of flooding is backup from the Main Street Bridge during heavy rains. Flooding further upstream was caused by ice jams. Stage damage curve showed a 5.5' flood stage above the top of bank/floodwall for the flood of record. During very heavy storms the Willowemoc comes out of the bank, usually only affecting the basement level of some commercial properties, but with the July 28, 1969 flood water came up to the 1st floor in some cases; the Stage damage curve showed a 2.5' flood stage above the top of bank/floodwall for the Willowemoc flood of record.
- Rockland – Darby Brook and an Un-Named Tributary were reported to have caused damages (basement flooding) from the July 28, 1969. The Stage damage curve showed a 0.5' flood stage above the top of bank for the Darby Brook flood of record. Flooding of some farm fields and basements from the rising Beaver Kill; the Stage damage curve showed a 1' flood stage above the top of bank
- Roscoe - The main flooding problem occurs at "Junction Pool, the confluence of the Willowemoc Creek and the BeaverKill. Sediment carried down both streams had built up creating a large gravel bar forcing the flow to the sides. The Stage damage curve for Junction Pool showed a 1' flood stage above the top of bank for the 1989 event. Some residential flooding occurs from a small tributary, Stewarts Brook; the Stage damage curve also showed a 1' flood stage above the top of bank for the 1989 event.

A September 1979 Reconnaissance Report by the Corps of Engineers for Livingston Manor, Town of Rockland reported minor flooding, about once every 2 years, and major flooding occurring an average of once every 10 to 25 years. In that report a summary of flooding was provided based upon the 1976 damage survey. A series of upstream reservoirs, and major stream relocation and dredging of the Willowemoc Creek were dismissed as uneconomical and environmentally detrimental. The recommended plan of improvement was divided into multiple features:

- A levee around the Willowemoc Hotel – First Cost of $162,000
- Modifying the Rock Avenue Bridge along the Willowemoc – First Cost of $74,000
- A levee along the North Side of Willowemoc Creek -First Cost of $420,000
- Levees & Floodwalls along the South Side of Willowemoc Creek – First Cost of $461,000
- A levee around the Sewage Treatment Plant – First Cost of $229,000
- Stream relocation & widening along the Little Beaver Kill – First Cost of $2,375,000
- Internal Drainage including 2 pumping stations and a retention pond for the levees – First Cost of $1,073,000
- Contingencies, Design, Supervision and Administration – First Cost of $2,399,000

Due to the unfavorable benefit/cost ratio (0.29 to 1) it was concluded that further studies were not warranted at that time.

The April 1981 Survey Feasibility Report, Flood Control and Flood Plain Management for the Tributaries to the Delaware River New York and its backup evaluated Rockland in detail.

SUMMARY OF DAMAGE SURVEY INFORMATION

Damage Center	Sub-Basin	Flood of Event	Total Damages (Nov 80 $)	Total Damages (2007 $)
Lewbeach	BeaverKill/ Shin Creek	July 28, 1969	$36,500	$87,000
Livingston Manor	Little BeaverKill/ Willowemoc Creek	July 28, 1969	$1,620,010	$3,864,000
Rockland	Darby Brook/ BeaverKill	July 28, 1969	$2,500	$6,000
Roscoe	Willowemoc/ BeaverKill	July 28, 1969	$17,200	$41,000

- For Lewbeach, the Beaverkill flood of record had a 1.5' flood stage and $1,930 in damages, while the Shin Creek tributary had the same flood stage and $21,000 in actual damages (not updated).
- For Livingston Manor, the Beaverkill flood of record had a 6' flood stage and $516,200 in damages, while the Willowemoc Creek had a 2.5' flood stage and $497,800 in actual damages (not updated).
- For Rockland, the Darby Brook and un-Named Trib had a 0.5'flood stage and $500 in damages while the Beaverkill had a 1' flood stage and $1,050 in damages. For Roscoe, Junction Pool (confluence of Willowemoc Creek and the Beaverkill had $5,750 in damages with 1' of water, and Stewart's Brook had $5,100 in damages from 0.5'.

Eight flood control plans were analyzed in detail. The one at Livingston Manor would have provided a 100 year level of protection. The plan involved channel relocation, levees and floodwalls on Willowemoc Creek and Little Beaver Kill and levees along Cattail Brook. The Initial cost was $7,720,000 with Average Annual Costs of $611,000 and Average Annual Benefits of $175,000 and a BCR of 0.3

The 1993 FEMA Flood Insurance Study describes the Willowemoc Creek as the major source of flooding. Local interests with state and Works Progress Administration (WPA) aid constructed approximately 1,600 feet of masonry wall and 1,400 feet of low levee along the banks of Willowemoc Creek in Livingston Manor with the wall built in front of the high school on the right bank and the levee downstream of the wall. In 1951, with state aid, approximately 1,000 feet of levee was constructed on the left bank below the confluence with the Cattail Brook. While these local protection works provide some protection they do not protect against rare events such as the 100-year event.

The 1997 Upper Delaware River Watershed, New York Expedited Reconnaissance Study stated that the January 1996 flood caused damage to 232 houses, 20 mobile homes, 27 businesses, 3 apartment buildings, and the water and sewer plants of the town. No specifics on exact location were provided nor proposals for further study at this location.

A May 2003 Draft Preliminary Restoration Plan for the Little Beaverkill Trout Habitat Restoration Project was prepared by the Bioengineering Group for the Corps of Engineers under its Section 206, Continuing Authority Ecosystem Restoration Authority. Thermal degradation of trout habitat is caused by borrow pits adjacent to the Little Beaverkill channel. Prior restoration measures to resolve the thermal degradation focused unsuccessfully on realigning the stream into its historic channel. Features of the proposed project included channel re-alignment of approximately 2,600 feet of the Little Beaverkill and bank stabilization, creation of floodplain wetlands, filling of the borrow pits, and establishment of a forested riparian buffer zone. Costs to implement included $200,000 for a Feasibility Study, $200,000 for Plans and Specifications, and $2,000,000 for construction.

A 12 page memorandum prepared by LU Engineers for NYSDOT evaluated the Livingston Manor Airport site for Mitigation purposes as part of the Conversion of Route 17 to I-86. It presented a conceptual framework for a restoration of about 800 yards of the Little Beaver Kill and creation of wetlands adjacent to the existing ponds. Its goals were to reduce thermal impacts on trout habitat, improve riparian habitat, and create additional wetlands to mitigate impacts to wetlands affected by highway construction. That evaluation concluded that the project as proposed would not result in significant flood reduction benefits.

In November 2005 FEMA Pre-Disaster Mitigation Grant for $1,450,000 (75% of the cost) was received for the Voluntary Acquisition and removal of 15 properties identified with major repetitive flood damages. This effort is ongoing.

A December 2005 Feasibility Analysis Report was prepared by the Firm of McFarland-Johnson. Inc, for the Town of Rockland to evaluate a flood control concept to protect Livingston Manor from Little Beaver Kill flooding. A Hydrologic and Hydraulic Analysis were conducted and Environmental Considerations evaluated. It concluded that a plan is feasible but would require some adjustments. A dry lake would need to have a storage volume of about 700 acre-feet for a 100 year level of protection which could be placed within 50 acres with a max depth of twelve feet assuming a levee system were placed around the entire storage area. A downstream levee would still be necessary.

The 2006 public draft update New York State Hazard Mitigation Plan does not mention county specific problems or plans.

Town of Rockland, contracted with the engineering firm of McFarland-Johnson who prepared a 3 page Flood Mitigation/Ecorestoration Feasibility Study, Potential Study Concepts package dated March 30, 2006 for Livingston Manor as part of a public coordination process. Streams in the area have been modified extensively. A combination

of measures would be required to achieve the desired flood mitigation benefits. The concepts are described briefly below.

- *Fulton Plan or Variation* - is intended to provide floodwater storage upstream of the hamlet in the old airfield area, through a combination of berm construction and excavation. The original Fulton Plan did not include a stream restoration component, but did wetland creation. There are variations including stream restoration, wetland creation, and one without a berm.
- *Flood Wall/Setback Levee* - construct a flood wall or setback levee along Pearl St. to prevent inundation of the hamlet center and would require at least some channel relocation/stream restoration due to width restrictions.
- *Little Beaverkill Stream Restoration* - The Little Beaverkill channel has been modified/relocated with several gravel pits through with the stream now flows. The stream warms substantially as it flows through the pits degrading trout habitat, and the effect of the pits may create a thermal barrier to trout passage. Restoration would provide significant benefits for the trout fishery and a stream restoration could be coupled with floodplain forest/wetland creation. This can be considered a standalone ecorestoration project but with some bearing on flood mitigation.
- *Create Floodplain Storage at the Poultry Plant Site along Willowemoc Creek* -. Considerable floodwater storage could be created by removing fill material and lowering ground elevations with a floodplain forest and wetland habitat created. This could be a standalone ecorestoration project, with the possibly for flood mitigation.
- *Longer Bridge Span/Larger Waterway Opening at Main Street* - The existing Main St. bridge over the Little Beaverkill is very short and the waterway opening small. Stream banks are steep, and there is no floodplain at the bridge location. With other measures (upstream flood wall or levee), replacing this bridge with a longer span could eliminate a major impediment to flow and reduce flooding. Construction of a longer-span bridge would require acquisition and demolition of some structures.
- *Levee Removal at the Central School* - There is a stone wall in front of the school to provide flood protection which transitions to a low levee downstream, in order to protect athletic fields from floodwaters. It is not necessary to protect the athletic fields from flooding. Removal, or partial removal, of the levee may be desirable to increase flood storage. A gap near the Route 178 bridge should also be evaluated.
- *Evaluate Additional Culverts under NYS Route 17* - A backwater occurs at the NYS Route 17 bridge below Livingston Manor, just downstream of the hamlet's sewage treatment plant. There is only one small culvert in the roadway segment located west of the bridge which contributes to flooding.
- *Upstream Detention/Floodwater Storage* - The potential exists for some floodwater storage in existing impoundments in the Little Beaverkill watershed upstream of the hamlet. Effort has focused on the Town-owned Lake Matawah. With the small drainage area of this single lake, it would not have a significant effect on flood discharges. However, modification of the outlet and lowering of the lake level to create wetlands and provide a modest amount of detention might be possible. This might be considered a standalone ecorestoration project.

An Initial Appraisal Report was completed in June 2006 by the Corps of Engineers for Livingston Manor, Town of Rockland. As the first step in a flood study under the Corps Small Flood Control Program it determined Federal interest and recommended further study. The Town of Rockland experienced over $1.9 million in flood damages in September 2004 and April 2005. A Feasibility study was recommended to consider both structural and non-structural solutions to the flooding problems. Structural solutions could include channel improvements, possible bypass of floodwaters before they enter the Manor, and modification of existing upstream detention basins. Non-structural solutions could include flood proofing, raising structures, buyouts, floodplain restoration and wetlands creation.

Another report, a Technical Support for a Feasibility Study of Livingston Manor in the Town of Rockland, New York, was prepared by McFarland-Johnson, Inc. in December 2007 for the Corps of Engineers. Its purpose was to assemble existing data on stream channel cross-sections and recommend a stability analysis and hydrologic and hydraulic analysis as part of a future feasibility study.

According to DRBC, based upon **a** comparative analysis of FEMA's National Flood Insurance Program (NFIP) closed claims in the Delaware River Basin there were 40 repetitive loss properties (payments totaling $2,291436) with 5 severe repetitive losses (payments totaling $1,2999,321). This does not include damages from noninsured properties and includes the 15 properties from the Pre-Disaster Mitigation Grant mentioned above.

ALTERNATIVE EVALUATION

HAMLET OF LIVINGSTON MANOR

- STRUCTURAL FLOOD CONTROL MEASURES A single solution is unlikely due to the extent of floodplain alteration. The McFarland-Johnson, a 3 page Flood Mitigation/Ecorestoration Potential Study Concepts package, dated March 30, 2006 needs to be evaluated in detail. The components, which need to be individually evaluated and justified, can be implemented as determined viable. These components are:
  - *Fulton Plan or Variation* Floodwater storage
  - *Flood Wall/Setback Levee Little Beaverkill Stream*
  - *Create Floodplain Storage at the Poultry Plant Site along Willowemoc Creek*
  - *Longer Bridge Span/Larger Waterway Opening at Main Street*
  - *Levee Removal at the Central School.*
  - *Evaluate Additional Culverts under NYS Route 17*
  - *Upstream Detention/Floodwater Storage* in the Little Beaverkill

- NONSTRUCTURAL FLOOD CONTROL MEASURES
  The potential for additional non-structural measures should not be ignored. The 2005 FEMA Hazard Mitigation Grant should be considered only an initial phase and not a complete action in itself. While additional mitigation will

have the potential to reduce flood benefits and potentially affect economic justification of structural solutions, the time required to design and implement these structural solutions is such that a concurrent non-structural solution should not be ignored.

HAMLET OF ROCKLAND

For Rockland, Darby Brook and the Beaverkill had a 1' flood stage or less in 1969 and $2,500 in damages, in today's dollars that equates to under $10,000.

- STRUCTURAL FLOOD CONTROL MEASURES

The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted.

HAMLET OF ROSCOE

The Willowemoc Creek, the BeaverKill and Stewarts Brook all had a 1' flood stage in 1969 and $17,200 in damages, in today's dollars that equates to under $50,000.

- STRUCTURAL FLOOD CONTROL MEASURES

The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted.

HAMLET OF LEWBEACH

For Lewbeach, the Beaverkill flood of record in 1968 had a 1.5' flood stage and $1,930 in damages, while the Shin Creek tributary had the same flood stage and $21,000 in actual damages, in today's dollars that equates to under $90,000.

- STRUCTURAL FLOOD CONTROL MEASURES

The level of damages precludes structural measures from being economically justified.

- NONSTRUCTURAL FLOOD CONTROL MEASURES

. Dry floodproofing, ring levees or grading by homeowners may be warranted.

1/ PUBLISHED REFERENCES

Corps of Engineers Comprehensive Study of the Delaware River Basin H.D. 522, 1962
Corps of Engineers Report (20 pages) titled Beaver Kill, Rockland New York Flood Skimming Project. September 1967
USGS Open File Report on the Flood of July 27-28, 1969 in Southeastern New York by Bernard Dunn and F. Luman Robinson 1969
Corps of Engineers Reconnaissance Report of the Flood Control Problem, Livingston Manor and Roscoe – Rockland, Rockland Town, Sullivan County, N.Y. August 1970
Corps of Engineers Plan of Study from the Tributaries of the Delaware River in New York State1975
Economic Damage Assessment by the Justin & Courtney, Inc. 1976
Reconnaissance Report by the Corps of Engineers for Livingston Manor, Town of Rockland, September 1979
Corps of Engineers Survey Feasibility Report, Flood Control and Flood Plain Management for the Tributaries to the Delaware River New York April 1981
Corps of Engineers Delaware River Basin Ice Jams Study 1985
Flood Insurance Study, June 2, 1993 Town of Rockland, Sullivan County, New York
Corps of Engineers Upper Delaware River Watershed, New York Expedited Reconnaissance 1997
McFarland-Johnson Town of Rockland, Flood mitigation/Ecorestoration feasibility study, Potential study concepts March 30,2006
DRBC, Analysis of Repetitive and Severe Loss Properties in the Delaware River Basin, October 2006
Technical Support for a Feasibility Study of Livingston Manor in the Town of Rockland, New York, McFarland-Johnson, Inc. December 2007 for Corps of Engineers

LIVINGSTON MANOR STREETS

NO. 58 (TOWN OF ROCKLAND)

1 Inch equals approx. 1340 Feet