
# DELAWARE RIVER BASIN

# INTERSTATE FLOOD MITIGATION TASK FORCE

# ACTION AGENDA

JULY 2007

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Gary Paulachok, United States Geological Survey
Kathy Hale, New Jersey Water Supply Authority
National Aeronautics and Space Administration
New York City Department of Environmental Protection
Raymond Krajcscovics, Trenton Emergency Management Services
Delaware River Basin Commission

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## Executive Summary

In September 2004, April 2005 and June 2006, three major floods caused devastation along the main stem Delaware River, repeatedly damaging property and disrupting tens of thousands of lives. These were the worst floods to occur on the main stem since the flood of record in 1955. The last occurrence of three main stem floods of comparable magnitude within so short a time span was the period from 1902 to 1904.[1]

Thankfully, during the 2004, 2005 and 2006 floods, advances in flood warning technology minimized loss of life. Nine deaths are attributed to these past three events; one was attributed to main stem flooding, whereas the remaining eight were attributed to tributary flooding.[2] Though tragic, this number compares favorably with the approximately 100 lives lost during the record event a half-century ago. However, encroachments by the built environment into the flood plain continue to create new threats – including the increased potential for property damage, personal injury or death, and an increased potential for harm to the riverine environment.

Over the past fifty years, businesses, industries, residences, roads, and utilities, including public and private water supply and wastewater facilities, have been constructed within the floodplain. One consequence is that our communities and built infrastructure are affected more than ever by floods. Another is that the environmental impacts of flooding are more serious than in the past. Flood waters infiltrate wastewater systems, introducing industrial waste and raw or partially treated sewage into waterways. In addition, debris and contaminants from the built environment are washed downstream, where they may not only cause additional damage to people and property, but potentially may settle on the river bottom and cause ecological harm for years to come. Development within the floodplain is accompanied by diminished vegetation, which leaves waterways more susceptible to stream bank erosion, particularly during floods. Severe erosion can convert a narrow, deep, clear and cold channel that is resistant to flooding, into a wide, shallow, turbid and warm one that is increasingly flood prone.

Reducing flood loss is a responsibility shared by federal, interstate, state, and local agencies throughout our region. Recognizing this, the governors of the four basin states – Delaware, New Jersey, New York and Pennsylvania – directed the executive director of the Delaware River Basin Commission, Carol Collier, to convene an interstate task force to develop a set of recommended measures for mitigating and alleviating flooding impacts along the Delaware and its tributaries. In their September 2006 letter to Ms. Collier, the governors wrote, "Individually, the Basin states can move forward with policies and regulations to reduce and mitigate the impacts of flooding, but we believe that through coordinated effort on a regional basis, we can do more to reduce flood loss within the Basin than we could accomplish acting separately, on our own. The Delaware River Basin Commission is the obvious vehicle for developing flood loss reduction and flood mitigation

[1] Serious floods along the main stem during this period occurred on March 2, 1902, October 11, 1903 and March 8, 1904. Flood stages on the main stem at Trenton during these events reached 23.6 feet (the 7th highest on record), 28.5 feet (3rd highest on record) and 30.6 feet (the highest ever), respectively. The 1904 event was caused by an ice jam at Trenton.

[2] Mortality data was obtained from the National Weather Service (NWS/NOAA) National Climatic Data Center (NCDC) Storm Event database.

plans that cannot be accomplished by any single state or local government but that require a holistic watershed approach. As much as any time since the Commission was created in 1961, now seems an appropriate moment for coordinated action through the DRBC."

The Delaware River Basin Interstate Flood Mitigation Task Force was assembled in October 2006. It is comprised of 31 members from a geographically diverse array of government agencies (legislative, executive, federal, state and local) and not-for-profit organizations. The group has identified a total of 45 consensus recommendations for a proactive, sustainable, and systematic approach to flood damage reduction. The recommendations are based upon a set of six guiding principles concerning floodplain restoration, floodplain protection, institutional and individual preparedness, local stormwater management and engineering standards, and the use of structural and non-structural measures. They are grouped within six priority management areas as follows:

- Reservoir operations: Included among the recommendations is a slate of actions for regulation and control of reservoir releases. The Task Force calls for an evaluation of reservoir spill and discharge mitigation programs along with development of a flood analysis model to evaluate alternative reservoir operating plans and to assess the downstream effect of reservoir voids of different magnitudes. These recommendations call for releases that would reduce the likelihood and volume of spills from some basin reservoirs during storm events to help mitigate flooding.
- Structural and non-structural measures: The Task Force calls on policy-makers to assign higher priority and allocate greater funding to the acquisition of property and elevation and/or flood-proofing of structures within the floodplain. It offers strong support for state dam safety programs and recommends improved maintenance of other flood control structures. An evaluation of mitigation measures basinwide by the U.S. Army Corps of Engineers is recommended, to include an analysis of the ecological, economic, long-term operation and maintenance, and social costs and benefits of all flood mitigation options.
- Stormwater management: The Task Force calls for minimizing stormwater runoff from new development and reducing runoff from existing development through the implementation of watershed stormwater management plans, long-term maintenance of stormwater infrastructure (including detention ponds, inlets, catch basins, outfalls and other devices), the use of non-structural stormwater management options, expanded incentives for achieving stormwater management objectives, stronger enforcement of stormwater management regulations, and the development of stream restoration and debris removal guidelines.
- Floodplain mapping: Because the Delaware River is an interstate waterway, coordination is needed for development of a seamless floodplain map that is consistent throughout the basin. The Task Force calls upon the states to coordinate flood study and mapping updates, incorporate existing and planned development and residual risk zones into new maps, and re-define and re-map the floodway along the main stem and its tributaries.
- Floodplain regulation: Currently, the regulations applicable to floodplain areas in the Delaware Basin vary widely. The Task Force urges that existing floodplain regulations be catalogued, evaluated and updated and that uniform regulation of floodplains within the basin be established. It further recommends that a

coordinated education, outreach and training program about floodplain protection and regulation be undertaken, that a flood hazard disclosure requirement be imposed, that a repetitive loss reduction strategy be adopted and that riparian zones be defined in accordance with uniform standards basinwide.

- Flood warning: The task force recommends that development of an advanced basinwide flood warning system proceed in a coordinated fashion. The existing system is comprised of flow gages, flash flood and flood forecasting, and education and outreach components. It is coordinated and funded by multiple organizations at the federal, state and local levels. The Task Force urges that the river gage network and its forecast points be evaluated, that rating tables be extended, that gages be flood hardened (i.e., able to withstand larger flood events), that flash flood forecasting be improved, that flood inundation maps be developed, that up-to-date Dam Emergency Action Plans be maintained, that a coordinated flood education and outreach program be developed and that a comprehensive program be undertaken to address coastal flooding.

During the public review phase of the draft recommendations, there was a broad based request for immediate action to mitigate future flooding impacts. To address this sense of urgency the Task Force has identified several core recommendations to enhance the basin's resiliency—its capacity to prepare for and recover from flooding. The following immediate actions are proposed:

- Establish areas of priority funding for acquisition, elevation, and flood proofing. *(Action S-6)*
- Develop an interoperable reservoir operating plan. *(Action R-2)*
- Develop and implement a consistent set of comprehensive floodplain regulations beyond minimum NFIP standards across the entire Delaware River Basin. *(Action FR-2)*
- Enable stormwater utilities – This approach benefits both water quality and quantity. In addition it reinforces the states' existing momentum for stormwater management and control of nonpoint source pollution. *(Action SM-2.3)*

The Interstate Flood Mitigation Task Force has concluded that no set of mitigation measures will entirely eliminate flooding along the Delaware River or its tributaries. However, the members believe that the combination of measures advocated in this report constitute a significant step in helping the Basin's increasingly vulnerable riverine and coastal communities to prepare for, respond to, and rebound from natural disasters.

An overview of the 45 recommendations is included as Table 1 of this document. Please note that these recommendations are not in any prioritized order, but instead are organized by priority management area. Assuming adequate resources are identified, an implementation matrix, included as Table 4 of this report, organizes the recommendations by anticipated implementation time frame.

## Delaware River Basin Flood Mitigation Task Force
## Table 1 - Recommendation Overview

| Recommendation | | | Ongoing | Short-term (1-3 Years) | Long-term (4+ Years) | Resources Needed | Lead Agency |
|---|---|---|---|---|---|---|---|
| Reservoir Operations | | | | | | | |
| #1 | R-1 | Develop a Flood Analysis Modeling Tool | X | | | $$ | DRBC |
| #2 | R-2 | Develop an Interoperable Reservoir Operating Plan | | X | | $$ | DRBC |
| #3 | R-3 | Evaluate Discharge Mitigation Programs for Reservoirs | X | | | $ | DRBC |
| #4 | R-4 | Evaluate Snowpack Based Storage Management | X | | | $ | DRBC |
| #5 | R-5 | Publish Information on the Basin's Existing Major Impoundments | | X | | $ | DRBC |
| #6 | R-6 | Evaluate Availability and Accuracy of Data | | X | | $ | DRBC |
| Structural and Non-Structural Measures | | | | | | | |
| #7 | S-1 | Fund a Comprehensive Flood Mitigation Study of the Entire Delaware River Basin | | | X | $$$$ per state | USACE |
| #8 | S-2 | Prioritize the Completion of State and Local Hazard Mitigation Plans | X | | | $$$ | State EMO's |
| #9 | S-3 | Ensure Financial Assistance for State, County and Municipal Flood Mitigation Projects | X | | | $$$$ | State EMO's |
| #10 | S-4 | Provide Training for Local Officials to Maximize Use of Available Mitigation Funding | | X | | $$ | DRBC |
| #11 | S-5 | Create Partnering Programs for Floodplain Acquisition | | X | | $$$$ | State DEP's |
| #12 | S-6 | Establish Funding Priority Areas for Acquisition, Elevation, and Floodproofing | | X | | $$$ | Basin States |
| #13 | S-7 | Maintenance of Flood Control Structures, excluding dams | | X | | $$$$ | State DEP's |
| #14 | S-8 | Dam Safety Programs | X | | | $$$$ | State Dam Agencies |
| #15 | S-9 | Evaluate and Coordinate Flood Mitigation Plans and Strategies | X | | | $$$ | DRBC |
| Stormwater | | | | | | | |
| #16 | SM-1 | Develop Regional and Tributary-Based Watershed Stormwater Management Plans | | X | | $$ per 100sq. mi. | Basin States |
| #17 | SM-2 | Long-term Management of Stormwater Best Management Practices (BMPs) and Infrastructure | X | | | $ per municipality | Basin States |
| #18 | SM-3 | Non-Structural Stormwater Management for New and Redevelopment | X | | | $ | Basin States |
| #19 | SM-4 | Enforcement of Existing Stormwater Standards and Regulations | | X | | $ | Basin States |
| #20 | SM-5 | Provide and Promote Incentives to Reduce Stormwater Runoff from Existing Development | | X | | $-$$$$ | Basin States |
| #21 | SM-6 | Develop and Maintain Precipitation and Streamflow Data | X | | | $ | USGS/NWS |
| #22 | SM-7 | Stream Restoration and Debris Removal Guidelines | | X | | $ | DRBC |
| #23 | SM-8 | Stormwater Management through Special Protection Waters Designation | X | | | $ | DRBC |

$ Key: $ = < $100,000 $$ = < $500,000 $$$ = < $1,000,000 $$$$ = > $1,000,000

## Delaware River Basin Flood Mitigation Task Force
## Table 1 - Recommendation Overview (Continued)

| Recommendation | | | Ongoing | Short-term (1-3 Years) | Long-term (4+ Years) | Resources Needed | Lead Agency |
|---|---|---|---|---|---|---|---|
| Floodplain Mapping | | | | | | | |
| #24 | FM-1 | Coordinated Flood Study and Mapping Updates | X | | | $$$$ | Basin States |
| #25 | FM-2 | Incorporate Existing and Future Planned Development and Residual Risk Zones into New Mapping | | | X | $$$$ | Basin States |
| #26 | FM-3 | Redefine and Remap the Floodway along the Delaware River Main Stem and its Tributaries | | | X | $$$$ | Basin States |
| Floodplain Regulations | | | | | | | |
| #27 | FR-1 | Catalog, Evaluate and Update Existing Floodplain Regulations in the Basin | | X | | $ | DRBC |
| #28 | FR-2 | Develop a Coordinated Education, Outreach and Training Program | | X | | $ | DRBC |
| #29 | FR-3 | Repetitive Loss Reduction Strategy for the Basin | | X | | $$ | FEMA |
| #30 | FR-4 | Flood Hazard Disclosure Requirements | | X | | $ | DRBC |
| #31 | FR-5 | Standardized Riparian Corridors | | | X | $ | DRBC |
| Flood Warning | | | | | | | |
| #32 | FW-1 | Inventory and Evaluate Precipitation Observing Stations in the Basin | | X | | $ | USGS |
| #33 | FW-2 | Evaluate River Gage Network | | X | | $ | USGS |
| #34 | FW-3 | Extend Rating Tables | | X | | $ | USGS |
| #35 | FW-4 | Flood Harden Gages at Key Forecast Locations | | | X | $$ | USGS |
| #36 | FW-5 | Improve Flash Flood Forecasting | | | X | $$ | NWS |
| #37 | FW-6 | Develop an Implementation Plan for the NWS Site Specific Model | | X | | $ | NWS |
| #38 | FW-7 | Evaluate River Forecast Points | | X | | $ | NWS |
| #39 | FW-8 | Provide River Forecasts with Confidence Level Information | | X | | $ | NWS |
| #40 | FW-9 | Develop Flood Forecast Inundation Maps | | X | | $$ | NWS |
| #41 | FW-10 | Maintain Up-to-Date High Hazard Dam Emergency Action Plan (EAP) Documents | X | | | $ | DRBC |
| #42 | FW-11 | Establish a Coordinated Flood Warning Education and Outreach Program | | X | | $ | DRBC |
| #43 | FW-12 | Develop a Flood Coordination Mechanism | | X | | $ | DRBC/ Basin States |
| #44 | FW-13 | Ice Jam Monitoring and Communications Plan | X | | | $ | State EMS |
| #45 | FW-14 | Coastal Flooding Impacts | | | X | $$$$ | MACOORA |

$ Key: $ = < $100,000 $$ = < $500,000 $$$ = < $1,000,000 $$$$ = > $1,000,000

## MEMBERS OF THE FLOOD MITIGATION TASK FORCE

| | |
|---|---|
| Rad Anderson | Chief, Planning Section, New York State Emergency Management Office (NYSEMO) |
| David K. Burd | Emergency Management Coordinator, City of Lambertville, NJ |
| John Comey | Executive Assistant to Director, Pennsylvania Emergency Management Agency (PEMA) |
| James Eisel | Supervisor of Delaware County, NY |
| Jeffrey Featherstone, Ph.D. | Director and Research Professor, Center for Sustainable Communities, Temple University |
| Peter Gabrielsen | Chief Hydrologic Services, NOAA/NWS |
| Hank Gruber | Chief of Basin Planning, U.S. Army Corps of Engineers |
| Robert A. Hainly | Assistant Director, USGS- PA Water Science Center |
| Dirk C. Hofman, P.E. | Retired, Cornelis Associates |
| Marcia A. Karrow | Hunterdon and Warren Counties, NJ State Assemblywoman |
| Richard A. Martinkovic | Commissioner of Public Safety, Sullivan County, NY |
| Frank G. McCartney | Executive Director, Delaware River Joint Toll Bridge Commission (DRJTBC) |
| Patricia A. McSparran | Director, Bureau of Waterways Engineering, Pennsylvania Department of Environmental Protection (PADEP) |
| Sgt. Paul Miller | State Hazard Mitigation Officer, New Jersey Office of Emergency Management (NJOEM) |
| John Moyle, P.E. | Manager, Bureau of Dam Safety and Flood Control, New Jersey Department of Environmental Protection (NJDEP) |
| Thomas Murphy | Water Resource Manager, New York City Department of Environmental Protection (NYCDEP) |
| William Nechamen, CFM | Chief, Flood Plain Management, New York State Department of Environmental Conservation (NYSDEC) |
| Henry S. Patterson, III | Executive Director, New Jersey Water Supply Authority |
| Joseph Picciano, P.E | Deputy Regional Director, FEMA/DHS Region II |
| Michael Powell, CFM | Shoreline and Waterway Management, Delaware Department of Natural Resources and Conservation (DNREC) |
| Geoffrey A. Reese, P.E. | Assistant Director, Lehigh Valley Planning Commission |
| David J, Steil | Bucks County, PA State Representative |
| Maya K. van Rossum | Delaware Riverkeeper, Delaware Riverkeeper Network |
| Gregory J. Westfall | Water Resource Planner, USDA Natural Resources Conservation Service (NRCS) |
| Kerry Wilson | State NFIP Coordinator, Pennsylvania Department of Community & Economic Development (PA DCED) |
| William Winslade | Manager of Yardley Borough, Pennsylvania |
| Delaware River Basin Congressional Task Force | Congressman Castle, Fitzpatrick, Gerlach, Hinchey and Holt |

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**Task Force Facilitation:** Robert Tudor (Deputy Executive Director, DRBC)

**Committee Chairs and Co-chairs:**
Richard Fromuth, P.E. (Operations Branch Head, DRBC)-Reservoir Operations; David Dech (Planning Director, Warren County, NJ) and Scott Steigerwald, P.E. (Special Projects Coordinator, PADEP Bureau of Waterways Engineering)-Structural and Non-Structural Mitigation Measures; Amy Shallcross, P.E. (Principal Watershed Protection Specialist, NJ Water Supply Authority)-Stormwater Management; Joseph Ruggeri, P.E., CFM (Engineer, NJDEP Dam Safety and Flood Control)- Floodplain Mapping; Vincent Mazzei, P.E. (Engineer, NJDEP Land Use Regulation)- Floodplain Regulations; Peter Gabrielsen (Chief Hydrologic Services, NOAA/NWS) and Laura Tessieri, P.E., CFM (Water Resources Engineer, DRBC)- Flood Warning

**Committee Members and Task Force Contributors:**
Peter Ahnert, Ph.D. (Hydrologist, NOAA/NWS), Shannon Blankinship (Executive Assistant, Delaware Riverkeeper Network), Orly Amir (Legislative Assistant, US Rep Rush Holt); Christine A. Bethke (Project Manager, USACE – Philadelphia); Sandy Blick (Engineer, NJDEP Division of Watershed Management); Phil Chase (Upper Delaware Council); Carol R. Collier (Executive Director, DRBC); Mary Colvin (Chief Community Mitigation Programs Branch, FEMA Region II); Paul Cronce (Office of Emergency Management, City of Lambertville); Jeff Darwak (Constituent Services Rep, US Rep. Fitzpatrick); Bill Douglass (Executive Director, Upper Delaware Council); Scott Duell (Natural Hazards Program Specialist, FEMA Region II), Dan Fitzpatrick, CFM (Program Specialist, PA DCED); Dean Frazier (Commissioner of Watershed Affairs, Delaware County, NY); Edward (Skip) Garlits (Stakeholder); William Gast, P.E. (Chief Water Planning Engineer, PADEP); Gene Gruber (Mitigation Division Director, FEMA/DHS Region III); Robert Homovich (Supervisor Town of Colchester, NY); Jim Mershon (On-site Coordinator, Merrill Creek Reservoir); Joseph A. Miri, Ph.D. (Chief, NJDEP Office of Water Policy); Robert Molzahn (President, Water Resources Association of the Delaware River Basin); Ken Murin, (Environmental Program Mgr., PADEP Bureau of Waterways Engineering); Mary Ellen Noble (Associate Director, Delaware Riverkeeper Network); Gary Petrewski, P.E. (Sr. Engineer, Peaking Power, PPL Electric Utilities Corporation); David Rosenblatt (Administrator Engineering/Construction, NJDEP); Ted Rodgers (Hydrologist, NOAA/NWS); Paul Rush, P.E. (Bureau of Water Supply, NYC DEP); Michael Shuler (Natural Hazards Program Specialist, FEMA Region III); Linda M. Spalinski (Delaware River Joint Toll Bridge Commission); Glendon Stevens, P.E. (Chief Hydrology, Hydraulics & Coastal Engineering, USACE – Philadelphia);

**Delaware River Basin Commission Support Staff:**
Sherry Garrahan, Susan Owens, Clarke Rupert, Donna Woolf

## I. Authorization

The Delaware River Basin Interstate Flood Mitigation Task Force was formed in response to a September 21, 2006 letter to Delaware River Basin Commission (DRBC) Executive Director Carol R. Collier from Delaware Gov. Ruth Ann Minner, New Jersey Gov. Jon Corzine, New York Gov. George Pataki, and Pennsylvania Gov. Edward Rendell, who also serve as DRBC commissioners. At a public meeting on September 27, 2006, the Commission's federal representative and current Chair, Lt. Col. Gwen E. Baker of the U.S. Army Corps of Engineers, joined the state representatives in a vote unanimously approving formation of an interstate task force.

In their letter to Ms. Collier, the four governors explained their joint action as follows: "Individually, the Basin states can move forward with policies and regulations to reduce and mitigate the impacts of flooding, but we believe that through coordinated effort on a regional basis, we can do more to reduce flood loss within the Basin than we could accomplish acting separately, on our own. The Delaware River Basin Commission is the obvious vehicle for developing flood loss reduction and flood mitigation plans that cannot be accomplished by any single state or local government but that require a holistic watershed approach. As much as any time since the Commission was created in 1961, now seems an appropriate moment for coordinated action through the DRBC." The governors offered "the full cooperation of the state emergency management and environmental agencies in this effort" and ambitiously charged the Task Force to propose a preliminary action plan with recommendations by the close of 2006 "to enable implementation measures to be started as early as possible in 2007." (Appendix A)

## II. Introduction

This report presents recommendations developed by the Interstate Flood Mitigation Task Force for reducing flood damage in the Delaware River Basin. Significant flood damage occurs annually in the basin. However, between September 2004 and June 2006, three major floods along the main stem Delaware River caused severe and repeated damage to thousands of structures and disrupted the lives of tens of thousands of people. The flooding was the worst since the record flood of 1955.

Because many floodplains are highly developed, floods cause damage to many facets of society; including business and residential properties, the transportation network, industry and utilities, which include public and private water supply and wastewater facilities. Furthermore, floods also present the potential for adverse environmental impacts by contaminating drinking water supplies, infiltrating sewer systems, and introducing raw or partially treated sewage into our waterways. Debris carried by floodwaters creates hazardous conditions for boaters, fishermen, and swimmers in and on the water. The loss of vegetation in the floodplain allows for increased erosion of public and private land and the loss of a healthy and natural floodplain degrades water quality as well as important ecosystems.

Each flood event has been analyzed by the National Weather Service, which has found that the flooding was primarily the result of unusually heavy rain and/or snowmelt, not only

during the events but in the days and months preceding the floods. During the most recent flood event in June 2006, rainfall totals at some locations in the western and northern portions of the basin totaled more than 15 inches over a seven-day period. Several factors contribute to flooding. Two key elements are rainfall intensity and duration. Intensity is the rate of rainfall, and duration is how long the rain lasts. Precipitation frequency tables developed by the National Oceanic and Atmospheric Administration determine the statistical probability for the combination of these two factors for the period of observed record in a specific area (NOAA Atlas 14). The probability of a 15" rainfall over a seven-day period in the Upper Delaware is a 1 in 700 chance in any given year. Large areas of the western and northern basin received over 10 inches of rain during the period – which is a 1 in 100 chance precipitation event. It should be noted a 100-year storm does not automatically produce a 100-year flood. This is because several factors, including topography, soil moisture and ground cover, independently influence the cause-and-effect relation between rainfall and streamflow. A 100-year rainfall event and a 100-year flood are completely different statistical accounts and cannot often be correlated.

While the primary cause of the flooding has been attributed to extreme precipitation events and pre-cursor conditions, other factors including, but not limited to, development, stormwater management, floodplain encroachment and reservoir management have been attributed by the public or larger scientific community as potential contributing and exacerbating factors.

The responsibilities for facilitating flood loss reduction are scattered across many federal, state, and local agencies and organizations in the Delaware River Basin. The responsibilities are far reaching; involving both planning and operational functions. Flood loss reduction functions are administered by numerous federal, state and local agencies. DRBC was formed, in part, to bring together various government and non-governmental stakeholders across jurisdictional boundaries for the shared interest of the watershed. One example of this is DRBC's Flood Advisory Committee (FAC) which was established in 1999. The committee has served to coordinate agencies efforts to improve the basin's flood warning system and mitigate flood losses. In addition, many good programs exist which depend on cooperation among agencies. Examples include the Federal Emergency Management Agency's Flood Mitigation Assistance (FMA) and Pre-Disaster Mitigation (PDM) programs which focus on providing mitigation assistance to State and local communities with the aim to reduce vulnerability *before* the next disaster threatens. Another example of cooperation among many parties and agencies is the Temporary Reservoir Release Spill Mitigation Program (Resolution 2006-18) recently established by the Delaware River Basin Commission.

Despite the administration of flood loss reduction programs aimed at preventative measures for damage reduction, flood losses still continue. Comprehensive and progressive action is needed to protect life, property and the natural waterways that support us all and to make the basin more flood resilient. Many agencies and organizations involved in flood loss reduction have expressed the desire to end the damage/personal loss/rebuild cycle that has been allowed to continue in the floodplains, but, through the task force process it was heard that strong measures and adequate funding are needed to end this cycle and ultimately reduce long-term flood damage costs.

The Delaware River Basin Interstate Flood Task Force convened on four occasions; October 25, 2006, November 11, 2006, December 6, 2006 and December 20, 2006. The Task Force is comprised of 31 members representing a broad array of governmental (both legislative and executive), and not-for-profit interests. In addition to the Task Force members, many more individuals participated in creation of this action plan through the formation of focus area work groups. The Task Force has identified a total of 45 recommendations to effectuate a more proactive, sustainable and systematic approach to flood damage reduction in the basin. These recommendations are divided into six (6) priority management areas as follows:

- Reservoir Operations;
- Structural and Non-Structural Measures;
- Stormwater Management;
- Floodplain Mapping;
- Floodplain Regulations; and
- Flood Warning

## III. Background

Geographic Setting

The Delaware is the longest un-dammed river east of the Mississippi River, extending 330 miles from the Catskill Mountains of New York State to the mouth of the Delaware Bay where it meets the Atlantic Ocean. The river is fed by 216 substantial tributaries, the largest being the Schuylkill and Lehigh rivers in Pennsylvania.

Nearly 15 million people (approximately five percent of the nation's population) rely on the waters of the Delaware River Basin for drinking and industrial use, but the watershed drains only four-tenths of one percent of the total continental U.S. land area. The Catskill Mountain region provides a high quality source of water and NYC obtains nearly half of its municipal water supply from three Delaware Basin reservoirs--Cannonsville, Pepacton, and Neversink. The headwaters of the Delaware River form in New York State, Pennsylvania, New Jersey, and Delaware. Within the basin, the river supplies drinking water to much of the Philadelphia metropolitan area and major portions of New Jersey. In addition, water is diverted from the basin to both NYC and NJ. For the river's entire length, from its headwaters in New York to the Delaware Estuary and Bay, the Delaware also serves as an ecological and recreational resource. Over the past half century, as a result of the maintenance of lower basin minimum flows, cold-water fisheries have been established in the tailwaters of the East Branch Delaware, West Branch Delaware, and Neversink rivers and the upper main stem Delaware River, and most of the main stem upstream of Trenton, NJ has been designated by Congress as part of the federal Wild and Scenic Rivers system.

In all, the basin contains 13,539 square miles, draining parts of Pennsylvania (6,422 square miles or 50.3 percent of the basin's total land area); New Jersey (2,969 square miles, or 23.3%); New York (2,362 square miles, 18.5%); and Delaware (1,004 square miles, 7.9%).

The natural drainage area of the Delaware River Basin crosses many man-made boundaries in addition to the four state lines: 25 congressional districts, two Federal Emergency Management Agency (FEMA) regions, two Environmental Protection Agency (EPA) regions, five U.S. Geological Survey (USGS) offices, four Natural Resources Conservation Service (NRCS) state offices, two National Weather Service (NWS) local forecast offices, 42 counties, and 838 municipalities. Coordination of efforts is critical for effective flood loss reduction to occur within the basin.

Figure 1 depicts the watershed and major reservoirs of the Delaware River Basin. The reservoirs include the U.S. Army Corps of Engineers' five projects that were designed to maintain dedicated flood storage capacity, and other major reservoirs not specifically designed for flood control, including water supply reservoirs, hydropower reservoirs, and reservoirs used primarily for recreation. The U.S. Army Corps of Engineers' multi-purpose projects include Jadwin, Prompton, Beltzville, Blue Marsh and Francis E. Walter Reservoirs. The New York City water supply and flow augmentation reservoirs include Cannonsville, Pepacton and Neversink. The hydroelectric power generation reservoirs are the Mongaup System and Lake Wallenpaupack. Other major multipurpose reservoirs listed in Table 1 include Marsh Creek, Lake Nockamixon, and Merrill Creek.

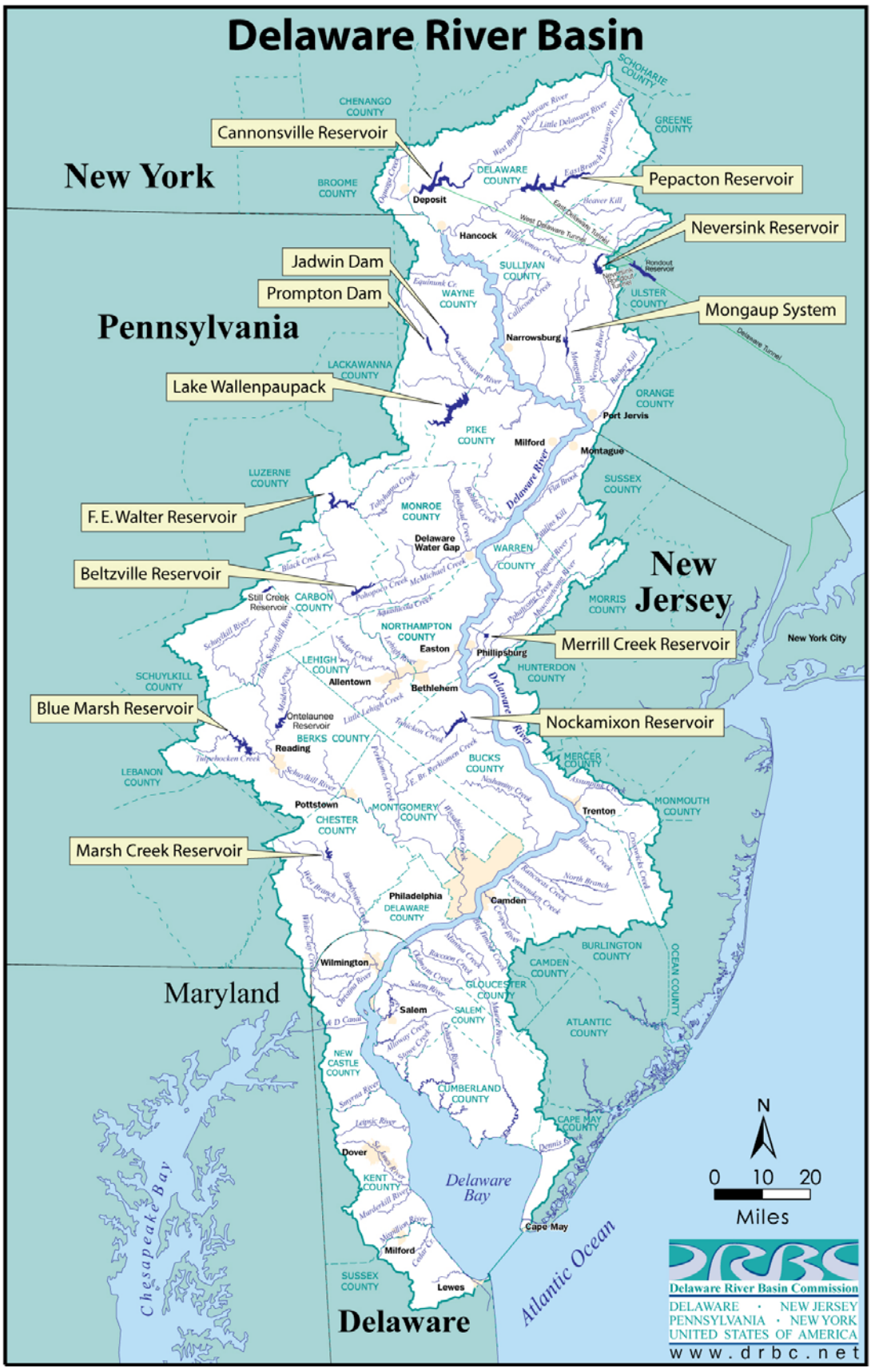



Figure 1. Map of the Delaware River Basin and Major Basin Reservoirs

Water Management in the Delaware River Basin

The waters of the Delaware River are apportioned through a 1954 U.S. Supreme Court Decree[3] and a federal-interstate compact enacted in 1961.[4] The compact created the Delaware River Basin Commission, an interstate and federal water resource agency with authority to regulate, plan and coordinate management of the water resources of the Delaware Basin. The Commission's members are the governors of the states of New York, New Jersey, Pennsylvania and Delaware and a federal member appointed by the President. Since 1997, the federal member has been the North Atlantic Division Commander of the U.S. Army Corps of Engineers, based in Brooklyn, New York.

In accordance with the Delaware River Basin Compact, the Commission has regulatory authority and responsibilities for planning and coordinating management of the Basin's water resources with respect both to water quality and water quantity. In the areas of reservoir operations and flow management, the Commission's authority is limited in that without the unanimous consent of the parties to the U.S. Supreme Court Decree of 1954, it may not "diminish or otherwise adversely affect the diversions, compensating releases, rights, conditions, [and] obligations" . . . contained in the Decree.[5] If the Decree Parties concur, however, they can act together through the Commission to modify the conditions of the Decree without returning to the Supreme Court. The parties to the 1954 Decree include the four basin states and the City of New York. For additional information about the Delaware River Basin Compact, the Commission and the Supreme Court Decree of 1954, see Appendix C.

The measures of certainty and flexibility afforded by the unique river basin management scheme created by the Decree and the Compact have provided the basis for more than four decades of joint watershed management by the basin states, the federal government and New York City, without further appeals to the court. Through the Commission, the parties have formally adjusted diversions and releases from New York City's Delaware system reservoirs more than a dozen times. Today, however, the parties face unprecedented challenges in the areas of flow management and allocation.

For nearly four-and-one-half decades after the Commission was created, the debate over allocation of water resources in the Delaware Basin revolved around ensuring an adequate supply of water for people and adequate in-stream flows for fish. Sustainable flows to meet ecological and recreational requirements became a vital objective, even though these uses were not contemplated by the Supreme Court when it apportioned the basin's waters 50 years ago. The advent of three successive main stem floods in 2004, 2005 and 2006 has rapidly transformed the flow management debate by adding flood mitigation to the mix of demands on limited water storage capacity.

[3] New Jersey v. New York, 347 U.S. 995 (1954).

[4] The Delaware River Basin Compact was enacted by concurring legislation of the states of Delaware, New York, New Jersey, and Pennsylvania and the federal government. *See* Pub. L. No. 87-328, 75 Stat. 688 (1961); Del. Code Ann. tit. 7, § 6501; N.J. Stat. Ann. §§ 32:11D-1 to 32:11D-110; N.Y. Envtl. Conserv. Law § 21-0701; Pa. State. Ann. § 815.101 ("Compact").

[5] Compact, § 3.3a

Flood Damage in the Delaware River Basin

Flooding affects all watersheds in the Delaware River Basin. However, flood damage potential is a function of human development in floodplains. The National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA), makes federally-backed flood insurance available in communities that adopt and enforce floodplain management ordinances in the effort to help reduce future flood losses. Through the collection of insurance premiums, the program effectively transfers the cost of flood loss reimbursement from tax payers to floodplain property owners. In addition to reimbursing flood victims for their losses, NFIP encourages development away from flood-prone areas and requires new and substantially improved structures to be constructed in a way that minimizes or prevents flood damage.

Unfortunately, flood insurance claims reflect only a fraction of the total cost of property damage caused by flooding. This is due in part to the fact that only a small percentage of property is insurable. For example, roads, bridges, public utilities and the natural environment cannot be insured. Further, many owners choose not to purchase the insurance because they are required to do so only if their property was purchased with federally-backed mortgages. In addition, flood insurance claims often occur in headwater areas, where property damage may result from stormwater flows as well as from stream flooding. Notwithstanding these limitations, insurance claims (since the NFIP's inception in the late 1970's) can provide a general picture of flood damage within the basin during the course of the flood insurance program.

Close to 20,000 flood insurance claim reimbursements have been awarded in the Delaware Basin since the late 1970s. The density of claims in certain areas reflects population density, the degree of development in floodplains, the number of policy holders, and flooding frequency.

Repeat flood insurance claims indicate areas where floodplain occupancy continues in spite of repeated inundation. Flood prone communities often find that available funds are not sufficient for either acquisition or elevation of residences and other buildings that are repeatedly flooded. As a means of illustrating the need for additional funding, DRBC staff has performed an analysis of properties within the basin that qualify as "repetitive loss"[6] and "severe repetitive loss"[7] properties. See Appendix D for the complete analysis. As an example of the severity of flooding in recent years, the number of repetitive loss properties in the basin prior to September 2004 was 209. Between September 2004 and February 2007, an additional 3,102 properties were added to this list. For total losses that occurred from the start of the NFIP program, January 1, 1978 through February 28, 2007, the NFIP made flood loss reimbursements totaling over $318 million on a total of 3,311 repetitive loss properties within the Delaware Basin.

[6] A property is considered a repetitive loss property by FEMA 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.

[7] A property is considered a severe repetitive loss property by FEMA either when there are at least 4 losses each exceeding $5000 or when there are 2 or more losses where the building payments exceed the property value.

In addition to the repetitive loss analysis, DRBC staff has prepared maps showing the locations and concentrations of individual flood insurance claims for each of the past three flood events -- September 2004, April 2005 and June 2006. The maps provide a look at the extent of damage from each event. These maps are provided in Appendix E.

Hydrologic Understanding of Severe Flooding Events

Three major floods have occurred on the Delaware River in the 22 months from September of 2004 through June of 2006. Although none were as devastating as the flood of 1955, collectively the three events comprised an unprecedented sequence of floods and accompanying property damage. Victims could somehow accept the September 2004 flood associated with Hurricane Ivan because it occurred almost exactly 50 years after the 1955 flood. It seemed to happen at exactly the right interval for a flood of its magnitude. The April 2005 flood was more difficult for people to accept, but after the June 2006 flood, there was little chance for the general public to make sense of what had happened. A basic explanation of the events is that each was the result of significant rainfall, not only during the event itself but in the preceding days and months. Each of the storms associated with these floods was unusual. However, the public now fears that because of floodplain encroachment, land development, reservoir management or other factors, flooding of this magnitude will be an annual occurrence into the future.

Two key contributors to flooding are rainfall intensity and duration. Rivers and streams may flood when prolonged rainfall over the course of several days, intense rainfall over a short period of time, or a debris or ice jam causes a river or stream to spill over its banks and inundate the surrounding area. Conditions prior to a rainfall event influence the amount of stormwater runoff into waterways. Thus, topography, soil conditions, and ground cover play very important roles. Dry soil accommodates greater infiltration of rainfall and reduces the amount of runoff entering streams. Conversely, soil that is saturated as a result of previous rains has a lower capacity for infiltration, and results in higher rates of surface water runoff. Since several factors independently influence the cause-and-effect relationship between rainfall and streamflow, a 100-year rainfall event and a 100-year flood are completely different statistical events and cannot often be correlated. Therefore, a 100-year storm does not automatically produce a 100-year flood.

The term “one-hundred-year flood” or base flood does not signify that such a flood occurs once every one hundred years. Rather, it means that there is a one in 100 (or one percent) chance that such a flood will occur in a given year. Two 100-year floods may occur one year apart or even one month apart, depending upon rainfall, snowmelt and soil conditions. A “20-year flood” is less destructive than a 100-year flood and is also more likely, with a one in 20 (or five percent) chance of occurring in any given year, whereas the catastrophic "500-year flood" has only a one in 500 (or 0.2 percent) chance of occurring in any given year.

The ability to predict the frequency of a particular event such as a flood depends on the length of the historical record. The period of recorded hydrologic data for the Delaware River is only about 100 years. As the historical record grows over time, however, the statistical probability of the current 100-year flood may well change. That is, the flood that we consider today to constitute the 100-year flood may over time and with more occurrences

become the 50-year flood. This statistical change can occur independent of changes in the landscape such as upland development and floodplain encroachment. It should be noted by the public and others that the 100-year *floodplain* is defined on the basis of the current hydrologic record and is only a reflection of statistical risk. The scientific community must continually update flood risk assessments and floodplain maps and communicate the associated risks to the general public.

## IV. Flood Mitigation Action Plan

The Task Force has concluded that no one set of mitigation measures will eliminate flooding along the Delaware River, but the members believe that a combination of measures will improve the basin's resiliency – its capacity to prepare for and recover from flooding in the future. The Task Force recommendations in this report are informed by the following six guiding principles of floodplain management and have been divided into six priority management areas.

Guiding Principles

1. **Preserve and Restore Floodplains Where Possible -** to recognize, preserve and restore the beneficial functions of floodplains for hazard reduction, water quality enhancement, wetland protection, wildlife habitat, riparian corridors, recreation, environmental relief, aesthetics and greenway areas.
2. **Be Prepared for Floods -** by developing advanced floodplain mapping, detailed risk assessments, enhanced early warning systems, multiple emergency notification measures, understandable response plans, workable recovery plans, and ongoing storm monitoring.
3. **Help People Protect Themselves from Flood Hazards -** through public interaction and involvement, available flood information, community outreach and education, self-help measures, flood proofing options, affordable flood insurance, and emergency preparedness.
4. **Prevent Adverse Impacts and Unwise Uses in the Floodplain -** through appropriate regulation and land use, open land preservation, acquisition of structures and relocation assistance programs, relocation of infrastructure (such as wastewater disposal plants), multi-objective planning, prohibiting unacceptable encroachments, and establishing ongoing maintenance practices that preserve and enhance environmental functions.
5. **Prevent Adverse Impacts from Development and Redevelopment** – by preparing tributary and regional stormwater management plans, adopting appropriate engineering standards into local ordinances, consistently administering and enforcing ordinances and providing long-term maintenance of facilities.
6. **Acknowledge the Values of Structural Flood Control Measures -** after a careful analysis of the ecological, economic, long-term operation and maintenance, and social costs and benefits of all mitigation options; identify those situations where a combination of structural solutions, structural modifications, and non-structural solutions is the most beneficial option.

Priority Management Areas:

In assessing the above guiding principles and in order to organize the following recommendations, the Task Force decided to divide the recommendations into six priority management areas. A focus area work group led by a committee chair was formed for each management area. Task Force members and contributors volunteered and worked within their work groups to form recommendations to then bring before the larger Task Force for review and approval. Discussions of the six priority management areas are as follows:

**A. Reservoir Operations:**

Three major main stem floods between September of 2004 and June of 2006 have focused attention on the potential management of the basin's major reservoirs for additional flood mitigation. The reservoirs include the Army Corps of Engineers' five projects that were designed to maintain dedicated flood storage capacity, and other major reservoirs not specifically designed for flood control, including water supply reservoirs, hydropower reservoirs, and reservoirs used primarily for recreation. There is a need to evaluate all of these reservoirs in order to develop plans to minimize their total discharge (spills plus releases) during flood conditions. On-line availability of rainfall forecasts and snowpack information from the National Weather Service are providing better information for release decisions prior to storm events, and probability of refill of reservoirs can be used as a basis for release programs aimed at limiting total discharge during flooding. Although, there are substantial hydraulic limitations on the controlled release capacity of most non-flood control reservoirs, forecast-based and variable release programs for the existing facilities can potentially contribute to flood crest reduction, particularly in reaches immediately downstream of reservoirs. Use of a comprehensive flood analysis model would allow for consideration of the cumulative effects of operations of all reservoirs on the main stem and would help promote coordinated operation and planning. These recommendations call for releases that would reduce the likelihood and volume of spills from some basin reservoirs during storm events to help mitigate flooding.

**B. Structural and Non-structural Measures:**

(Excerpted from Association of State Flood Plain Managers, No Adverse Impact Policy) "Flood damages in the United States continue to escalate. From the early 1900's to the year 2000, flood damages in the United States have increased six fold, approaching $6 billion annually. This occurred despite billions of dollars for structural flood control, and other structural and non-structural measures. We continue to intensify development within watersheds and floodplains, and do it in a manner where flood prone or marginally protected structures are suddenly prone to damages because of the actions of others in and around the floodplain.

Current national floodplain management standards allow for: floodwater to be diverted onto others; channel and overbank conveyance areas to be reduced; essential valley storage to be filled; or velocities changed with little or no regard as to how these changes impact others in the floodplain and watershed. The net result is that through our actions we are intensifying damage potentials in the nation's floodplains. This current course is one that is not equitable to those whose property is impacted, and is a course that has shown to not be economically sustainable."

Due to a host of economic, environmental, and political reasons, flood management has been historically moving away from large scale flood control projects and moving instead towards floodplain management and mitigation measures such as acquisition, elevation, floodplain regulation, and stormwater management. In some cases, though, after careful analysis of the ecological, economic, social, long-term operation, and maintenance costs and benefits, structural solutions such floodwalls, dams, engineered conveyances, and control structures may still be warranted. For the prevention of stream tributary flooding, small local flood control structures may be beneficial and should be investigated and analyzed. For example, backwater flooding along stream tributaries could be controlled and prevented through the use of flap gates, flood gates, tide gates, and pumping stations.

In advancing non-structural measures in the basin, multiple approaches are needed. Communities must be encouraged to complete and locally adopt their All-Hazards Mitigation Plans. The cost of mitigation projects identified in their respective hazard mitigation plans is often cost prohibitive for municipalities to fund individually. Greater funding is needed to help ensure that the local projects, such as acquisition, elevation, and flood proofing, can be implemented. Effective mitigation will require the cooperation and coordination of residents, elected officials, and all federal, state, and local agencies with flood mitigation responsibilities. Additionally, expansion of floodplain awareness and strengthened floodplain regulations basin-wide will allow for better planning and stricter protection of floodplains in the future.

**C. Stormwater Management:**

Historically stormwater management regulations have focused on addressing the peak rate of runoff from development and have not addressed water quality impacts, strived to avoid runoff through the use of low impact development strategies, or worked to minimize the volume of runoff through stormwater best management and infiltration practices. The result has been to actually exacerbate and create flooding conditions. Current regulatory regimes fail to provide the tools to successfully and comprehensively address stormwater runoff from existing development. But a number of new legal requirements, regulatory regimes, and models now exist to minimize and better address stormwater runoff from new development and from redevelopment. One such model is encouraging site/project design that incorporates low impact/non-structural stormwater management as a means to simulate natural drainage and infiltration functions.

In addition to managing stormwater runoff from future planned development, there are many good ways to reduce runoff from existing developments. Regional, tributary-based watershed stormwater management plans can provide a comprehensive and holistic approach to stormwater management by evaluating existing flooding problems, considering potential impacts from future land use practices, and identifying successful projects, programs, initiatives, ordinances, and regulatory regimes. When implemented, these plans could minimize the volume and peak rate of runoff while at the same time address water quality and other impacts associated with runoff from new and existing development. Successful planning efforts can provide necessary justification for tougher design requirements for new development and redevelopment and identify possible strategies for addressing existing development. However, little of the Delaware Basin Watershed is currently under approved stormwater management plans due to inadequate funding mechanisms.

**D. Floodplain Mapping:**

The mission of a successful floodplain mapping program is to provide public residents, emergency management personnel, insurance companies, design professionals, and State and local regulatory authorities accurate, up-to-date, and user-friendly floodplain maps.

FEMA develops and produces flood hazard data and maps in order to administer the National Flood Insurance Program (NFIP). The Delaware River Basin is comprised of two FEMA Regions, FEMA Region II and FEMA Region III. This requires the states and FEMA Regions to coordinate and confer on methodology and mapping specifics so that a seamless map can be created across state boundaries. For instance, agreement on discharges to the river and floodway standards must be made. The current minimum FEMA floodway standard allows for a 1.0' rise. Presently, the floodway of the main stem of the Delaware is mapped at a 1.0' rise because it is an interstate waterway. The NJ floodway standard for its other waterways is a more restrictive 0.2' rise.

Future hydrologic conditions are not typically taken into consideration during the development of floodplain maps used to identify flood-prone areas. As future development occurs, runoff from that development may increase flows in flood-prone areas downstream. In NJ, for example, State land use regulatory permits required by the NJDEP, the NJ Flood Hazard Area Maps are defined by the 100-year event plus a 25% increase in discharge. This 25% safety factor is incorporated to take into account future build-out. DE, PA, NY, and local communities within NJ currently use the 100-year flood event without any considerations for future build-out.

**E. Floodplain Regulations:**

Often, development in the floodplain has negative effects. These negative effects can include increased flood stages, increased velocities, increased flows, water pollution, and erosion and sedimentation. Development in the floodplain disturbs the naturally vegetated floodplain diminishing its flood absorption and protection capabilities, which in turn threatens to put people and emergency personnel in harms way in the event of a flood.

Current national floodplain management standards have two essential components. The first is to recognize the concept of a two-part floodplain, known as the floodway and the flood fringe. The floodway is the central portion of the floodplain, which is characterized by higher water velocities and greater depths of flow than the flood fringe. Since the floodway conveys the majority of flood flows, it should be left open to the passage of floodwaters wherever possible to avoid increases in flood elevations. The flood fringe comprises the outer areas of the floodplain on both sides of the floodway, and is characterized by lower flood depths and velocities than the floodway. The flood fringe also stores water during a flood. The preservation of flood storage is essential to ensuring that flood depths do not increase. The second component of floodplain management is the requirement that the lowest floor of buildings in the floodplain must be constructed at or above the level of the 1% chance flood (100-year flood) otherwise known as the base flood elevation (BFE).

Local communities are required to adopt and enforce at least the FEMA minimum standards for participation in the National Flood Insurance Program (NFIP). However, post-storm surveys have shown that FEMA compliant structures continue to sustain damages,

even when built properly. Constructing to slightly higher standards is a very cost-effective way to mitigate flood damages over the long term. For example, New York requires elevation in an unnumbered A Zone to three feet above the highest adjacent grade (two feet for ordinances/laws adopted before 1992), and New Jersey has established a floodway based on a 0.2 foot rise. Beyond minimum NFIP standards, there is no consistent set of floodplain regulations basinwide to uniformly manage development in the floodplain of the basin.

**F. Flood Warning:**

The river flood warning system in the Delaware River Basin is comprised of several elements and is coordinated and funded by numerous organizations at the federal, state, and local levels. Three main elements of the flood warning system include gaging, flood and flash flood forecasting, and education and outreach.

Effective flood warning is not possible without the collection and rapid transmission of precipitation and streamflow data. The maintenance of stream gages is critical to flood warning. The stream gaging program is operated by the U.S. Geological Survey, who also coordinates funding for the program. Most stream gages in the Delaware River Basin are cost shared through a cooperative funding program between the U.S. Geological Survey, U.S. Army Corps of Engineers, the Basin States of Delaware, New Jersey, Pennsylvania, and New York, the Delaware River Basin Commission, and some utilities and industries. Stream gages are especially important because they are used to reference flood height and to develop the stage-discharge or "rating" curve which relates predicted streamflow to flood stage elevation. The funding for the stream gages is an annual issue, and flood warning capabilities are reduced when gages are discontinued.

It is the responsibility of the National Weather Service (NWS) to provide flood forecasts and issue flood warnings. The NWS uses rainfall observations, streamflow and stage data, and computer modeling to forecast flood levels at river forecast points during storm events. NWS flood forecasts are then broadcast to state and county emergency offices and to the public over emergency management communications systems, NOAA Weather Radio, television and radio, and the Internet. State and county emergency managers relay the information to emergency personnel at the municipal level. Road closures, evacuation, and rescue actions are implemented at the local level. In addition to river flood warning, the NWS also issues flash flood warnings which are transmitted over NOAA Weather Wire to emergency managers and also placed on the Internet.

A key component of a successful flood warning system is communication with the public. Media plays an essential role in informing the public of flood forecasts, and the media needs to coordinate with the NWS and emergency managers to relay flood information. But, the public must also be aware of sources for flood-warning information and be capable of interpreting the flood message. Adequate lead time, knowledge of vulnerable property locations, and knowledge of the hazards associated with driving in flood waters, are minimum requirements for responding to a flood. The failure in any of these links in the warning system hinders flood warning.

The Task Force's flood warning recommendations focus on the components of the existing flood forecast and warning system in the basin. The system currently is supported by funding from a number of cooperating federal, state, and local agencies. The system has

three key major components; observing, forecasting, and warning. The recommendations listed identify deficiencies in the current warning system and areas where development and implementation of scientific and technical solutions can improve the timeliness and accuracy of the flood forecasts and warnings. User response to flood forecasts and warnings is critical to minimize the loss of life and property during flood events; therefore, education and outreach is also high priority.

Implementation of the recommendations will be based on funding and available resources; however there are a number of recommendations that require minimal or no funding and could be implemented at once.

## V. Recommendations

### A. Reservoir Operations

R-1: Develop a Flood Analysis Modeling Tool

R-2: Develop an Interoperable Reservoir Operating Plan

R-3: Evaluate Discharge Mitigation Programs for Reservoirs

R-4: Evaluate Snowpack Based Storage Management

R-5: Publish Information on the Basin's Existing Major Impoundments

R-6: Evaluate Availability and Accuracy of Data

Water Supply Reservoirs and Flood Protection: Lessons from Historical Data

With the devastating effects of the recent Delaware River floods, floodplain residents and elected officials are urging that year-round flood storage voids be maintained in water supply reservoirs. The three New York City (NYC) Delaware Basin reservoirs – Cannonsville, Pepacton, and Neversink – are receiving the most attention because they were full prior to each of these floods and uncontrolled spills formed a component of downstream floodwaters. As a result, some flood victims have concluded that the reservoirs caused the flooding and that without reservoir spills, their homes and businesses could be spared inundation in the future. The historical data support neither of these contentions and is offered below as background information.

As Table 2 shows, five of the ten highest main stem flood crests recorded at Trenton, N.J. occurred in 1902, 1903, 1904, 1936 and 1942 before the NYC reservoirs were constructed. The record flood of August 1955 along the main stem Delaware River occurred before the Cannonsville Dam was built. Although the Neversink and Pepacton reservoirs were both in place, neither reservoir spilled during the 1955 flood. None of the three NYC reservoirs spilled during the flood of 1996. Thus, seven of the ten worst main stem floods in the Delaware Basin recorded at Trenton over the past 100 years occurred in the absence of reservoirs or in the absence of spills. Although they might be helpful in reducing flood crests, year-round voids will not stop flooding along the main stem Delaware.

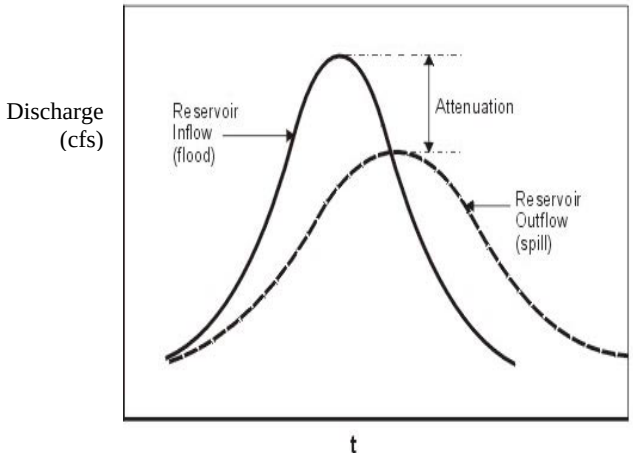
**Table 2: Historic Flood Crests for the Delaware River at Trenton, N.J.**

| *FLOOD RANK* | *CREST STAGE (in Feet)* | *CREST DATE* | *NOTES* |
|---|---|---|---|
| 1 | 30.60 | 3/8/1904 | Ice Jam; NYC Reservoirs Not Built |
| 2 | 28.60 | 8/20/1955 | No spills; Cannonsville Not Built |
| 3 | 28.50 | 10/11/1903 | NYC Reservoirs Not Built |
| 4 | 25.33 | 4/4/2005 | Spills |
| 5 | 25.09 | 6/29/2006 | Spills |
| 6 | 24.43 | 3/19/1936 | NYC Reservoirs Not Built |
| 7 | 23.60 | 3/2/1902 | NYC Reservoirs Not Built |
| 8 | 23.41 | 9/19/2004 | Spills |
| 9 | 22.20 | 1/20/1996 | No Spills |
| 10 | 21.12 | 5/24/1942 | NYC Reservoirs Not Built |

Despite the fact that flooding would still occur along the Delaware even if a year-round void program were implemented, reservoir management actions could reduce flood crests for a given flood. For this reason the Task Force has included reservoir management at water supply reservoirs as an element of this report, and there is sound justification for addressing all measures for reservoir management that that do not adversely impact water supplies.

Hydrologic theory and observed data show that even when they are full and spilling, reservoirs lower and delay the maximum flood discharges at dam sites when compared to natural undammed conditions. This is referred to as "attenuation". Attenuation is a function of reservoir storage as compared to runoff volumes, rainfall intensities, rainfall duration and spillway rating curves. One example from the flood of April 2005 is documented by the U.S. Geological Survey (USGS) in its publication, Flood of April 2-3, 2005, Neversink River Basin, New York[8]. USGS, which maintains flow gages throughout the basin, estimated that the peak rate of inflow to the city's Neversink Reservoir during the April 2005 event was 23,100 cubic feet per second (cfs). This estimate represents the rate of flow that would have occurred at the dam location if the dam had never been built. However, the actual peak discharge from the reservoir recorded by the USGS was a greatly reduced 12,300 cfs. By this measure, the dam nearly halved the rate of peak flow that would otherwise have moved downstream as a result of the storm. However, had a void existed in Neversink Reservoir prior to the storm, the reduction in peak flow would have been greater and resulted in lower downstream flood peaks. Although the reductions achieved miles downstream would be only slight, such measures merit careful consideration but must be weighed against the impact to water supply for New York, New Jersey and Pennsylvania.

**Reservoir Attenuation:**




From *"A Review of the Role of Dams in Flood Mitigation,"* a paper submitted to the World Commission on Dams in March 2000 by Peter Hawker.

[8] Suro, Thomas P., and Gary D. Firda. Flood of April 2-3, 2005, Neversink River Basin, New York. U.S. Geological Survey Open File Report 2006-1319. (2006).

Balancing the Needs for Flood Mitigation and Water Supply:

While some of the basin's multipurpose reservoirs, such as those owned and operated by the Corps of Engineers, maintain year round flood storage voids, such voids are not maintained by the basin's water supply reservoirs. On the contrary, water supply reservoirs fill during the winter and spring months of normal years. They are managed to reach full capacity in late spring in order to provide water supply storage for the coming year.

While recent management actions have been taken at the New York City reservoirs to increase releases during the summer and winter periods, the reservoirs continue to be managed to be full in the late spring. The following are several points that relate to and limit the potential for creating and maintaining year-round voids at these reservoirs:

**1)** The Supreme Court Decree of 1954 gives the City of New York the legal right to take an average of up to 800 mgd from the three reservoirs for water supply. Although historical diversions have been less than the full allocation, the City manages for the full storage condition in the late spring, in the event that all of the storage might be needed in a severe drought.

**2)** Storage in the three New York City reservoirs is shared with the other Delaware River Basin States. During dry periods, the states of Delaware, Pennsylvania, and New Jersey rely on storage in the NYC reservoirs to provide downstream releases to maintain flows in the main stem Delaware River and freshwater inflow to the Delaware Estuary. For example, during the month of August of 1999, an average of 73 percent of the flow at Montague, NJ, and 46 percent of the flow at Trenton, NJ was provided by releases from the NYC reservoirs. Some 2.5 million Pennsylvania and New Jersey residents obtain their drinking water from the Delaware River downstream of the Delaware Water Gap. During droughts, freshwater inflows from the reservoirs to the Delaware Estuary are needed to repel salt that might otherwise creep upstream through tidal action and threaten the water supply intakes of the City of Philadelphia and New Jersey American Water Company. In addition to public water supply, the releases are depended on for coldwater fishery maintenance and recreational boating.

**3)** Weather forecasting is not yet sufficiently advanced to furnish reliable drought predictions. Severe droughts can develop within a matter of months. By way of example, on May 1, 2001, NYC's Delaware Basin reservoirs were 100 percent full, holding approximately 271 billion gallons (bg) of water. In fact, the three reservoirs were spilling from April 13 through April 30, 2001. On December 15, 2001, less than eight months later, combined reservoir storage bottomed out at 63.348 bg, or only 23.4 percent of capacity, before slowly beginning to rebound. One frequently voiced request from flood victims is that a 20 percent year-round void be maintained in the NYC Delaware reservoir system. If a 20 percent (54 bg) void had been in effect in May 2001, the reservoirs would have entered the drought with approximately 217 bg of stored water rather than 271 bg. The system did not refill again until spring 2003. Table 3 lists the DRBC drought management periods since 1980. Periods are triggered by NYC reservoir storage levels.

**Table 3: Dates of Drought as Determined by the DRBC Drought Management Plan (1980-Present)**

| *ENTERED DROUGHT WATCH/WARNING/ EMERGENCY* | *ENDED DROUGHT WATCH/WARNING/ EMERGENCY* | *NUMBER OF MONTHS OF DROUGHT MANAGEMENT* |
|---|---|---|
| 10/17/1980 | 4/27/1982 | 18.5 |
| 11/13/1982 | 3/27/1983 | 4.5 |
| 11/9/1983 | 12/20/1983 | 1 |
| 1/23/1985 | 12/18/1985 | 11 |
| 1/16/1989 | 5/12/1989 | 4 |
| 9/13/1991 | 6/17/1992 | 9 |
| 9/21/1993 | 12/6/1993 | 2.5 |
| 9/15/1995 | 11/12/1995 | 2 |
| 10/27/1997 | 1/13/1998 | 2.5 |
| 12/14/1998 | 2/2/1999 | 1.5 |
| 10/29/2001 | 11/25/2002 | 13 |

**4)** Sufficient discharge capacity to maintain year-round voids in each of the three NYC Delaware Basin reservoirs is currently unavailable. Creating it would entail retrofitting the release works of these three reservoirs. Assuming the proposed voids could be maintained, NYC would need to evaluate whether its system could be managed under such constraints in a manner that would not jeopardize water supply, water quality, aggravate flood problems, or adversely affect the structural integrity of its dams.

A request has been made for a 20 percent year round-void through the re-allocation of approximately 54 billion gallons from water supply and low flow maintenance storage to flood control. Such a requested re-allocation of storage is the overriding issue associated with the year-round void question. Under the 1954 Supreme Court Decree, the year-round void issue is within the jurisdiction of the governors of the four basin states and the City of New York. The water policy implications of this issue may not be quickly or easily resolved. A major concern by Task Force members is that regardless of how this question is resolved, the Delaware River and its tributaries will continue to flood, and additional measures are needed to lower flood damages. It is in this context that the reservoir management recommendations and the other recommendations of this report are presented.

**Recommendation R-1: Develop a Flood Analysis Modeling Tool**

**Finding:** DRBC Resolution 2006-20 authorizes the Executive Director of the DRBC to accept funding for the development of a flood analysis model for the basin. While the commission already has an OASIS model capable of modeling reservoirs throughout the basin, the daily time step and other limitations of that model render it ineffective for complex modeling of storm events and associated reservoir operations. A more complex model, incorporating shorter time step operations and accounting for other factors contributing to hydrology in storm events, is needed to evaluate the potential for the basin's major reservoirs to be operated for flood mitigation.

The model is required for the DRBC staff to furnish the technical support that the Commission has directed the staff to provide for the development of flood mitigation plans for existing reservoirs. The model would enable the Commission to evaluate the feasibility of various reservoir operating alternatives and the effect of reservoir voids of different magnitudes on flooding at locations downstream from the reservoirs. Such a model would include representation of rainfall and snowmelt runoff, flow routing and reservoir hydraulics, and would calculate flow rates at all National Weather Service flood forecast points for any storm scenario. The model would allow evaluation of the effects of altering the existing structural conditions for major basin reservoirs for consideration as a potential flood mitigation measure to better accommodate forecast based operations. The model would also be useful as an educational tool for demonstrating the operations of reservoirs and basin flood hydrology. A graphical user interface would promote communication and understanding related to reservoir operations. Hydrologic models previously developed for the basin by the National Weather Service and U.S. Army Corps of Engineers would provide data and guidance for development and calibration of the new model.

**Recommendation:** DRBC should develop a flood analysis modeling tool as specified by resolution 2006-20. The initial version of the model should be able to evaluate the operations of all major Delaware basin impoundments. Later versions of the model could be developed to include possible future structures. The model should provide output in a form conducive to public education and outreach, and input data used for model comparisons by DRBC should be available to the public.

The model should allow the simulation of any storm scenario in 6-hour time steps and include pre-storm hydrologic conditions, including streamflow conditions, soil moisture, and snowmelt. The model should also include provisions for altering reservoir release rates prior to and during storm events. The model should provide for analyzing the effects of structural alterations of major basin reservoirs and should allow for evaluation of diversions, for other than water supply purposes, at those reservoirs. The main stem Delaware River and all non-tidal tributaries, especially those with major impoundments, should be included in the model. The model results should be made available on-line for use by interested parties.

**Implementation:** DRBC (Project Management), Contract with U.S. Geological Survey/ U.S. Army Corps of Engineers, NOAA-National Weather Service (advisory role)

**Funding Mechanism:** Funding has been committed by the Delaware River Basin States; $150,000 each from New Jersey, New York, and Pennsylvania; $50,000 from Delaware.

**Estimated Cost:** $500,000

**Implementation Time Frame**: 18 months from the date of contract

**Recommendation R-2: Develop an Interoperable Reservoir Operating Plan that includes Potential Flood Mitigation by All Major Reservoirs**

**Finding:** Three major main stem floods between September of 2004 and June of 2006 have focused attention on the potential management of the basin's major reservoirs for additional flood mitigation. The reservoirs include the U.S. Army Corps of Engineers' five projects that were designed to maintain dedicated flood storage capacity, and other major reservoirs not specifically designed for flood control, including water supply reservoirs, hydropower reservoirs, and reservoirs used primarily for recreation. There is a need to evaluate all of these reservoirs to develop plans in advance to minimize their total discharge (spills plus releases) during flood conditions. On-line availability of rainfall forecasts and snowpack information from the National Weather Service are providing better information for release decisions prior to storm events, and probability of refill of reservoirs can be used as a basis for release programs aimed at limiting total discharge during flooding. Although there are substantial hydraulic limitations on the controlled release capacity of most non-flood control reservoirs, forecast-based and variable release programs for the existing facilities can potentially contribute to flood crest reduction, particularly in downstream reaches near the reservoirs. Use of the flood analysis model described in Recommendation R-1 would allow consideration of the cumulative effects of operations at all reservoirs, and would promote coordinated operations.

The support of reservoir owners is essential for the successful development and implementation of flood operating plans. In addition, implementation of any flood operation plan that would affect water supply storage in the New York City Delaware Basin reservoirs would require unanimous agreement of the Parties to the 1954 Supreme Court Decree. To support negotiation of any agreements among the Parties, modeling with the DRBC's existing OASIS daily flow model and the proposed flood-analysis model described in Recommendation R-1 is required, to evaluate the potential effects of flood management proposals on the fundamental purpose of the reservoir.

The development and implementation of flood operating plans for reservoirs depends on the availability of high quality data and forecast information. Precipitation and runoff rates, snowpack conditions, and streamflow both upstream and downstream of reservoirs are needed to make operational decisions prior to and during flood events.

**Recommendation:** Develop a reservoir operation plan that includes potential flood mitigation by all major reservoirs located in the basin. Such a plan should not be expected to alleviate all future flooding, but could provide a measure of additional flood mitigation by means of seasonal or forecast based operations, including on tributary streams. The plan should consider opportunities for coordination of reservoir operations throughout the basin before and during flood events and assess data collection necessary for decision making

**Implementation:** DRBC, Decree Parties, U.S. Army Corps of Engineers, New York City, hydro-power companies, PADNRC (Nockamixon and Marsh Creek Reservoirs)

**Funding Mechanism:** Potential federal funds using DRBC flood model development funding as a local match.

**Estimated Cost:** Plan development will primarily require staff resources of DRBC, reservoir owners, and parties to the 1954 Supreme Court Decree, where applicable. A contract for services may be necessary depending on the number of model analyses required.

**Implementation Time Frame**: Three years

**Recommendation R-3: Evaluate Discharge Mitigation Programs for Reservoirs**

**Finding:** Discharge mitigation programs involve making controlled reservoir releases (through valves or gates) prior to storm events to minimize total discharge (uncontrolled flow over the spillway plus releases) during flood events. Spillways are a safety feature of all large dams and are required to prevent overtopping of the dam during severe flood events. Although large reservoirs, even when spilling, attenuate flows downstream, high total discharge rates can result in flooding immediately downstream of dams and contribute to the total flood flow further downstream. Programs designed to reduce total discharge rates offer some flood mitigation potential. Discharge mitigation programs may include maintenance of seasonal and snowpack based voids in water supply reservoirs to the extent that sufficient release capacity exists, and pre-storm releases based on potential runoff from forecast storm events. The capacity of a reservoir's outlet valves and piping (release works) is a critical limiting factor in the ability to lower reservoir levels and maintain voids, particularly for water supply reservoirs.

Discharge mitigation programs developed for individual reservoirs could be evaluated using the proposed flood analysis model described in Recommendation R-1, to determine their combined effects during various flood events, and could form the basis for a coordinated flood operation plan. Limited modeling performed by the National Weather Service has shown that relatively small reservoir voids can provide limited flood crest reduction in the reaches close to reservoirs. The continuing risk of flooding requires that evaluation of discharge mitigation measures, including adjustments to existing programs, not be delayed until after development of the flood analysis model.

DRBC Resolution 2006-18 approved a temporary discharge mitigation program for the New York City Delaware Basin reservoirs. As is true of any program that affects the diversions and releases from the New York City Delaware Basin Reservoirs established by the 1954 U.S. Supreme Court Decree, this discharge mitigation program, which could have potential impacts on water supply during subsequent dry periods, required the unanimous consent of the Parties to the Decree. The program provides increased release rates from the reservoirs when storage levels are above established thresholds during the fall and winter months. However, these releases are not large enough to prevent the reservoirs from filling during prolonged wet periods when runoff into the reservoirs exceeds the combined release and diversion rates. This program is temporary for the 2006/2007 winter season and is being re-evaluated in the Decree Party negotiations for a Flexible Flow Management Plan (FFMP)[9] for the basin's reservoirs. Under discussion are release and diversion capacities at these reservoirs. In addition, the official flood stages immediately downstream of the Cannonsville and Neversink reservoirs have been re-evaluated by the National Weather Service, and are being taken into account in the FFMP. There is a need to establish the maximum rate at which the reservoirs can be lowered prior to a storm event without causing flood problems downstream or adverse impacts on water supplies.

PPL is developing a snowpack and runoff based discharge mitigation program for implementation at Lake Wallenpaupack.

[9] Details on the Decree Parties' Flexible Flow Management Program can be found online at www.drbc.net.

**Recommendation:** Discharge mitigation programs should be evaluated, and both short term and long term programs should be considered for the reservoirs in the basin, while accounting for the fundamental purpose(s) of the reservoir storage (e.g. ecological, water supply, and hydropower uses). Potential release and diversion capabilities, as well as flood stages immediately downstream of dams, should be further evaluated to determine the maximum rate at which reservoirs can be lowered prior to a storm event or during an emergency, without adverse impacts on water supply, downstream flooding or structural integrity of the dams. Due to continuing risk of flooding, and the time requirement for development of the flood analysis model, evaluation of new discharge mitigation measures and consideration of adjustments to existing discharge mitigation programs should proceed in the short term using the best available information. Potentially feasible discharge mitigation programs should be submitted to the owners/operators of all major impoundments within the basin and, with respect to the New York City Delaware Basin Reservoirs to the Decree Parties for their consideration.

**Implementation:** City of New York, U.S. Army Corps of Engineers, hydro-power companies, PADCNR, DRBC, Decree Parties

**Funding Mechanism:** Existing budgets of individual dam owners, and state and federal agencies; possible NOAA grants.

**Estimated Cost:** Staff time, plus cost of monitoring and administration.

**Implementation Time Frame**: Beginning winter 2006/2007 and on-going. On February 20, 2007, the Commission posted for public comment a proposed Flexible Flow Management Plan (FFMP) incorporating a discharge management element that provides for increased releases (Table 1 in the FFMP) from the three New York City Delaware Basin Reservoirs when total system storage is above a discharge mitigation rule curve (Figure 1 in the FFMP). In order to establish maximum discharge rates (Table 2 in the FFMP), official flood stages downstream of the three reservoirs were updated by the National Weather Service in December 2006.

**Recommendation R-4: Evaluate Snowpack Based Storage Management Programs for All Major Reservoirs**

**Finding:** Snowpack based storage management is one type of discharge mitigation that has previously been implemented in the Delaware River Basin. Such programs are based on the concept that a percentage of the water equivalent in the snow pack on the watershed above a reservoir will eventually flow into the reservoir and can be counted as storage. During cold conditions, when snowpack is accumulating, freezing temperatures may reduce runoff rates into water supply reservoirs and allow the creation of voids over a period of time, depending on release capacities. In 2005, just prior to the late March/April flood event, a snowpack based void of approximately 11 billion gallons had been created in Pepacton Reservoir under a snowpack based storage management plan agreed to by the Parties to the 1954 Supreme Court Decree. Although the reservoir did fill and spill during the event, the void offered 11 billion gallons of storage capacity that would not otherwise have been available. Because a portion of the snowpack can be counted as storage, snowpack based programs pose less risk to water supply than other types of discharge mitigation programs. Snowpack water equivalence is monitored remotely by the National Weather Service and can be supplemented with field surveys or automated monitors. Frequent monitoring is required because snowpack can accumulate or disappear quickly; making it difficult to maintain representative voids due to limited release works capacity at water supply reservoirs. The temporary discharge mitigation program approved for the New York City Delaware Basin Reservoirs does not specify a snowpack related void, but counts 50 percent of the snowpack water equivalent as storage used for purposes of determining the release rates. PPL is developing a discharge mitigation program for Lake Wallenpaupack which accounts for both snowpack and forecast rainfall in determining potential runoff.

Snowpack based programs do not eliminate the need to also consider rainfall forecasts and are only one element of discharge mitigation programs for reservoirs.

**Recommendation:** Use of snowpack based storage management programs for all major reservoirs should be evaluated, while recognizing the limited seasonal availability and marginal risk reduction offered by this type of flood mitigation and the potential for increased risk to other water uses.

**Implementation:** City of New York, U.S. Army Corps of Engineers, hydro-power companies, PADCNR, DRBC, Decree Parties

**Funding Mechanism:** Existing budgets of individual dam owners and state and federal agencies; possible NOAA grants

**Estimated Cost:** Staff time, plus cost of monitoring and administration.

**Implementation Time Frame**: Beginning winter of 2006/2007 and on-going. Snow pack would be included in the determination of total system storage during the winter and early spring months.

**Recommendation R-5: Publish Information on the Basin's Existing Major Impoundments**

**Finding:** On-line information about basic physical features, storage uses, current storage amounts, inflow (runoff) and release rates, release capacity, diversion rates and diversion capacity is not available for all reservoirs. In the aftermath of the recent flooding, the observed data and hydrologic principles related to reservoir impacts during flooding, such as the attenuation effect on flood peaks and the percentage of drainage area impounded by reservoirs have often been challenged. There is a need for clear and consistent presentation of this information by public agencies and reservoir owners. The proposed flood analysis model described in Recommendation R-1 can be useful in displaying the combined effects of multiple reservoirs over a range of different storm events, and could be an educational tool for all interests. Additionally, there is need for clearer public information about discharge mitigation programs. Most recently, the discharge mitigation program approved by DRBC Resolution 2006-18 was erroneously reported in some newspapers as mandating a 20 percent void in the three New York City reservoirs. In reality, the program provides for greater releases when total storage is at 80 percent or greater of full storage capacity, but does not mandate a specific void. This has understandably led to confusion when the public has observed the subsequent refill of the reservoirs due to an extended period of high precipitation.

**Recommendation:** Publish and present information on the system uses and capabilities of the basin's existing major impoundments.

All information related to reservoir and dam facilities should be reviewed by reservoir owners prior to publication to assure that the information will not compromise the security of the facilities. The information should be presented at public workshops throughout the basin, and posted on the DRBC web site.

**Implementation:** Dam owners, DRBC, U.S. Army Corps of Engineers, NOAA, USGS

**Funding Mechanism:** Existing budgets of each implementing agency, possible FEMA grants for outreach, model development has been funded

**Estimated Cost:** Staff time

**Implementation Time Frame**: Starting immediately and on-going

**Recommendation R-6: Evaluate Availability and Accuracy of Data**

**Finding:** Recommendations R-1 thru R-5 depend on accurate hydrologic data. There is a need to determine the adequacy of data collection, both in the reservoir watersheds and downstream, for the purpose of developing and implementing plans to reduce reservoir discharge during flooding. Real time data for observed rainfall, streamflow, snowpack, antecedent soil moisture, and air temperature conditions provide information needed for runoff forecasting by the National Weather Service as well as information needed to make adjustments in operations. Accordingly, there is a need to coordinate the assessment of data collection for flood related reservoir operations with the assessments required for improvement of the basin-wide flood warning network. Because of the dependency of reservoir operations on rainfall/runoff forecasts, data required for the calibration and verification of the National Weather Service runoff forecasting models should also be considered in the assessment of data collection needs.

In addition to data collection, there is a need to maintain, update, and share data so it is available to users. The online data services provided by the National Weather Service and U.S. Geological Survey are highly developed for these purposes and could potentially be expanded to include additional data as monitoring is added to the collection network for the Delaware River Basin.

Developing discharge mitigation programs using storage other than flood control storage will involve assessing tradeoffs between the benefits provided by flood control voids and the costs accrued to the other reservoir purposes, including hydroelectric power, water supply, and recreational uses. Such assessments will, by necessity, need to move beyond the simple modeled analyses of stage (crest) reductions achievable through revised operations of the reservoirs, to evaluations of (i) potential reduction in flood damage (in dollar terms), and (ii) the impacts (both environmental and economic) on fisheries and other in-stream uses, water supply, reduction in power generation, and other reservoir uses. This will require the development of up-to-date stage-damage curves, to assess the former, and other up-to-date analytical tools, to assess the latter. These updated flood stage-damage curves and such other tools will need to be available, or developed, to fully assess various discharge mitigation plan options.

**Recommendation:** Evaluate the availability and adequacy of data necessary to implement recommendations R-1 thru R-5. Data collection should also be evaluated to ensure the most efficient means of data storage, updating, and sharing. Coordinate with the National Weather Service and U.S. Geological Survey in determining new data collection needs. Implementation of this recommendation should be coordinated with actions recommended in the Flood Warning portion of this Task Force Report.

**Implementation:** National Weather Service, U.S. Geological Survey, reservoir owners, DRBC

**Funding Mechanism:** Potential NOAA flood warning grants, Staff resources of National Weather Service, USGS, State DEP's, DRBC, reservoir owners

**Estimated Cost:** Staff resources required for evaluations, Costs for any new or upgraded streamflow, precipitation, or snowpack monitoring.

**Implementation Time Frame**: Could begin in 2007 in coordination with implementation of some flood warning recommendations.

## B. Structural and Non-Structural Measures

S-1: Fund a Comprehensive Flood Mitigation Study of the Entire Delaware River Basin

S-2: Prioritize the Completion of State and Local Hazard Mitigation Plans

S-3: Ensure Financial Assistance for State, County and Municipal Mitigation Projects

S-4: Provide Training for Local Officials to Maximize Use of Available Mitigation Funding

S-5: Create Partnering Programs for Floodplain Acquisition

S-6: Establish Funding Priority Areas for Acquisition, Elevation, and Floodproofing

S-7: Maintenance of Flood Control Structures, excluding dams

S-8: Dam Safety Programs

S-9: Evaluate and Coordinate Flood Mitigation Plans and Strategies

**Recommendation S-1**: **Fund a Comprehensive Flood Mitigation Study of the Entire Delaware River Basin**

**Finding**: A comprehensive flood mitigation study of the Delaware River Basin has not been performed since the 1984 Delaware River Basin Report by the US Army Corp of Engineers. This report was authorized by Congress at the request of the Delaware River Basin Commission in response to the Tocks Island Dam deferment. Tocks Island was de-authorized by Congress in 1992. The study examined flood damage reduction alternatives for the section of the Delaware River from Burlington, NJ to Stroudsburg PA, the area that would have received flood protection from the Tocks Island Project. All practicable localized structural and non-structural flood damage reduction alternatives were investigated. This was the last comprehensive flood control study done on the main stem Delaware River.

Currently, there is a $3.9 million comprehensive effort underway to look at tidal and non-tidal flooding along the Delaware River in New Jersey. This effort is being sponsored by NJDEP.

Also ongoing is a federally funded $1 million effort by the Philadelphia District of the U.S. Army Corps of Engineers to study potential enhancements to the use and management of water resources in the Delaware River Basin. A subset of the objectives of this study relate to flood mitigation. They include an evaluation and update of storm frequency curves along the main stem Delaware, an assessment of national flood insurance claims data to identify areas of concentrated claims and structural inventories to be used in determining detailed flood vulnerability assessments.

**Recommendation:** The Governors of Delaware, New Jersey, New York, and Pennsylvania, as well as the respective state legislative delegation and congressional delegation should financially support a comprehensive basin-wide flood mitigation study to be performed by the U.S. Army Corps of Engineers. The study should include tidal and non-tidal reaches of the Delaware River and its tributaries. Structural and non-structural options for flood mitigation should be considered.

**Implementation**: U.S. Army Corps of Engineers, DRBC, Basin States

**Funding Mechanism:** Federal 50%, Non-Federal Sponsor 50%. The four Basin States should act in concert, led by DRBC, to jointly fund this study and act as the Non-Federal Sponsor.

**Estimated Cost:** $10 to $20 million

**Implementation Time Frame**: Feasibility Study duration is 3 to 5 years after receipt of initial Federal and Non-Federal funds.

**Recommendation S-2**: **Prioritize the Completion of State and Local Hazard Mitigation Plans**

**Finding**: The Disaster Mitigation Act of 2000 (DMA 2000) amends the Stafford Act and is the legislation designed to improve planning for, response to, and recovery from disasters by requiring state and local entities to have all hazard mitigation plans in place. The Federal Emergency Management Agency (FEMA) has issued guidelines for all hazard mitigation plans under DMA 2000 regulation. FEMA Mitigation programs require States and local governments to have approved all hazard mitigation plans to be eligible for all FEMA disaster mitigation funding. In order for a municipality to be eligible for cost-shared federal funds aimed at flood mitigation, either an approved flood and/or all hazards mitigation plan must be prepared.

All four basin states (Delaware, New Jersey, New York and Pennsylvania) have approved State Mitigation Plans. Pennsylvania has an approved Enhanced State Mitigation Plan. A State with a FEMA approved Enhanced State Mitigation Plan at the time of a disaster declaration is eligible to receive increased funds under the Hazard Mitigation Grant Program funding. The Enhanced State Mitigation Plan must demonstrate that a State has developed a comprehensive mitigation program, that the State effectively uses available mitigation funding, and that it is capable of managing the increased funding.

**Recommendation S-2.1:** Each municipality should create and maintain an approved all hazards mitigation plan. States should prioritize assistance to municipalities for the creation and maintenance of local Hazard Mitigation Plans to allow for access to FEMA mitigation project funding.

**Recommendation S-2.2:** Each Basin State should strive to obtain an Enhanced State Hazard Mitigation Plan status. In addition, each State should establish a process to address and prioritize NFIP repetitive and severe repetitive flood loss properties in their jurisdiction. Proper record keeping of all flood mitigation projects is necessary. The State Mitigation Units must receive adequate funding and personnel levels in order to carry out these tasks.

**Implementation:** State DEP's, State EMO's, DRBC, county and municipal governments

**Recommendation S-3**: **Ensure Financial Assistance for State, County and Municipal Flood Mitigation Projects**

**Finding**: The cost of mitigation projects identified in their respective hazard mitigation plans is often cost prohibitive for municipalities to fund individually. Some states already provide financial assistance for the non-federal share. Greater and continued federal and state financial assistance through grants and loans is needed to help ensure that the local projects can be implemented before the next flood occurs.

**Recommendation S-3.1:** To support the flood mitigation activities of federal agencies so that each agency's programs, knowledge and expertise are used to maximize public benefits, the basin states should provide funding of the non-federal share of State, county and/or municipal sponsored flood damage reduction projects in an equitable manner to projects assisted by all Federal agencies including but not limited to the Army Corps of Engineers, the Natural Resource Conservation Service, and Federal Emergency Management Agency.

**Recommendation S-3.2:** Beyond assisting with the non-federal share of project grants, each basin state should consider the creation of an on-going State funded hazard mitigation funding program. The intent of the State led program is to expand the "pot" of available mitigation funding so that more projects can be supported.

**Implementation:** State DEP's, State EMO's, DRBC, county and municipal governments

**Recommendation S-4**: **Provide Training for Local Officials to Maximize Use of Available Mitigation Funding**

**Finding**: Municipalities are not taking full advantage of the federal programs for acquisition and demolition of structures.

**Recommendation:** Through training and educational programs, encourage municipalities to make maximum use of federal and state funding for the acquisition of flood prone structures, demolition of these structures and conversion of the lands to naturally vegetative open space in perpetuity. There is a need for extensive training in various areas, such as responsibilities under the National Flood Insurance Program, developing Hazard Mitigation Plans and the application for flood mitigation grants. In addition, each County and Municipal Office of Emergency Management should consider assigning a "Mitigation Officer" to be the lead person to deal with all mitigation planning and implementation.

**Implementation:** DRBC, State DEP's, State EMO's, county and municipal governments

**Recommendation S-5**: **Create Partnering Programs for Floodplain Acquisition**

**Finding**: Through various open space and farmland preservation funding programs, a priority should be given to applications that are within floodplain areas. Often the land areas acquired under these programs will have restrictions that may limit their use for future flood mitigation projects that could potentially be identified in future flood mitigation plans.

**Recommendation S-5.1:** Through various open space and farmland preservation funding programs, a priority should be given to applications that are within floodplain areas. Programs such as Growing Greener in Pennsylvania and Green Acres/Blue Acres in New Jersey are important for providing required local matching funds in combination with federal FEMA funding.

**Recommendation S-5.2:** Encourage Basin States and the Federal government to provide funding for acquisition of developed and undeveloped property in the floodplain for purposes of floodplain protection and restoration and to partner with flood mitigation programs to address multiple purposes when appropriate.

**Implementation:** Federal Agencies, State Agencies, FEMA, DRBC, State DEP's, State EMO's, NYCDEP, PA DCNR, county and municipal governments

**Recommendation S-6**: **Establish Funding Priority Areas for Acquisition, Elevation, and Floodproofing**

**Finding**: As recently articulated by the Congressional Task Force on Natural and Beneficial Functions of the Floodplain, June 2002, floodplains "reduce flooding and limit flood-related damages through their floodwater conveyance and storage functions." As a result, protecting and restoring floodplain functions "will reduce flood losses" in addition to providing groundwater recharge, filtering sediment and contaminants, transporting nutrients, supporting habitats for a variety of sensitive living resources, providing open space that may be able to be used for multi-objective management (passive recreation, active recreation, buffers) and enhancing communities' quality of life.

Communities subject to increasing flood damages include both historic communities as well as recent development. Historic communities which have been colonized for centuries, such as Frenchtown, Lambertville, New Hope, Trenton, Yardley and others, play an important role in the history of our region and nation. New development has contributed to increasing flood damages by both placing new homes in harm's way and increasing flood flows and peaks for pre-existing communities. Floodplains will continue to flood.

**Recommendation S-6.1:** As recommended by the congressional task force, DRBC and states should focus available funds on implementation of natural, nonstructural solutions to reduce flood damages where practicable. Efforts should include prioritization of areas for acquisition, elevation and floodproofing of structure and/or basement utilities with emphasis in historic communities being placed on flood proofing and elevation and emphasis being placed on acquisition in all other communities.

**Recommendation S-6.2:** DRBC and the basin states should create a program that identifies and prioritizes individual projects within the watershed for flood-proofing, elevation or acquisition. The intent of this program would be to endorse and support prioritized projects by assisting with their funding applications so that more projects can receive cost-shared mitigation funding.

**Recommendation S-6.3:** The states, counties and local governments should make a concerted effort to purchase or otherwise preserve existing open space lands that are in the floodplain within the Delaware River Basin. Where necessary, these areas should be revegetated with native trees, shrubs and under story plants.

**Implementation:** DRBC, State agencies, county and municipal governments

**Challenges:** In Pennsylvania, legislation is needed to give DEP the authority to implement non-structural approaches.

**Recommendation S-7**: **Maintenance of Flood Control Structures, excluding dams**

**Finding**: Orphaned or abandoned, unmaintained flood control structures exist throughout the basin. Continued neglect of these structures could lead to catastrophic failure.

**Recommendation S-7.1**: Ensure adequate funding and mechanism to maintain existing flood control structures where it is demonstrated that their continuing operation provides an effective flood control measure. In evaluating flood control structures, ensure that long-term operation and maintenance costs are identified and included in all benefit/cost ratios so that the long-term functioning of the structures is not compromised.

**Recommendation S-7.2:** The basin states should provide adequate inspection and training of local officials, and when necessary enforcement, to ensure the integrity and maintenance of all basin flood control structures.

**Recommendation S-7.3:** All States have dam safety and inspection programs; however, no similar program exists for levees. An inventory to identify the nature, extent and impact of existing levees should be carried out in conjunction with Federal, State and local authorities.

**Recommendation S-7.4:** Legislation is needed to disband the "meadow companies" in southern New Jersey and find a responsible party to operate and maintain these levees.

**Recommendation S-7.5:** Owners of orphaned or abandoned, unmaintained flood control structures need to be determined and, when necessary, a mechanism must be established to transfer ownership to a new sponsor to assume maintenance responsibilities.

**Implementation:** State DEP's, State EMO's, county and municipal governments, DRBC

**Recommendation S-8: Dam Safety Programs**

**Finding:** Dam failures, either during dry weather or during flood events, have the potential to create catastrophic flooding in the Delaware River Basin. The basin states all have existing dam safety programs designed to require regular inspections of high hazard dams, as well as requiring dam owners to develop dam failure inundation maps and emergency action plans. Less than optimal inspection schedules, reporting and follow-ups, or inadequate response to inspection findings, have the potential to increase the threat of dam failures. In the extreme, the identification of conditions that threaten dam safety could lead to emergency drawdown of a reservoir to reduce such threats, as was recently the case at the Swinging Bridge dam on the Mongaup River.

**Recommendation S-8.1:** All owners of high hazard dams in the Basin should commit resources towards an appropriate inspection and maintenance program for their dams, including development of emergency action plans.

**Recommendation S-8.2:** Each basin state should have sufficient funding and resources for a strong dam safety inspection program, and to require repair of any inadequacies.

**Recommendation S-8.3:** Each basin state should support federal and/or state legislation providing funding for support of the National Dam Safety Program, state dam safety programs, and to assist with the cost of needed dam repairs and rehabilitation.

**Implementation:** dam owners, State dam safety agencies, FERC, State and Federal legislatures

**Recommendation S-9**: **Evaluate and Coordinate Flood Mitigation Plans and Strategies**

**Finding**: The Governors have pointed out that "The Delaware River Basin Commission is the obvious vehicle for developing flood loss reduction and flood mitigation plans that cannot be accomplished by any single state or local government but that requires a holistic watershed approach."

**Recommendation S-9.1:** With regard to flood mitigation and planning, the DRBC should evaluate, develop and implement policies based on recommendations of specialized focus groups including but not limited to:

- The Task Force On The Natural And Beneficial Functions Of The Floodplain, "The Natural & Beneficial Functions Of Floodplains, Reducing Flood Losses By Protecting And Restoring The Floodplain Environment, A Report For Congress", June 2002 (FEMA 409);
- The Association of Floodplain Managers (ASFPM), "National Flood Programs in Review 2000", http://www.floods.org/policy/natlpolicy.asp
- The Association of Floodplain Managers (ASFPM), No Adverse Impact (NAI) Floodplain Management, http://www.floods.org/NoAdverseImpact/whitepaper.asp,
- The Multihazard Mitigation Council, NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities.

**Recommendation S-9.2:** The DRBC should conduct a comprehensive evaluation of flood loss and flood mitigation strategies that are currently being employed in the basin by all agencies at all levels of government to determine where enhancements to existing programs are necessary and where new ones should be created. The evaluation can examine the following: floodplain management and land use guidance and local enforcement, flood incident response for damage assessment, critical data collection, and technical assistance to local governments, flood insurance programs, and all-hazards mitigation planning efforts.

**Recommendation S-9.3**: The DRBC should create a model Flood Hazard Mitigation Plan for use by counties and municipalities in the Basin.

**Implementation:** DRBC

## C. Stormwater

SM-1: Develop Regional and Tributary-Based Watershed Stormwater Management Plans

SM-2: Long-term Management of Stormwater BMPs and Infrastructure

SM-3: Non-Structural Stormwater Management for New and Redevelopment

SM-4: Enforcement of Existing Stormwater Standards and Regulations

SM-5: Provide and Promote Incentives to Reduce Stormwater Runoff from Existing Development

SM-6: Develop and Maintain Precipitation and Streamflow Data

SM-7: Create Stream Restoration and Debris Removal Guidelines

SM-8: Stormwater Management through Special Protection Waters Designation

**Recommendation SM-1**: **Develop and Implement Regional and Tributary-Based Stormwater Management Plans**

**Finding:** The purpose of stormwater management plans is to develop an understanding of existing stormwater issues, coordinate stormwater facility maintenance among those responsible for it, identify engineering standards to mitigate impacts from development and re-development and comprehensively plan for the future infrastructure. The States have provisions for the development of regional and tributary-based stormwater management plans. Yet, few regional or tributary-based stormwater management plans have been completed in the Basin due, in part, to inadequate state and local funding resources. Existing plans, developed before the implementation of the EPA Phase II stormwater rules[10], also need to be updated. Plans often include hydrologic and hydraulic modeling to identify problem areas, including those that flood, require maintenance, and need corrective action and retrofits. Once the stormwater system has been characterized through modeling and the planning process, actions that reduce flooding can be prioritized for implementation.

**Recommendation SM-1.1:** States should mandate and fund the development and adoption of regional and tributary-based watershed stormwater management plans in areas where appropriate. States and DRBC should prioritize the tributaries and main stem river areas that faired the worst during the past three floods for plan development. States should mandate an emphasis on volume reduction strategies, backflow prevention and use of stormwater best management practices and low impact development practices for new development, redevelopment and existing development to prevent future problems and address problems of the past.

**Recommendation SM-1.2:** Regional and tributary-based watershed stormwater management plans should assess the stormwater system with the most up to date hydrologic data available.[11] Hydraulic and hydrologic models of the tributary watershed should be developed.

**Recommendation SM-1.3:** Regional and tributary-based watershed plan developers should investigate and recommend remedial and retrofit opportunities for existing stormwater problems and local flood control[12] based on hydrologic and hydraulic analyses.

**Recommendation SM-1.4:** DRBC should consider the development of a Delaware River Basin-Based Stormwater Management Plan, which may include the development and implementation of basin-wide stormwater management requirements for new development, redevelopment, and for NPDES or other stormwater permits. The plans should emphasize the use of stormwater runoff prevention, low impact development, stormwater volume reduction and best management practices.

**Implementation:** States, DRBC, Counties, Municipalities, Stormwater Authorities

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[10] The intent of the rules is the protection of water quality but implementation has resulted in reductions in the amount of stormwater generated through the implementation of best management practices.

[11] Such as the National Oceanic and Atmospheric Administration "Precipitation-Frequency Atlas of the United States" Atlas 14, 2004.

[12] One opportunity might be extreme flood event diversion storage to further mitigate existing flooding above and beyond regulatory requirements. Flood flows would only be redirected during infrequent large events. Flows could be redirected to athletic fields, playgrounds, parklands, and other open spaces.

**Funding Mechanism:** State and Federal appropriations; Stormwater Authority user fees

**Estimated Cost:** $15 Million (one time minimum) for plans assuming half of the Basin still unstudied and approximately $200,000 per 100 square mile watershed. Costs uncertain for DRBC basin-wide stormwater management plan.

**Implementation Time Frame:** Immediate (Basin-wide planning within the next 5 years)

**Recommendation SM-2**: **Long-term Management of Stormwater Best Management Practices (BMPs) and Infrastructure**

**Finding:** Local governments are required to manage stormwater under the Federal Clean Water Act's National Pollution Discharge Elimination System (NPDES) permit system. Municipal separate storm sewer systems (MS4s) are required to develop and implement stormwater pollution prevention programs (SWPPP) to reduce the discharge of pollutants from their storm sewer system to the maximum extent practicable. Unfortunately, maintenance of existing stormwater infrastructure (detention ponds, inlets, catch basins, outfalls, conveyance facilities) is often inadequate due to lack of funding and dispersed responsibility (municipalities, counties, states, private land owners, and corporations). Without adequate maintenance, stormwater management facilities may not function properly and may contribute to flooding. Remedial projects such as culvert replacements or local flood control projects are also deferred or ignored due to lack of funding. A consistent and sufficient funding source for long-term maintenance of stormwater management facilities is needed. The responsibility for stormwater infrastructure management (capital planning and improvements, operations, maintenance, remedial actions, retrofits, and replacements) could be delegated to a regional entity (new or existing) to facilitate funding, consistency and accountability.

**Recommendation SM-2.1:** As an option for long-term maintenance of stormwater BMPs and infrastructure, each State should determine if statutory authority exists within its current regulatory framework for an entity (existing or new) to assume the responsibilities associated with the management of stormwater infrastructure (capital planning and improvements, operations, maintenance, remedial actions, retrofits, and replacements) on a regional or watershed basis. Specifically, statutes should allow the authority or entity to provide dedicated funding for planning and plan implementation (see SM-1), operations, maintenance, rehabilitation, and new facilities. State laws must allow the oversight entity all appropriate powers and liabilities necessary to execute the actions required to manage the stormwater system. Additional or new legislation, if needed, should be promulgated to allow and empower stormwater oversight entities. States should work with such entities to develop watershed-based or regional stormwater management plans.

**Recommendation SM-2.2:** States and municipalities should provide a sufficient, dedicated annual funding source to manage and maintain the stormwater conveyance system and associated structures, mitigate known problems, and plan for the future. FEMA should provide funding through the Hazard Mitigation Program to assist municipalities with remedial projects.

**Recommendation SM-2.3:** States should investigate the opportunities for existing entities, such as counties or wastewater utilities, or new entities, such as stormwater authorities, to facilitate and ensure stormwater management, maintenance and planning.

**Implementation:** State legislature, State Environmental Agencies, Counties, Municipalities

**Funding Mechanism:** Staff time (legislation), grants, appropriated funds

**Estimated Cost:** $40 Million for maintenance annually assuming approximately half of the basin's municipalities need funding or funding supplements of $100,000 per year. Remedial needs extensive but costs unknown.

**Implementation Time Frame:** Short-term (propose legislation); Long-term (assumption of responsibility or formation of authorities)

**Recommendation SM-3: Non-structural Stormwater Management for New Development and Redevelopment**

**Finding:** The use of nonstructural stormwater management strategies is widely recognized as beneficial in reducing the generation of stormwater onsite and the impact of stormwater from a site. Non-structural strategies may include, but are not limited to, requirements for the use of better site design, Low Impact Development (LID) and Green Technologies, limitations on impervious surfaces, clustering, changes to zoning densities, infiltration, stormwater reuse, onsite re-vegetation, vegetated buffers and habitat restoration projects. However, few states have mandated criteria requiring the use of non-structural stormwater management measures and developers have expressed uncertainty about their use.

**Recommendation SM-3.1:** States should require low impact development practices, non-structural stormwater management strategies, stormwater volume reduction and water quality enhancement for all new development and redevelopment draining into the Delaware River. Requirements for non-structural practices should be prescriptive such that all possibilities for use are exhausted before consideration of structural measures.[13]

**Recommendation SM-3.2:** States should develop and conduct a technical education program(s) about the use and implementation of non-structural stormwater management practices for land development professionals (regulators, reviewers, planners, architects, engineers, designers, and contractors).

**Recommendation SM-3.3**: States should develop and conduct an education program for the public, elected officials and decision makers to explain the benefits of non-structural approaches to stormwater management and how their use benefits the community and will lessen the impact of new development and redevelopment on existing flooding problems.

**Recommendation SM-3.3**: The DRBC should coordinate and craft a model ordinance that recognizes the existing efforts and approaches of the States.

**Implementation:** States, local and county ordinances, State permits, Stormwater Authority, DRBC

**Funding Mechanism:** Municipalities, Developers application fees; State, State permit fees should include not only the review of the particular application, but also the subsequent inspections by State staff.

**Implementation Time Frame:** Immediate

[13] As an example, see New Jersey's non-structural point system program at http://www.njstormwater.org/pdf/nsps_userguide2006013.pdf

**Recommendation SM-4: Enforcement of Existing Stormwater Standards and Regulations**

**Finding:** Each State has different engineering standards for stormwater management and soil and erosion control, which are applied through municipal ordinances. Municipalities may waive standards, require mitigation or accept cash in lieu of facilities as part of the give and take development approval process. Municipal enforcement of approved development plans is also inconsistent regarding construction inspection, correction of violations and requirements for as-built plans and earth disturbance thresholds. Stormwater flows to tributaries within watersheds, not political boundaries; therefore, one municipality's implementation of stormwater management requirements affects all other municipalities located downstream.

**Recommendation SM-4.1:** States should ensure compliance with existing state stormwater management laws and regulations at the municipal level. The preference would be to have unified stormwater management standards among all municipalities within the Delaware River Basin, but until such standards can be developed[14], more consistent implementation of existing regulations is needed.

**Recommendation SM-4.2:** To ensure long-term functionality of stormwater infrastructure, municipal separate storm sewer systems (MS4s) are required by permit to implement an inspection and maintenance program. Municipalities should ensure that stormwater infrastructure (both the conveyance system and contributing BMPs) undergo detailed inspections and that adequate maintenance is performed regularly for the protection of public safety.

**Implementation:** States, Municipalities; Delegated Entities (counties, conservation districts)

**Funding Mechanism:** Staff time; Review and inspection costs paid by developers applying for approvals.

**Implementation Time Frame:** Immediate

[14] Unification of stormwater management standards can be implemented through regional and tributary-based watershed planning (see SM-1).

**Recommendation SM-5: Provide and Promote Incentives to Reduce Stormwater Runoff from Existing Development**

**Finding:** Many regulations are in place to regulate the stormwater from new development and redevelopment. Such regulations will only lessen the impacts on flooding from new development and redevelopment through requirements of best management practices (BMPs). However, few regulations have the authority to mandate additional management of stormwater generated from existing development, which may be the most significant contributor to flooding. Retrofits to existing stormwater management systems and structures and land use management BMPs are rarely installed due to cost and/or availability of land. Land management practices include vegetated buffers[15] along streams, re-vegetation of large lawn areas[16], installation of porous pavement and redesigning detention basins to be infiltration basins, among others. These BMPs and retrofits may reduce flooding caused by stormwater runoff from existing developments, particularly more frequent, localized flooding.

Incentives are available to agricultural landowners through various programs for actions that will improve water quality, not quantity. Enrollment is limited to farms participating in specific programs with rigorous requirements. For incentives on existing development NYC DEP[17]with the Catskill Watershed Corporation has developed a stormwater retrofit program, which provides a 75% cost-share for the retrofitting of existing sites to treat stormwater runoff in the Catskill and Delaware (West of Hudson) watersheds. Over 35 projects have been completed for $3.9 million dollars, including a seeding program; installation of stormwater collection, conveyance and treatment structures in residential areas; and purchase of a truck-mounted "vac-all" for the maintenance of stormwater structures. However, in other areas of the Delaware River Basin, few incentives, if any, are available for retrofitting residential and commercial development with enhanced BMPs. Incentives and mechanisms are needed to provide for retrofit and remediation of poorly functioning stormwater management systems.

**Recommendation SM-5.1:** States should investigate and implement opportunities for reduction, control, infiltration and reuse of stormwater in existing development, including retrofits of onsite stormwater facilities and best management practices for existing developed sites. Such opportunities may include the preservation and/or installation of vegetated buffers along streams, replacement of large lawn areas with native grassland vegetation, vegetated rooftops, retrofitting detention basins for infiltration, re-routing parking lot and roof runoff from impervious areas and storm drains to pervious areas, and replacing older BMPs with more advanced technology.

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[15] Vegetative buffers absorb and hold stormwater, gradually releasing the water back to the stream over a longer period of time (than less vegetated areas), which helps regulate the flow and reduce downstream flooding during a storm.

[16] Large lawn areas, compacted during construction, essentially act as large impervious surfaces, doing little to infiltrate water or slow runoff velocity. Lawn areas can be replaced with low maintenance native warm season grasses, wildflowers, trees, and shrubs. The additional vegetation intercepts overland flow and may reduce the velocity with which stormwater enters the stormwater drainage system or stream channel.

[17] Refer to the following websites for details http://www.nyc.gov/html/dep/watershed/html/stormretro.html# and http://www.cwconline.org/programs/strm_wtr/strm_wtr.html. The New York City Watershed Memorandum of Agreement with New York State, EPA, and other groups mandated the program.

**Recommendation SM-5.2:** States should secure funding for incentive-based programs, similar to NYC DEP Stormwater Retrofit Programs and other agricultural incentive programs for retrofits of poorly functioning stormwater management systems and changes in land use practices.

**Implementation:** Federal, State, Local, Stormwater Authority

**Funding Mechanism:** State and Federal Grants, Low interest loans

**Implementation Time Frame:** Immediate

**Recommendation SM-6: Develop and Maintain Precipitation and Streamflow Data**

**Finding:** Accurate understanding of stormwater management (and flooding) issues is possible only with accurate precipitation and streamflow data throughout a watershed. Hydrologic relationships and standards are based on statistical analysis of recorded data to determine probabilities of occurrence. One-time or infrequent recording of data provides less than optimum statistical analyses. Further, stormwater management and flooding are based on relatively infrequent events typically thought of as 2-year, 10-year, 100-year or even higher return periods. Often misunderstood, these terms **do not** mean the intervals between like events. For example, two events (precipitation or flooding) that hydrologists consider statistically as 100-year events could occur in consecutive years or even multiple times in a single year. The facts are that our ability to classify extreme events is hampered by lack of long-term recording of precipitation and runoff data. Long-term, for these purposes, is data of a minimum of 100 years. With shorter periods of record, the hydrologic relationships shift with new events (such as three severe events on the Delaware River in three years serving to re-define a 100-year flood). Accurate definition of extreme events is critical for creating hydrologic analyses to support stormwater management planning and for accurate floodplain delineations and evaluation/design of flood control measures.

**Recommendation SM-6.1:** DRBC, USGS, NWS/NOAA and the States should maintain continuous precipitation, streamflow and tide gages throughout the Delaware River Basin to provide data needed to establish current statistical probabilities of severe events.

**Recommendation SM-6.2:** NOAA, NWS and USGS should provide bi-annual updates, plus non-routine updates after significant events, of the statistical precipitation and runoff evaluations at all gages to provide current estimates of design return period events for use in watershed modeling and planning studies.

**Implementation:** DRBC, USGS, NWS/NOAA, States

**Funding Mechanism:** Federal government with possible state and local cost-share.

**Estimated Costs:**
Continuous streamflow gage: $30,000 installation with $14,000 for Operation and Maintenance (O&M), per gage, annually
Precipitation gage: $1,600; O&M; $4,000 (new and more expensive equipment is expected to be the standard soon) per gage, annually.
Tidal gage: $8,500; O&M: $14,000 per gage, annually.

**Implementation Time Frame:** Immediate and on-going

**Recommendation SM-7: Create Stream Restoration and Debris Removal Guidelines**

**Finding:** Protecting healthy stream channels and maintaining functioning conveyance systems for the efficient movement of stormwater is an essential component of flood management. Obstructed drainage systems, culverts, bridge openings and stream channels may create backwater conditions and cause localized flooding. However, some types of natural woody debris in the stream channel provide flood reduction benefits, reduction of streamflow velocities, erosion protection, as well as food and habitat for aquatic life. Debris removal and/or conveyance maintenance may become necessary as the result of individual or accumulated flood events or be required in advance of storm events to minimize flooding. Communities have expressed concern, confusion and frustration about the permitting process and fees for this work. After the most recent major flooding events, some municipalities performing emergency repairs imparted significant ecological damage to the stream with the use of heavy equipment and uninformed practices. Debris removal or conveyance maintenance must consider and preserve the hydrologic, hydraulic and ecological function of the stream.

**Recommendation SM-7.1:** States should examine the current practices of debris removal and/or conveyance maintenance and the associated permitting processes. States need to develop guidelines, best management practices (BMPs) and categories of actions (general maintenance, pre-flood, emergency, and post-flood) and define which are allowed under each type of permitting program (emergency, by-rule, general, individual, other) and activities that are considered de minimis activities for which no permit is needed. States also should examine how each permit program (including fees) affects the timing and execution of the work. Office of Emergency Management (OEM) officials, public works officials, watershed groups and engineers with knowledge in hydrology, geomorphology, and natural channel design and other appropriate experts should be included in the development of the guidelines and evaluation of the permitting programs. States should develop educational programs to explain what actions are considered appropriate under different permit programs and BMPs.

**Recommendation SM-7.2:** States should develop a professional certification program in natural stream channel restoration and BMPs for public works officials, contractors, engineers and others and consider requiring oversight by a certified professional for all types of work within the stream.

**Recommendation SM-7.3:** States should require restoration of areas damaged by debris removal and conveyance maintenance, including access pathways.

**Implementation:** State environmental and natural resource agencies, DRBC, US Fish and Wildlife Service, National Park Service, Delaware Riverkeeper Network, NYCDEP, watershed groups, local OEM and public works officials

**Funding Mechanism:** Staff time; EPA grants for educational component

**Implementation Time Frame:** Immediate

**Recommendation SM-8: Stormwater Management through Special Protection Waters Designation**

**Finding:** The DRBC has designated the Lower Delaware River as interim Special Protection Waters. The Special Protection Waters designation protects the water quality of the Lower Delaware River and requires new and expanding facilities to create and implement nonpoint source pollution control plans, which must provide a reduction in polluted stormwater runoff through its implementation. Both water quality and water quantity benefits can be realized by stressing the use of best management practices (BMPs) that minimize the onsite generation of stormwater and infiltration strategies to reduce the runoff volume and peak rate.

**Recommendation SM-8.1:** DRBC should grant permanent Special Protection Waters designation to the Lower Delaware River.

**Recommendation SM-8.2:** When approving nonpoint source pollution control plans, DRBC should require the use of BMPs that minimize the generation of runoff, reduce runoff velocities, infiltrate stormwater and protect and restore water quality.

**Recommendation SM-8.3:** DRBC should develop a Special Protection Water guidance manual.

**Implementation:** DRBC, Delaware Riverkeeper Network

**Funding Mechanism:** Staff time; application fees

**Implementation Time Frame:** Immediate

## D. Floodplain Mapping

FM-1: Coordinated Flood Study and Mapping Updates

FM-2: Incorporate Existing and Future Planned Development and Residual Risk Zones into New Mapping

FM-3: Redefine and Remap the Floodway along the Delaware River Main stem and its Tributaries

**Recommendation FM-1: Coordinated Flood Study and Mapping Updates**

**Finding:** Existing floodplain maps along the Delaware River are based on pre-1985 studies that may underestimate the current 100-year flood elevation, the floodways, and flood hazard areas. Along common stretches of river, current maps for New Jersey and New York are not consistent with those of Pennsylvania. New development could be proposed in flood prone areas that are not identified as floodplain on existing maps.

The NJDEP, PADCED and NYSDEC are currently working together with FEMA to complete a five-year digital map modernization program, based on countywide studies rather than municipal studies. The countywide studies insure more consistent information between municipalities and provide a digital environment that allows for easier revisions and updates.

In New Jersey, the NJDEP has set aside $1,000,000 to begin the preparation of new floodplain delineations and associated mapping for the main stem of the Delaware River along Mercer, Hunterdon, Warren and Sussex Counties. On May 16, 2006, the NJDEP executed a Cooperative Technical Partnership (CTP) agreement with FEMA in order to leverage state funding with the current federal Flood Map Modernization Program resources.

The NJDEP is also coordinating with USGS, USACE and FEMA on the development of updated hydrologic information for the Delaware River, which will be incorporated into the hydraulic modeling for the new mapping. Also, it is expected that current Light Detection and Ranging (LiDAR) information for Mercer, Hunterdon and Warren Counties will be used for this effort. This state of the art new mapping will be a valuable resource during times of emergency and for the regulation of land use along the floodplain area. The goal of this mapping effort is to more accurately define the limits of the flood hazard area and associated base flood elevation.

In New York, the NYSDEC in cooperation with FEMA and NYCDEP will soon begin county-wide DFIRM mapping, with full LiDAR, in the three New York counties that contain parts of the Delaware Basin: Delaware, Sullivan and Ulster Counties. A small portion of Broome County is also in the Delaware Basin, and that is scheduled for DFIRM mapping in 2007. Orange County is currently being remapped by FEMA as part of the Map Modernization plan. NYCDEP has committed itself to pay the full amount for detailed floodplain mapping within its West of Hudson watersheds, including headwater reaches and tributaries to the Pepacton, Cannonsville and Neversink Reservoirs.

FEMA is attempting to get final approval to develop Flood Advisory Maps for portions of the Delaware Basin in NY that experienced greater than 100-year anticipated flood flows in June 2006. FEMA has already completed Flood Advisory Maps for portions of the Neversink River and East Branch Delaware River as a result of the April 2005 floods. The Flood Advisory Map data will be incorporated into countywide DFIRMS.

In Pennsylvania, the Delaware Valley Regional Planning Commission (DVRPC) is currently preparing LiDAR data for various counties in PA that will be used by FEMA. The database revisions of the official FEMA Flood Insurance Rate Maps (FIRMs), which will primarily benefit Philadelphia and its surrounding counties, will more effectively display possible flood affected areas. DCNR is also gathering LiDAR data throughout parts of Pennsylvania

affected by Hurricane Ivan in 2004. FEMA contractors have identified and surveyed high water marks from the June 2006 flood throughout the Basin this past summer. FEMA will use this data to evaluate the accuracy of the current 100 year flood levels, and the actual updates of the various flood frequencies should it be necessary. FEMA and DCED are partnering with USGS to update flood-frequency data at streamgaging stations and peak-flow regression equations used in Pennsylvania. The results will be displayed on the internet using USGS StreamStats web application.

**Recommendation:** The NJDEP, PADEP, PADCED and NYSDEC in coordination with federal entities (e.g. FEMA, USGS, USACE), should develop new floodplain delineations and associated mapping for the main stem and significant tributaries of the Delaware River. The new study should include updated hydrology (i.e. updated flood frequencies), verification of stage discharge curves, LiDAR elevation data or topography within two-foot accuracy with finer resolution when required, state of the art hydraulic modeling and new delineations. Before initiating the study there should be concurrence on the methodology among DRBC, FEMA, NJDEP, NWS, PADEP, PADCED and NYSDEC.

The new delineations should be used to produce inundation maps for emergency management, be tied into NWS forecast locations where inundation forecasts are necessary and serve as basic input to FEMA's map modernization initiative. Taken together, the floodplain maps (verified by field inspection), inundation maps and modernized FIRM (flood insurance rate) maps should yield the most credible state of the art floodplain delineations that will support flood mitigation before, during and after flood events.

**Implementation:** NJDEP, PADEP, PADCED, NYSDEC, FEMA, USGS, NWS

**Funding Mechanism:** FEMA Map Modernization funds; NYC DEP funding for areas in the NYC water supply watersheds; NYSDEC; NJDEP, PADEP, PADCED, et al.

**Estimated Cost:** To Be Determined (NYS portion estimated at $10 million)

**Implementation Time Frame:** As soon as possible or could be coordinated with FEMA’s Map Modernization Program schedule.

**Challenges:** The assortment of mapping projects must be coordinated so that there is a consistent methodology and results.

FEMA Map Modernization funds are not sufficient. States must contribute funding and Congress must ensure that FEMA Map Modernization program continues to be fully funded.

**Recommendation FM-2: Incorporate Existing and Future Planned Development and Residual Risk Zones into New Mapping**

**Finding:** Future development is not typically taken into consideration during the development of floodplain maps to identify flood-prone areas. As future development occurs, runoff from that development may increase flows in flood-prone areas downstream. In NJ, for State land use regulatory permits required by the NJDEP, the NJ Flood Hazard Area Maps are defined by the 100-year event peak flow rate plus 25%. This 25% safety factor is incorporated to take into account future build-out. DE, PA, NY, and local communities within NJ currently use the 100-year event without any considerations for future build-out.

It is also important to consider that although an area may be located outside of the 100-year or the 100-year plus 25% floodplain, it does not completely rule out the possibility that the area may be susceptible to potential flooding impacts. For example, an area could be flooded by a larger event like the 500-year frequency event. In addition, an uncontrolled release of water during either a non-storm or storm event, like the catastrophic failure of an upstream dam or the breach of a levee, could result in significant flooding impacts beyond anticipated 100-year floods

**Recommendation FM-2.1:** Current and future planned development should be taken into consideration when preparing new floodplain maps for the main stem of the Delaware River and other streams and rivers within the Delaware Basin. Floodplain maps should include a residual risk factor of at least 25% to consider current and future planned development, to recognize possible variability's in hydrologic modeling, to consider temporary blockages to culverts and other hydraulic impediments that may exist from time to time, and to more accurately define flood risk. Updated flood-frequency data are needed in order to add the appropriate 25% to the appropriate base level of the 100-year flood flow.

**Recommendation FM-2.2:** Residual risk zones, including the 500-year floodplain and areas subject to levee or dam failures, should also be taken into consideration when preparing new floodplain maps for the main stem of the Delaware River and other streams and rivers within the Delaware Basin.

**Implementation:** NJDEP, PADEP, PADCED, PA Consortium, NYSDEC, FEMA

**Funding Mechanism:** Partial funding through FEMA Map Modernization

**Estimated Cost:** To Be Determined

**Implementation Time Frame:** As soon as possible or could be coordinated with FEMA's Map Modernization Program schedule.

**Challenges:** This would require an adjustment in floodplain map scoping for projects that are already funded and ongoing. Also, this cannot be implemented unless the local communities request it OR unless State law is changed to require it.

The vehicle that could be used to promote the benefits of this initiative to local communities is the Community Rating Systems (CRS). Under the CRS program, there is an incentive for communities to do more than just regulate construction to minimum National Flood Insurance Program (NFIP) standards. Residents of communities that adopt higher regulatory standards would be eligible to receive a reduction in their flood insurance premiums.

Homeland Security protocols and guidelines regarding the distribution of sensitive materials like dam and levee failure inundation maps need to be considered.

FEMA Map Modernization funds are not sufficient. States must contribute funding and Congress must ensure that the FEMA Map Modernization program continues to be fully funded.

**Recommendation FM-3: Redefine and Remap the Floodway along the Delaware River Main stem and its Tributaries**

**Finding:** The existing flood hazard area maps greatly underestimate the limit of the floodway along the main stem Delaware River and other waterways within the Delaware River Basin. The flood hazard area, or floodplain, is the area along a waterway that is expected to be or has been inundated by floodwaters. The floodway, which is the inner portion of the flood hazard area nearest the stream or river, is the most dangerous area that carries deeper flows and higher velocities during a flood. New construction is generally prohibited in floodways because it is unsafe and obstructs the passage of floodwaters. However, areas immediately adjacent to floodways where development is commonly allowed are often subject to flood depths and velocities similar to those of the floodway.

A regulatory floodway is defined as the channel of a river or other watercourse and portions of the floodplain adjoining the channel that must be reserved in order to carry and discharge the base (or 100-year) flood without cumulatively increasing the water surface elevation more than a designated height. The minimum FEMA floodway determination allows for a 1.0-ft rise. The current New Jersey State floodway standard, allows for a more conservative 0.2-ft. rise in flood depths. This more stringent, lower rise determination results in a larger regulatory floodway. Even though NJ has adopted this more stringent standard on its in-state waterways, the less stringent FEMA standard was used to delimit the floodway for the main stem of the Delaware River to avoid inconsistencies between different floodway criteria on the New Jersey and Pennsylvania sides of the river. Both Pennsylvania and New York allow a 1.0-ft rise floodway standard throughout the Delaware River Basin.

As a result, designated floodways are extremely narrow along the Delaware and new construction is sometimes improperly permitted in close proximity to streams and rivers simply because they are not currently demarcated as floodways. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations. Greater portions of communities would likely lie within mapped floodways if the 0.2-ft floodway standard were to be used. Adequately defining the floodway and regulating development in these floodways is one way to ensure flood loss reduction.

**Recommendation FM-3.1:** NJDEP, PADEP, PADCED and NYSDEC should evaluate their existing flood hazard maps in order to determine whether a more stringent standard should be used to define floodway boundaries throughout the Delaware River Basin. A comparison should be made between the current mapping protocol, which uses a 0.2-ft rise in flood depths in New Jersey and a 1.0-ft rise in both Pennsylvania and New York to delineate floodways, with floodway boundaries calculated using a 0.1-ft rise, which is more conservative and likely to expand floodway widths. Such a change could help to prevent new construction in close proximity to streams and rivers in many areas.

If the NJDEP, PADEP, PADCED and NYSDEC subsequently determine that re-mapping their floodways is necessary to ensure that the public is adequately protected from the hazards of new construction in areas prone to severe flooding, the States should then adopt a new floodway standard for flood hazard mapping throughout the Delaware Basin and revise the floodway maps accordingly.

Beyond remapping the floodway, communities and states can also choose to have more stringent regulations than the FEMA NFIP minimum standards within the current mapping constraints. One example is New Castle County, Delaware where their floodplain regulations state that no fill or residential construction is allowed in the floodplain. (National minimum regulations only dictate this type of constraint in the floodway.) This example of a more stringent floodplain regulation achieves a similar and even more stringent goal than redefining the current floodway.

**Implementation:** NJDEP, PADEP, PADCED or PA Consortium, NYSDEC, FEMA

**Funding Mechanism:** Partial funding through FEMA Map Modernization

**Estimated Cost:** To Be Determined

**Implementation Time Frame:** As soon as possible or could be coordinated with FEMA's Map Modernization Program schedule.

**Challenges:** The comparison should include main stem as well as upland streams. In upland areas, expansion of the floodway could encompass the entire floodplain. This will present a significant challenge to mountain communities in narrow valleys. Local communities outside of New Jersey would have to adopt the more conservative floodway standard into their local laws. (In NY and PA, local communities would need to request this OR State law would need to be changed to require this.)

The vehicle that could be used to promote the benefits of this initiative to local communities is the CRS. Under the CRS program, there is an incentive for communities to do more than just regulate construction to minimum NFIP standards. Residents of communities that adopt higher regulatory standards would be eligible to receive a reduction in their flood insurance premiums.

FEMA Map Modernization funds are not sufficient. States must contribute funding and Congress must ensure that the FEMA Map Modernization program continues to be fully funded.

## E. Floodplain Regulations

FR-1: Catalog, Evaluate and Update Existing Floodplain Regulations in the Basin

FR-2: Develop a Coordinated Education, Outreach and Training Program

FR-3: Repetitive Loss Reduction Strategy for the Basin

FR-4: Flood Hazard Disclosure Requirements

FR-5: Standardized Riparian Corridors

**Recommendation FR-1: Catalog, Evaluate and Update Existing Floodplain Regulations in the Basin**

**Finding:** There is no consistent set of floodplain regulations basinwide to uniformly manage development within the floodplain areas of the basin. Currently, floodplain regulations vary widely from State to State and often from community to community. As a result, development may be occurring in the floodplain of one State or community that may be adversely affecting other States and communities. Development in the floodplain individually and cumulatively results in adverse impacts somewhere in the watershed. These adverse impacts can include increased flood stages, increased velocities, erosion and sedimentation, water quality degradation and habitat loss. In addition to these negative effects, development in the floodplain disturbs naturally vegetated riparian corridors and often threatens the safety of both residents and emergency personnel in the event of a flood.

For each community to participate in the National Flood Insurance Program (NFIP), it must adopt by ordinance the minimum Federal standards contained in the Flood Damage Prevention Ordinance. NFIP establishes the minimum level of protection from development that should be provided to floodplain areas. Local communities and states are encouraged to provide a greater level of protection than the NFIP minimum provides.

In determining suggested revisions to the floodplain regulations, the No Adverse Impact (NAI) concept for floodplain management should be evaluated and principles and means of implementation that follow the NAI concept should be proposed. The NAI approach was developed by the Association of State Floodplain Managers (ASFPM) and is defined as follows, "No Adverse Impact floodplain management is an approach which ensures that the actions of one property owner or a community do not adversely impact the properties and rights of other property owners." A few major principles of NAI that should be evaluated and considered for the Delaware River Basin include:

1) No Net Rise – New floodplain development must be designed so that it does not increase flood heights

2) Compensatory Storage – Any fill in the floodplain must be compensated by the provision of an equal volume of storage to replace what is lost. This reinforces the No Net Rise provision by preserving the ability of the floodplain to store water.

3) Minimum Flood Corridor – The purpose of the corridor, which applies to all mapped floodplains, is to provide a natural buffer which absorbs stormwater, stabilizes stream banks, filters pollutants, and protects aquatic life. The width of the buffer is established in proportion to the size of the stream channel.

4) Best Available Information – If mapping is available which exceeds FEMA's standards, or includes floodplain delineation for smaller steams not included on FEMA floodplain maps, such mapping is used to apply the floodplain regulations. This allows the use of more accurate and comprehensive mapping where available. One example of such mapping in the Delaware River Basin is the recent mapping completed for the Pennypack watershed in Montgomery County, PA. It should be noted that this detailed restudy required a certain level of resources.

All States and municipalities should be encouraged to adopt floodplain protection regulations and ordinances that surpass the NFIP minimum, embrace the no adverse impact approach of the ASFPM and, to the maximum extent possible, prevent future construction, fill or devegetation of the 100 year floodplain.

The Delaware River Basin Commission adopted Flood Plain Regulations on November 10, 1976. The regulations went into effect on January 1, 1977. The standards of floodplain use contained in these regulations apply to the non-tidal portions of the Delaware River and its tributaries. They were designed as minimum compliance standards to be followed by local units of government in the promulgation of flood plain regulation ordinances. The floodplain regulations are utilized by the Delaware River Basin Commission in reviewing certain categories of water-related projects pursuant to Section 3.8 of the Delaware River Basin Compact. This includes, but is not limited to, wastewater treatment plant effluents greater than 50,000 gpd and surface water withdrawals greater than 100,000 gpd. The regulations should be evaluated and updated in accordance with current floodplain management guidance.

**Recommendation FR-1.1:** Existing DRBC, State, county and local floodplain regulations should be cataloged and evaluated.

**Recommendation FR-1.2:** A consistent set of comprehensive floodplain regulations beyond minimum NFIP standards needs to be implemented across the entire Delaware River Basin, which responsibly reflects the conditions and needs of the various watershed regions within the basin. For example, there should be a consideration of how the regulations need to respond to the differing conditions of the headwaters, fluvial and bay areas, as well as, the upland, piedmont and estuary regions.

Specifically, these regulations should reflect and include, at a minimum, the following:

- A prohibition on new buildings in the floodway
- A restriction on the volume of flood storage that can be displaced in the flood fringe
- Standards for the lowest habitable floor of new buildings
- A mechanism to reasonably deal with repetitive loss structures
- A requirement to elevate new roadways where feasible
- A recognition of the importance of riparian corridors and measures to protect and restore natural vegetation and habitat in these areas

The establishment of a joint working group or basin legislator forum is needed to compose and implement a set of comprehensive basinwide floodplain regulations. Every effort should be made to encourage New Jersey, New York, Pennsylvania and Delaware to participate in the establishment and adoption of a set of consistent regulations within the Delaware River basin under the auspices of the Delaware River Basin Commission.

All implementation and enforcement is encouraged to remain under the existing framework whether State or local.

**Recommendation FR-1.3:** A model ordinance recommending more beneficial floodplain regulations should be developed for the communities of the basin with basinwide regulations and standards set. Examples of concepts to be contained in the model ordinance include

freeboard recommendations, compensatory storage, and a means for communities to determine the requirement for substantial improvement through a cumulative sum. There should be a cumulative loss count taking into consideration all payments made for a particular structure. Once the cumulative loss figure reaches over 50% the property must go on a high priority list for purchase and have greater access to funds for elevation and/or purchase with homes willing to accept a purchase being given a higher priority.

**Recommendation FR-1.4:** The Delaware River Basin Commission Floodplain Regulations need to be evaluated and updated based on current floodplain management guidance. The new regulations should apply to both freshwater and estuarine and saline waterways in the basin and should be applicable to all floodplain development.

**Implementation:** Basin states, State NFIP coordinators, FEMA, DRBC, county planning and engineering departments, municipalities, Delaware Riverkeeper Network, watershed groups, local code officials and local floodplain administrators

**Challenges:**
Each of the basin's 838 communities will need to be contacted to properly assess all existing floodplain management practices within the basin.

The implementation mechanism and resulting enforcement differs in each State.

Any change in the determination of the floodway would require remapping by FEMA.

Drafting the model ordinance will not be difficult once a comprehensive set of floodplain regulations is constructed for the basin, per recommendation FP-2 above. However it will take much longer for each of the basin's 838 communities to review and adopt these regulations. The process could take several years and there could be resistance in some communities.

**Recommendation FR-2: Develop a Coordinated Education, Outreach and Training Program**

**Finding:** Enforcement of floodplain regulations often occurs at the local level by local officials. Floodplain managers come from a variety of curricula and backgrounds. In small communities, floodplain managers are sometimes part-time employees. The role of these floodplain managers is expanding due to increases in disaster losses and the emphasis being placed upon mitigation to alleviate the cycle of damage-rebuild-damage. There is a need for a coordinated education, outreach and training program in the basin for floodplain managers, local planning and zoning boards, professionals and the public. Communities need to be armed with the proper knowledge to properly evaluate whether development is reasonably safe from flooding or will exacerbate local flooding conditions.

**Recommendation:** A coordinated education, outreach and training program needs to be developed in the basin for floodplain managers, local planning and zoning boards, professionals and the public. The expansion of floodplain awareness and strengthened floodplain regulations basinwide will allow for better planning and stricter protection of floodplains in the future.

The Certified Floodplain Managers (CFM) certification should be encouraged for all local floodplain managers and professionals. This national certification is supported by the Association of State Floodplain Managers (ASFPM) and lays the foundation for ensuring that highly qualified individuals are available to meet the challenge of breaking the damage cycle and stopping its negative drain on the nation's human, financial, and natural resources.

The local State chapters of ASFPM, the New Jersey Association of Floodplain Managers (NJAFM) and the New York State Floodplain and Stormwater Managers Association (NYSFSMA) are expected to be able to coordinate and help greatly with this task. Pennsylvania and Delaware are encouraged to consider implementing State chapters.

**Implementation:** FEMA, DCA, PADEP, PADCED, NJDEP, NYDEC, DRBC, ASFPM, NJAFM, NYSFSMA, DRN

**Challenges:** Given the large number of people that would necessarily be involved and impacted by such an effort, the coordination and funding of the program would likely be the biggest challenges.

**Recommendation FR-3: Repetitive Loss Reduction Strategy for the Basin**

**Finding:** There is a need for a repetitive loss reduction strategy to prioritize funding sources and areas in the basin. Many local communities and counties in the basin have scarce resources and are in need of technical assistance to prepare and prioritize applications for Federal funding; such as acquisition and elevation programs.

**Recommendation:** The Delaware River Basin should be a priority area for acquisition and elevation efforts. Consequently, a repetitive loss reduction strategy should be developed for the basin so that at-risk structures can successfully compete for funding sources. This strategy should include a well-rounded program that encourages, at a minimum, the following:

- The offer and acceptance of buyouts for repetitive loss properties
- Funding sufficient to provide fair market value for purchased properties
- Assistance in relocating flood victims into homes with affordable mortgage rates
- Adequate food-proofing of non-residential and historic structures, which cannot feasibly be purchased or elevated

Additionally, the State, county and local governments should make a concerted effort to better utilize the existing state funding sources for the purposes of purchasing, preserving and restoring flood prone lands in the Delaware River Basin. States should also encourage municipalities to make maximum use of federal funding (i.e. FEMA and NRCS) for the acquisition of flood prone structures, demolition of these structures and conversion of the lands to naturally vegetated open space by providing funding to assist with the non-Federal share of municipal sponsored mitigation projects funded by FEMA as part of the Hazard Mitigation Grant Program.

Efforts should include prioritization of areas for acquisition. Furthermore, historic communities should be targeted for flood proofing and elevation, while priority should be given to acquire and remove structures in non-historic communities. In cases where the Army Corps of Engineers has recommended and approved such measures, consideration should be given to the placement of structural measures, such as levees and flood retention walls, to protect non-commercial structures in non-historic communities.

States should also create and implement programs to remove highly vulnerable public works structures from the floodplain with a special emphasis on wastewater treatment plants that are routinely overwhelmed by floodwaters, and which discharge untreated or partially treated sewage into surface waters. As part of this program, all public works without a National Historic Register (NHR) listing that have experienced repetitive loss should be phased out by requiring removal from the floodplain upon substantial change, wherever feasible.

**Implementation:** FEMA Region II, FEMA Region III, DRBC, PEMA, NJOEM, SEMO, NRCS

**Funding Mechanism:** FEMA funding, NRCS Watershed Program funding
**Challenges:** Effective mitigation requires increased Federal and State funding as well as the cooperation and coordination of residents, elected officials and all Federal, State and local agencies with flood mitigation responsibilities.

**Recommendation FR-4: Flood Hazard Disclosure Requirements**

**Finding:** Property owners may first become aware they are living in a flood prone area either after they have experienced flooding or when a lender for a federally-insured mortgage company requires flood insurance. Although homeowners that require a federally-insured mortgage are required to prove they are not in a floodplain, other mechanisms need to be in place to alert those people buying homes without a mortgage and for those cases where no buildings yet exist onsite. Even for those homeowners who do have flood insurance, they may be unaware of the actual potential for flooding and actions that they can take to minimize damage.

**Recommendation:** The States should adopt flood hazard disclosure requirements for all real estate transactions. To the extent that a current property owner is aware of the flood history of a site, these facts should be made known in writing to any potential buyers of the property either by the property owner or the real estate licensee responsible for selling the property. Such notifications should be filed with the host municipality. The existence of permits or other documentation from the States, flood insurance records, easements onsite or tax records should be part of the disclosure requirements. Additionally, flood insurance companies should provide reminders to their policyholders, at the time of policy renewal, that they live in a flood prone area and include steps they can take to minimize loss.

**Implementation:** State Insurance Regulators

**Challenges:** Legislation required.

**Recommendation FR-5: Standardized riparian corridors should be considered along all basin streams, rivers and estuary waters.**

**Finding:** Healthy vegetation adjacent to surface waters is essential for maintaining bank stability, water quality protection, absorptive capacity of floodplain soils, reducing stream flow velocities and providing flood storage. The indiscriminate disturbance of such vegetation destabilizes the banks of channels and other surface waters, which leads to increased erosion and sedimentation that exacerbates the intensity and frequency of flooding. The loss of vegetation adjacent to surface waters also reduces filtration of stormwater runoff and thus degrades the quality of these waters. Such impacts adversely affect the health and habitat of fish and wildlife that depend upon clean surface waters and therefore disrupt the ecological balance that is necessary for life. Humans are ultimately affected by this imbalance, since clean water is essential for all life. Floodplains vegetated with native trees, shrubs and herbaceous plants help reduce flood volumes, velocities and peaks.

**Recommendation:** Standardized riparian corridors should be considered along all basin streams, rivers and estuary waters, the size of which appropriately reflects the relative gradient and natural resources of the watershed. A study to identify and prioritize certain riparian corridors throughout the basin that can provide areas for efficient floodplain restoration and increased floodplain storage should be performed.

Disturbance to existing vegetation within the corridors should be highly discouraged, while incentives should be developed to encourage revegetation and enhancement of previously disturbed areas with native trees, shrubs and herbaceous plants. Any subsequent regulatory guidelines that are developed for riparian corridors should also recognize that some intrusion into these areas is unavoidable and that preexisting land uses must be accommodated

**Implementation:** FEMA, DRBC, NFIP State coordinators, PADEP, NJDEP, NYSDEC, NRCS, municipalities, watershed groups

**Challenges:** Determining the appropriate width of the riparian corridor in various portions of the watershed could prove challenging. Furthermore there could be some local opposition to the institution of these corridors, since they necessarily limit the amount of near-stream development that can occur.

## F. Flood Warning

Gaging

FW-1: Inventory and Evaluate Precipitation Observing Stations in the Basin

FW-2: Evaluate & Upgrade River Gage Network

FW-3: Extend Rating Tables

FW-4: Flood Harden Gages at Key Forecast Locations

Flash Flood and Flood Forecasting

FW-5: Improve Flash Flood Forecasting

FW-6: Develop an Implementation Plan for the NWS Site Specific Model

FW-7: Evaluate & Establish New River Forecast Points

FW-8: Provide River Forecasts with Confidence Level Information

FW-9: Develop Flood Forecast Inundation Maps

FW-10: Maintain Up-to-Date High Hazard Dam Emergency Action Plan (EAP) Documents

Education and Outreach

FW-11: Establish a Coordinated Flood Warning Education and Outreach Program

FW-12: Develop a Flood Coordination Mechanism

FW-13: Ice Jam Monitoring and Communications Plan

Coastal Flooding Impacts

FW-14: Coastal Flooding Impacts

**Recommendation FW-1: Inventory and Evaluate Precipitation Observing Stations**

**Finding:** There is no comprehensive inventory of precipitation observing stations available for the basin. An inventory and analysis of the observing stations is needed to determine improvements required to make the maximum use of existing precipitation observations to improve the delivery of flood warnings.

**Recommendation FW-1.1:** Develop a comprehensive inventory of precipitation observing station (automated and spotters) gages in the Delaware River Basin. The purpose of this inventory is to provide the information necessary to evaluate the existing precipitation network, maximize it for flood forecasting and identify areas for improvement.

**Implementation:** DRBC/NWS/USGS/NYCDEP

**Estimated Cost:** $20,000 One-time

**Implementation Time Frame:** Immediate

**Recommendation FW-1.2:** Precipitation gages not used by the NWS flood forecasting models need to be evaluated to determine if they should be added to the existing flash flood and river flood warning program in the Delaware River Basin. The evaluation should include an analysis of sub basins and the adequacy of the precipitation gages in each. The evaluation should determine:

- The location of additional gages required to improve the flood warning network relative to flood risk.
- The existing non-NWS gages that can be incorporated into the NWS network.
- The upgrades required to make existing non-NWS gages compatible with NWS requirements where the gages are to be added to the network

Upon completion of this evaluation, recommendations would be made on upgrades as well as locations and costs for additional new precipitation gages.

**Implementation:** DRBC, NWS, USGS

**Estimated Cost:** $30,000 One-time

**Implementation Time Frame:** Short Term

**Recommendation FW-2: Evaluate & Upgrade River Gage Network**

**Finding:** Several river gages in the basin do not meet the needs of the NWS flood forecast operations in the basin. For example, the West Branch Delaware River at Stilesville, NY, at the outlet of Cannonsville Reservoir, is not equipped with satellite telemetry for real time access.

**Recommendation:** The existing river gage network in the basin should be evaluated for locations and telemetry deficiencies (e.g. backup communications, reporting - frequency 4 hr to 1 hr, and rating curves). Evaluate the deficiencies and develop an implementation plan for upgrades based on flood forecasting requirements and user input. The 2002 "Recommendations to Address Flood Warning Deficiencies in the Delaware River Basin" report by DRBC provides some specific inventory information.

**Implementation:** NWS, DRBC, USGS

**Implementation Time Frame:** Immediate to long term

**Challenges:** Once the requirements are established the one time and recurring funding costs will be needed and support for these is required.

**Recommendation FW-3: Extend Rating Tables**

**Finding:** Rating tables (stage-discharge relationships) were exceeded at a number of forecast points in the Delaware River Basin during the floods of 2005 and 2006. On-the-fly straight line extrapolations used for the rating curves are known to be highly inaccurate. This makes it extremely challenging to forecast for points downstream since flow measured at these points is highly suspect.

**Recommendation:** Investigate having the USGS extend the rating curves for all forecast points to 125% of record flow.

**Implementation:** USGS, NWS

**Implementation Time Frame:** Short term

**Recommendation FW-4: Flood Harden Gages at Key Forecast Locations**

**Finding:** During the June 2006 flood, stream stages exceeded the design capacity of several stream gages at critical locations. The stream gage construction plans were designed based on existing flood-frequency analyses and installed considering constraints such as access, available land setting, and funding limits.

**Recommendation:** To preserve data transmission during critical periods, consideration should be given to flood harden gages at key forecast locations in the basin, including gage structure relocation or elevation of the existing structure. In order to flood-harden existing stream gages to withstand the 100-year or 200-year flood flow, an updated flood-frequency analysis must be performed at the gage of interest.

**Implementation:** USGS

**Implementation Time Frame:** Long term

**Challenges:** Funding

## FLASH FLOOD AND FLOOD FORECASTING

### Recommendation FW-5: Improve Flash Flood Forecasting

**Finding:** Much flood damage occurs in headwater basins, away from the major rivers. There is a need to develop better means for disseminating and delineating flood and flash flood warnings in headwater regions. Local, real-time monitoring equipment such as radio rain gages and Doppler radar technology, and related software are required to implement improved flash flood warning through high-resolution graphical displays.

As illustrated by flood insurance claims data, significant flood damage occurs in headwater areas where flood warning lead time is extremely short. In most cases, only a generalized warning for portions of a county can be issued.

**Recommendation:** Combine GIS and Doppler radar technology to improve small watershed flash flood forecasting.

Prototype graphical product distribution should be developed for urbanized portions of the Delaware River Basin. This will require work with the NWS, emergency managers, and potential local users to provide a product that is distributed in real time and quickly understood. This would provide local emergency managers with a real time image of where their resources should be concentrated to respond to the flooding. The work would be consistent with national NWS standards.

The initial phase of this work would involve a prototype application to several urban, county-sized sections of the Delaware River Basin that are prone to flash flooding, and would consist of the following:

- Addition of an automated flood warning system of rain gages, telemetry, and software to the existing precipitation network as necessary for verification of rainfall estimates.
- Work with NWS and county and local emergency officials to develop graphical products for distributing flash flood information.
- Provide software for distribution of graphical products.
- Educate local emergency officials and coordinate with media on the use of Doppler radar for estimating flooding potential and issuing warnings.

**Implementation:** NWS, DRBC, USGS

**Estimated Cost:** $510,000 One Time; $10,000 annual

**Implementation Time Frame:** Long term

**Challenges:** NWS baseline product requirements and development will define the implementation schedule

**Recommendation FW-6: Develop an Implementation Plan for the NWS Site Specific Model**

**Finding:** Flash flood forecasting produces warnings for a certain forecast area based on areal rainfall amounts. In the Delaware River Basin, there are headwaters and feeder streams that respond rapidly to excessive rainfall. It is very difficult to gain lead-time and provide specific point forecasts for these streams under this type of situation. A NWS site specific model could provide specific flash flood forecasts for a known location. Some of the Delaware forecast points that are on smaller rivers and headwater points respond in a flash-flood like manner.

**Recommendation:** Develop an implementation plan for the NWS site-specific model to improve warning timeliness and accuracy for areas susceptible to flash-flooding.

**Implementation:** NWS, DRBC

**Estimated Cost:** None

**Implementation Time Frame:** Short term

**Recommendation FW-7: Evaluate and Establish New River Forecast Points**

**Finding:** The gage height at which flooding begins (flood stage) is not representative of the level at which flooding occurs or has not been established for a number of the basin's stream gages.

**Recommendation FW-7.1:** Establish flood stages and impact statements for potential flood forecast points where gaging stations are equipped with real time telemetry. It is estimated that there are approximately 35 such gages distributed throughout the basin.

**Implementation:** NWS/DRBC

**Estimated Cost:** $ 70,000 One-time;$ 5,000 O&M

**Implementation Time Frame:** Long term

**Recommendation FW-7.2:** Evaluate and prioritize needs for establishment of new forecast points in basin. Determine need for upgrading existing stream gages or adding new gages. The evaluation should include an analysis of subbasins and the adequacy of the flood forecast points in each. Based on this evaluation, a determination should be made as to which existing stream gages, not now used as flood forecast points, should be upgraded for this purpose, and where additional gages are needed. This evaluation should also focus on funding mechanisms for the gages and the work load associated with the establishment of the new forecast point.

**Implementation:** NWS, DRBC, USGS

**Estimated Cost:** $30,000 One-time

**Implementation Time Frame:** Short term

**Challenges:** Criteria needs to be developed

**Recommendation FW-8: Provide River forecasts with confidence level information**

**Finding:** Many inquiries about forecasts ask for a confidence level and uncertainty of the NWS issued forecasts. Not everyone has access to information on the confidence in NWS forecasts. MARFC forecasters include ranges as comments in their forecast guidance, but these never reach most users.

**Recommendation:** Confidence level information should be added to river forecasts and displayed on the NWS AHPS web page. Bracketed forecasts based on uncertainty can be added in the short-run when needed.

A long-term goal is to establish short term (7-day) probabilistic forecasts at all river forecast points in the basin. It is necessary to develop and implement better techniques to incorporate ensemble and probabilistic precipitation forecasts and hydrologic model uncertainty into short-term probabilistic hydrologic forecasts.

**Implementation:** NWS

**Implementation Time Frame:** Short term, Long term

**Recommendation FW-9: Develop Flood Forecast Inundation Maps**

**Finding:** GIS based flood warning technology improvements have not been applied in the Delaware River Basin.

**Recommendation:** Develop a flood forecast inundation mapping prototype. The effectiveness of flood stage forecast mapping at the local user level should be demonstrated on a prototype basis in high risk basins. Flood inundation mapping would initially focus on high priority flood damage centers along the main stem Delaware and Schuylkill Rivers for prototype application. An objective of the mapping would be to provide representation of impact as a function of river stage wherever hydrologically applicable. Education of map users should be built into this program and usefulness of the products should be evaluated from the local perspective. This recommendation is consistent with the objectives represented in Recommendation FM-1.

**Implementation:** NWS, USGS, DRBC, USACE, FEMA

**Implementation Time Frame:** Long Term

**Challenges:** Access to Digital Elevation Models (DEM).

**Recommendation FW-10: Maintain Up-to-Date High Hazard Dam Emergency Action Plan (EAP) Documents**

**Finding:** Several large impoundment reservoirs and control structures which have the potential to cause severe flooding to the Delaware River in the event of a catastrophic dam breach failure are located within the Delaware River Basin. Many of these structures have Emergency Action Plans (EAP).

An EAP is a document that contains information to be used by emergency management coordinators and personnel in the event of a sudden dam failure or the uncontrolled release of stored water. Dam inundation mapping is the key component of the EAP document since it clearly illustrates the extent and timing of potential downstream impacts during a dam breach or uncontrolled release of water event. The standard text of an EAP also includes emergency notification flowcharts; statement of purpose; project description; emergency detection, evaluation, and classification; general responsibilities; preparedness; plans for training, exercise, updating and posting; and approval and distribution information.

The dam owner is responsible for the preparation and maintenance of the EAP document. Regulatory authority in the Delaware River Basin over the dam owner's responsibilities may lie within several federal and state agencies including the Federal Energy Regulatory Commission (FERC), the NJDEP, the Pennsylvania Department of Environmental Protection (PA DEP), and the New York State Department of Environmental Conservation (NYSDEC).

**Recommendation:** The owners of dams located within the Delaware River Basin should prepare and maintain a current EAP document with associated up-to-date dam breach inundation mapping. The DRBC should coordinate and ensure that EAP documents for all large impoundments within the Delaware River Basin are shared between the states of New Jersey, Pennsylvania, and New York and available to at-risk communities for emergency management purposes.

**Implementation:** DRBC, Basin States, FERC

**Implementation Time Frame:** Long Term

## EDUCATION AND OUTREACH

### Recommendation FW-11: Establish a Coordinated Flood Warning Education and Outreach Program.

**Finding:** Local knowledge of the meaning of forecast flood stages needs to be improved in some portions of the basin. This effort must be achieved through work with local officials and the public.

**Recommendation:** A coordinated flood warning education and outreach program should be established for the Delaware River Basin. The program should include information on how the flood warning system works, how river flood warning and flash flood warning information can be obtained, and the importance of local knowledge of the meaning of flood stages. The program should include information about the multiple benefits of stream gages and the need to continuously fund the operation and maintenance of these gages. Encouraging and identifying potential cost sharing opportunities should be part of this effort.

The program should also focus on providing high-water historical information to impacted areas (e.g. public buildings and other highly visible locations)

The program should combine information prepared by the NWS, U.S. Army Corps of Engineers, and state and federal Emergency Management Agencies. Information on flood warning assistance opportunities for communities should be readily available. Press releases and conferences can be coordinated through the DRBC Public Information Office. Brochures would be distributed at meetings, public information sessions, and to middle and high school science teachers. Efforts would be made to work with local officials to provide improved knowledge of flood stages and interpretation of flood forecasts. The potential for a National Weather Service password protected site dedicated to emergency management personnel should be examined.

**Implementation:** NWS, DRBC, USGS, USACE

**Estimated Cost:** $50,000 annual

**Implementation Time Frame:** Short term, Long term. There is a potential opportunity for outreach to coincide each March during National Flood Awareness Week.

**Recommendation FW-12: Develop a Flood Coordination Mechanism**

**Finding:** The need for improved communications at all levels to the public before, during and after a flood event is an underlying need expressed by flood victims. During the last three floods on the Delaware River, flood victims sought information and were uncertain what agencies to turn to for flood information, including flood prevention and recovery.

Citizens and local emergency responders indicated a need for a single point of contact to provide upfront information and education to residents, local officials and local emergency responders on flood management and recovery. They also expressed a need for methods and materials to assist communities in these efforts.

**Recommendation:** A coordination mechanism should be developed to handle issues that arise between flood victims and other entities and manage the flow of information during and after the flood event and coordinate information between agencies.

Citizens should participate in the development of such plans and be made aware of management issues associated with flooding before, during and following a flood event. Additionally, the emergency management warning system at the local level could be improved by annually publicizing the plan, the role of the agencies involved and the role and responsibility of the public in following the plan.

As part of the communication plan, flood information methods and materials should be created for communities that would provide information on:

- State and federal regulations, model ordinances for local governments on land use planning to direct development away from flood prone areas;
- Flood prevention and preparedness literature for homeowners;
- Financial and insurance information and techniques to safeguard against flooding in the home;
- Explanation of confusing terminology such as 100 year flood;
- Contact numbers of relevant agencies, such as NJOEM, DRBC, NWS, FEMA, and USACE for citizens to obtain literature and information about flood prevention preparation and mitigation;
- Contacts for medical assistance and counseling services following flooding;
- Information on how to bring property into compliance with flood mitigation standards;
- Explanations of the differing requirements between federal, state and local regulators;
- Information on how long the process for recovery will take;
- Promote the NWS's StormReady program encouraging communities to receive StormReady designation; and
- Encourage communities to implement reverse 911 systems by providing documentation and program development guidelines.
- Advertise the importance of having NOAA Weather Radios (NWRs) available, particularly during potential weather-related power outages, since most are equipped with battery back-up capability. NOAA Weather Radio, a 24-hour radio broadcast by the NWS, has excellent radio coverage with 100% coverage along the Delaware River.

- Encourage the use of internet and RSS feeds (personal notification) for AHPS data.
- Implement reverse notification systems to help ensure timely evacuations during a flood event.

**Implementation:** NWS, DRBC, USACE, USGS, states

**Implementation Time Frame:** Short term, Long term

**Recommendation FW-13: Ice Conditions Monitoring and Communications Plan**

**Finding**: Ice jam flooding is a particular threat during rapid thaws or heavy rain events that follow a prolonged period of subfreezing temperatures. Ice jams caused record flood stages along on the Delaware River at Port Jervis, NY (1981) and Trenton, NJ (1904). Rapid rises in stage are an especially hazardous element of ice jam flooding. This may be caused by water backing up behind the ice jam, or by the breakup of ice jams upstream. During the 1981 ice jam flood at Port Jervis, NY and Matamoras, PA, both factors combined to cause a rise in stage of 14.5 feet in one hour. One death was attributed to the flooding and a total of 950 structures sustained damage amounting to $14.7 million (1981 dollars). Although some areas are more prone to ice jams than others due to factors such as channel geometry or obstructions such as bridge piers, the timing of ice jam flooding is very difficult to predict and warning time may be very short. Accordingly, monitoring of ice conditions, ice jams, and backwater conditions behind ice jams provides critical information if rapid thawing or heavy rain is forecast when heavy ice accumulations are in place.

During such conditions, teleconferences and other communication methods among state and county emergency management officials and the National Weather Service can provide for an exchange of information on ice conditions and provide contact information for reporting changing conditions or ice related problems. One example of such coordination was evident during the late winter of 2007 when the Pennsylvania Emergency Management Agency convened several such coordination sessions. It would be useful to expand this type of coordination activity to an interstate scale for the Main Stem Delaware River. In addition, it would be useful to enhance real time monitoring of ice conditions at bridges through the use of web cameras or local observers. The Delaware River Joint Toll Bridge Commission recently announced plans to install video and automated water level monitoring at bridges crossing the Delaware River. This would allow for increased ice conditions monitoring and flood monitoring potential in general. Further, the Ice Jam Information Clearinghouse, located on-line at http://www.crrel.usace.army.mil/icejams/, provides a centralized means of storing and retrieving ice jam data.

**Recommendation:** Expand ice conditions monitoring and coordination of information by:

1 Expanding ice jam emergency preparedness conferencing to the interstate level for coordination of briefings by the National Weather Service Binghamton and Mount Holly Offices;
2. Incorporating enhanced real time monitoring by the Delaware River Joint Toll Bridge Commission with data collection by the National Weather Service on ice conditions;
3. Working with the Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) to ensure posting of all available ice jam information, and
4. Publicizing successful ice jam mitigation measures through the CRREL web site.

**Implementation:** State and County EMO's, Corps (CRREL), Delaware River Joint Toll Bridge Commission, National Weather Service, DRBC, National Park Service

**Funding Mechanism:** Bridge monitoring equipment to be funded by Joint Toll Bridge Commission. Agency staff time required for coordination with Corps of Engineers and teleconferences.

**Implementation Time Frame:** Start Winter 2007/2008

**Recommendation FW-14: Coastal Flooding Impacts**

**Finding:** Communities in the tidal reaches of the Delaware River and Bay are equally vulnerable to catastrophic flood events. The convergence of a major storm event with an incoming tide, or a Category 3, 4, or 5 Hurricane can create dramatic water level rises along both the main stem and the tidal portions of tributary streams. These major events can also have dramatic impact on sensitive coastal habitats such as wetlands that have become more exposed to harm as the result of increasing adjacent development and loss of tree cover and buffers. As waterfront and bayside living becomes more economically attractive the level of development has increased, subjecting more communities to the dangers of major storm events and storm surges.

**Recommendation:** Develop a comprehensive program for coastal communities and resources protection including:

- A model that takes into consideration the convergence of storm events, high flows from non-tidal stream and river reaches, storm events in nearby ocean and coastal regions and the Chesapeake Bay that dramatically impact storm events and surges in the Delaware Estuary and Bay.
- A flood warning system using the new model.
- Identification of high hazard areas and new floodplain mapping based on this model using conservative assumptions.
- DRBC regulations that prohibit development on the highly vulnerable river islands, floodways and floodplains.
- DRBC regulations requiring buffers along sensitive wetland, marsh and water ecosystems to provide buffering and needed protection from major storm events.

**Implementation:** DRBC, NOAA, USGS, USACE, DE, NJ, MACOORA

**Implementation Time Frame:** Long Term

**Challenges:** Existing fledgling efforts are sub-regional and must be pulled together (through pilot projects) into a regional coordinated system with integrated operations and management.

## IV. Implementation Considerations

Implementation of this plan is critical and will require a commitment of funding and resources to reduce flood loss in the basin. The Task Force has identified some constraints that will affect implementation of the recommendations and which will require further analysis by the four governors, Task Force members and the public. These identified constraints are as follows:

a) Implementation time frame; identification of short-term actions

b) Staffing levels

c) Required legislation and/or regulation

d) Funding

e) Interstate coordination

f) Local support

In an effort to prioritize the recommendations contained in this report, the following immediate actions are proposed:

- Establish areas of priority funding for acquisition, elevation, and flood proofing. *(Action S-6)*
- Develop an interoperable reservoir operating plan. *(Action R-2)*
- Develop and implement a consistent set of comprehensive floodplain regulations beyond minimum NFIP standards across the entire Delaware River Basin. *(Action FR-2)*
- Enable stormwater utilities – this approach has water quality and quantity benefits and re-inforces the states' existing momentum for stormwater management and control of nonpoint source pollution; its time is *now*. *(Action SM-2.3)*

Notably, there was significant constructive tension among task force members as to the relative value of a "flood control" approach as compared to a "floodplain management" approach. The first four recommendations listed above fall into the latter category. The second encompasses both. The consensus of the task force is that aggressive implementation of a *floodplain management* strategy over the short term should be coupled with a methodical evaluation of *flood control* options over the long term. The task force members plan to meet annually commencing in late 2007, in order to monitor progress in implementing the action plan.

Table 4 is an implementation matrix which attempts to organize the recommendations by implementation time frame (on-going, short-term 1-3 years and long-term 3+ years) assuming adequate resources are identified.

## Delaware River Basin Flood Mitigation Task Force
## Table 4 - Recommendations by Implementation Time Frame

| Recommendation | | Lead Agency | Desired Result | Resources Needed |
|---|---|---|---|---|
| **Ongoing Actions** | | | | |
| R-1 | Develop a Flood Analysis Modeling Tool | DRBC | Prevention/ Public Education | $$ |
| R-3 | Evaluate Discharge Mitigation Programs for Reservoirs | DRBC | Prevention | $ |
| R-4 | Evaluate Snowpack Based Storage Management | DRBC | Prevention | $ |
| S-2 | Prioritize the Completion of State and Local Hazard Mitigation Plans | State EMO's | Prevention/ Public Education | $$$ |
| S-3 | Ensure Financial Assistance for State, County and Municipal Flood Mitigation Projects | State EMO's | Structural Projects | $$$$ |
| S-8 | Dam Safety Programs | State Dam Agencies | Emergency Services | $$$$ |
| S-9 | Evaluate and Coordinate Flood Mitigation Plans and Strategies | DRBC | Prevention/ Public Education | $$$ |
| SM-2 | Long-term Management of Stormwater Best Management Practices (BMPs) and Infrastructure | States | Prevention | $ per municipality |
| SM-3 | Non-Structural Stormwater Management for New and Redevelopment | States | Prevention | $ |
| SM-6 | Develop and Maintain Precipitation and Streamflow Data | USGS/NWS | Emergency Services | $ |
| SM-8 | Stormwater Management through Special Protection Waters Designation | DRBC | Natural Resource Protection | $ |
| FM-1 | Coordinated Flood Study and Mapping Updates | Basin States | Prevention/ Public Education | $$$$ |
| FW-10 | Maintain Up-to-Date High Hazard Dam Emergency Action Plan (EAP) Documents | DRBC | Emergency Services | $ |
| FW-13 | Ice Jam Monitoring and Communications Plan | State EMS | Emergency Services | $ |
| **Short-term Actions (1-3 Years)** | | | | |
| R-2 | Develop an Interoperable Reservoir Operating Plan | DRBC | Prevention | $$ |
| R-5 | Publish Information on the Basin's Existing Major Impoundments | DRBC | Emergency Services | $ |
| R-6 | Evaluate Availability and Accuracy of Data | DRBC | Emergency Services | $ |
| S-4 | Provide Training for Local Officials to Maximize Use of Available Mitigation Funding | DRBC | Education | $$ |
| S-5 | Create Partnering Programs for Floodplain Acquisition | State DEP's | Structural Projects | $$$$ |
| S-6 | Establish Funding Priority Areas for Acquisition, Elevation, and Floodproofing | Basin States | Structural Projects | $$$ |
| S-7 | Maintenance of Flood Control Structures, excluding dams | State DEP's | Emergency Services | $$$$ |
| SM-1 | Develop Regional and Tributary-Based Watershed Stormwater Management Plans | States | Prevention | $$ per 100sm |
| SM-4 | Enforcement of Existing Stormwater Standards and Regulations | States | Prevention | $ |
| SM-5 | Provide and Promote Incentives to Reduce Stormwater Runoff from Existing Development | States | Prevention | $-$$$$ |
| SM-7 | Stream Restoration and Debris Removal Guidelines | DRBC | Natural Resource Protection | $ |

R=Reservoir Operations, S=Structural/Nonstructural, SM=Stormwater Management, FM=Flood Mapping, FR=Flood Regulations, FW=Flood Warning

$ Key: $ = < $100,000 $$ = < $500,000 $$$ = < $1,000,000 $$$$ = > $1,000,000

## Delaware River Basin Flood Mitigation Task Force
## Table 4 - Recommendations by Implementation Time Frame (Continued)

| Recommendation | | Lead Agency | Desired Result | Resources Needed |
|---|---|---|---|---|
| **Short-term Actions (1-3 Years) (Continued)** | | | | |
| FR-1 | Catalog, Evaluate and Update Existing Floodplain Regulations in the Basin | DRBC | Prevention/ Public Education | $ |
| FR-2 | Develop a Coordinated Education, Outreach and Training Program | DRBC | Public Education | $ |
| FR-3 | Repetitive Loss Reduction Strategy for the Basin | FEMA | Structural Projects | $$ |
| FR-4 | Flood Hazard Disclosure Requirements | DRBC | Prevention | $ |
| FW-1 | Inventory and Evaluate Precipitation Observing Stations in the Basin | USGS | Emergency Services | $ |
| FW-2 | Evaluate and Upgrade River Gage Network | USGS | Emergency Services | $ |
| FW-3 | Extend Rating Tables | USGS | Emergency Services | $ |
| FW-6 | Develop an Implementation Plan for the NWS Site Specific Model | NWS | Emergency Services | $ |
| FW-7 | Evaluate and Establish New River Forecast Points | NWS | Emergency Services | $ |
| FW-8 | Provide River Forecasts with Confidence Level Information | NWS | Emergency Services | $ |
| FW-9 | Develop Flood Forecast Inundation Maps | NWS | Emergency Services | $$ |
| FW-11 | Establish a Coordinated Flood Warning Education and Outreach Program | DRBC | Emergency Services | $ |
| FW-12 | Develop a Flood Coordination Mechanism | Basin States | Public Education | $ |
| **Long-term Actions (3+ Years)** | | | | |
| S-1 | Fund a Comprehensive Flood Mitigation Study of the Entire Delaware River Basin | USACE | Structural Projects | $$$$ per State |
| FM-2 | Incorporate Existing and Future Planned Development and Residual Risk Zones into New Mapping | Basin States | Prevention/ Public Education | $$$$ |
| FM-3 | Redefine and Remap the Floodway along the Delaware River Main Stem and its Tributaries | Basin States | Property Protection | $$$$ |
| FR-5 | Standardized Riparian Corridors | DRBC | Natural Resource Protection | $ |
| FW-4 | Flood Harden Gages at Key Forecast Locations | USGS | Emergency Services | $$ |
| FW-5 | Improve Flash Flood Forecasting | NWS | Emergency Services | $$ |
| FW-14 | Coastal Flooding Impacts | MACOORA | Emergency Services | $$$$ |

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## Definitions

**100-Year Flood:** The flood that has a 1 percent chance of being equaled or exceeded in any given year. It is also known as the Base Flood.

**Flood Fringe (FEMA):** That portion of the floodplain that lies beyond the floodway and serves as a temporary storage area for floodwaters during a flood. This section receives waters that are shallower and of lower velocities than those of the floodway.

**Flood Level:** An established gage height at a given location above which a rise in water surface level is defined as a flood for the corresponding river or stream reach. Flood level is usually set at a stage where the river or stream begins to overflow its banks and create a potential hazard to lives, property, or commerce. Flood level may equal or exceed bankfull stage but should rarely be less than bankfull stage.

**Floodplain Management Regulations:** Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain ordinance, grading ordinance, and erosion control ordinance), and other applications of the police power. The term describes such state or local regulations, in any combination thereof, which provides standards for the purpose of flood damage prevention and reduction.

**Floodplain Management:** The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to, emergency preparedness plans, flood control works, and floodplain management regulations.

**Floodplain:** Any land area susceptible to being inundated by waters from any source.

**Floodway:** A regulatory floodway is defined as the channel of a river or other watercourse and portions of the floodplain adjoining the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height

**Special Flood Hazard Area (SFHA):** Darkly shaded area on a Flood Hazard Boundary Map (FHBM) or a Flood Insurance Rate Map (FIRM) that identifies an area that has a 1 percent chance of being flooded in any given year (100-year floodplain). Over a 30-year period, the life of most mortgages, there is at least a 26 percent chance that this area will be flooded. The FIRM identifies these shaded areas as FIRM Zones A, AO, AH, A1-A30, AE, A99, AR, AR/A, AR/AE, AR/A1- A30, AR/AH, AR/AO, V, V1-V30, and VE.

## Acronyms

| | |
|---|---|
| AHPS | Advanced Hydrologic Prediction Service |
| ASFPM | Association of State Floodplain Managers |
| BMP | Best Management Practice |
| CRS | Community Rating System |
| DCA | Department of Community Affairs |
| DFIRM | Digital Flood Insurance Rate Map |
| DCNR | Department of Conservation and Natural Resources |
| DRBC | Delaware River Basin Commission |
| DRN | Delaware Riverkeeper Network |
| DVRPC | Delaware Valley Regional Planning Commission |
| EAP | Emergency Action Plan |
| EMO | Emergency Management Office |
| EPA | Environmental Protection Agency |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| GIS | Geographic Information System |
| GPD | Gallons per Day |
| MACOORA | Mid-Atlantic Coastal Ocean Observing Regional Association |
| NAI | No Adverse Impact |
| NFIP | National Flood Insurance Program |
| NHR | National Historic Register |
| NJAFM | New Jersey Association for Floodplain Management |
| NJDEP | New Jersey Department of Environmental Protection |
| NJOEM | New Jersey Office of Emergency Management |
| NOAA | National Oceanic and Atmospheric Administration |
| NRCS | Natural Resources Conservation Service |
| NWS | National Weather Service |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSFSMA | New York State Floodplain and Stormwater Managers Association |
| PADCED | Pennsylvania Department of Community and Economic Development |
| PADEP | Pennsylvania Department of Environmental Protection |
| PEMA | Pennsylvania Emergency Management Agency |
| SEMO | New York State Emergency Management Office |
| USACE | United States Army Corps of Engineers |
| USGS | U.S. Geological Survey |