Delaware River Basin Commission
DELAWARE · NEW JERSEY
PENNSYLVANIA · NEW YORK
UNITED STATES OF AMERICA

# Water Supply Reservoirs and Flood Protection

## Lessons from Historical Data

Three devastating floods took place along the main stem Delaware River in a two-year period between September 2004 and June 2006. The three New York City (NYC) Delaware Basin reservoirs – Cannonsville, Pepacton, and Neversink – were full prior to each of these floods and uncontrolled spills formed a component of downstream floodwaters. As a result, some flood victims erroneously concluded that the reservoirs caused the flooding and that absent reservoir spills, their homes and businesses could be spared inundation in the future. The historical data support neither of these contentions.

As Table 1 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 during the past century occurred in the absence of reservoirs or in the absence of spills.**

***Table 1: 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 |

***Flood ranking and crest data courtesy of the U.S. Geological Survey (USGS). Flood stage is 20 feet.***

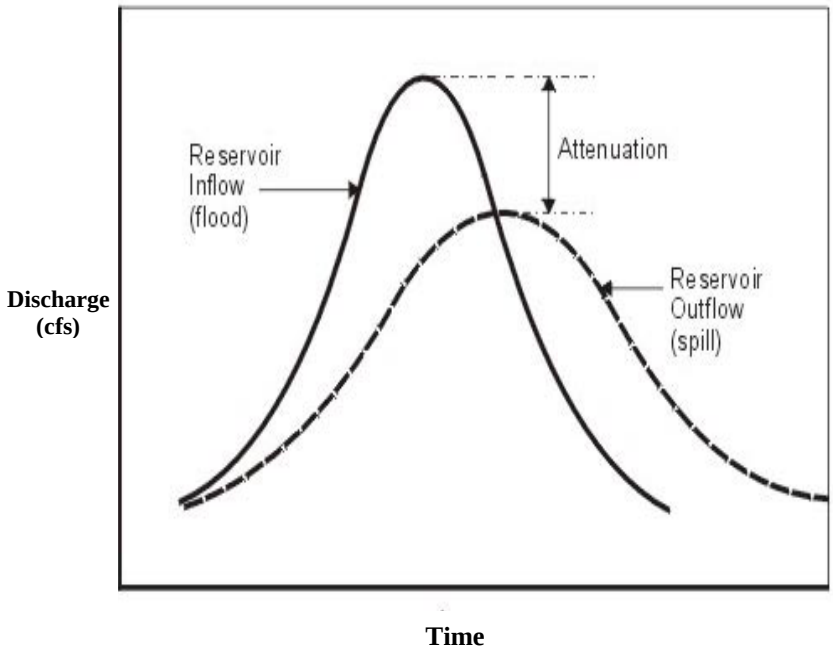
**The data strongly suggest that flooding would occur without reservoirs in place and that eliminating reservoir spills entirely will not eliminate main stem floods.**

**Hydrologic theory and observed data show that even when an impoundment is 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."** Figure 1 illustrates this effect. Attenuation is a function of available reservoir storage, surface area and spillway length. An 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*. USGS, which maintains flow gauges 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 not 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 traveled downstream as a result of the storm.

If a storage void had existed in Neversink Reservoir prior to the flood event, the void would have filled with runoff during the event – further delaying the timing and reducing the volume of the reservoir spill. The reduction in peak flow would have been greater and resulted in lower peak discharges from the reservoir, although the impact on flood crests would diminish with increased distance from the dam.

***Figure 1***




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.

The Interstate Flood Mitigation Task Force convened by the Delaware River Basin Commission (DRBC) in October 2006 at the request of the four basin state governors has recommended that the governors re-evaluate the way that all major reservoirs within the basin are managed. While stopping short of advocating permanent voids, task force members called for evaluating the cumulative effects of operations at all existing major basin reservoirs to develop a coordinated action plan to reduce the likelihood and volume of spills as long as vital water supplies for Delaware, New Jersey, New York, and Pennsylvania are not adversely affected. Complex hydrologic modeling is required to define the effect of management alternatives at multiple reservoirs on flood crests from various storm events. The basin states have provided funding for the development of such a model.

## Balancing the Needs for Flood Mitigation and Water Supply

Although some of the multi-purpose reservoirs within the Delaware Basin, including those owned and operated by the U.S. Army Corps of Engineers, maintain year-round flood storage voids, such voids are not maintained in 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.

Over the past several years, releases from the basin's NYC reservoirs have been increased during the summer months to maintain adequate cold water flows for fish in the upper watershed and in the winter months to mitigate the potential for spills. However, as has been the case since the three reservoirs were placed into operation decades ago, they are managed to reach their full capacity in the late spring. The following factors limit the potential for creating and maintaining year-round voids at these reservoirs:

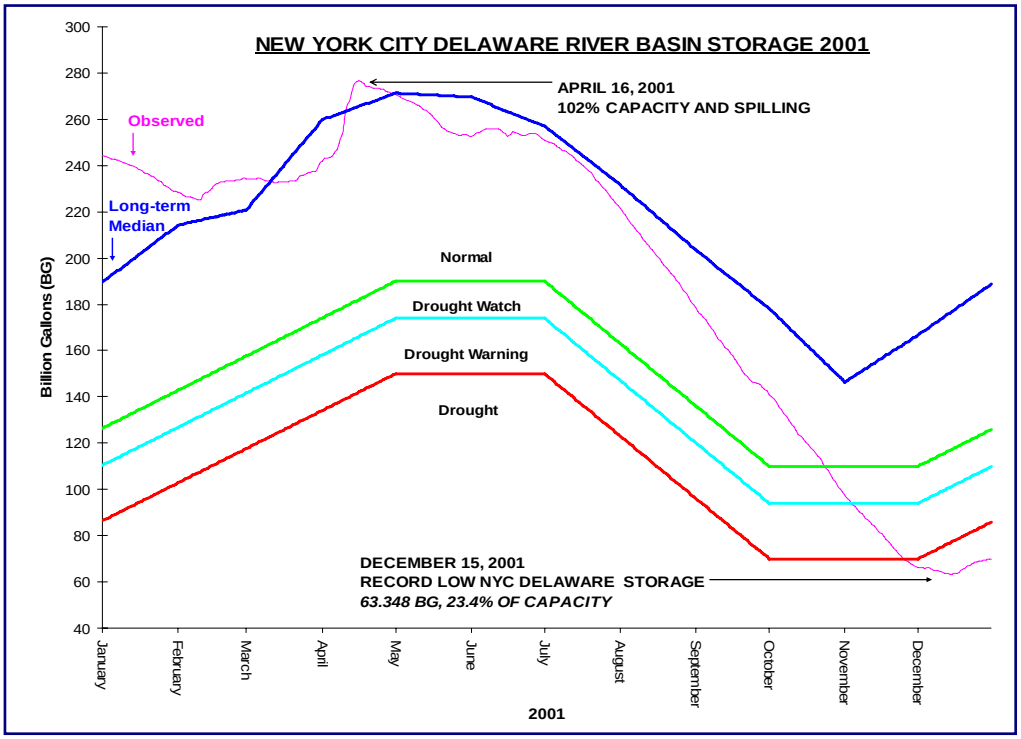
1. The U.S. Supreme Court Decree of 1954 gives NYC the legal right to take an average of up to 800 million gallons per day (mgd) from its three Delaware Basin reservoirs to supply the city with drinking water. Although New York City has historically taken less than its full allocation, it manages the

reservoirs to achieve full storage in the late spring in order to hedge against the possibility that a severe drought might develop.

2. During dry periods, the states of Delaware, Pennsylvania, and New Jersey rely on releases from the NYC reservoirs to maintain flows in the main stem Delaware River that are needed to furnish the region with vital water supplies as well as to sustain aquatic life and support popular fishing and boating activities. **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 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 the New Jersey American Water Company. Over half of Philadelphia's water supply comes from the Delaware River. During the month of August 1999, an average of 73 percent of the flow of the main stem at Montague, N.J. and 46 percent of the flow of the main stem at Trenton were comprised of releases from the three NYC reservoirs.

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 (see below), 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 had declined to 63.348 bg, or only 23.4 percent of capacity, before slowly beginning to rebound. One frequent request by flooding victims is that a 20 percent year-round void be maintained in the NYC Delaware reservoir system. If a void of this size – some 54 bg – 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 2 lists the DRBC drought management periods triggered by NYC reservoir storage since 1980.

The top photo is a view of a full Cannonsville Reservoir. The bottom photo, taken by NYCDEP on 12/20/2001, shows the reservoir at 6.5% capacity.



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 additional measures such as 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.

***Table 2: 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 |
|---|---|---|
| 10/17/1980 | 4/27/1982 | 18.5 |
| 11/13/1982 | 3/27/1983 | 4.5 |
| 11/9/1983 | 12/20/1983 | 1.0 |
| 1/23/1985 | 12/18/1985 | 11.0 |
| 1/16/1989 | 5/12/1989 | 4.0 |
| 9/13/1991 | 6/17/1992 | 9.0 |
| 9/21/1993 | 12/6/1993 | 2.5 |
| 9/15/1995 | 11/12/1995 | 2.0 |
| 10/27/1997 | 1/13/1998 | 2.5 |
| 12/14/1998 | 2/2/1999 | 1.5 |
| 10/29/2001 | 11/25/2002 | 13.0 |

## Increasing Community Flood Resiliency: A Multi-Pronged Approach

The Delaware Basin Interstate Flood Mitigation Task Force has evaluated flood prevention and mitigation options and has concluded that no set of mitigation measures will eliminate flooding along the Delaware River and its tributaries. Task force members believe, however, that a combination of measures will improve the basin's resiliency – its capacity to prepare for and recover from flooding. Included among the 45 recommendations presented to the basin state governors in July 2007 are a slate of actions for regulation and control of releases from upper basin reservoirs. While these recommendations stop short of advocating permanent voids, they call for releases that would reduce the likelihood and volume of spills from some basin reservoirs during storm events to help mitigate flooding.

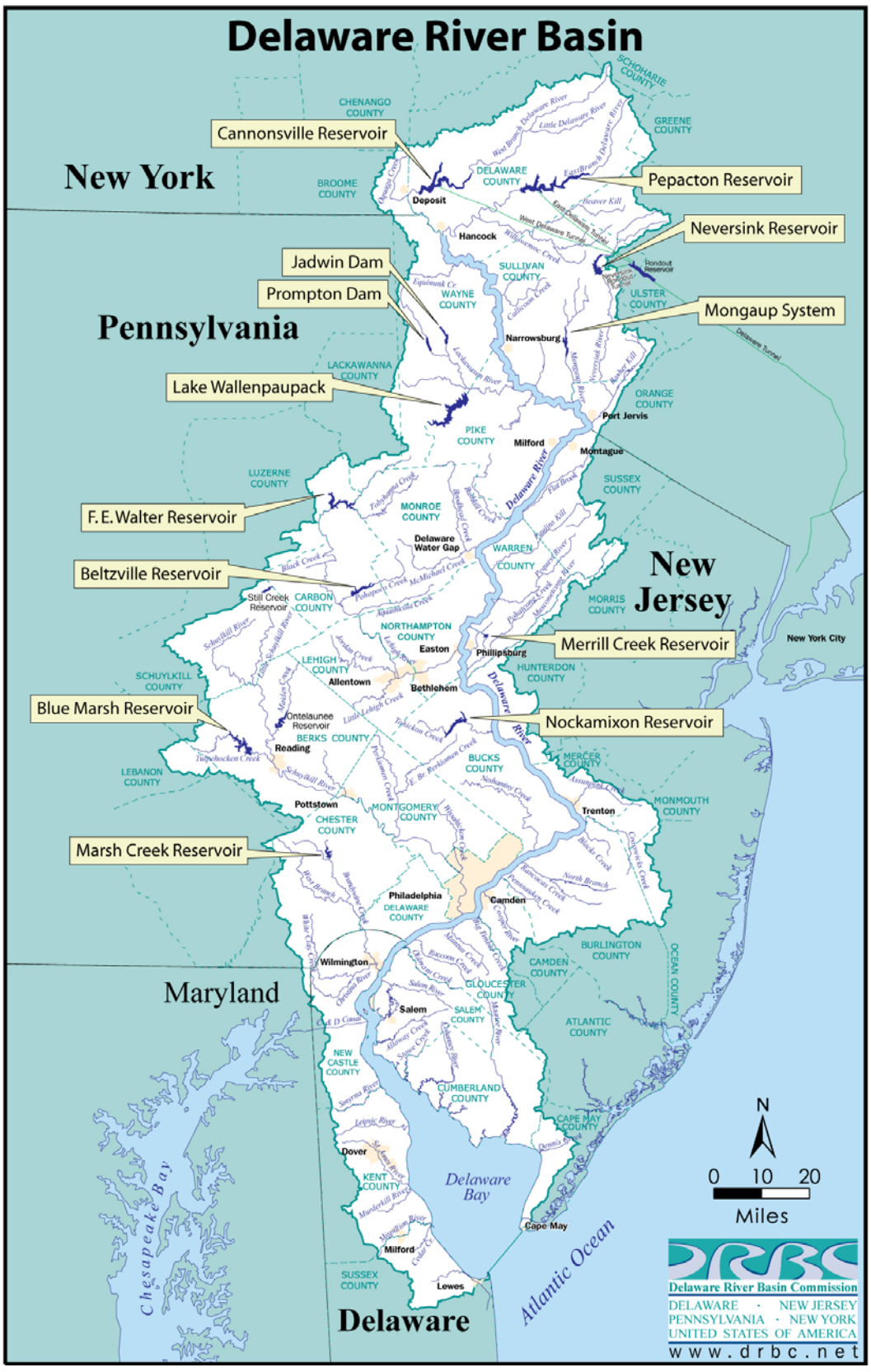
In addition:

1. The parties to the 1954 U.S. Supreme Court Decree and DRBC have been engaged in a complex, collaborative effort to balance the multiple, competing uses of NYC's water supply reservoirs while recognizing the rights established by the 1954 decree. That effort has resulted in a "Flexible Flow Management Program" (FFMP) unanimously agreed to by the decree parties in September 2007 and now the focus of a DRBC public rulemaking process which would allow for commission implementation. One component of the FFMP agreement is a discharge mitigation program.

2. Snowpack-based storage management programs are in place for the NYC reservoirs and the PPL Lake Wallenpaupack hydroelectric facility. Because a portion of the snowpack can be counted as water supply storage, snowpack-based programs pose less risk to supply than other types of discharge mitigation programs.

3. The DRBC is contracting with the USGS, Army Corps of Engineers, and the National Oceanic and Atmospheric Administration/National Weather Service to develop a flood analysis modeling tool. This tool will facilitate evaluation of reservoir operations at all major Delaware River Basin impoundments. When completed, the new flood analysis model should enable decision makers to evaluate the

combined effects of structurally altering major reservoirs in the basin or operating the basin's reservoirs differently.




Visit the DRBC web site at www.drbc.net for more information.