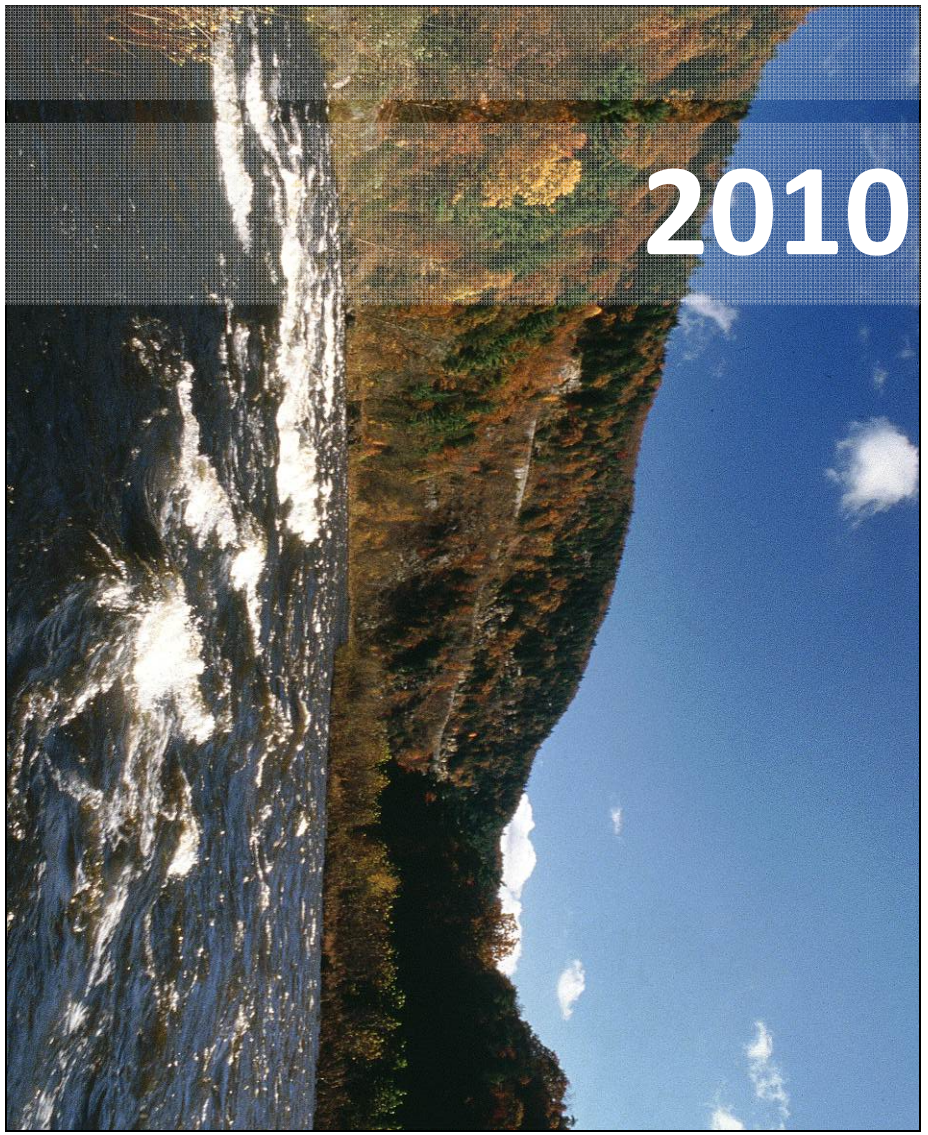
Hydrologic Conditions in the Delaware River Basin



Delaware River Basin Commission

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Hydrologic Conditions in the Delaware River Basin
Annual Report 2010

Hydrologic Highlights of 2010

The Delaware River Basin's hydrologic highlights of 2010 included a drought that spanned the late spring and summer months and late-September storms that produced minor to moderate flooding in the lower basin tributaries and in the upper basin above Port Jervis, N.Y. A dry weather pattern began in April 2010 and the lack of regular rainfall resulted in below-normal streamflow and declining groundwater conditions throughout the basin. These conditions triggered drought declarations for the first time since Delaware lifted a statewide drought watch in April 2008:

- On August 5, concerned about persistent hot and dry conditions, the New Jersey Department of Environmental Protection (NJDEP) declared a drought watch and requested voluntary water conservation for the northeast region of the state. Only a small portion of the Delaware River Basin (DRB) in Morris County was impacted by this declaration.
- On September 8, prompted by record-high temperatures and water demands, combined with near-record precipitation lows, NJDEP expanded the drought watch to include the entire state of New Jersey.
- On September 16, continuing declines in groundwater and surface water prompted the Pennsylvania Department of Environmental Protection to declare drought watches and warnings and request voluntary water conservation for 17 counties in the Pennsylvania portion of the DRB.
- On September 24, the DRBC declared a lower basin drought warning after storage in both the Beltzville and Blue Marsh reservoirs dropped below their respective drought warning elevations.

Dry weather persisted into early autumn and by the end of September, 90-day precipitation totals in a large region of the basin were only 50-75% of normal, with some localities receiving only 25-50% of their normal precipitation. Figure 1 presents the "percent of normal precipitation" for the three-month period preceding the arrival of late-September storms.

Drought relief arrived during the last days of September from two back-to-back storm events. The first storm occurred during September 27-28 and produced less than two inches of precipitation in eastern Pennsylvania and New York and less than one inch in the southern portion of the DRB. Due to the dry conditions and low runoff, this storm had little impact on streams and reservoirs in the basin. Within the same week, Tropical Depression 16 brought moisture up the east coast, through North Carolina, Virginia, and Delaware into eastern Pennsylvania, New Jersey, and New York. The system impacted the basin during September 30-October 1, producing high winds and three to seven inches of rain with locally higher amounts of eight to 10 inches. Major flooding[1] occurred on the West Branch of the Delaware River near Delhi, N.Y. and minor to moderate flooding took place at points along some of the Delaware's tributaries. The only points along the main stem Delaware River that experienced flooding were at Callicoon, N.Y. (moderate flooding) and Barryville, N.Y. (minor flooding).

The two September storms replenished waterways and reservoirs throughout the basin. On October 31, 2010, the DRBC's lower basin drought warning automatically terminated after water levels in Blue Marsh and Beltzville reservoirs recovered and remained above their respective drought warning storage elevations for 30 consecutive days as required by DRBC's Water Code. Hydrologic conditions continued to improve as the basin

[1] The terminology used to characterize the severity of flooding (major, moderate, and minor) is based on the National Weather Service's Advanced Hydrologic Prediction Service (AHPS) hydrographs, which are published on-line at the time of each storm event.

received more regular rainfall. This allowed New Jersey to end its statewide drought watch on October 26 for all but the Coastal North drought region, which was later lifted on November 9. On November 10, Pennsylvania lifted drought watches and warnings in its portion of the DRB.

Precipitation

Annual precipitation totals ranged from 39.50 inches in Lackawanna County, Pa. to 51.30 inches in Morris County, N.J. Annual precipitation departures-from-normal ranged from 4.70 inches (10.6%) below normal in Sussex County, Del. and Mercer County, N.J. to 6.70 inches (15.5%) above normal in Delaware County, Pa. Despite the lower basin drought, 26 of the 38 reported counties[2] within the DRB ended the year with above-normal precipitation.

The observed precipitation above Montague, N.J. was 47.30 inches, or 4.04 inches above normal, in 2010. Similarly, observed precipitation above Trenton, N.J. was 47.54 inches, or 2.65 inches above normal and precipitation at Wilmington, Del. was 43.96 inches, or 1.15 inches above normal. Figure 2 presents the annual precipitation by county in the basin and Table 1 presents normal and observed monthly precipitation totals at selected stations in the DRB for 2010.

Streamflow

Monthly mean streamflow observations at selected stations on the Lehigh River, Schuylkill River, and the main stem of the Delaware River were generally slightly below normal to above normal January through April 2010. Hot weather combined with drier than normal conditions produced below-normal streamflow during May through September for the majority of these stations.

Streamflows recovered during October after the storms of late September and the above-normal rainfall during October. Observed monthly mean streamflow at selected stations during October was the highest of any month during 2010. The Delaware River at Montague and Trenton averaged three to four times the normal October flow. Table 2 presents observed monthly mean streamflow at selected stations for 2010 and Figures 3 and 4 present annual hydrographs for 2010 at Montague and Trenton.

Reservoir Storage

Lower Basin

Streamflows declined to below-normal levels throughout the basin during the summer, which resulted in commission-directed releases from Beltzville Reservoir (located on the Pohopoco Creek, a tributary of the Lehigh River) and Blue Marsh Reservoir (located on the Tulpehocken Creek, a tributary of the Schuylkill River) to maintain the streamflow objective of 3,000 cubic feet per second (cfs) for the Delaware River at Trenton. DRBC-directed releases began in early July and were required almost daily during August and September. Beltzville and Blue Marsh reservoirs were depleted to drought warning storage elevations by late September, prompting DRBC to declare a lower basin drought warning on September 24. As a result of this warning, the Trenton flow objective was decreased from 3,000 cfs to 2,500 cfs. In addition, New Jersey's diversion of water from the Delaware River near Bull's Island through the Delaware and Raritan Canal was reduced from 100 million gallons per day (mgd) to 85 mgd.

Nine billion gallons (bg) of stored water was directed from the two reservoirs to meet the Trenton flow objective from July through September. Releases continued until late September when runoff from heavy rains

[2] This information is based on precipitation data from the National Weather Service (NWS) Middle Atlantic River Forecast Center for 38 of the 42 counties located either partially or completely in the DRB. Data for the remaining four counties are not available. Departures from normal are calculated by DRBC staff.

allowed storage in both reservoirs to recover and remain above drought warning elevations. The DRBC's lower basin drought warning was lifted on October 31, 2010. Figures 5 and 6 present reservoir elevations for 2010 for Beltzville and Blue Marsh.

No releases were made from Merrill Creek Reservoir during 2010. Storage in this reservoir, located near Phillipsburg, N.J., is used to replace evaporative water losses ("consumptive use") caused by power generation when the basin is under DRBC-declared drought operations and the equivalent average daily flow target for the Delaware River at Trenton is below 3,000 cfs. Although the criteria for releases was met, at the time the release should have occurred significant rain was forecast for the basin and DRBC requested that Merrill Creek refrain from making releases. Above-normal rainfall during October kept the streamflow at Trenton above 3,000 cfs and Merrill Creek releases were not required for the remainder of the lower basin drought warning.

Upper Basin

The three New York City (NYC) Delaware Basin reservoirs -- Cannonsville, Pepacton, and Neversink -- are located in the upper DRB and operated under the Flexible Flow Management Program (FFMP)[3]. On January 1, 2010, combined storage in the three NYC reservoirs was 246.1 bg, which is 91% usable capacity and 56.5 bg above the long-term median for the date. Combined storage in these reservoirs remained above the long-term median through early March, when it briefly dipped below the median for a 10-day period, then refilled to 100% usable storage capacity by late March. The normal refill date for the NYC reservoirs is May 1. By early April, combined storage was again on the decline and by late April, below-normal rainfall caused the combined storage to drop below the long-term median, where it remained for the duration of the summer. Combined storage did not go below the drought watch level during 2010; consequently, DRBC's basinwide drought operating plan was not triggered.

In late September, storms produced heavy rain in the DRB. The runoff produced from these storms replenished the reservoirs and combined storage was above the long-term median in early October, where it remained until the end of the year. Figure 7 presents NYC reservoir storage levels for 2010.

The Office of the Delaware River Master directed releases from the NYC reservoirs during 2010 to meet the normal flow objective of 1,750 cfs for the Delaware River at Montague. Releases totaling approximately 43.7 bg were directed from the NYC reservoirs during dry periods from June through September. By comparison, directed releases totaled 9 bg in 2009 and 101 bg during the drought year 2001. DRBC directed additional releases in 2010 totaling 4.09 bg from the Interim Excess Release Quantity (IERQ), a bank of water used to protect fisheries habitat and to meet the Trenton flow target.

Temporary Supplemental Release Program

In the fall of 2009, the FFMP was adjusted by the five Decree parties to include a Temporary Supplemental Release Program (TSRP). The TSRP, developed in response to work that was needed on the Rondout West Branch Tunnel, allowed for additional water to be released from the NYC reservoirs than was normally authorized under the FFMP. The extra releases under the TSRP were intended to reduce the NYC reservoirs by the amount of storage that could not be diverted to Rondout during the time the Rondout West Branch Tunnel was shut down for repairs. The TSRP, implemented by the NYC Department of Environmental Protection, was in effect from September 1, 2009 through May 31, 2010.

[3] Beginning in October 2007, the NYC reservoirs were operated in accordance with the FFMP, a temporary operations plan unanimously approved by the parties to the 1954 U.S. Supreme Court Decree (four basin states and NYC).

Groundwater

The average monthly groundwater level in eight reported U.S. Geological Survey (USGS) observation wells in the Pennsylvania portion of the basin remained above the long-term average for the first four months of 2010. In response to drier conditions, the average monthly level declined to below the long-term average by May. This downward trend continued through September when conditions began to recover after above-normal rainfall returned to the basin. Despite significant gains during the last quarter of the year, the average monthly groundwater level remained below the long-term average at the end of 2010.

The groundwater level in the New Castle County, Del. coastal plain well began the year above the normal range[4]. By April, drier conditions caused the water level to decline into the normal range. Although this downward trend continued for the remainder of the year, the water level remained within the normal range at the end of 2010.

The groundwater level in the Cumberland County, N.J. coastal plain well began the year above the normal range. By May, water levels trended downward, responding to drier conditions during the spring and summer months. The water level was in the normal range in September before increasing to above the normal range in October, where it would remain until the close of 2010. Figures 8, 9, and 10 provide graphical presentations of groundwater levels throughout the year for the eight USGS network wells in Pennsylvania, the Delaware Geological Survey (DGS) well in New Castle County, and the USGS well in Cumberland County.

Salt Front

The *salt front* is defined as the 250 parts-per-million (ppm) isochlor. The seven-day average location of the salt front is used by DRBC as an indicator of salinity intrusion in the Delaware Estuary. The salt front's location fluctuates along the main stem Delaware River as streamflow increases or decreases in response to changing inflows, diluting or concentrating chlorides in the river. Long-term average mid-month locations range from river mile 61 in mid-April (0.5 miles below Pea Patch Island, Del.) to river mile 81 in mid-October (Marcus Hook, Pa.). The farthest recorded upstream location of the salt front, river mile 102, was measured during the 1960's drought of record.

During 2010, the salt front location reached river mile 86 in late September, a location that is eight miles upstream of the Delaware-Pennsylvania state line and six miles downstream of the mouth of the Schuylkill River. Figure 11 presents the seven-day average location of the 250-ppm isochlor during 2010.

[4] *Water level ranges are defined as: Above Normal (>75-percentile); Normal (25- to 75- percentile); Below Normal (<25-percentile).*