2019

Hydrologic Conditions in the Delaware River Basin

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

Water Resource Operations

2019 Highlights

Following the record-breaking year of 2018, the high precipitation pattern continued during the first half of 2019. Among the official National Weather Service (NWS) Automated Surface Observing System (ASOS) observations[1], three locations within the basin had the wettest May-July periods on record.

- **Trenton, NJ** accumulated 20.66 inches of rain over the period, breaking the previous record of 18.94 inches set in 2013. This was even higher than the record-breaking year of 2018, which only received 18.08 inches of rain for the same period. Normally, Trenton receives around 13.7 inches May-July.
- **Allentown, PA** received a total of 24.41 inches of rain during May-July, breaking the previous record of 24.08 inches set back in 1984. This is 11 inches above the normal amount received during this time.
- **Reading, PA** had the largest accumulation of precipitation through the period of 24.61 inches, exceeding the previous record of 20.66 inches set in 2004. The record was broken on July 10, 2019 – over 20 days before the end of the period. The normal precipitation for Reading for May-July is only 12.5 inches, almost half of 2019's May-July total.

Although a wet year by many standards, 2019 also contained a dry period. Two stations had the second driest September on record in 2019, and one station had the driest September on record.

- **Sussex, NJ** only received 0.73 inches in September, breaking the previous record by 0.07 inches and becoming the driest September on record. The normal September precipitation in Sussex is 3.91 inches.
- **Wilmington, DE** had 0.48 inches of rain fall, and was the second driest September on record, after September of 2005 (0.44 inches). Normally, Wilmington receives 4.32 inches in September.
- **Mount Pocono, PA** accumulated 1.29 inches of rain, ranking second for least amount of rain in September. The record for driest September in Mount Pocono was set in 2014 at 1.1 inches. Normally, Mount Pocono receives 5.3 inches of rain for September. It is notable that if it were not for

[1] Source: Applied Climate Information System (ACIS) via https://xmacis.rcc-acis.org/

a storm on September 2, this year would have been the driest September on record for Mount Pocono.

The wet period earlier in the year led to high streamflows in some areas. The Schuylkill River at Philadelphia reached 250 percent of its normal streamflow in July[2]. The dry period late Summer into early Fall led to below average stream flows. In particular, the month of September had the lowest streamflows of 2019. The United States Geological Survey (USGS) stream gages at Montague, Trenton, and the Schuylkill River at Philadelphia recorded average monthly streamflow less than 50 percent of normal[2].

Releases from the both the New York City (NYC) reservoirs (Cannonsville, Pepacton, and Neversink)[3] and the United States Army Corps of Engineers (USACE) reservoirs[4] were required to meet flow objectives set by the Water Code[5]. The minimum combined storage in the NYC reservoirs occurred on October 14, 2019 at a value of approximately 150 BG.

Precipitation

Precipitation totals varied by location within the basin. The central region of the basin received 67 inches of precipitation, the most in the basin. The least amount fell in the southern part of the basin, where some areas only received 39 inches for the year. Table 1 lists rainfall, departures and ranks for the nine representative locations[6]. Figure 1 presents maps of rainfall amounts and departures[7].

The driest area of the basin was in the far western area, near the head waters of the Schuylkill River in PA. Precipitation in these areas was approximately nine inches below normal. The dry area was localized. Some areas just to the south received up to 20 inches above normal. Figure 1 presents precipitation amounts and departures for 2019. The upper basin and parts of the southern part of the basin received normal amounts of precipitation, while near the estuary and coast precipitation totals were below average for the year. The total annual

[2] Source: USGS National Water Information System (NWIS) via https://waterdata.usgs.gov/nwis
[3] Source: New York City Water Supply Control Center (NYC WSCC)
[4] Source: DRBC
[5] https://www.nj.gov/drbc/library/documents/watercode.pdf
[6] Source: ACIS
[7] Source: Advanced Hydrologic Prediction Service (AHPS) Precipitation Analysis - https://water.weather.gov/precip/

precipitation across the basin varied by approximately 20 inches among the NWS ASOS observing stations. Figure 2 shows total annual precipitation for 2019 at nine locations in the basin[8].

Figure 3 details the monthly precipitation amounts at each of the nine stations[8]. In the months May-July, many areas of the basin received much above normal rainfall amounts. Three stations received the most rainfall for the period May-July in the period of record. These stations were Reading, PA, Allentown, PA, and Trenton, NJ. Many other stations also ranked in the top 5 for most precipitation for the months of May-July[8].

In contrast, September 2019 was a dry month, and three stations (Mount Pocono, PA, Wilmington, DE, and Sussex, NJ) ranked the second driest September on record[8]. All other stations ranked within the top ten years for driest September. Two stations (Mount Pocono, PA and Reading, PA) would have been the driest September of their respective periods of record, if not for a storm that impacted the region on September 2nd, 2019[8].

Streamflow

The first half of the year featured many high streamflow events with the continued high precipitation pattern from the Fall of 2018. January and February had monthly average flows of approximately twice normal values. The basin received normal amounts of precipitation in March, which resulted in approximately normal streamflow at most gages. The wet period of the early part of the summer also resulted in high flows, with the Schuylkill river at Philadelphia reaching up to 250 percent of normal. Other gages such as Trenton, Montague, and the Lehigh River at Bethlehem were up to 200 percent of normal streamflow during the early part of the summer[9].

In August through October, below normal streamflow was observed at most monitoring stations. September was dry with most stations reporting 50 percent of normal stream flow for the month. Figure 4 presents the time-series (hydrographs) and average monthly flow for 2019 at Montague, Bethlehem,

[8] Source: ACIS
[9] Source: USGS NWIS

Trenton, and Philadelphia. At the end of the year, most flows were normal or near normal across the basin for November and December[10].

Reservoir Storage and Releases

Lower Basin

Both 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) maintained storage in the normal range during 2019[10]. The Delaware River Basin Commission's (DRBC) Lower Basin drought operating plan was not implemented because the reservoir water level criteria at both reservoir were not met.

Releases of water from Beltzville Reservoir were made at DRBC's request on September 21 and 22 to support the Trenton Flow Objective. A total of 0.148 billion gallons were used[11]. The releases were made in advance of requests for water from the Excess Release Quantity, a volume of water in the NYC reservoirs reserved for use by the lower basin. A total of 1.3 BG was released at DRBC's request from the Excess Release Quantity for the Trenton Flow Objective[12].

Beltzville and Blue Marsh remained at their normal pool elevations for most of the year, as shown in Figures 5 and 6[10]. In accordance to the operating plan, storage in Blue Marsh was reduced to its winter pool starting in mid-October, and remained there from November through the end of the year.

Releases were not made from Merrill Creek Reservoir during 2019[13]. At the beginning of 2019, Merrill Creek Reservoir held approximately 15.6 BG of water. At the end of year, the reservoir held approximately 15.5 BG of water. Storage in Merrill Creek Reservoir, located in Phillipsburg, New Jersey, is used to replace evaporative losses caused by power generation when the basin is under DRBC-declared drought operations and the equivalent average daily flow target at Trenton, New Jersey is below 3,000 cfs.

Upper Basin

[10] Source: USGS NWIS
[11] Source: DRBC
[12] Source: NYC WSCC
[13] Source: Merrill Creek Reservoir Administration

Releases from the three NYC Delaware River Basin (DRB) Reservoirs were made in accordance with the 2017 Flexible Flow Management Program[14]. The River Master directed releases from the NYC reservoir to meet the Montague flow objective. The volume of water released for Montague was approximately 26 BG, from August 3rd until October 13th. Releases for thermal mitigation and rapid flow change mitigation totaled 994 million gallons (MG) and 477 MG, respectively[14]. Thermal mitigation releases were made for six multi-day events (17 days total) in July and early August. Rapid flow change mitigation releases were made for two events in October[14].

As of January 1st, 2019, the combined reservoir storage of the NYC reservoirs was 264 Billion Gallons (BG). All three NYC reservoirs spilled in April. The combined storage was approximately 150 BG on October 14th, 2019, its lowest value for the year and approximately 50 BG above drought watch at that time. At the end of December, the combined storage was 240 BG, 15.6 BG above the long-term median for December[15]. Figure 7 presents the combined storage of the NYC reservoirs for 2019.

Groundwater

Groundwater levels in the eleven indicator wells for the basin remained mostly in the normal or even above normal range[16]. Most wells experienced a sharp decrease in groundwater levels starting in July. A few wells in the western and northern parts of the basin reached below normal levels (classified as drought watch using USGS Statistics[17]) in early October before a series of storms during the second half of the month recharged the aquifers. At the end of 2019, most wells were in the range of normal conditions, with a few nearing drought watch levels. Figure 8 presents the time series of groundwater levels at four of the eleven representative wells for the basin.

[14] Source: Office of the Delaware River Master (ODRM)

[15] Source: NYC WSCC

[16] Source: USGS Groundwater Watch - https://groundwaterwatch.usgs.gov/usgsgwnetworks.asp

[17] http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=60995&DocName=DROUGHT%20MANAGEMENT%20IN%20PENNSYLVANIA.PDF%20%20%3Cspan%20style%3D%22color%3Agreen%3B%22%3E%3C%2Fspan%3E%20%3Cspan%20style%3D%22color%3Ablue%3B%22%3E%3C%2Fspan%3E%2011%2F9%2F2020.

Salt Front

The salt front is defined as the 250 parts-per-million isochlor. The seven-day average location of the salt front is used by DRBC as an indicator of salinity intrusion in the Delaware Estuary for reservoir operations. The location of the salt front fluctuates along the main stem Delaware River as streamflow increases or decreases. During low flows, chlorides become concentrated in the river due to the reduced amount of freshwater entering the estuary. Long-term median mid-month locations range from river mile 67 in April (two miles downstream of the Delaware Memorial Bridge) to river mile 76 in September (two miles downstream of the Pennsylvania-Delaware State line)[18].

In 2019, the salt front began the year below Reedy Island (River Mile 54 or RM54). DRBC does not report the approximate location of the salt front below RM 54 due to unavailability of specific conductance data needed for the calculation[19]. For the first half of the year, the salt front oscillated above and below Reedy Island, in response to the high flow events. In July, the salt front began moving upstream. As flows decreased starting in September, the salt front moved upstream more quickly. The most upstream seven-day averaged location of the salt front was approximately RM 86 in mid-October before rapidly receding to river mile 68 over the course of two weeks, in response to a high flow event. The salt front fluctuated between RM 68 and 72 for the remainder of the year. The time series of daily location and seven-day average location are presented in Figure 9.

[18] Source: DRBC

[19] The DRBC Calculates the salt front location when data is available. USGS data was used to calculate the location, and were considered to be Accepted at the time of the creation of this report (October 2020).

Tables and Figures

Station	Number of Years Reporting	2019 Precipitation Total	Normal	Departure	Annual Rank
Reading, PA	70	53.75	43.27	+10.48	3
Callicoon, NY	9	58.53	53.54	+4.99	3
Allentown, PA	80	60.66	45.53	+15.13	4
Trenton, NJ	40	50.39	46.44	+3.95	6
Sussex, NJ	19	40.77	45.28	-4.51	10
Philadelphia, PA	80	47.43	51.53	+5.9	20
Wilmington, DE	71	47.97	43.08	+4.89	20
Mount Pocono, PA	19	47.73	48.78	-1.05	11
Millville, NJ	61	40.51	41.59	-1.08	39

Table 1: Precipitation Statistics and observations for representative locations in the basin. Upper Basin locations include Callicoon, NY; Mid-Upper Basin locations include: Sussex, NJ (note: just outside the basin), Mount Pocono, PA; Allentown, PA; Mid-Lower Basin locations include: Trenton, NJ; Reading, PA; Philadelphia, PA; Lower Basin locations include: Wilmington, DE; Millville, NJ. Source: ACIS

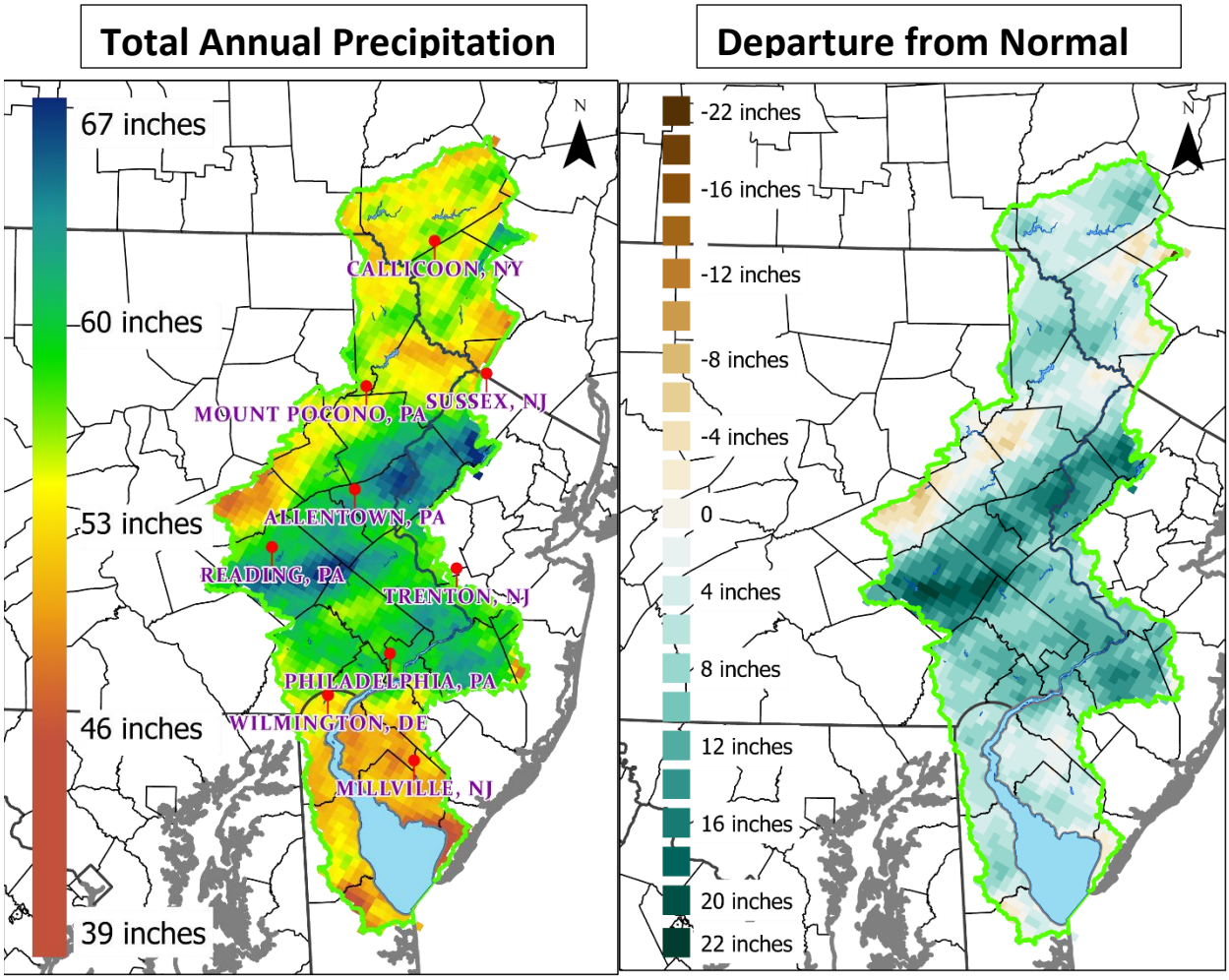

Figure 1: Total Annual Precipitation (left) and departure from normal (right) for 2019. Lighter browns correspond to drier areas, while darker greens correspond to wet areas. A corridor of wet conditions occurred along an axis southwest to northeast through the center portion of the basin, including the stations of Reading, PA and Allentown, PA. Source: AHPS Precipitation Analysis

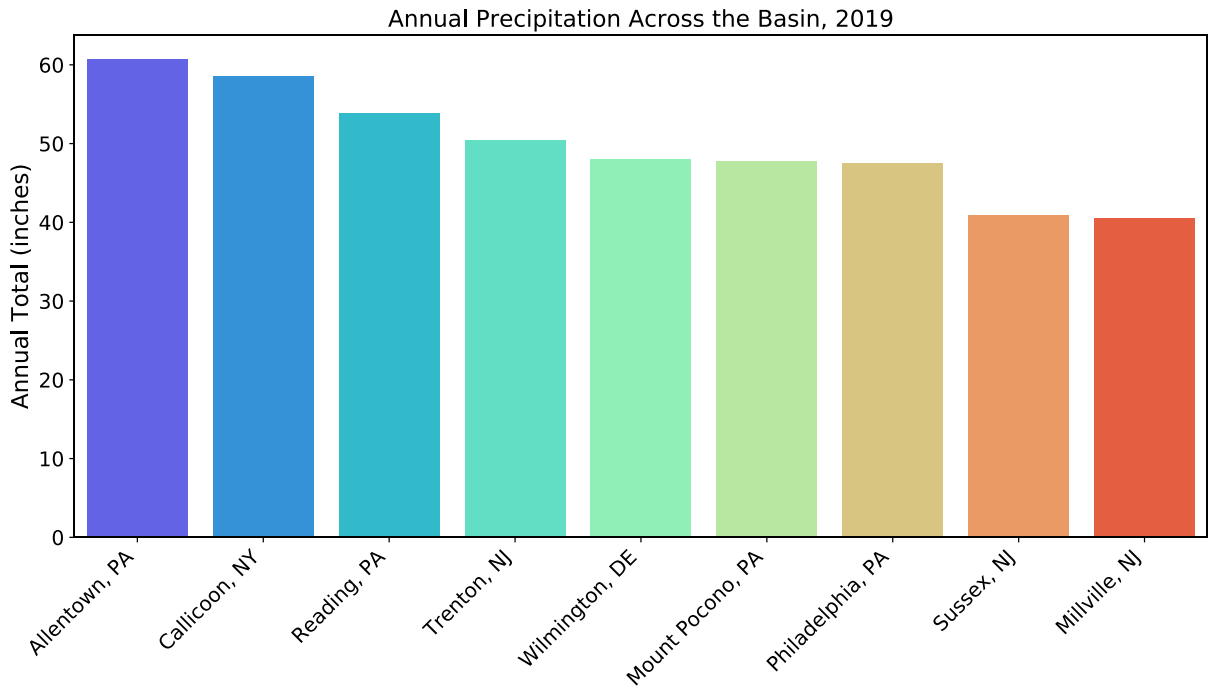

Figure 2: Precipitation totals at nine locations in the basin for 2019. The difference from the largest amount to the smallest amount was approximately 20 inches. Southern areas received less precipitation than northern regions of the watershed. Source: ACIS

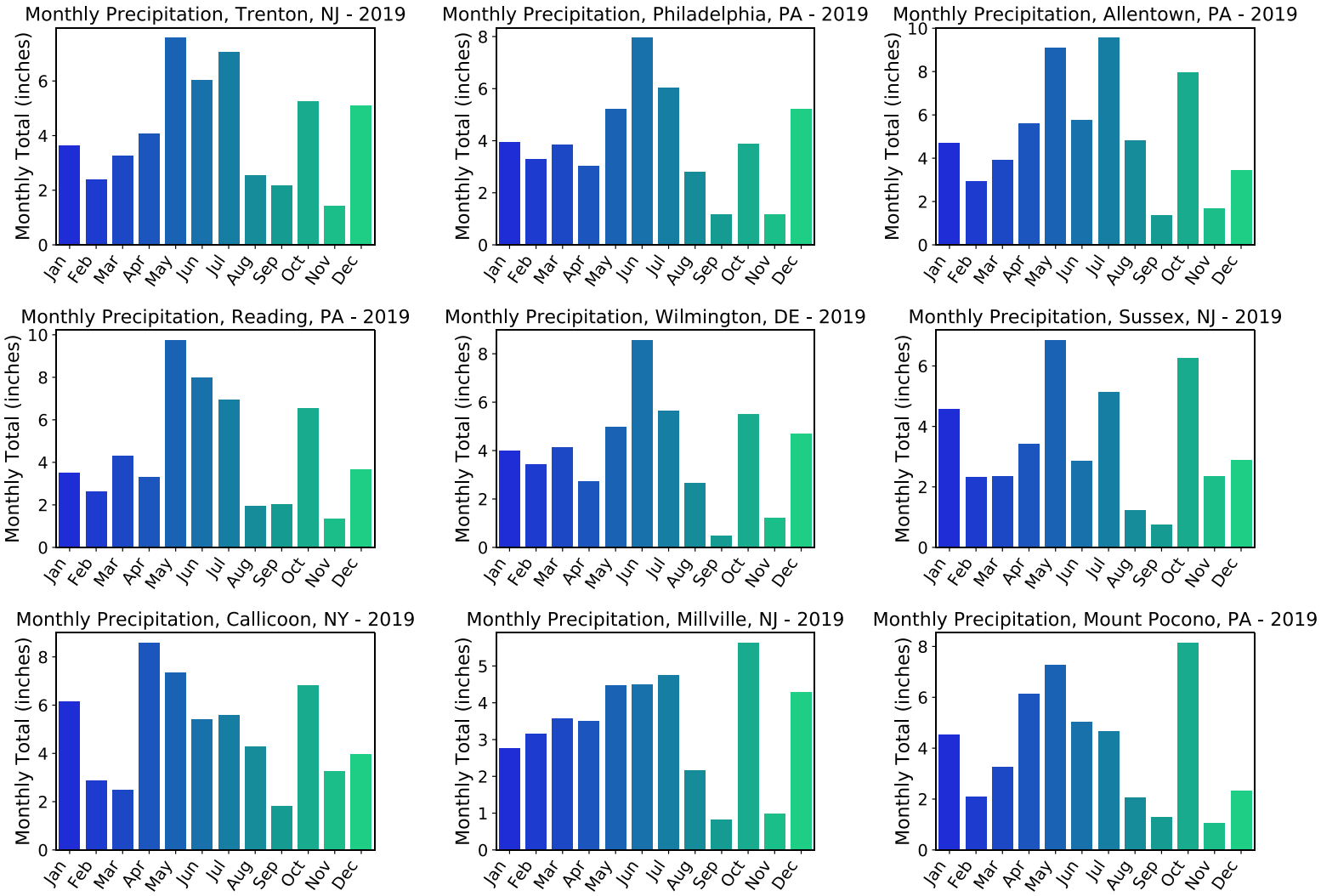

Figure 3: Pattern of monthly precipitation at each representative station throughout the basin. Similar patterns include the wet period May – July, and the dry period August – September. October featured a return to wet conditions, before November became dry again. Reading, PA received the most rain for the month of May, totaling close to 10 inches. Wilmington, DE received the least amount of rain during September, with less than 0.3 inches. Source: ACIS

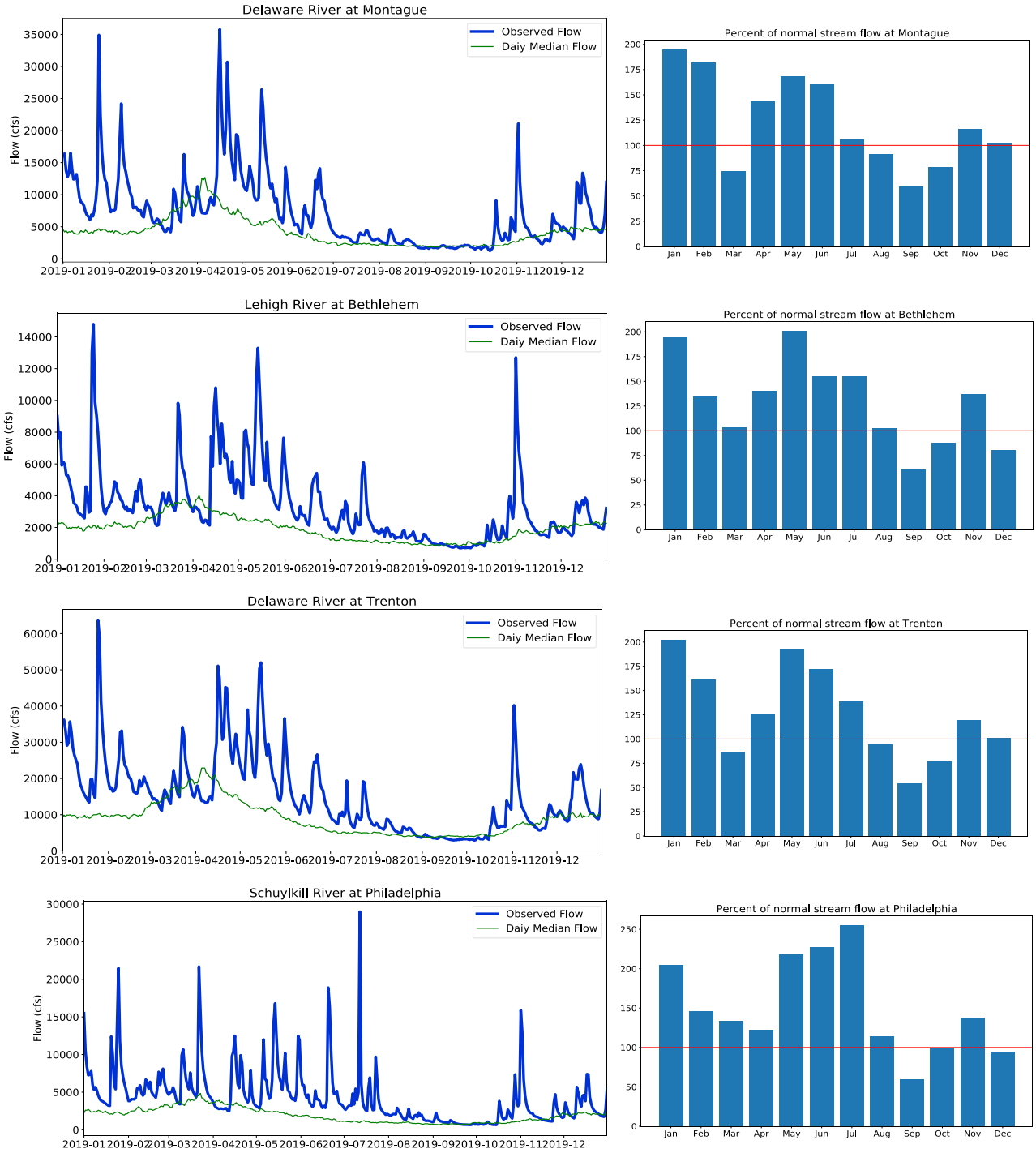

Figure 4: Time-series of streamflow (blue) at four gages in the Delaware River Basin along with the daily median flow (green) (graphics on the left). Percent of normal monthly flow at four gages (graphics on right), with normal flow shown as the red horizontal line. Source: USGS NWIS

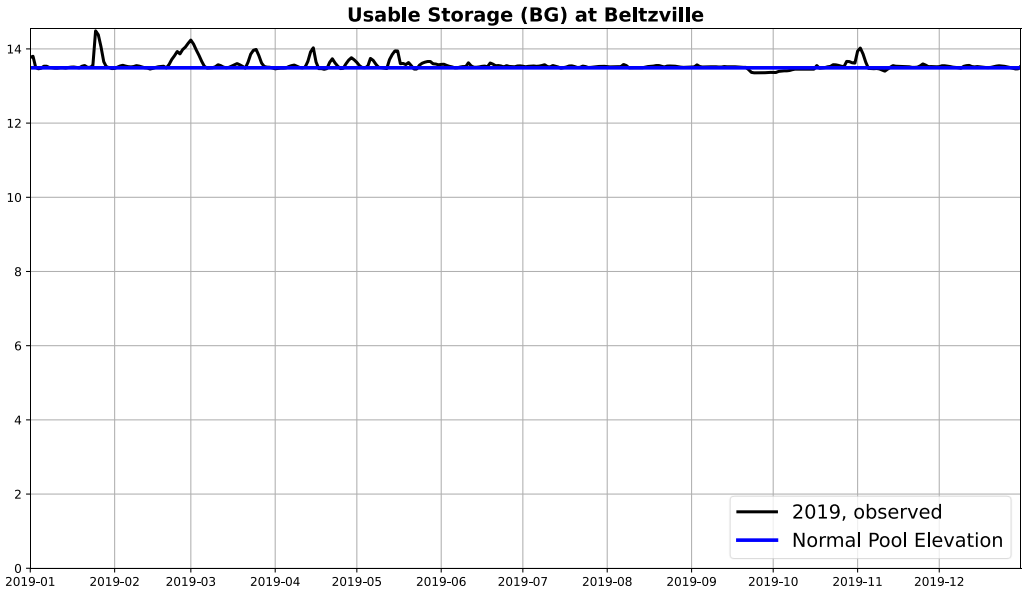

Figure 5: Usable Storage in BG at Beltzville Reservoir. The slight reduction in storage in September occurred because DRBC asked for water to meet the Trenton Equivalent Flow Objective. Source: USGS NWIS

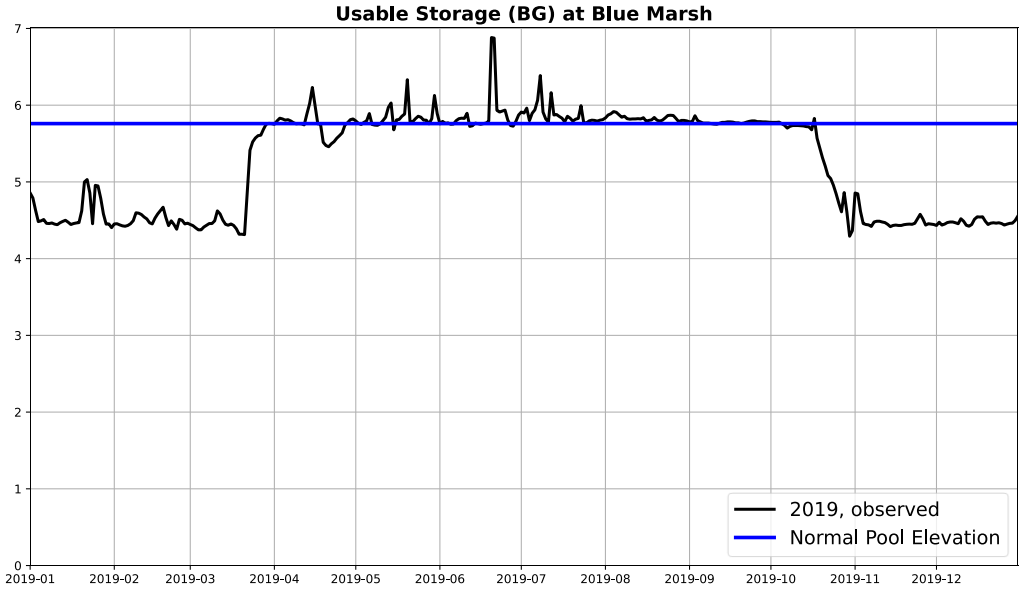

Figure 6: Usable Storage in BG at Blue Marsh Reservoir. Storage remained at or above normal, with a few decreases in storage due to anticipation of heavy rain events. The filling in March to the summer pool and dewatering in October to the winter pools are also evident. Source: USGS NWIS

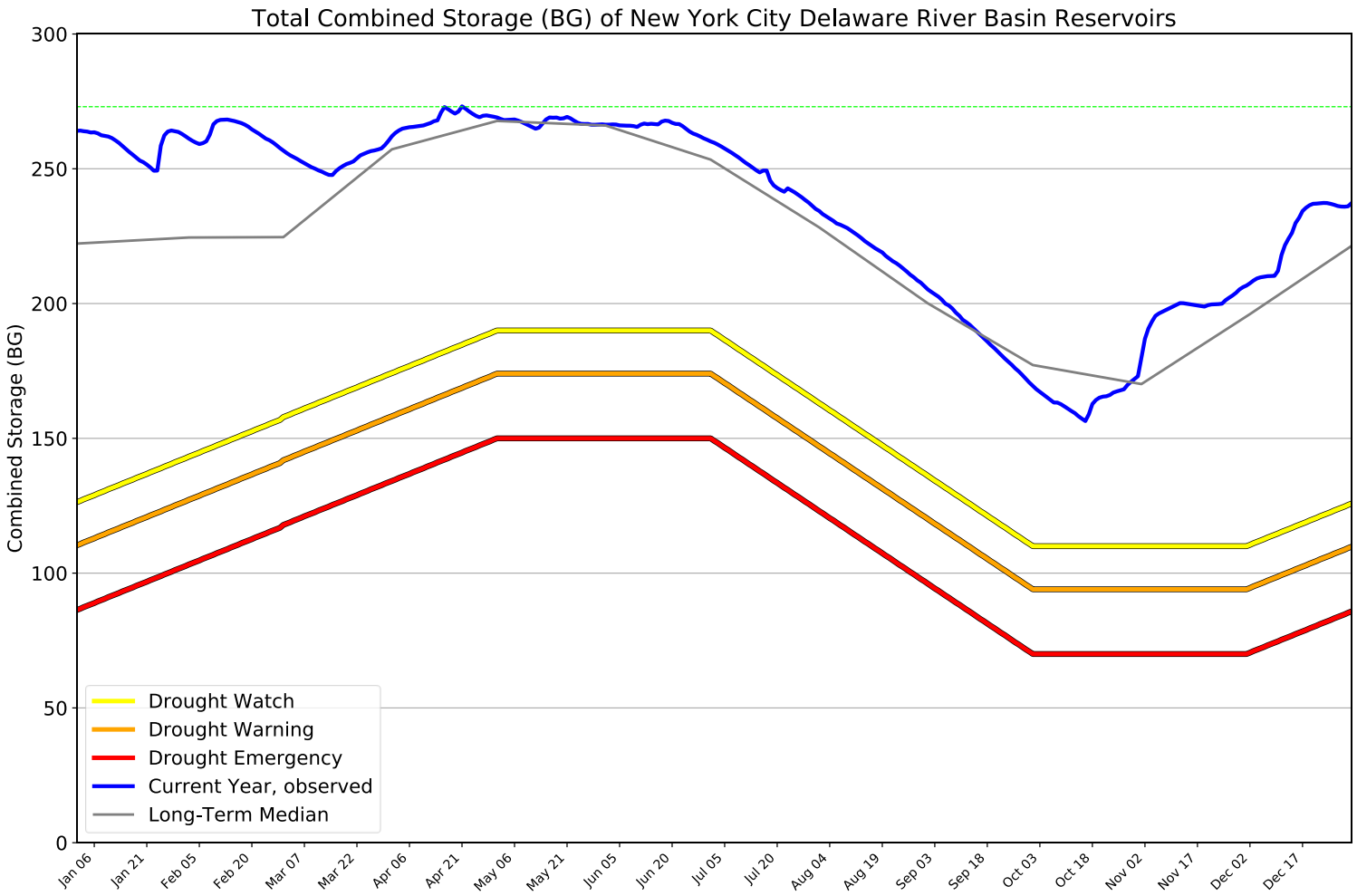

Figure 7: Combined Storage from the NYC DRB reservoirs (Pepacton, Cannonsville, and Neversink). Storage was above the long-term median for much of the year except from mid-September to mid-October, when inflows were low. On October 14, the level came within approximately 50 BG of a drought watch. Source: NYC WSCC

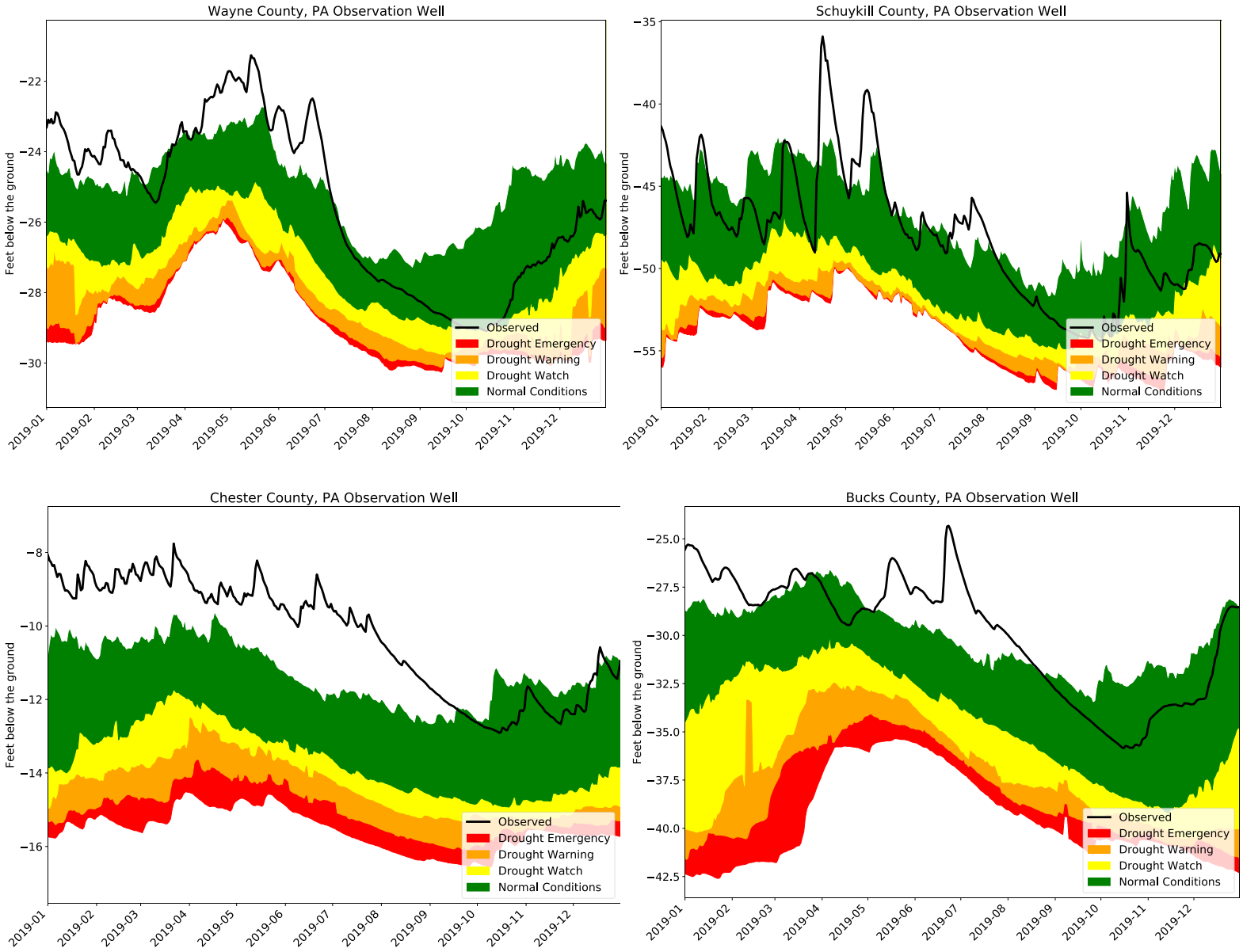

Figure 8: Water levels at four representative groundwater wells in the basin. Upper basin well – Wayne County, PA. Mid-Upper basin well – Schuylkill County, PA. Mid-Lower basin well – Chester County, PA. Lower basin well – Bucks County, PA. Ground water levels were much above normal for most for the year, except in the fall when the upper basin and mid-upper basin wells briefly reached drought watch levels. Source: USGS Groundwater Watch

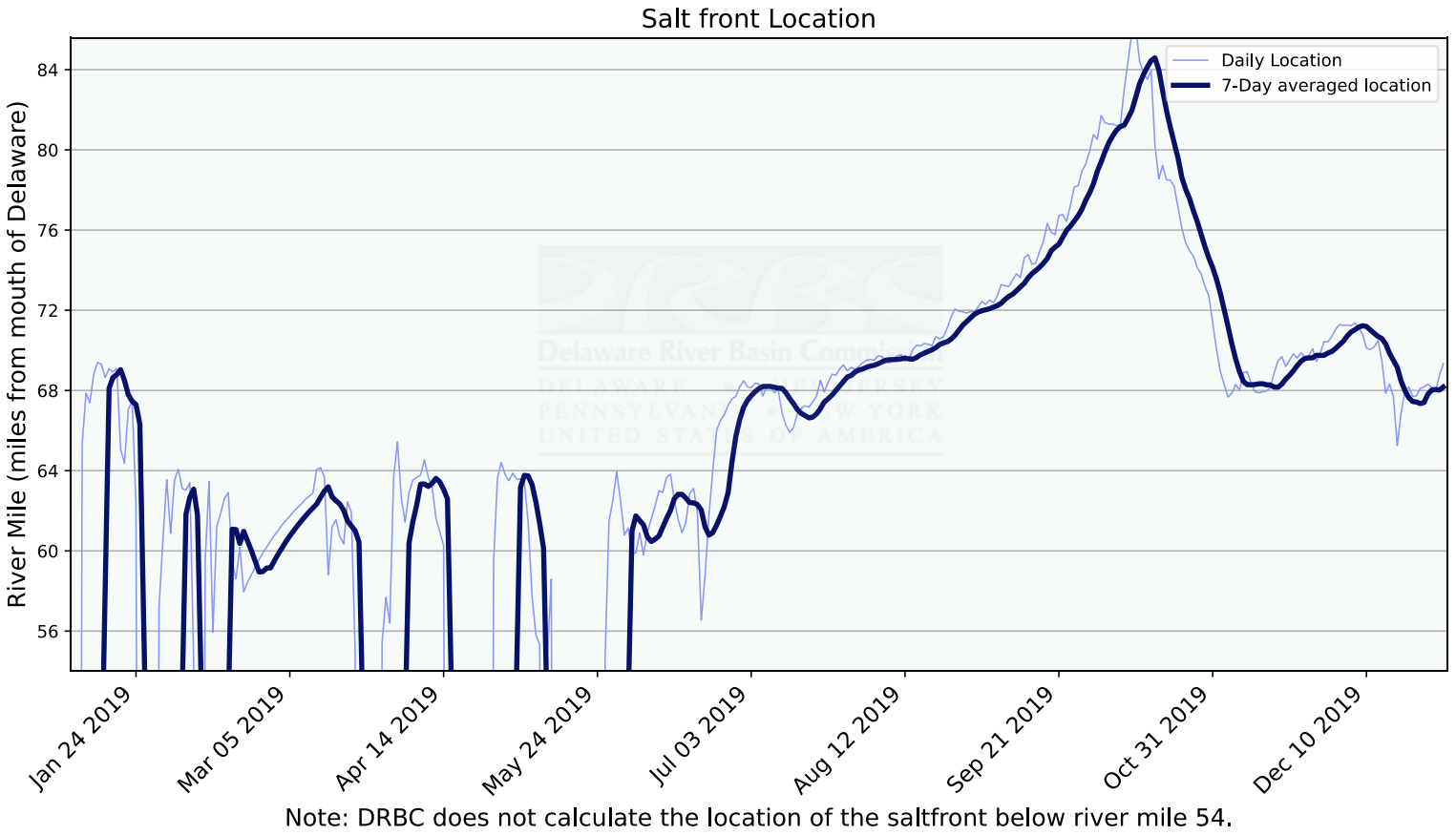

Figure 9: Salt front location time series for 2019. The salt front location was in its normal range or below the normal range during the first half of the year. The salt front moved upstream in July until reaching its maximum location of near River Mile 85 in mid-October. The salt front returned to the normal range in November of 2019. Source: USGS/DRBC

This report was compiled by DRBC staff in October of 2020.