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MEMORANDUM

Flexible Flow Management Program: Performance Report June 1, 2023 – May 31, 2024

The goals of the Flexible Flow Management Program (FFMP)[1] are to protect water supplies, manage droughts and maintain flow objectives during periods of low flows. In addition, conservation releases are enhanced to maintain tailwater temperatures, and to minimize spilling of reservoirs through use of the Conditional Seasonal Storage Objective (CSSO). The following is a summary of the performance of the FFMP during the release year 2023 – 2024 (June 1, 2023, through May 31, 2024).

In the upper basin, above Montague, precipitation was an inch or more above average for eight months (July, August, October, December, January, March, April and May) and a half inch or more below average for three months (October, November, and February)[2]. June had normal precipitation. In the lower basin, above Trenton, precipitation was an inch or more above average for seven months (June, July, September, December, January, March and April) and a half inch or more below average for five months (August, October, November, February and May)[2].

The combined storage in the New York City reservoirs is used to define drought levels for the basinwide drought management plan, adopted in the Delaware River Basin Water Code (18 CFR 410 Part 410) and incorporated in the FFMP. During the release year, the combined storage was not less than the drought watch line, and the drought management plan was not implemented. At the beginning of the release year, storage in the three New York City (NYC) reservoirs (Pepacton, Cannonsville, and Neversink) was below the median value. In mid-August, the storage entered the discharge mitigation zone (L1) and remained relatively steady until December. Heavy rain events at the end of December resulted in combined storage greater than 100 percent. The reservoirs spilled intermittently until February, when below normal precipitation occurred. The reservoirs filled again with intermittent spilling from early March until late April. The storage then began to decrease with increased diversions to meet summer water demands. For information about hydrologic events is available in the Annual Hydrologic Conditions Reports for the Delaware River Basin, published on the Delaware River Basin Commission (DRBC) website[3].

The FFMP established four banks of water from the NYC reservoir storage used for specific purposes from the Interim Excess Release Quantity. The Interim Excess Release Quantity (IERQ) with a total of 10 BG (15,468 cfs-days) is provided to further protect the ecology of the river by supporting releases for Thermal mitigation (1.6 BG or 2,500 cfs-days), Rapid Flow Change Mitigation (0.6 BG or 1,000 cfs-days), the Trenton Equivalent Flow Objective (6.1 BG or 9,423 cfs-days), and the New Jersey Diversion Amelioration (1.6 BG or 2,545 cfs-days). Another bank of water, called the New Jersey Diversion Offset

[1] https://webapps.usgs.gov/odrm/documents/ffmp/Appendix_A_FFMP-20180716-Final.pdf
[2] Data Source: Applied Climate Information System - https://www.rcc-acis.org/
[3] https://www.nj.gov/drbc/programs/flow/annual-hydro-reports.html

Bank is accumulated during the summer season and amounted to 1.3 BG (2,075 cfs-days) during the release year, but was not needed. In release year 2023-2024, the rapid flow change mitigation bank was not used. Releases of 234 cfs-days were used from the thermal mitigation bank (described below). No releases were required from the Trenton Flow Objective bank or New Jersey Diversion Offset Bank. The other banks were not used.

The flows at Montague[4] and Trenton[5] were below normal in June. Beginning in July, flows were above normal[6] for most of the time between July and November, mid-December through mid- February, and intermittently from late- March into mid-April. The rapid increases in flow were observed after high volume rainfall events in December, January, February, March and April. Flows were in the normal range in late fall and after mid-April. In 2023-2024 no water in excess of the conservation releases was required from the NYC reservoirs to meet the flow objective at Montague or from the lower basin reservoirs (Blue Marsh and Beltzville) to meet the flow objective at Trenton.

As defined in the FFMP, the diversion from NYC is limited to 800 million gallons per day (mgd) based on a running average beginning on June 1 until May 31 of the previous year. The running average did not exceed 800 mgd during the release year 2023-2024. The average diversion from the NYC reservoirs during the release year 2023-2024 was 410 mgd. In New Jersey, the diversion is limited to 100 mgd as a monthly average. The average diversion for the release year 2023-2024 was 87 mgd. The monthly diversions were approximately 100 mgd for June through September.

Conservation releases are designed to protect the ecology of the stream reaches below the NYC reservoirs. In release year 2023-2024, the required conservation releases based on the FFMP tables were as follows: Cannonsville – 168,932 MG, Pepacton – 81,330 MG, and Neversink – 31,363 MG**Error! Bookmark not defined.**. All or a portion of the releases on a given day may have been used to meet the Montague Flow Objective. The 4G release table was used for all of the release year 2023-2024**Error! Bookmark not defined.**.

The thermal releases are designed to protect stream reaches below the NYC reservoirs from exceeding 24 degrees C, with a goal of the temperature not exceeding 20 degrees C (FFMP). In release year 2023-2024, the stream reaches at Bridgeville, Lordville, Hale Eddy, Harvard, and Hancock never exceeded 24 degrees C[7]. Releases from the thermal bank were made on 5 days for 2 events in July 2023, and September 2023. A total of 234 cfs-days (0.15 BG) used in total for thermal mitigation**Error! Bookmark not defined.**. The summer of 2023 (June – August) was the 58th warmest summer on record for the Upper Basin and 31st warmest the Lower Basin[8].

To enhance flood mitigation, water is released from the NYC reservoirs based on a Conditional Seasonal Storage Objective (CSSO). Discharge mitigation releases are made from a reservoir when the combined storage is in the L1 zone, and the individual reservoir elevation/storage is above the CSSO. Releases to achieve the CSSO create a high probability of maintaining fifteen percent void spaces in individual reservoirs between November 1 and February 1, and at least a ten percent void space in individual

[4] USGS 01438500 - https://waterdata.usgs.gov/usa/nwis/uv?01438500
[5] USGS 01463500 - https://waterdata.usgs.gov/usa/nwis/uv?01463500
[6] Normal is defined as the 25th to 75th percentile of flow on a given day
[7] Data Source: USGS Gages (01426500, 01417500, 01427000, 01436690, 01427207)
[8] NCEI NCDC - https://www.ncdc.noaa.gov/cag/national/rankings

reservoirs between approximately September 15 and March 1. Discharge mitigation releases for this release year were 117,674 MG from Cannonsville, 68,002 MG from Pepacton, and 24,683 MG from Neversink and the reservoir elevations were above the CSSO for 165, 236, and 249 days, respectively. Cannonsville reservoir spilled 30,614 MG over 79 days, Pepacton reservoir spilled 39,311 MG over 72 days. Neversink reservoir spilled 17,015 MG over 89 days**Error! Bookmark not defined.**. Hale Eddy gage, below Cannonsville, was above action stage for 7 non-sequential days. Harvard gage, below Pepacton, was above action stage for 4 non-sequential days. It should be noted that Locations below the reservoirs can reach NWS Action Flood Stage in the absence of, or prior to, significant spills.

As established in the Delaware River Basin Water Code[9], DRBC is responsible for managing salinity intrusion in the Delaware River by maintaining the flow objective at Trenton, N.J. The purpose of the flow objective at Trenton is to prevent the salt front, an indicator of salinity intrusion, from moving too far upstream. The salt front is a calculated indicator based on the 7-day average location of the 250 mg/L isochlor in the river[10]. The normal range of the salt front is between river mile 67 and 76 (river miles are defined as the along-channel distance from the mouth of the estuary). The DRBC directs releases from reservoirs to meet the flow objective, which impedes the upstream movement of the salt front to protect drinking water intakes near Philadelphia, PA approximately 110 river miles from the mouth of the bay. In accordance with both the Water Code and the FFMP 2017 agreement, in a drought emergency, the flow objectives depend on the location of the salt front. The increased Montague flow objective provides more water from the upper basin to reduce the amount of water needed from the lower basin reservoirs to meet the Trenton flow objective. During the 2023-2024 release year, a drought emergency did not occur in the basin, and releases were not made for management of the salt front.

The salt front was in or near the normal range from June through November. At the end of the year, the salt front was below RM 54 due to heavy rain that occurred in December. The salt front was at its most upstream location on November 22 at RM 71.8. From February through March, the salt front moved downstream again due to a higher-than-normal precipitation in February and March along with typical higher spring flows. For a two-week period in March, the salt front moved upstream near river mile 68 due to average flows. Flows increased after another Nor'Easter in the first week of April, and the salt front was below river mile 54 by the end of the month[11]. In May, the Reedy Island gage was out of service and salt front information could not be calculated.

Summary: In release year 2023-2024, precipitation above normal across the basin. The NYC Storage was above the long-term median for most of the year, except in June through mid-July and mid-April through May. Flows were above normal for much of the year and only below the normal range in June. Brief periods of normal flow occurred in late fall, February and after mid-April. The NYC Diversion and NJ Diversion did not exceed their respective limits as set forth in the Water Code and FFMP. The conservation releases were in Table 4G for the entire release year. Warm summer air temperature led to increased water temperatures at the beginning of the release year, and thermal mitigation was used for three days July and two days during September 2023. Discharge mitigation releases were needed for much of the year. The salt front was in or below the normal range and its most upstream location was

[9] https://www.nj.gov/drbc/library/documents/watercode.pdf
[10] https://www.nj.gov/drbc/programs/flow/salt-front.html
[11] The location of the salt front below river mile 54 is unavailable due to the lack of data for the calculation.

RM 71.8 on November 22, 2023, one mile upstream of the confluence of the Delaware and Christina Rivers.

For non-provisional, approved data, contact the Delaware River Basin Commission (salt front), the NYC Department of Environmental Protection (NYCDEP), the Office of the Delaware River Master (ODRM), or the United States Geological Survey (USGS)[12]. This report is available online at: https://www.nj.gov/drbc/programs/flow/FFMP_PerformanceRpts.html

ACKNOWLEDGEMENTS

This report was prepared by the Delaware River Basin Commission staff. Ms. Sara Sayed and Ms. Amy Shallcross, P.E., Manager of Water Resource Operations, authored this report. Ms. Sayed is a Water Resource Scientist and Ms. Shallcross is the Manager of Water Resource Operations.

SUGGESTED CITATION
DRBC. 2024. FFMP Performance Report 2023-2024. Delaware River Basin Commission. West Trenton, NJ. URL: https://www.nj.gov/drbc/programs/flow/FFMP_PerformanceRpts.html

[12] USGS - https://www.usgs.gov/

FFMP Implementation Performance

Release Year 2023-2024
June 1, 2023- May 31, 2024

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Water Resource Scientist
Amy Shallcross, PE
Manager, Water Resource Operations

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December 2024

Data Sources

All data used in the analysis are provisional.

Final/approved data are available from:

NYC Department of Environmental Protection (NYCDEP)

Office of the Delaware River Master (ODRM)

United States Geological Survey (USGS)

Methodology for calculations is included for reference on the last slide.

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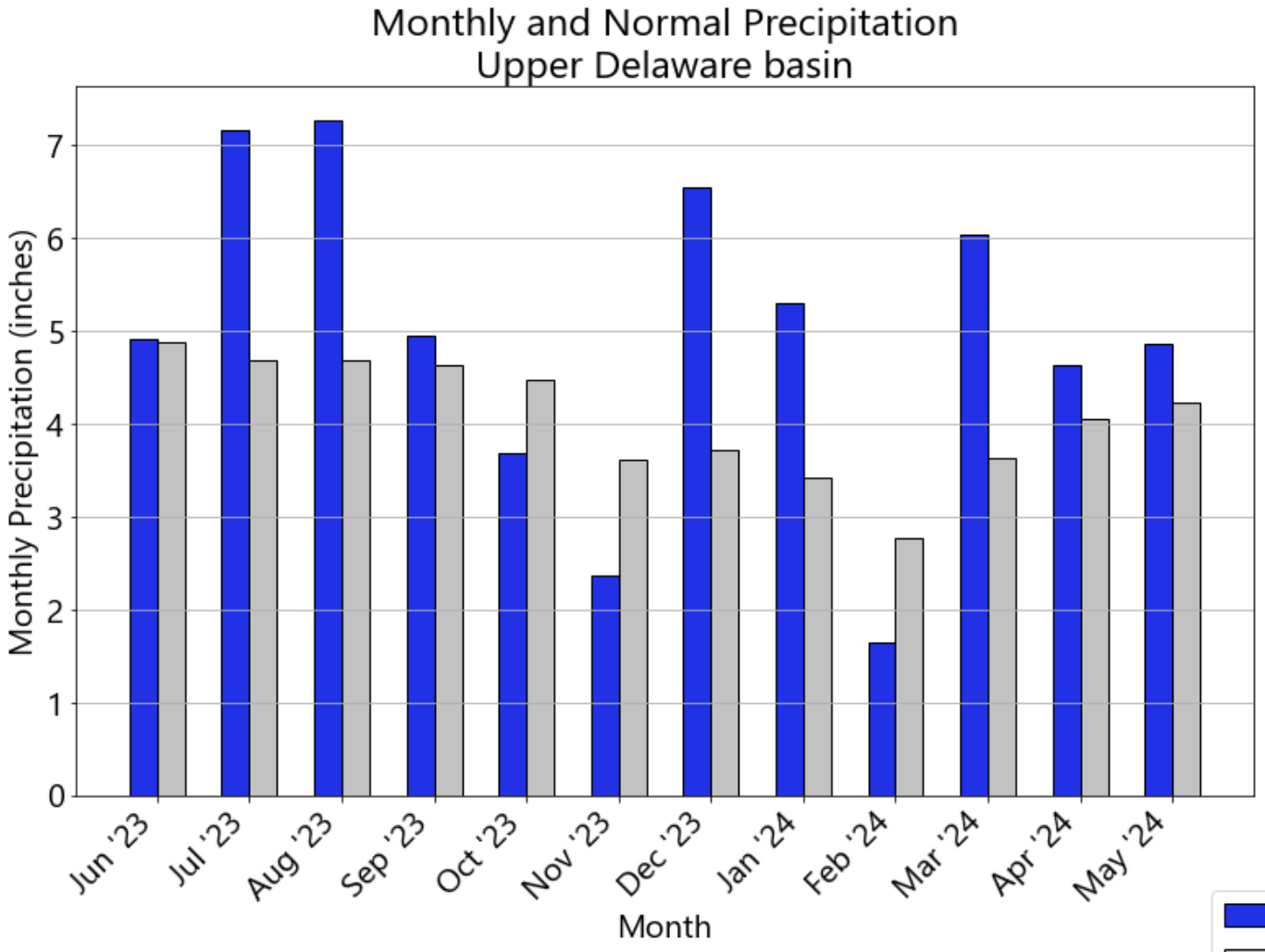
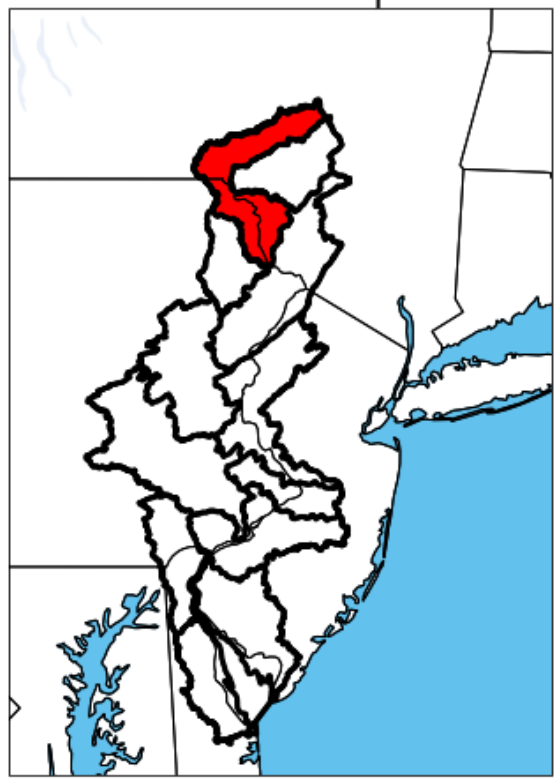
FFMP Performance Goals

- Manage Droughts
- Maintain Flow Objectives
- Provide enhanced conservation releases
- Maintain desirable tailwater temperatures
- Minimize spills with Conditional Seasonal Storage Objective (CSSO)

Precipitation – Upper Basin





Source: ACIS, USGS HUC: 02040101
Monthly Normal is based of 4 stations in the Upper Delaware basin

Monthly Observed Precipitation
Monthly Normal (1991 - 2020)

Data Source: ACIS

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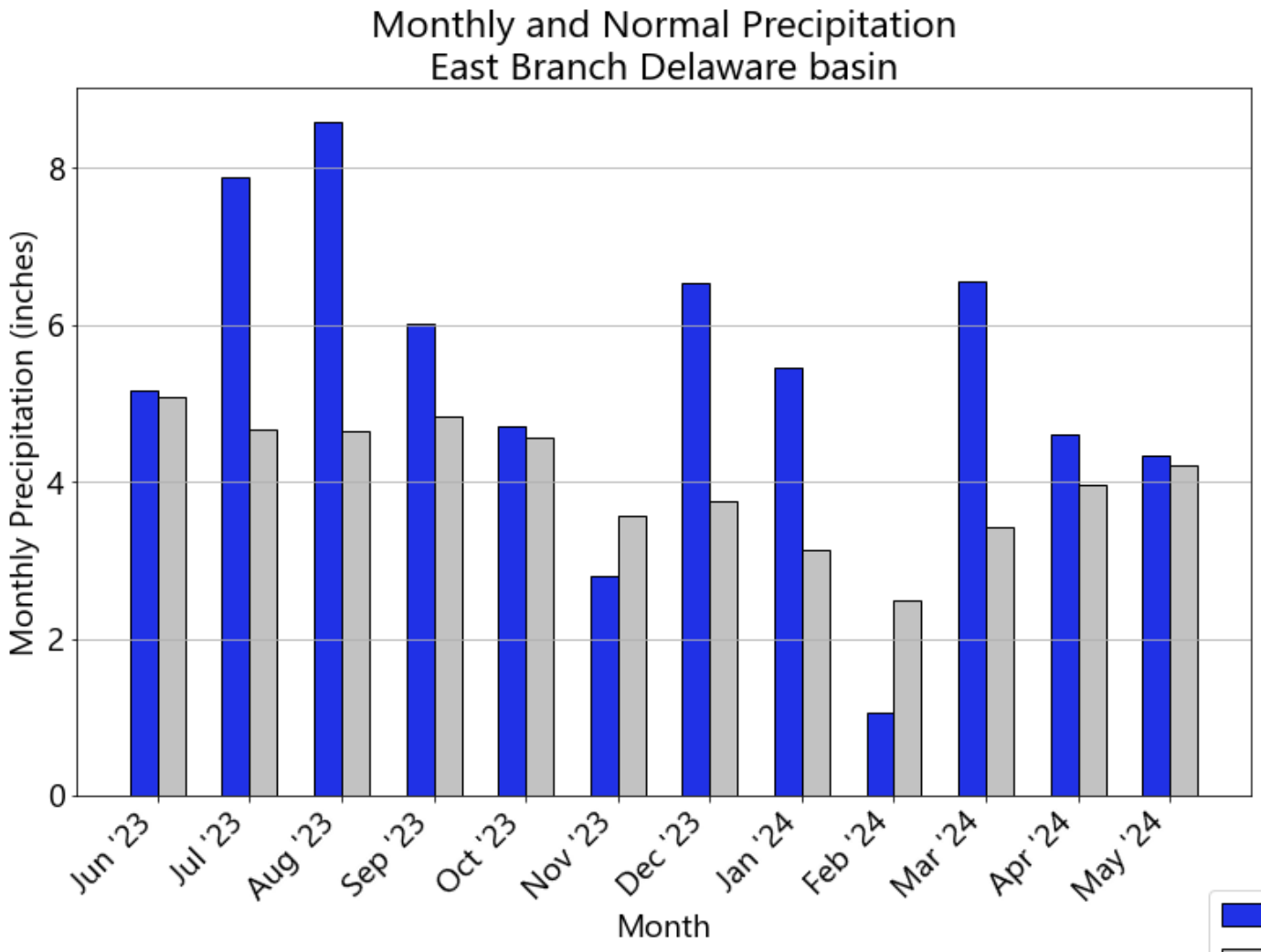
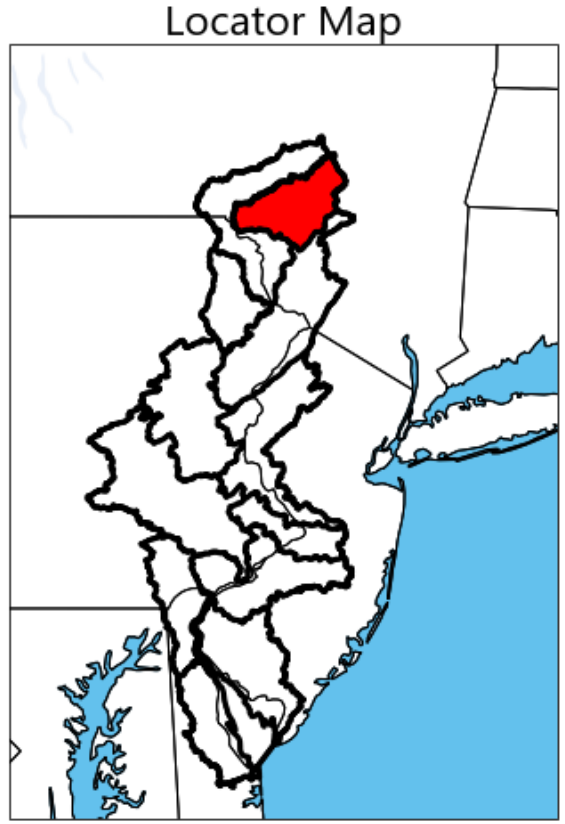
Precipitation – Upper Basin





Source: ACIS, USGS HUC: 02040102
Monthly Normal is based of 1 stations in the East Branch Delaware basin

Monthly Observed Precipitation
Monthly Normal (1991 - 2020)

Data Source: ACIS

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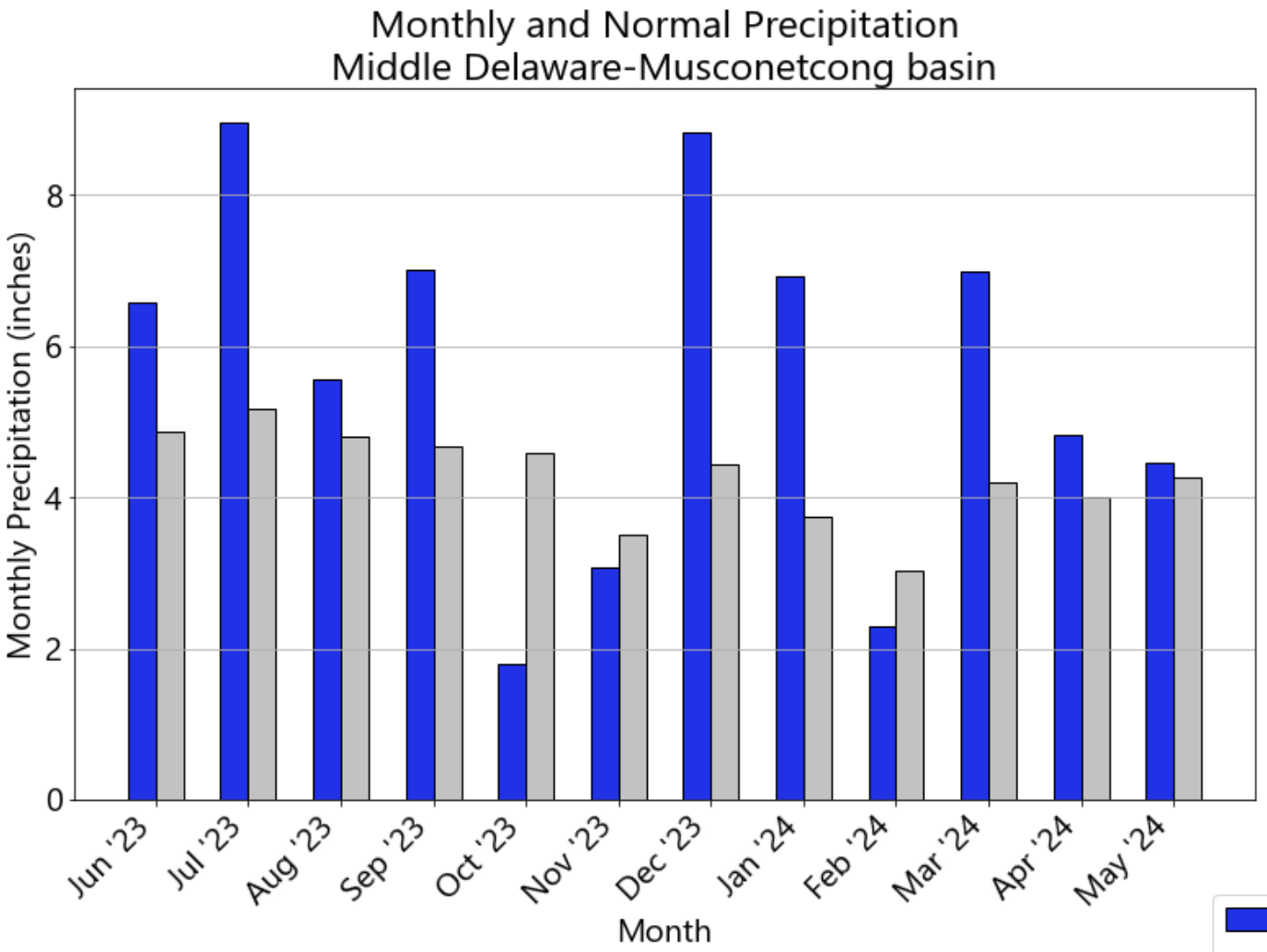
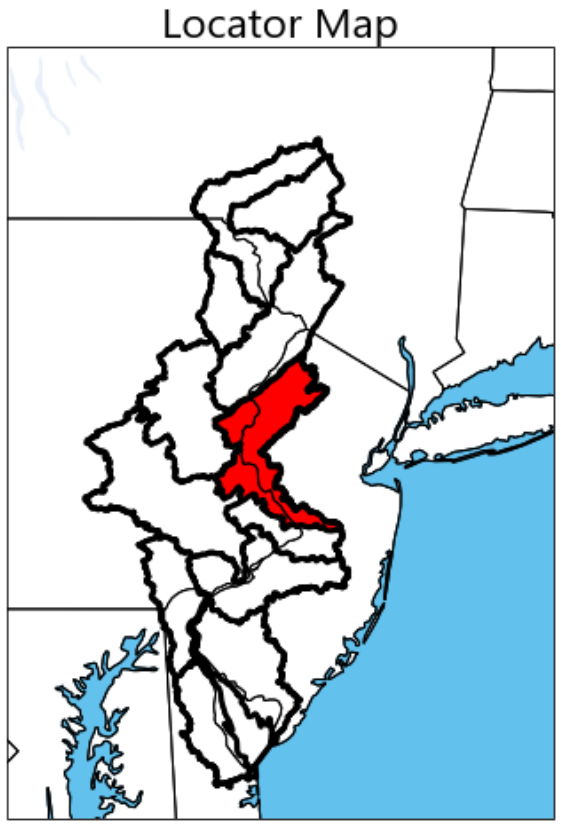
Precipitation – Middle Basin





Source: ACIS, USGS HUC: 02040105
Monthly Normal is based of 8 stations in the Middle Delaware-Musconetcong basin

Monthly Observed Precipitation
Monthly Normal (1991 - 2020)

Data Source: ACIS

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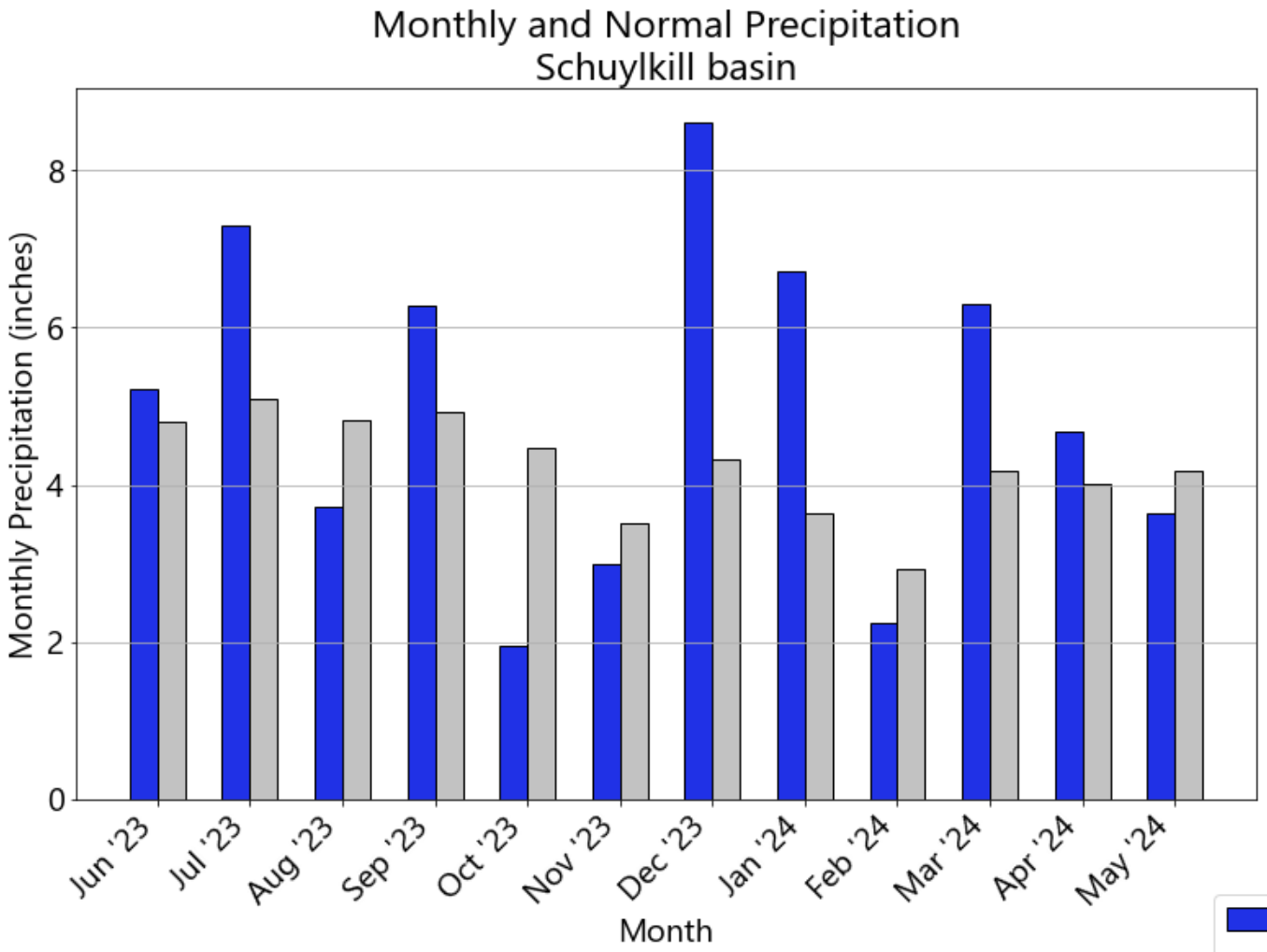
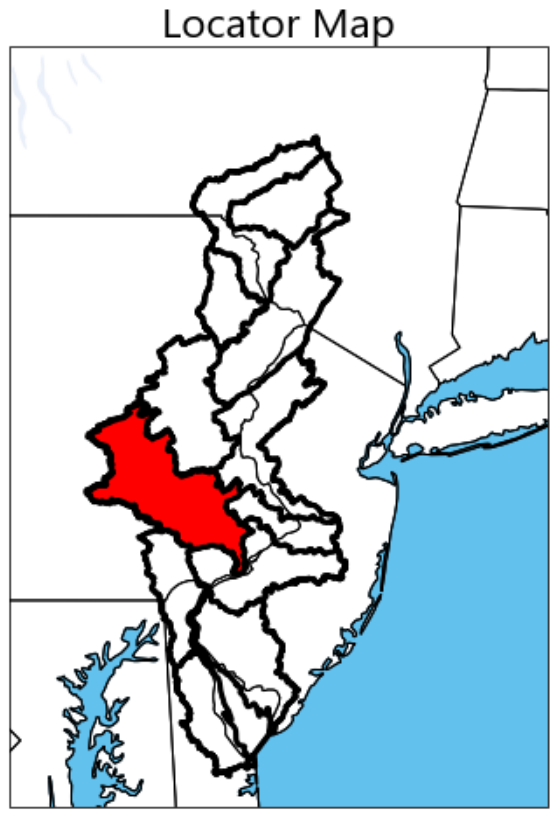
Precipitation – Lower Basin





Source: ACIS, USGS HUC: 02040203
Monthly Normal is based of 20 stations in the Schuylkill basin

Monthly Observed Precipitation
Monthly Normal (1991 - 2020)

Data Source: ACIS

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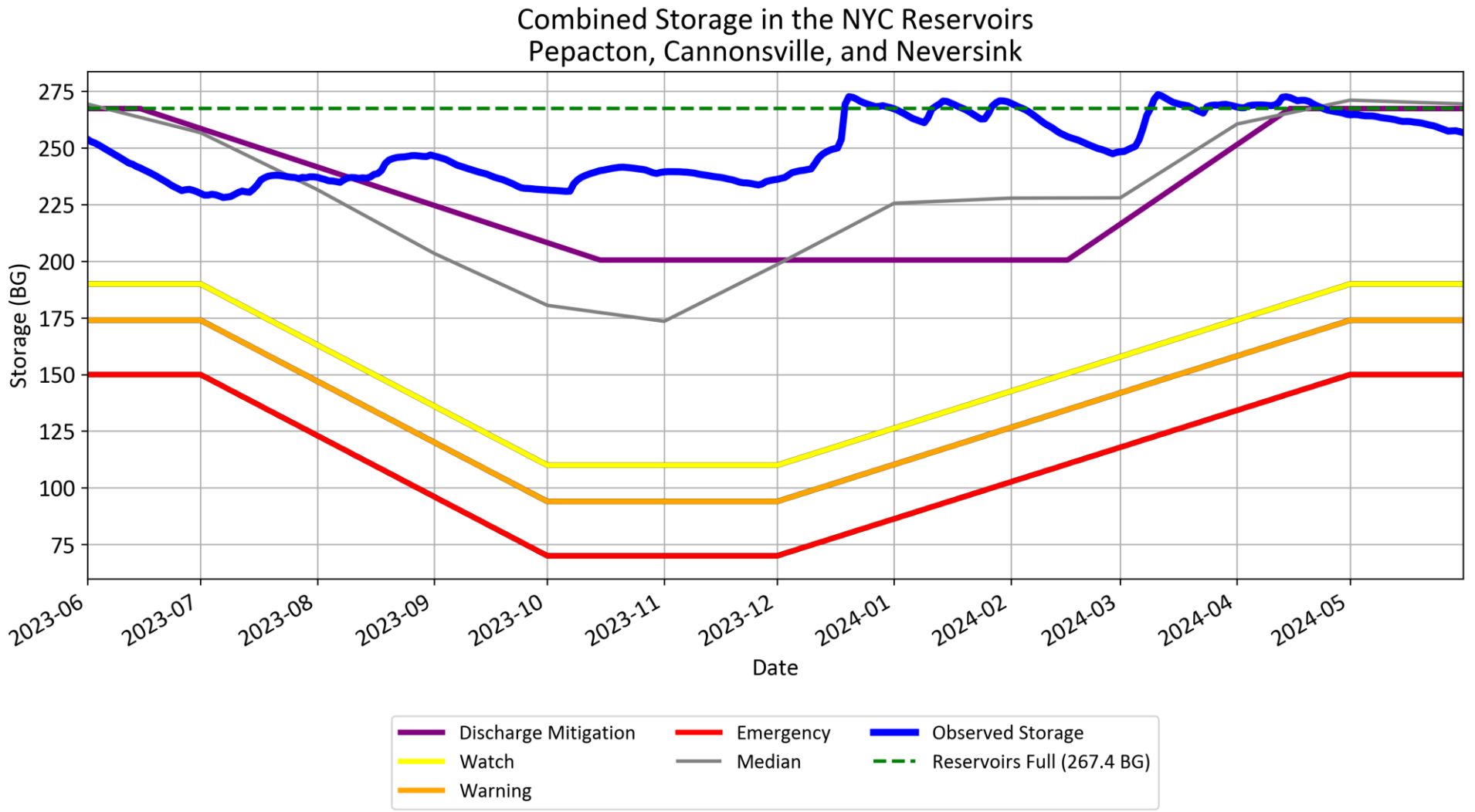
New York City Reservoir Storage



Data Source: NYCDEP

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Flow Objectives

Water Released from NYC to Meet Flow Objectives (MG)	
Montague*	12,238
Trenton **	0
Total	0

Water Released from Lower Basin to Meet Trenton Flow Objectives (MG) **	
Beltzville	0
Blue Marsh	0
Total	0

*Releases made to meet the Montague Flow Objective, called directed releases, include the conservation release for the days when water is needed. Dates: 6/4-13, 6/18-6/26, 11/20.
**Releases made to meet the Trenton Flow Objective are from a bank established by the FFMP (TEFO Bank) and are in addition to the directed release.
*** Releases made from lower basin reservoirs for the Trenton Flow Objective exclude the conservation release.

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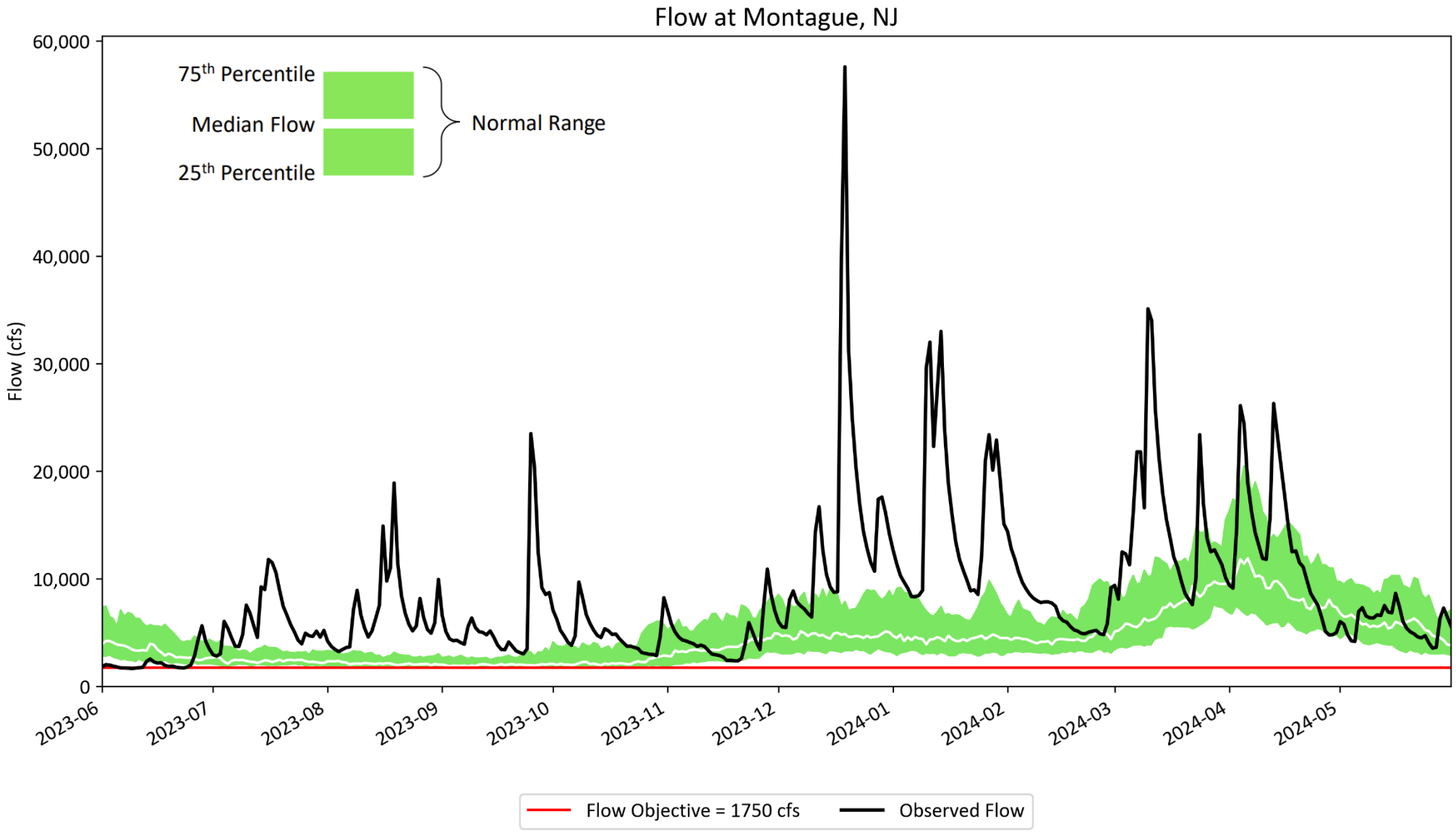
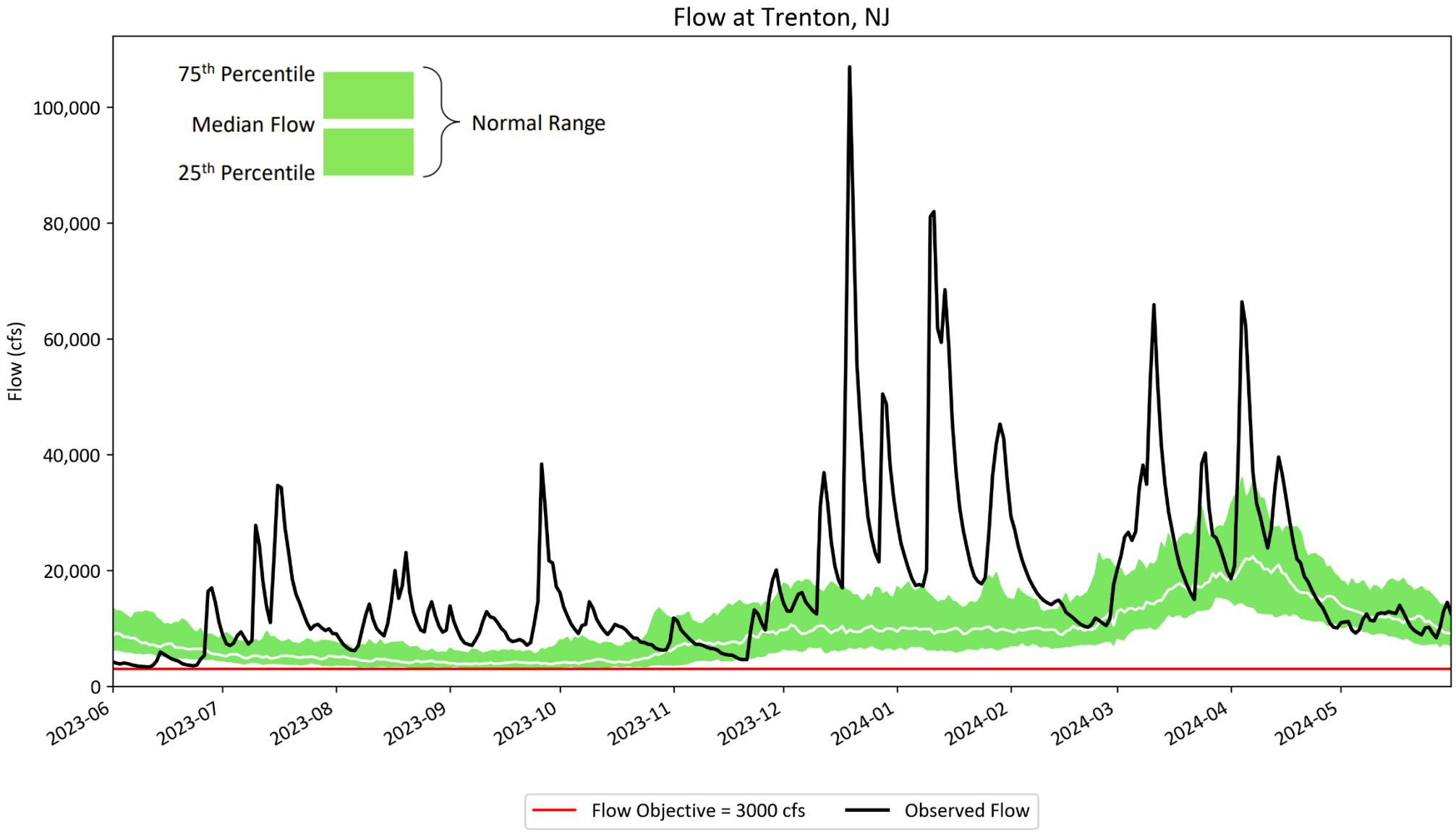
Flow at Montague



Data Source: USGS

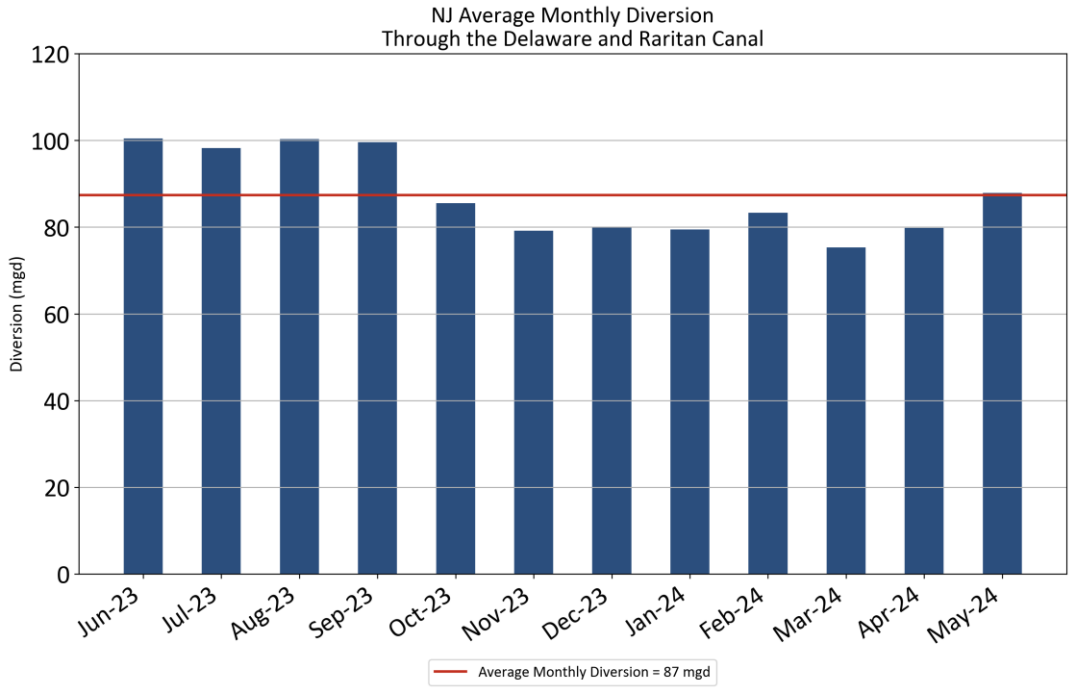
Flow at Trenton

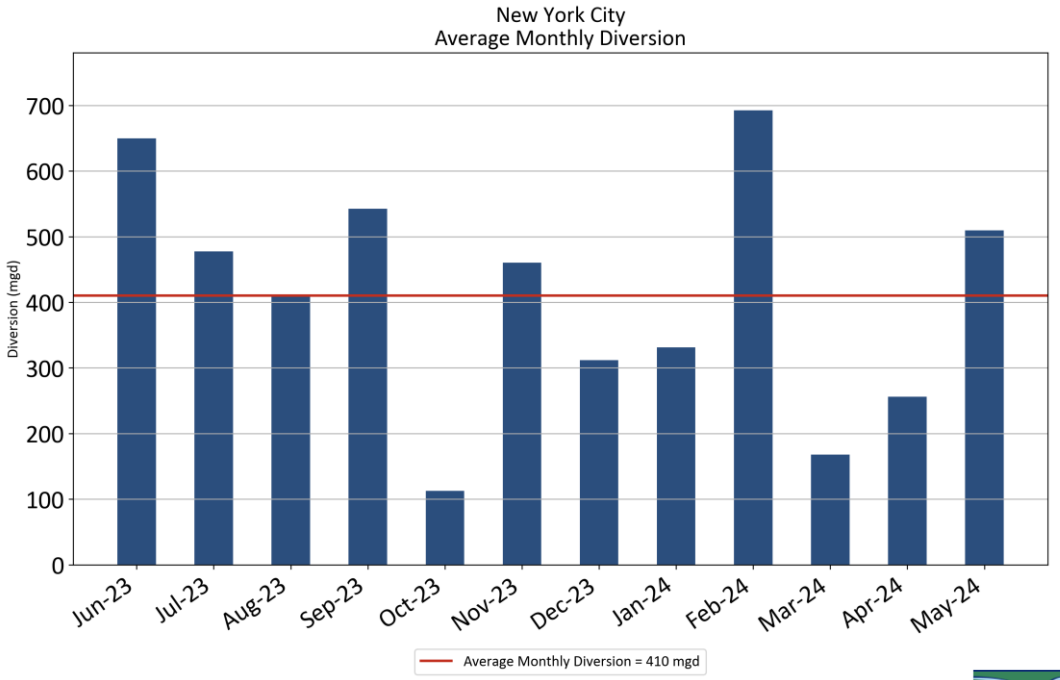


Data Source: USGS

Diversions

Monthly Average Daily Diversion (June 1, 2023 – May 31, 2024)	
New Jersey	New York
87 mgd	410 mgd





Data Source: USGS, NYCDEP

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Conservation Releases

Total Volume of Conservation Releases (MG)			
	FFMP 2017 Tables Based on Storage (6/1/23 - 5/31/24)	**REV1**	**Multiple of Revision 1**
Cannonsville	168,932	20,686	8.4
Pepacton	81,330	14,593	5.8
Neversink	31,363	8,680	3.9
Values are the conservation releases required by the FFMP Tables Only. All or a portion of the release may have been used to meet the Montague Flow Objective. Additional release volume may have been required for bank use.			

Note: Conservation releases for 2023-2024 were all based on Table 4G

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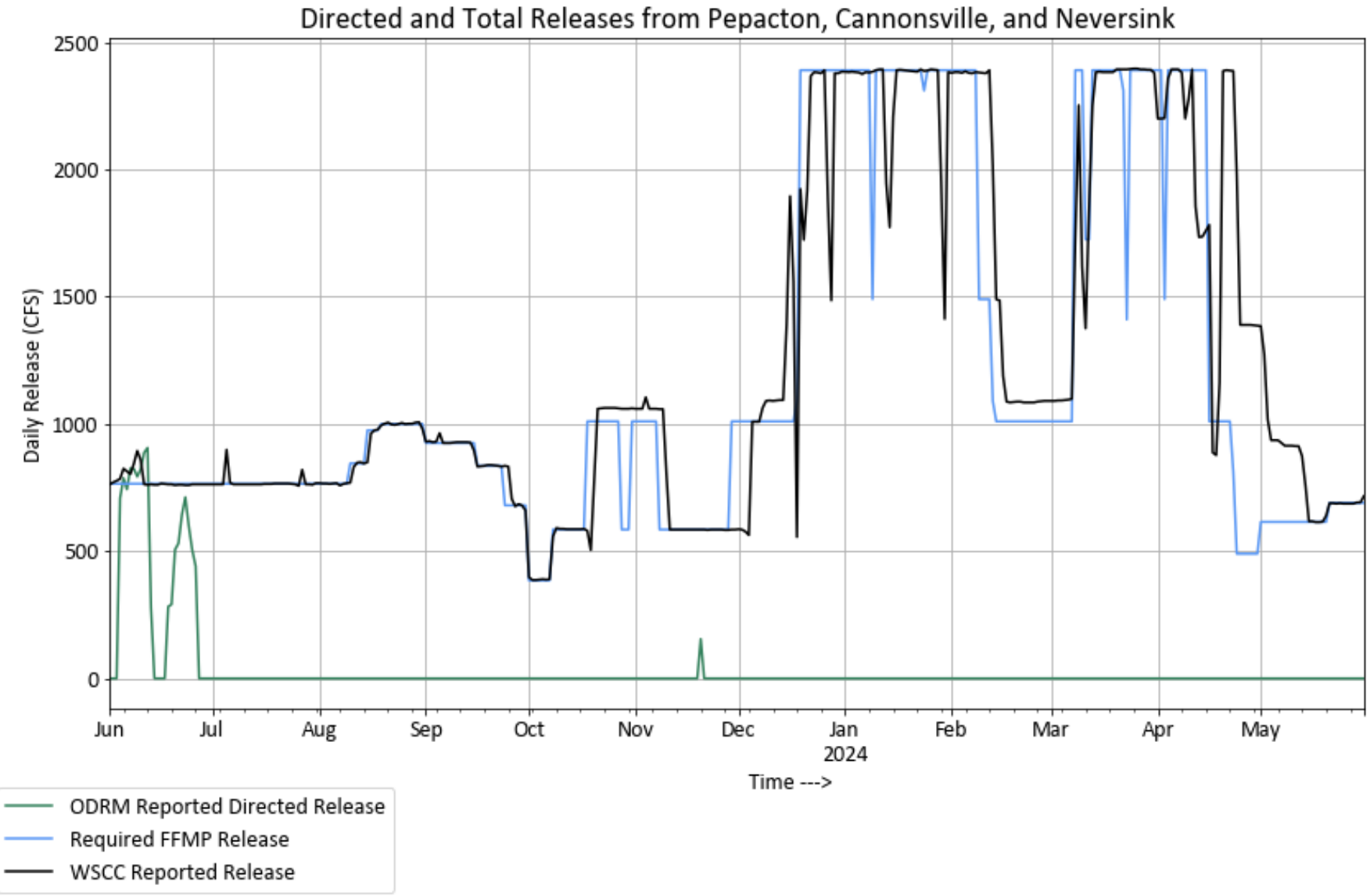
Combined Release History



Data Source: NYCDEP, ODRM, USGS

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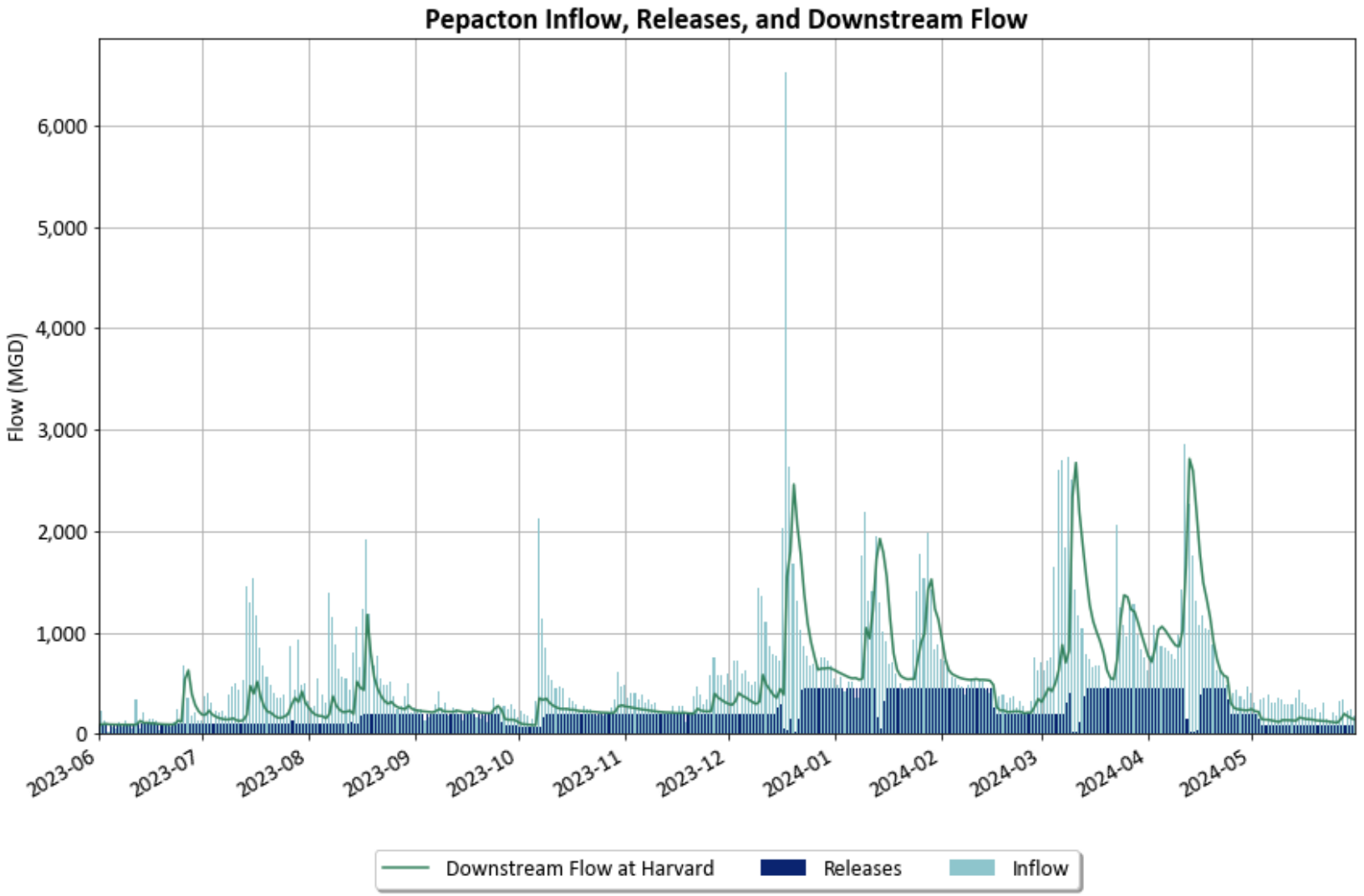
Pepacton: Inflow, Releases and Downstream Flow



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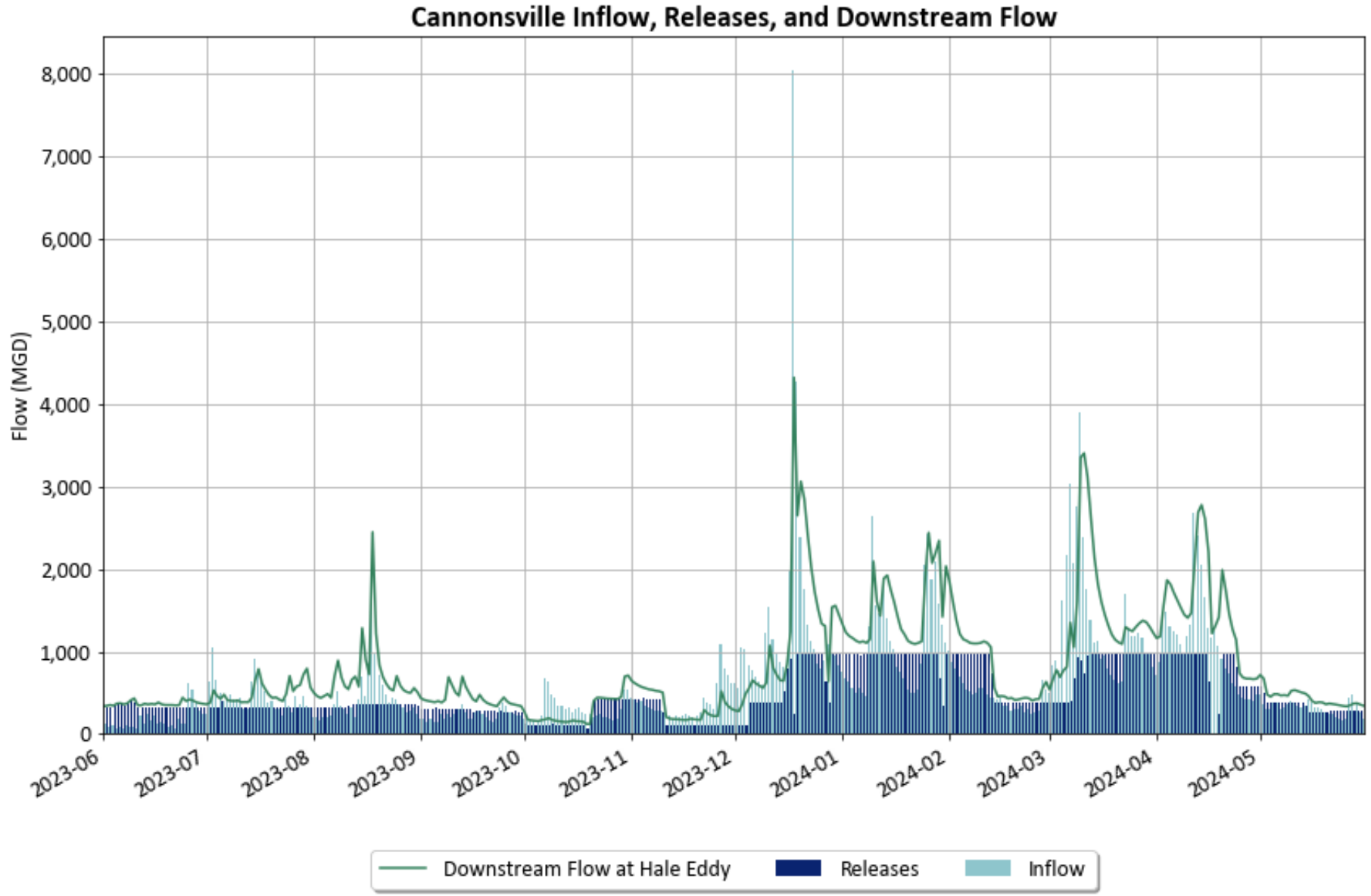
Cannonsville: Inflow, Releases and Downstream Flow



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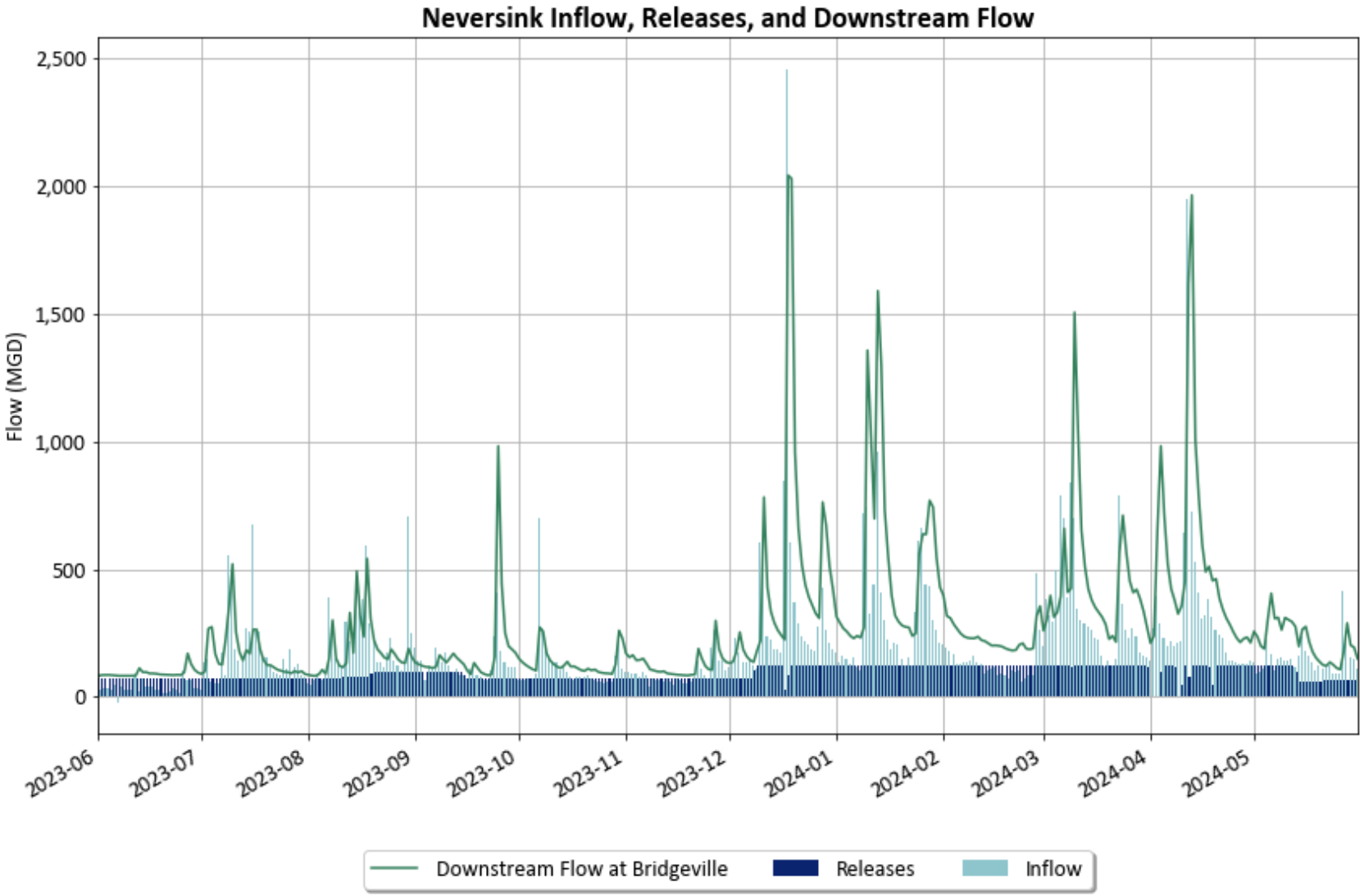
Neversink: Inflow, Releases and Downstream Flow



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FFMP Bank Use

FFMP 2017 Bank	Used	Size
NJ Diversion Amelioration Bank	0	of 2,545 cfs-days
Rapid Flow Change Mitigation Bank	0	of 1,000 cfs-days
Thermal Mitigation Bank	234	of 2,500 cfs-days
Trenton Equivalent Flow Objective Bank	0	of 9,423 cfs-days
NJ Diversion Offset Bank*	0	cfs-days

Thermal Releases were made on 5 days for 2 events in July 2023, and September 2023. A total of 234 cfs-days were used.

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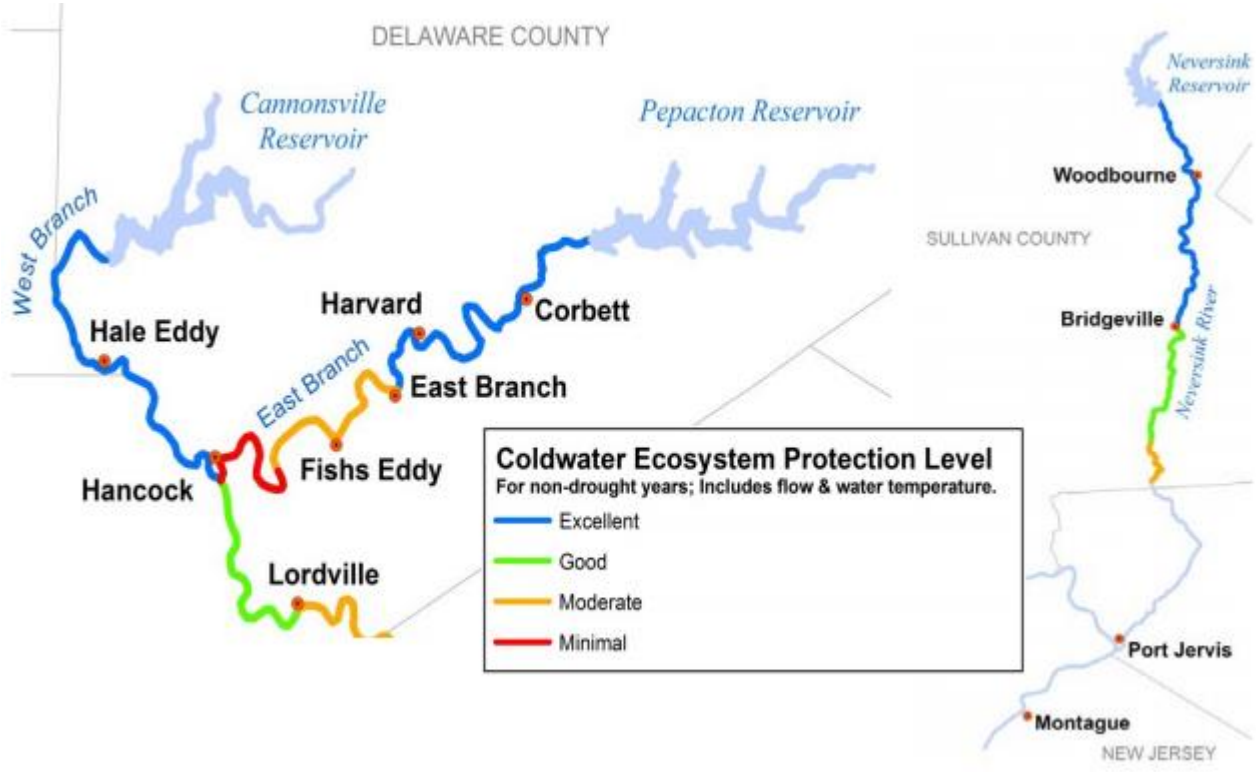
Habitat Protection
(Temperature)



- Goals for Excellent Habitat:
  - Summer Temperature typical less than 20 ^{0}C
  - Rare Exceedances of 24 ^{0}C

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Air Temperature

Location	Exceedances of 24 ^{0}C		Exceedances of 20 ^{0}C	
	Days Maximum Temperature above 24 ^{0}C	Days Average Temperature above 24 ^{0}C	Days Maximum Temperature above 20 ^{0}C	Days Average Temperature above 20 ^{0}C
Hale Eddy	0	0	0	0
Harvard	0	0	1	0
Hancock	0	0	2	0
Lordville	0	0	50	26
Bridgeville	0	0	38	2

Goals for Excellent Habitat: Summer Temperature typical less than 20 ^{0}C, Rare Exceedances of 24 ^{0}C

For June- Aug 2023, the Upper Basin air temperature was ranked the 58th warmest and Lower Basin air temperature ranked 31st warmest

Thermal Releases were made on 5 days for 2 events in July 2023, and September 2023. A total of 234 cfs-days were used

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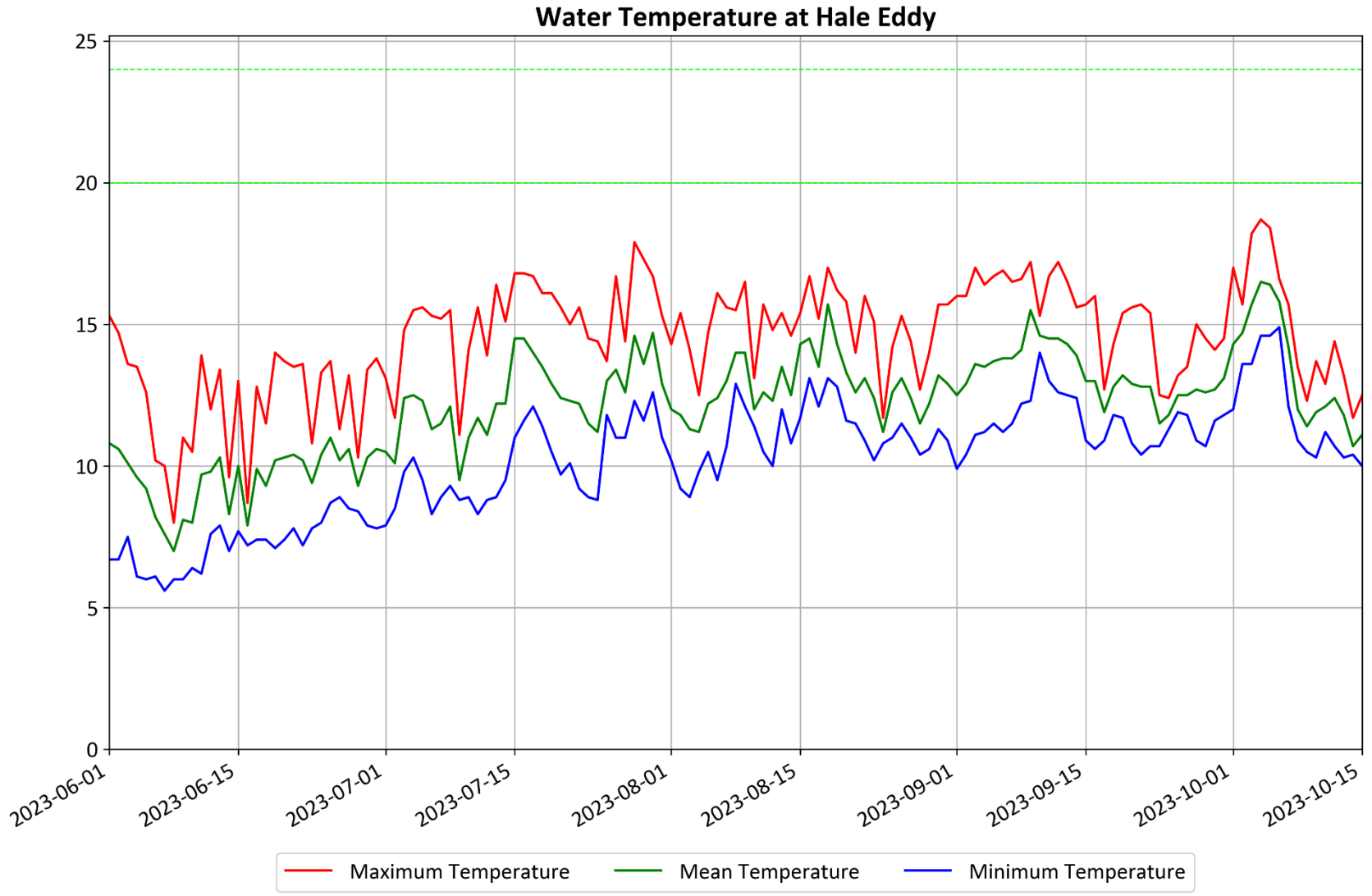
Water Temperature at Hale Eddy



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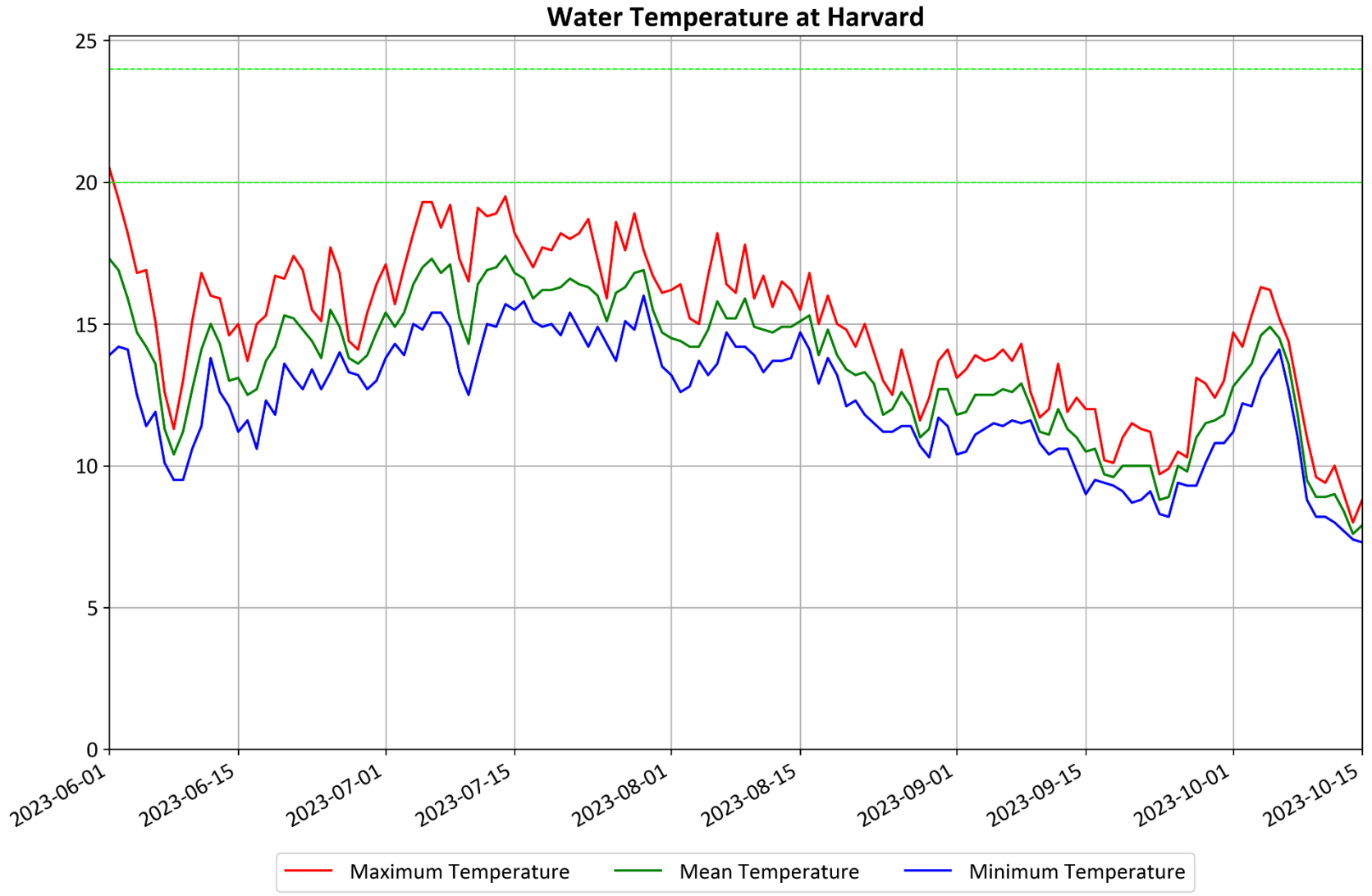
Water Temperature at Harvard



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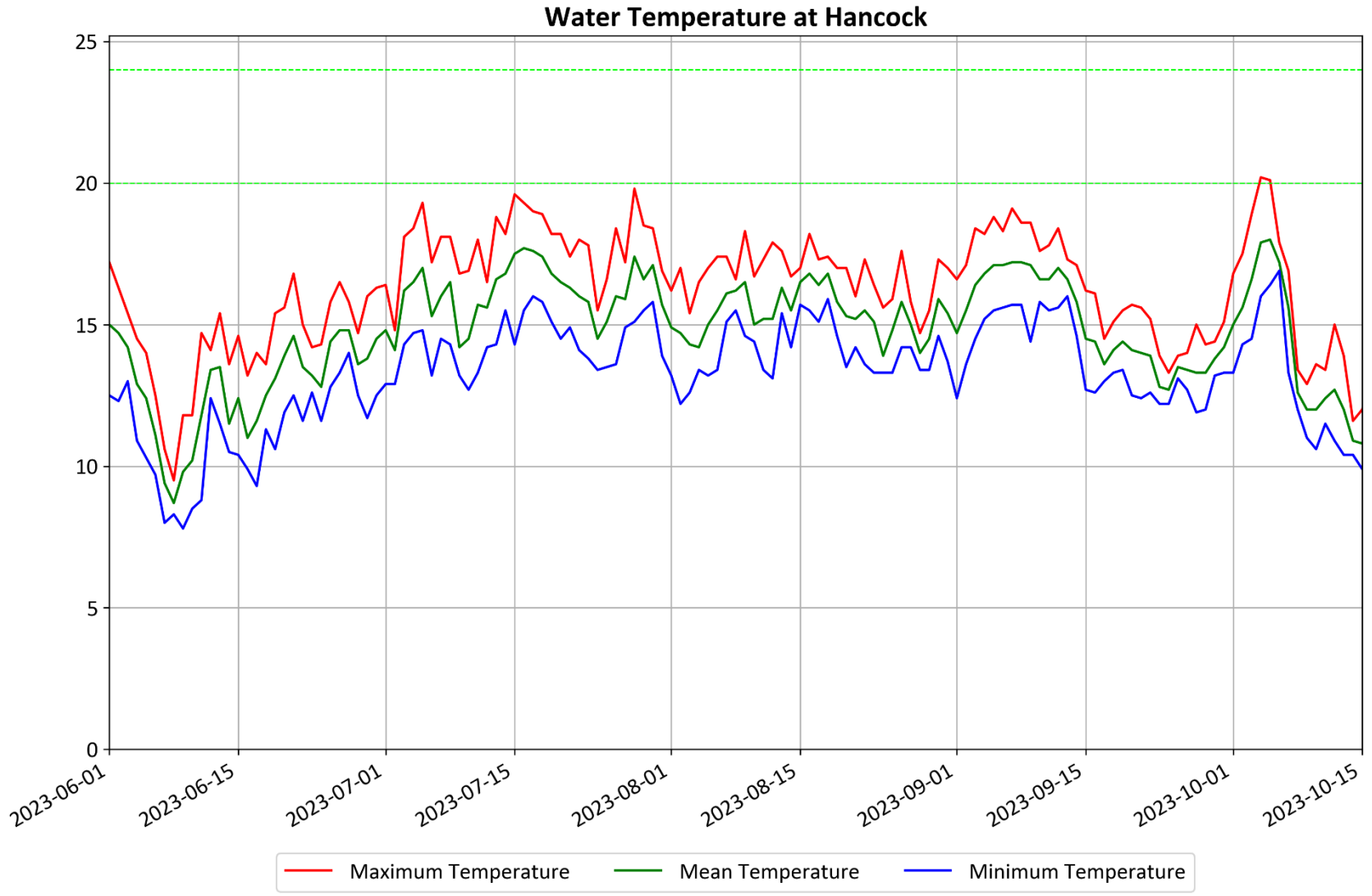
Water Temperature at Hancock



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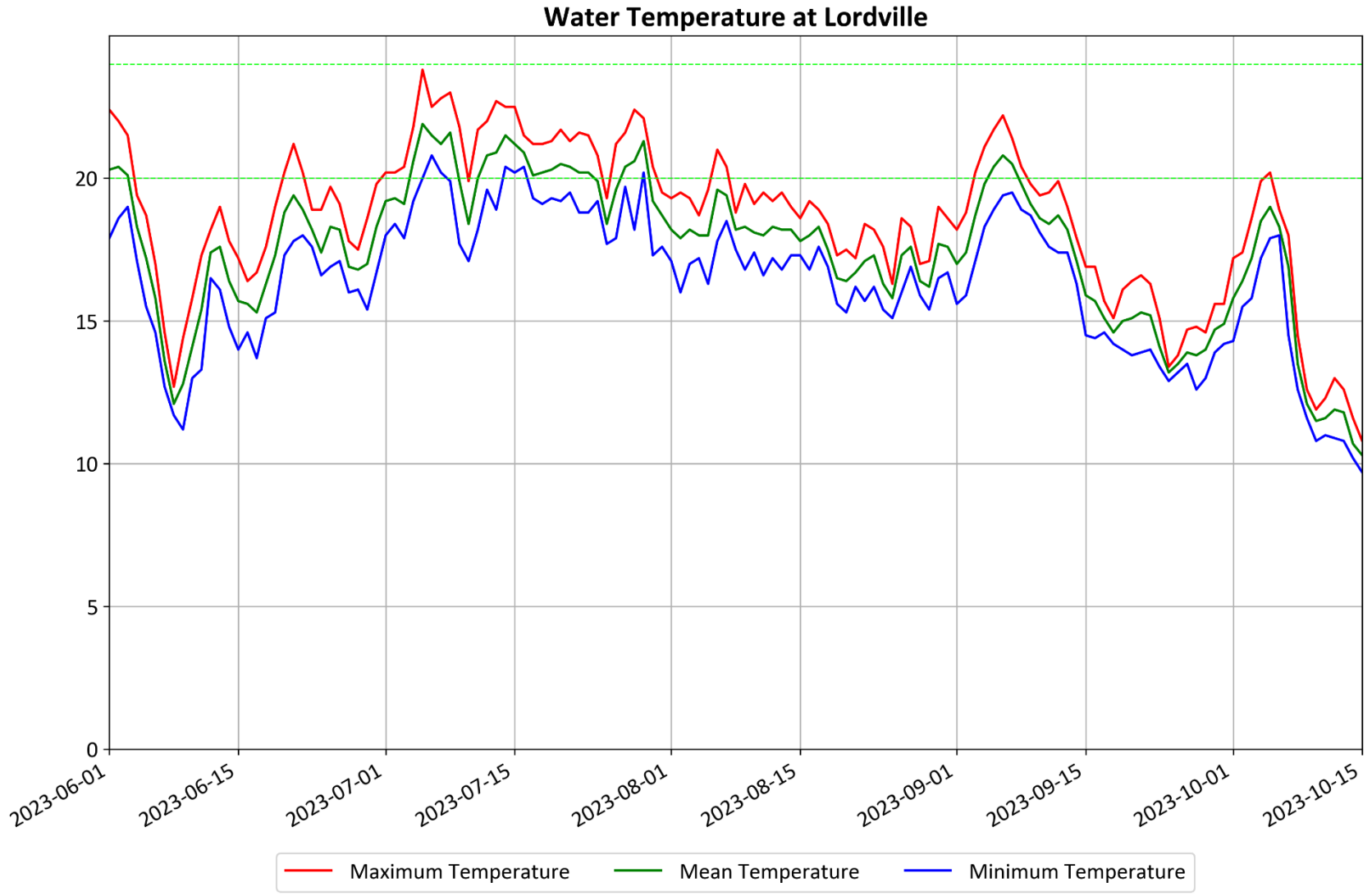
Water Temperature at Lordville



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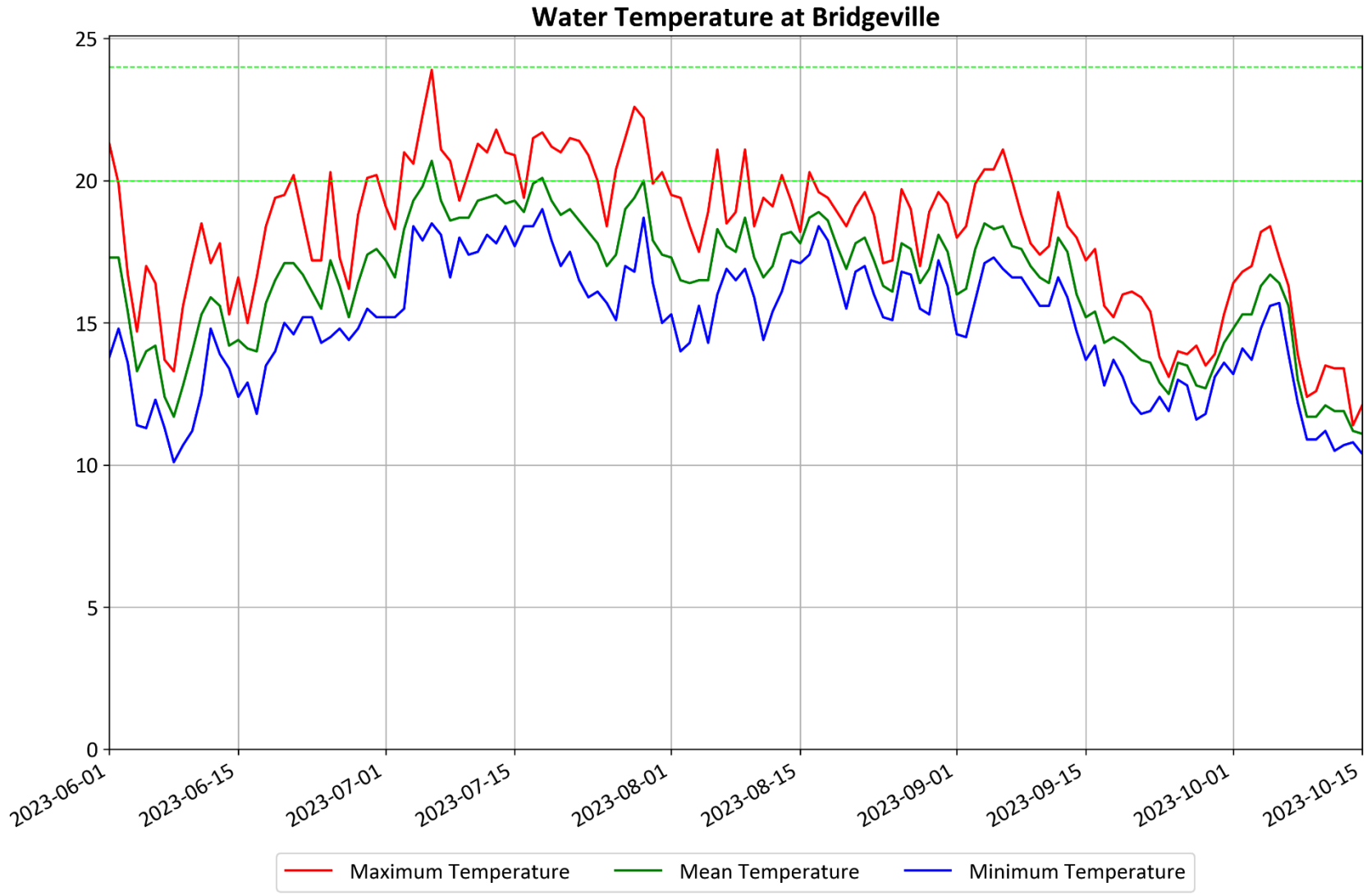
Water Temperature at Bridgeville



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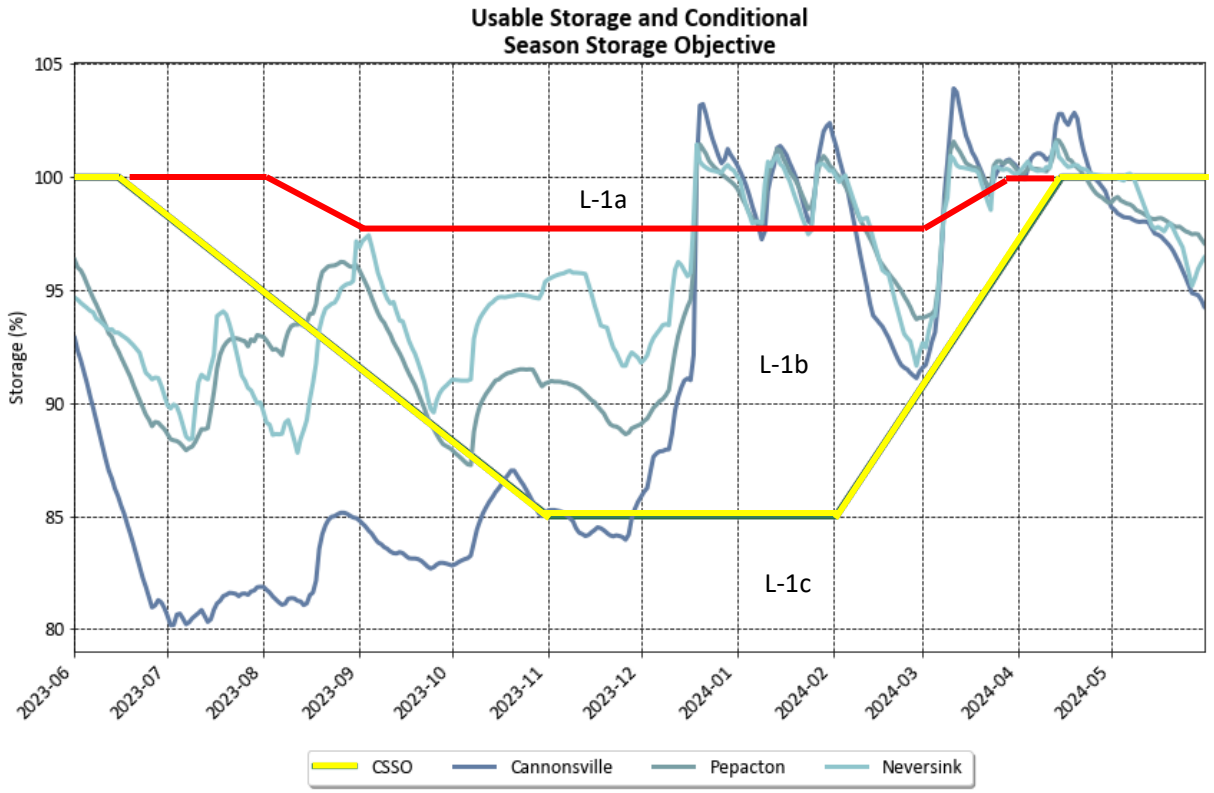
Discharge Spill Mitigation



	Spill Volume (MG)	Days
Cannonsville	30,614	79
Pepacton	39,311	72
Neversink	17,015	89

	All L1 Discharge Mitigation Releases (MG)*	Number of days Above the CSSO
Cannonsville	117,674	165
Pepacton	68,002	236
Neversink	24,683	249

*The CSSO is the yellow line, per FFMP Figure 2.

- Locations below the reservoirs can reach NWS Action Flood Stage in the absence of, or prior to, significant spills.
- Hale Eddy gage was above action stage for 7 non-sequential days.
- Harvard gage was above action stage for 4 non-sequential days.

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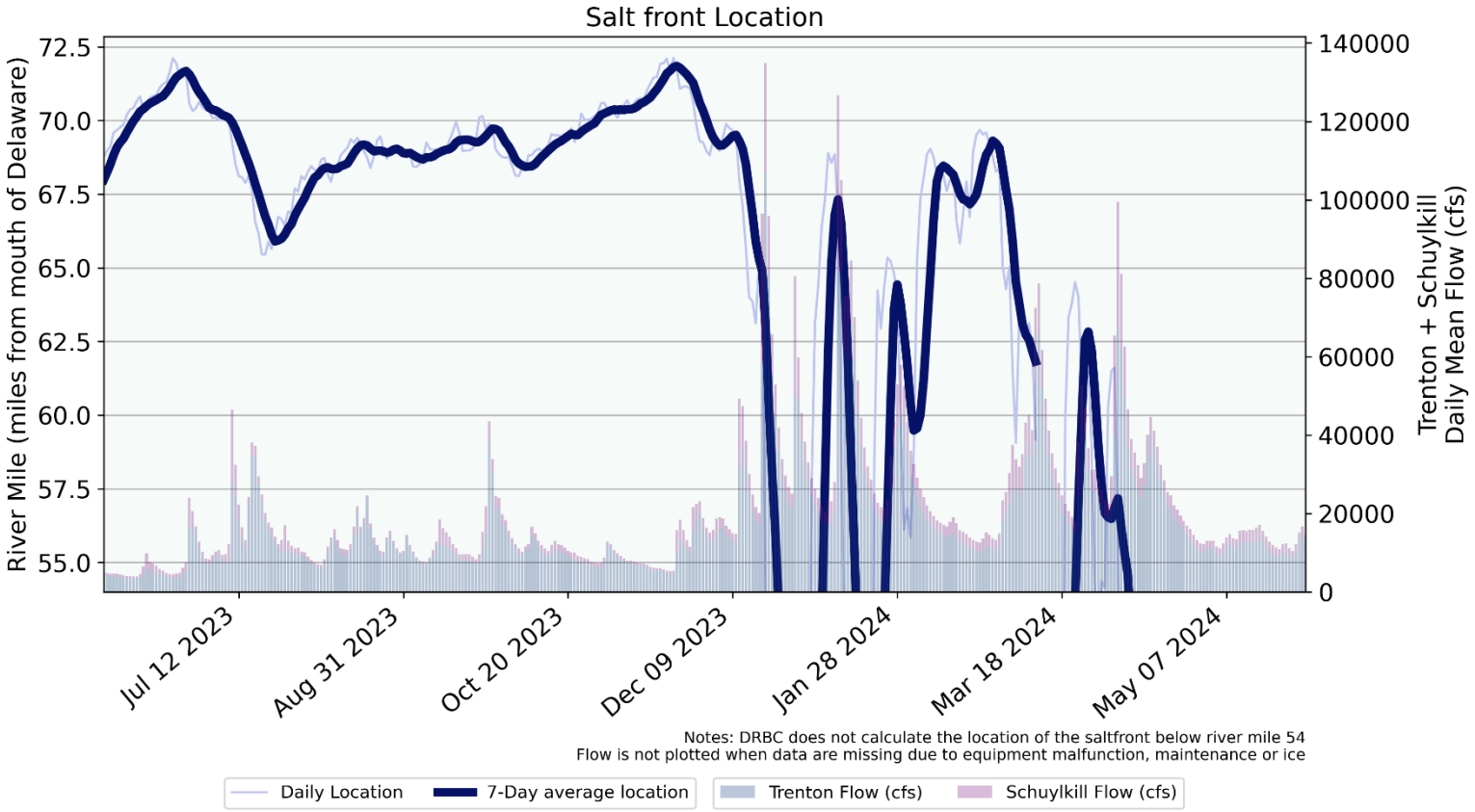
Salinity Management (DRB Water Code)



- DRBC is responsible for making releases to manage the salt front
- Under the FFMP 2017 agreement, the Montague Flow Objective is based on the location of the salt front **only during a drought emergency**.
- No drought emergency occurred during this FFMP release year.

Delaware River Basin Water Code: The Delaware River Basin Commission directs reservoir releases from Basin Reservoirs to meet the Trenton Flow Objective under normal and drought conditions.

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Summary

- Normal operations were in effect for the release year.
- Montague and Trenton flow objectives were met within operational constraints (weather forecasts, power generation)
- Conservation releases were in Table 4g for the entire releases season.
- Thermal mitigation releases were only required on 5 days.
- Discharge mitigation releases (L1-a, L1-b, L1c) were required at all three reservoirs due to the above average rainfall and inflow.

Methodology

- **Flow Objectives**: Amount of water released for flow objectives is calculated by summing the NYC WSCC spreadsheet directed release column for each reservoir. FFMP Bank releases (e.g., thermal releases) are excluded from the releases for Montague.
- **Diversions:**
  - NJ Diversion is calculated using the daily discharge observations from the USGS Port Mercer gage, 01460440. The averages are of the daily discharge for each month and the average of the daily discharge for the entire year (release year 6/1-5/31).
  - NYC diversion is determined from the WSCC data spreadsheet (column E, daily total). The averages are of the daily discharge for each month and the average of the daily discharge for the entire year (release year 6/1-5/31).
- **Conservation release volume:** the sum of the conservation released based on the zone (L1, L1-a, L1-b, L1-c, L2) and FFMP Table (4E, 4F, 4G). It should be noted that more water may have been released for Montague. For example, if no releases were required for Montague, this is the amount of water that would have been released with minor differences related to transitions among tables and zones. REV1 amounts refer to the first revision of D-77-20 CP and are the total amount over the release year that would have been released based on this release program.
- **Bank Use:** was obtained from the accumulated Daily River Master Data, dated June 1, 2024.
- **Discharge Mitigation Releases (CSSO)** – volume of water released when a reservoir is in L1. Number of days above CSSO: days when reservoir is in L1-a or L1-b.