Delaware River Basin Commission

The Science of Flow Management

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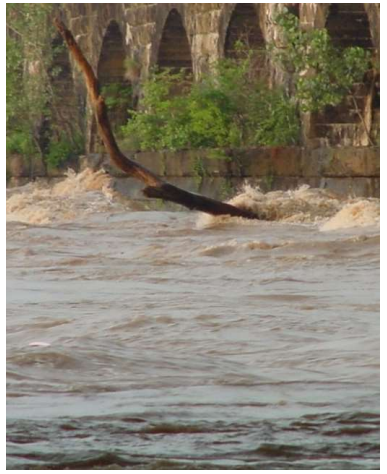
Water Resources Association of the Delaware River Basin

September 22, 2020



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Delaware River and Basin

- Main stem (Hancock NY => Ocean) is 330 miles long – No Dams
- The River forms interstate boundaries over its entire length
- Watershed drains 13,539 square miles in 4 states
- Drinking water for 13.3 million people (approximately 5 % of the U.S. population)
- Water withdrawals exceed 6.4 billion gallons/day
- Significant Exports to NYC (up to 800 MGD) and NJ (up to 100 MGD)
- Contributes over $21B in economic value

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Flow Management

* **Goals**
  * Recreation
  * Flood Risk/Damage Reduction
  * Water Supply - Low flow augmentation
  * Water Quality
  * Aquatic Life
  * Navigation
  * Power Generation
* **Resources** (FINITE)
  * Storage
  * Run-of-river

Delaware River Sojourn

Water Users

Phila.gov

Suk

http://wikimapia.org/21274124/Kimberly-Clark-Inc-Chester-Papermill#/photo/1905408

Photo: Peretz Partensky, https://www.flickr.com/photos/ifl/7238282472/in/album-72157629823114004/; unedited

* Drinking Water Providers
* Manufacturing
* Refining
* Energy Production

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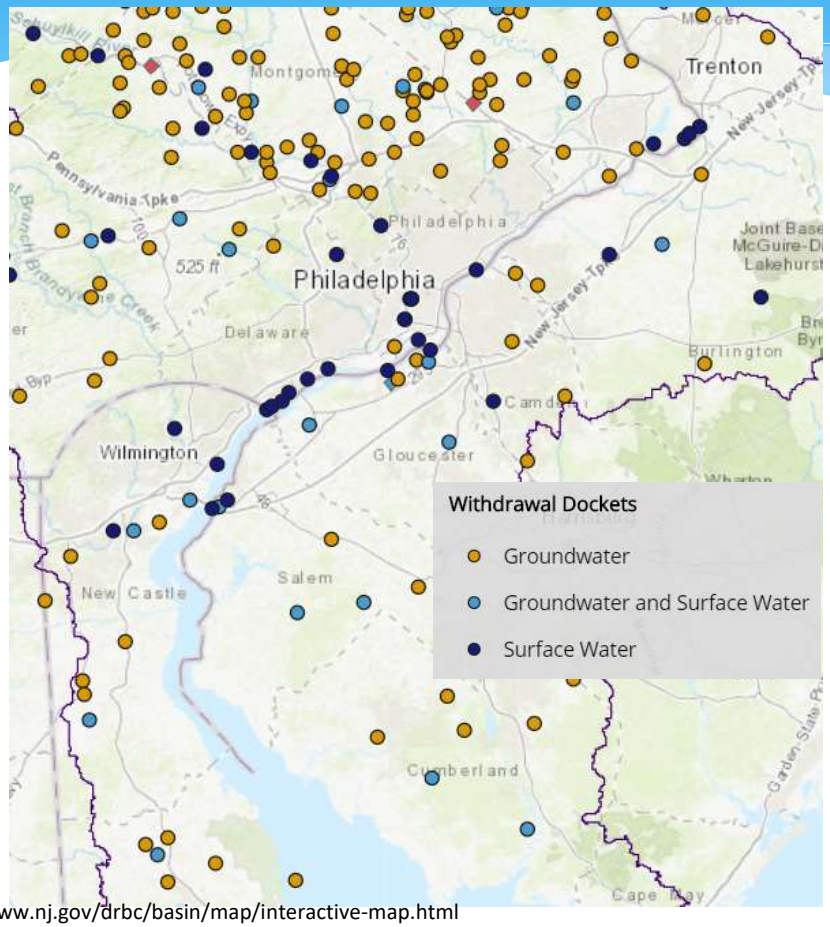
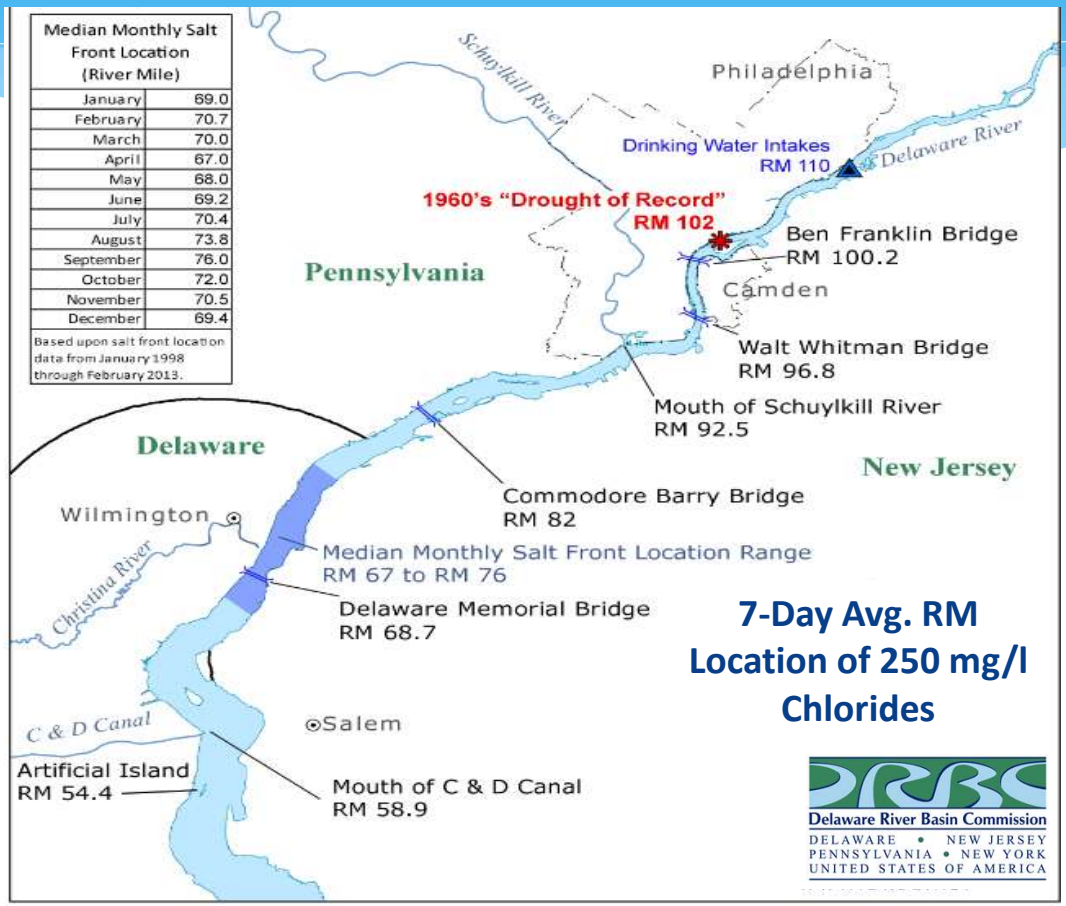
Water Supply



https://www.nj.gov/drbc/basin/map/interactive-map.html

Median Monthly Salt Front Location (River Mile)	
January	69.0
February	70.7
March	70.0
April	67.0
May	68.0
June	69.2
July	70.4
August	73.8
September	76.0
October	72.0
November	70.5
December	69.4

Based upon salt front location data from January 1998 through February 2013.



Types and Mechanisms

* Flood Risk Mitigation
  * Passive (dry dams, controlled outlet)
  * Pro-active (pre-event releases)
* Water Supply (rule curves, phased limits)
* Low Flow Augmentation
  * Flow Objectives
  * Conservation Releases (static, tied to inflow, tied to storage)
  * Water quality – based (pH, DO, Temp)
  * Consumptive Use replacement
* Forecast Informed Reservoir Operations (FIRO, NYC – Operations Support Tool)

Background

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Water Supply and Droughts

* New York City - Reservoirs
* New Jersey - Run of River - Canal
* Pennsylvania – Run of River

* 1929-1931 - Drought
* 1931 – Supreme Court Decree
* 1954 – Amended Supreme Court Decree
* 1964-67 – Drought
* 1983 – Good Faith Agreement
* 2007 – Flexible Flow Management Program

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Key Terms of the Decree

1954

* **Out-of-basin diversions** for NJ (100 mgd) an d NYC (800 mgd)
* **Compensating releases** to maintain flow to the lower portion of the River (NYC responsibility)
  * **Flow objective at Montague, NJ**
  * "Excess" water between 6/15 and 3/15
* Treatment of Port Jervis Sewage (NYC responsibility) improve water quality going downstream
* Establish **River Master** to administer Decree

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Key Terms of the Good Faith Agreement

1983

* Established **drought operating curves**
* Created **Trenton Flow Objective**
* **Phased reductions of Diversions and Flow Objectives**
* **Banking** "Excess Water"
* Provided **enhanced conservation releases** during normal conditions

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Trenton Flow Objective

Concept:

- ✓ Based on drought status
  - ✓ Basinwide – NYC Storage
  - ✓ Lower Basin – Beltzville and Blue Marsh Storage
- ✓ Varies Seasonally
- ✓ Varies with location of the "salt front" (drought emergency)

Goals:

- ✓ Salinity Repulsion
  - ✓ Drinking Water
  - ✓ Industry
  - ✓ Power
- ✓ Freshwater Inflows to Estuary

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Water Management Schematic for the Delaware River Basin

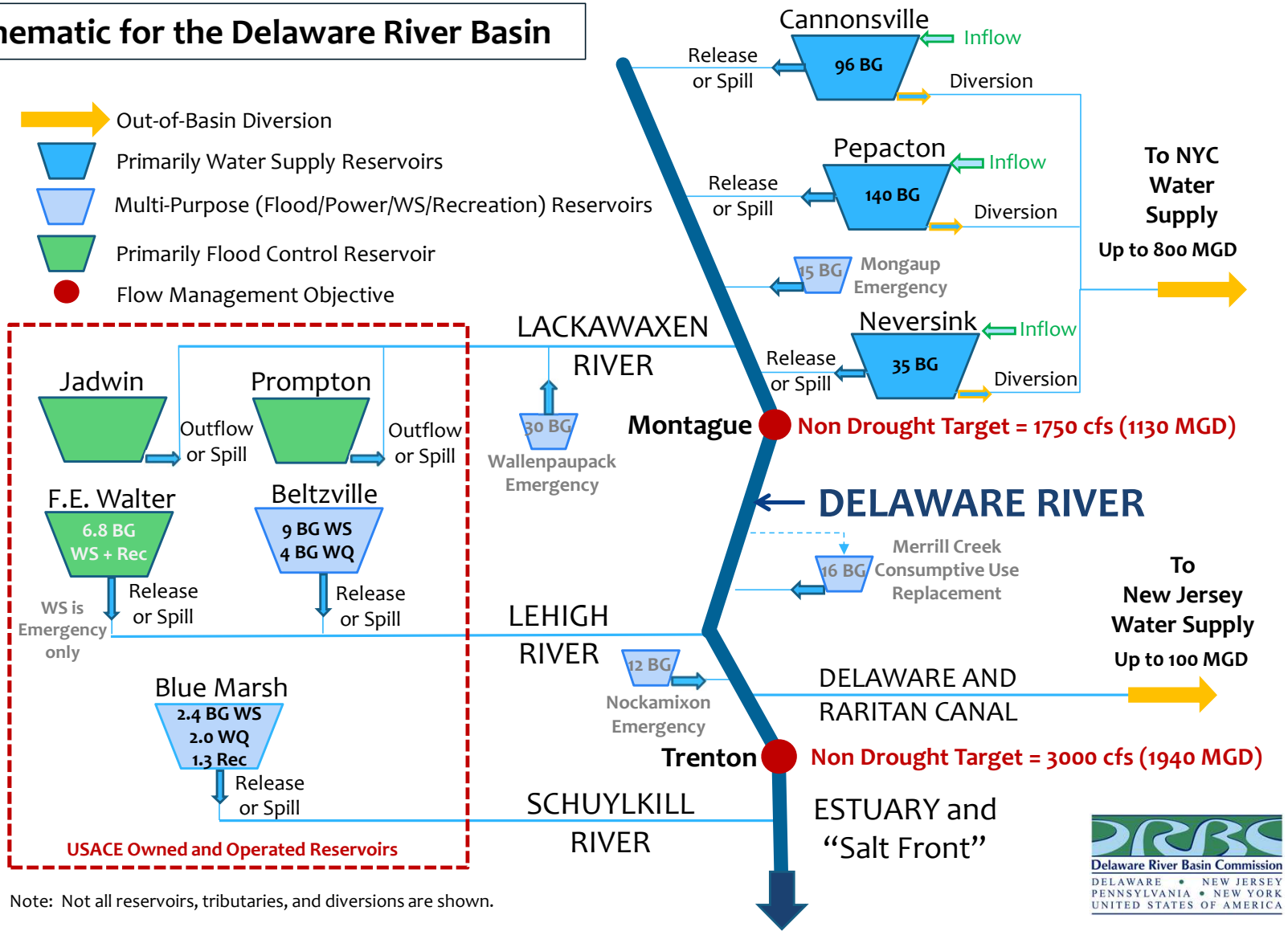
How everything came together:

1834 Canal
1927/29 Hydropower
- Mongaup
- Wallenpaupack

1931 Supreme Court Decree
1945 Delaware Aqueduct
1950s Canal for Water Supply
1954 Neversink
1954 Supreme Court Decree
- Montague Flow Objective
- Diversion Limits NYC/NJ

1955 Pepacton
1955 Hurricane Diane
1958 Nockamixon
1960s Drought
1960 Prompton and Jadwin
1961 FE Walter
1964 Cannonsville
1972 Beltzville
1977 Experimental Fisheries
1978 Blue Marsh
1983 Good Faith Agreement
- Trenton Flow Objective
- Phased Reductions

1988 Merrill Creek
2007 Flexible Flow Mgmt Plan



Note: Not all reservoirs, tributaries, and diversions are shown.

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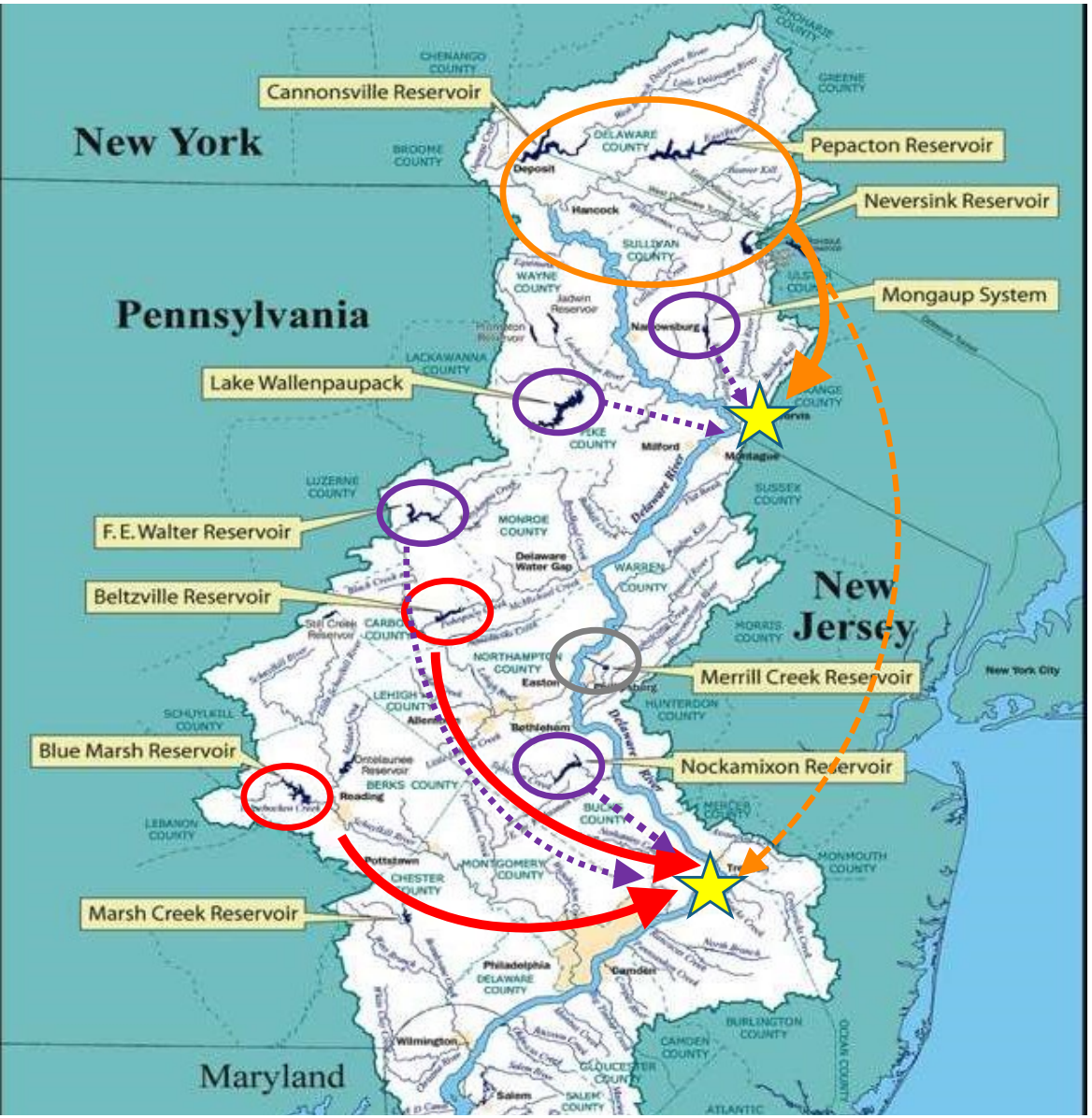
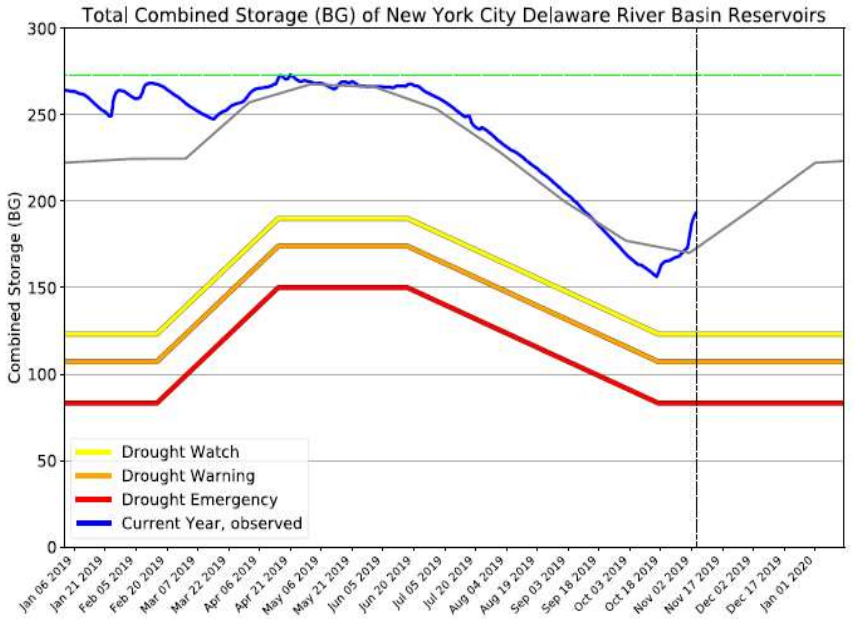


Sources of Water

for Flow Objectives



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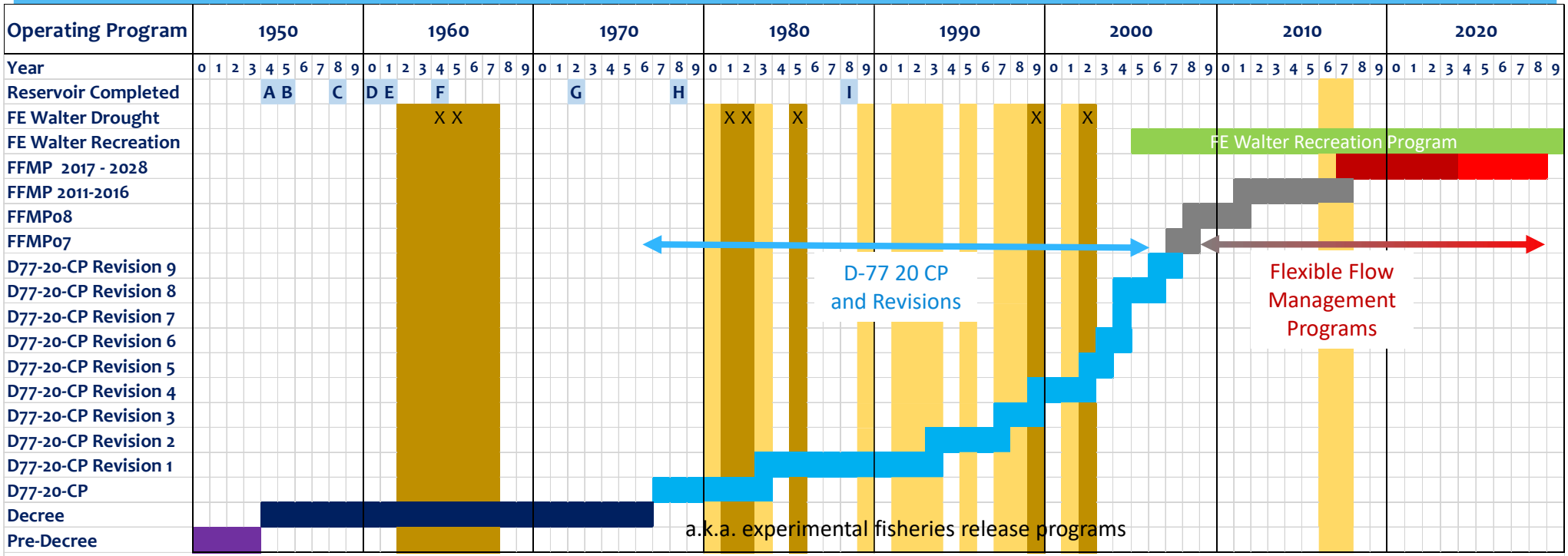
Reservoir Operating Programs



X= Reservoir Construction Completed [A=Neversink, B=Pepacton, C=Nockamixon, D=Promtpon and Jadwin, E=FE Walter; F=Cannonsville, G=Belzville, H=Blue Marsh, I=Merrill Creek. Lake Wallenpaupack and the Mongaup System were constructed in the 1920s]; Dates are approximate.

Drought Watch or Warning Drought Emergency X Water Stored in FE Walter for Drought Relief

Conservation releases – flow objectives – out-of-basin diversions – flood mitigation – Excess Release Quantity

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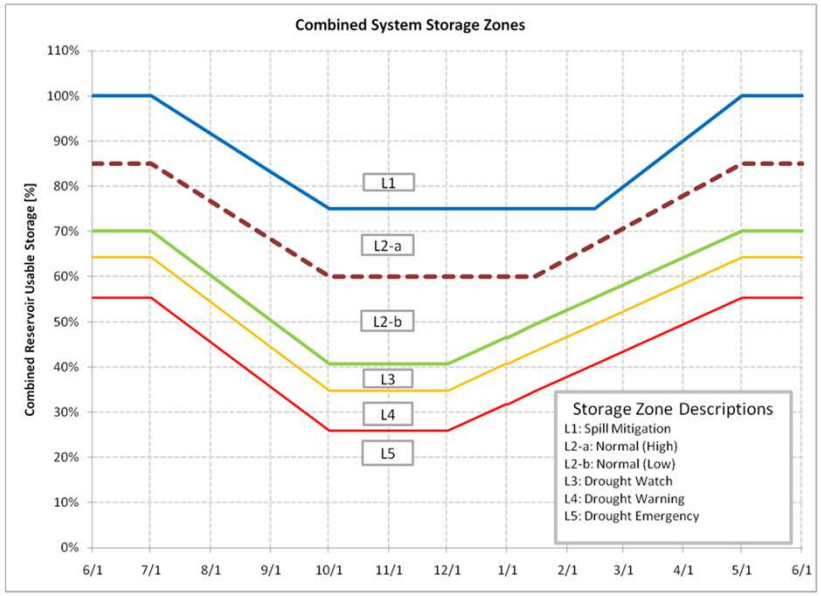
Flexible Flow Management Program

Delaware Basin Flow Objectives		
	Montague	**Trenton**
NYC Storage Condition	(cfs)	(cfs)
Normal (L1, L2)	1,750	3,000
Drought Watch (L3)	1,650	2,700
Drought Warning (L4)	1,550	2,700
Drought Emergency (L5)	1,100-1,650*	2,500-2,900*
Severe Drought (to be negotiated depending upon conditions)		
* Varies with time of year and location of salt front		

Figure 1

Drought Zones based on NYC Combined Storage



7-day average location of Salt Front	Flow Objectives During Drought Emergencies					
	Montague, NJ			Trenton, NJ (Gage+Blue Marsh Releases)		
River Mile	Dec-Apr.	May-Aug.	Sept-Nov.	Dec-Apr.	May-Aug.	Sept-Nov.
Upstream of R.M. 92.5	1,600	1,650	1,650	2,700	2,900	2,900
Between R.M. 87.0 and R.M. 92.5	1,350	1,600	1,500	2,700	2,700	2,700
Between R.M. 82.9 and R.M. 87.0	1,350	1,600	1,500	2,500	2,500	2,500
Downstream of R.M. 82.9	1,100	1,100	1,100	2,500	2,500	2,500

PHASED REDUCTIONS

Drought Status	Diversions NYC	Diversions NJ
Normal	800	100
Watch	680	100
Warning	560	90
Emergency	520	80

Key Considerations

* What is already in the river?	* baseflow
* What is leaving the river?	* withdrawals, evaporation, exfiltration
* What gets into the river?	* runoff, releases, discharges
* What else is happening?	* boating releases, drawdown, spills
* What source is available?	* USACE, NYC, PADEP, Hydropower
* How fast will it get there?	* 2-6 days
* Are there any adjustments?	* drought conditions

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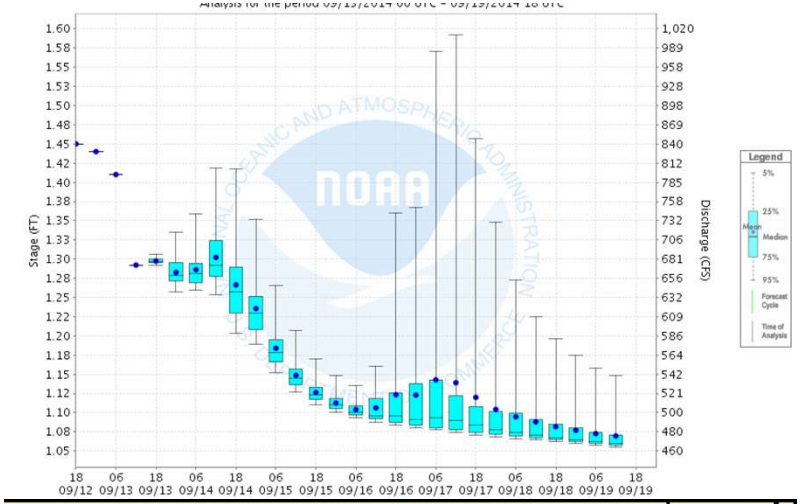
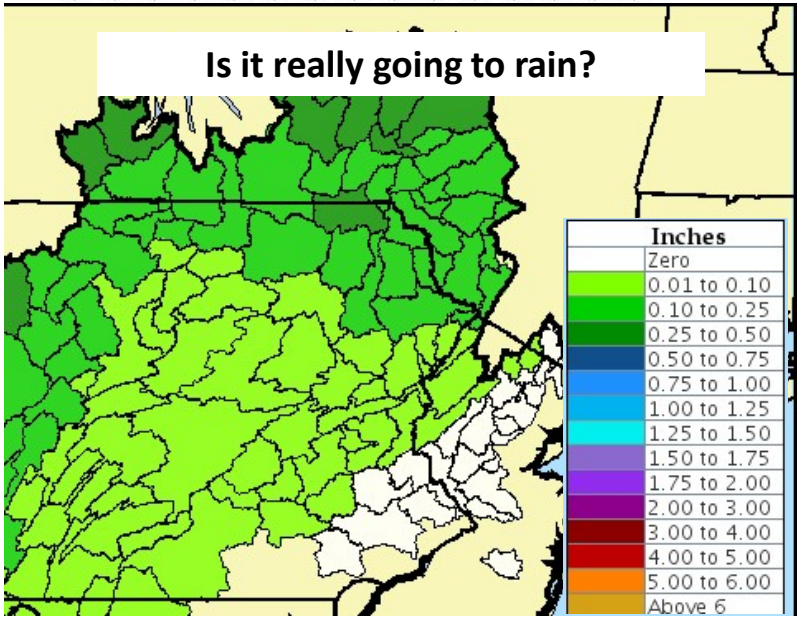
How quickly will baseflow drop?



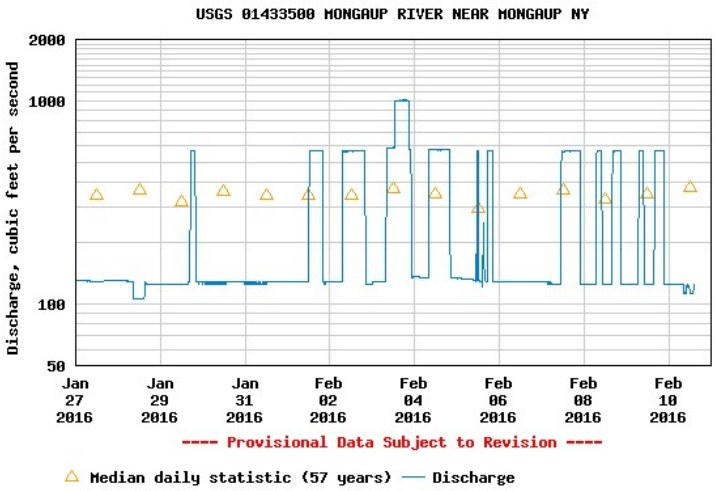
Is it really going to rain?



Will it get there on time?

Approximate Travel Times During Low Flow Conditions				
	Hours		Days	
	Montague	Trenton	Montague	Trenton
Cannonsville	48	96	2	4
Pepacton	60	108	2.5	4.5
Neversink	33	84	1.4	3.5
Wallenpaupack	16	64	0.7	2
Rio	8	56	0.3	2
Merrill Creek		24		1
FE Walter	44	60		2.5
Beltzville		32		2
Nockamixon		12		0.5
	Philadelphia			
Blue Marsh		38		

Will scheduled hydropower release occur?



Will the River Master meet Montague?

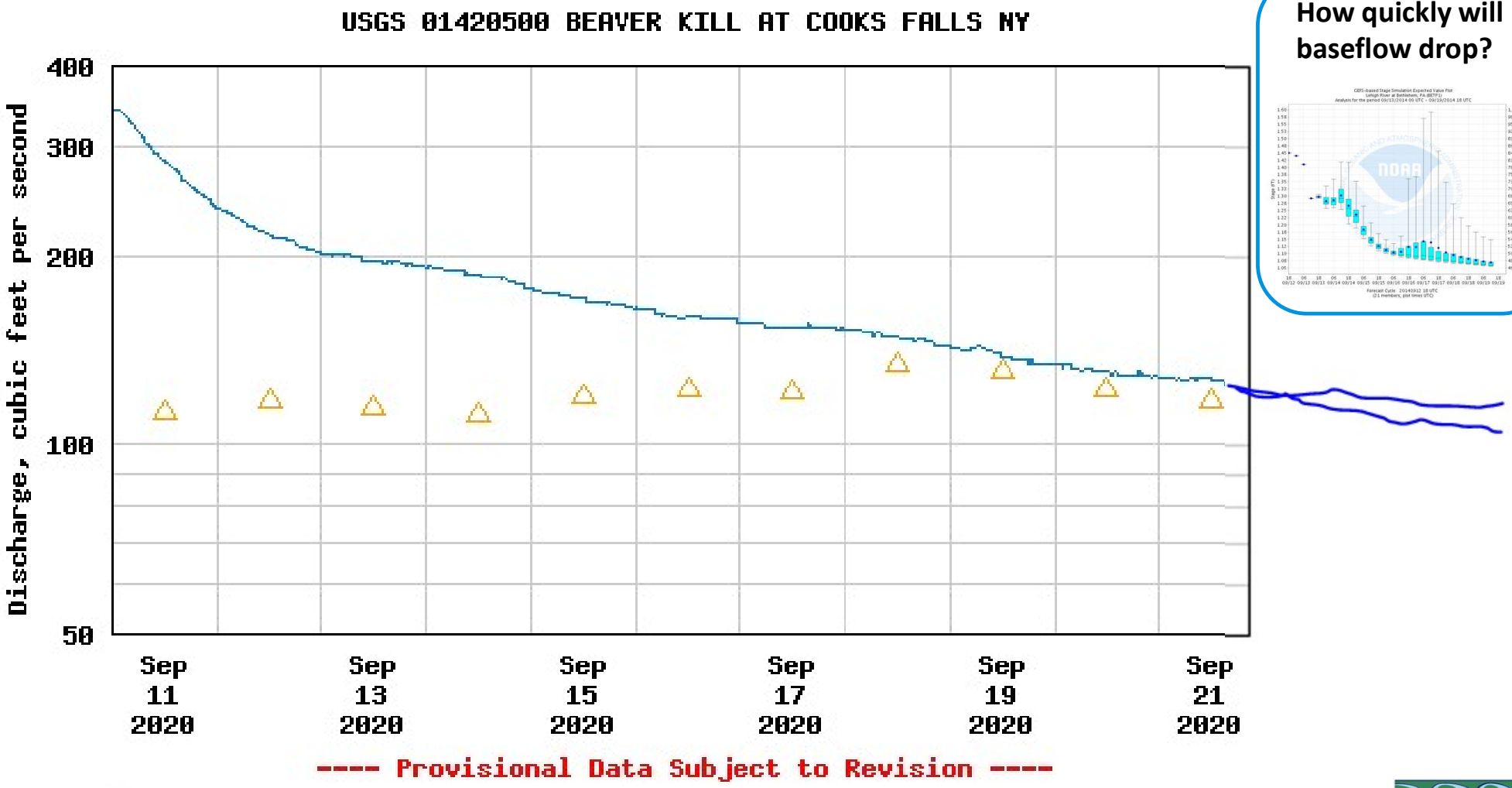
USGS science for a changing world

What is NJWSA taking from the Canal?

NJWSA EST. 1981

Are there recreation releases from reservoirs?

USACE



How quickly will baseflow drop?

Plot Courtesy of USGS

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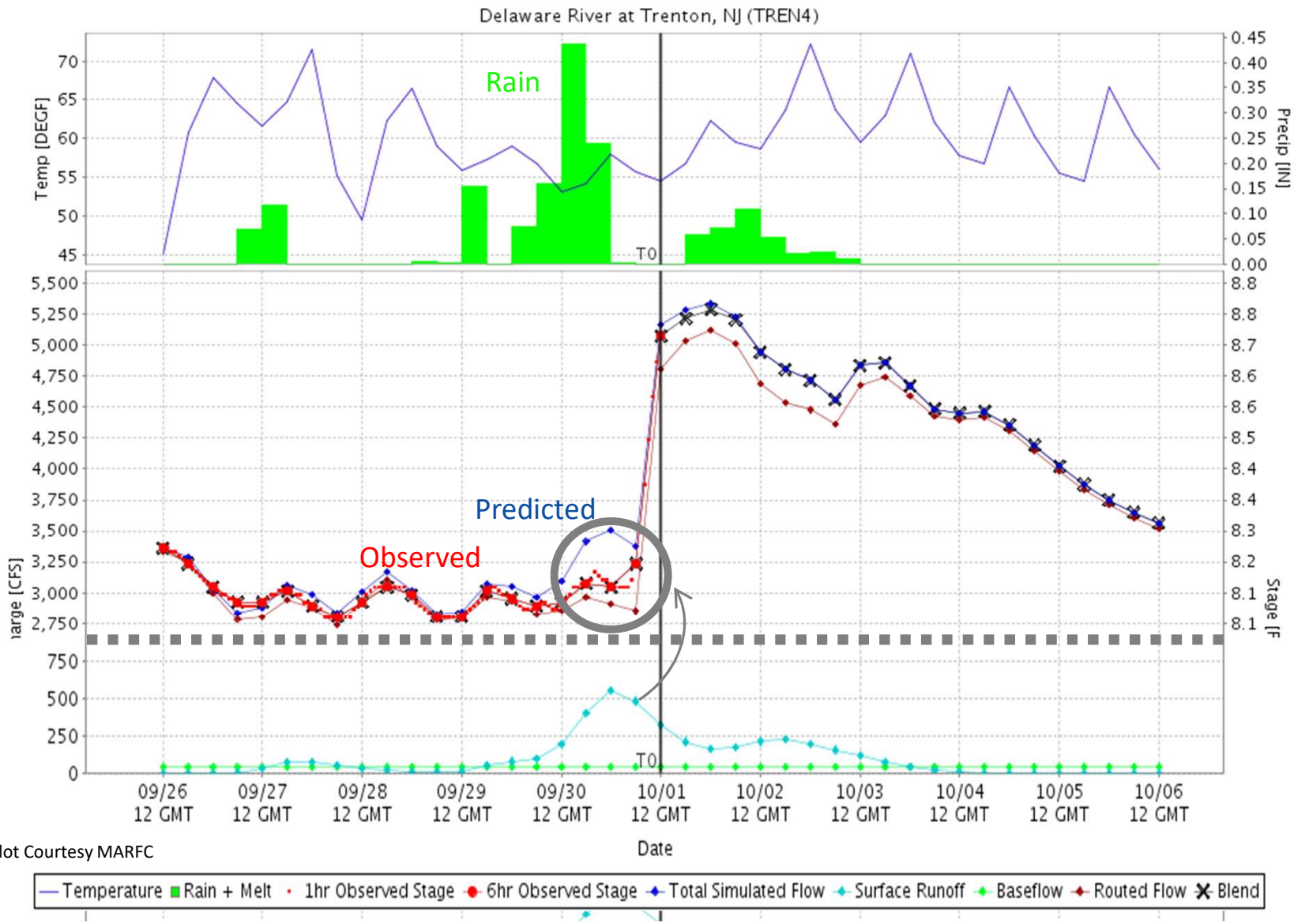

Plot Courtesy MARFC

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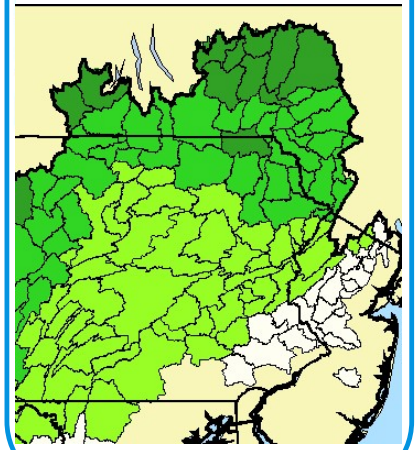

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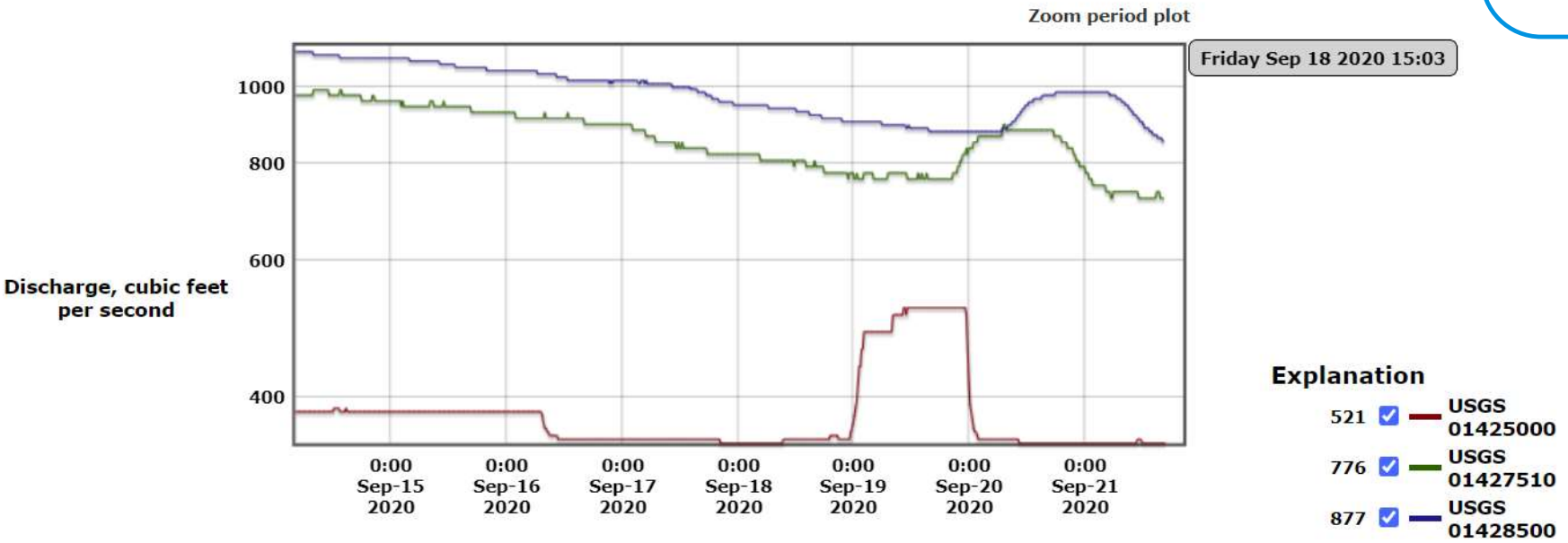
USGS 01425000 WEST BRANCH DELAWARE RIVER AT STILESVILLE NY
USGS 01427510 DELAWARE RIVER AT CALLICOON NY
USGS 01428500 DELAWARE R ABOVE LACKAWAXEN R NEAR BARRYVILLE NY



Plot Courtesy of USGS

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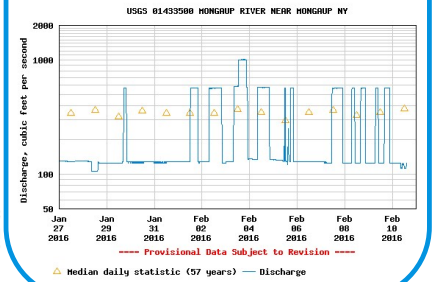
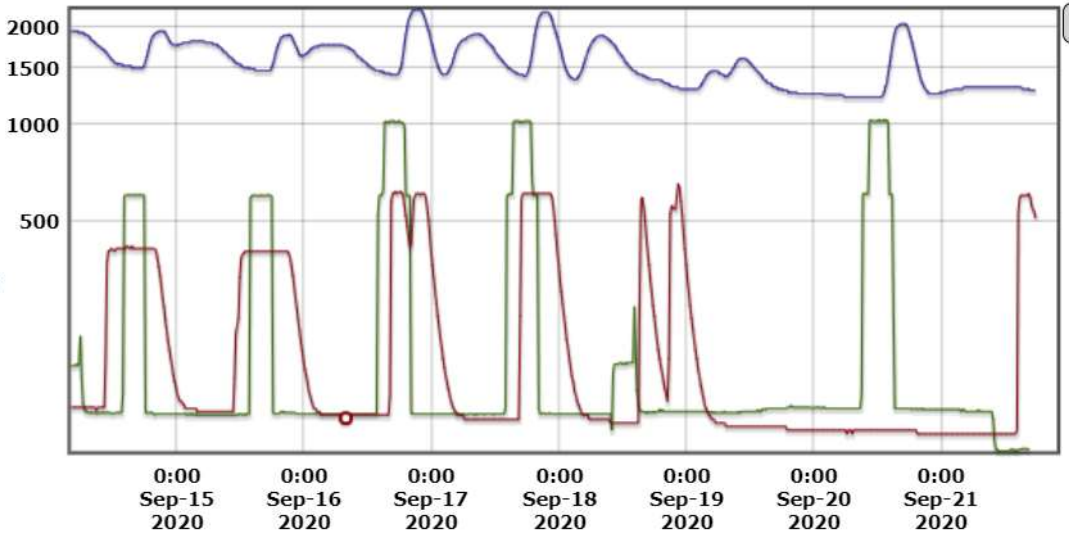
Will scheduled hydropower generation occur?



USGS 01432110 Lackawaxen River at Rowland, PA
USGS 01433500 MONGAUP RIVER NEAR MONGAUP NY
USGS 01434000 DELAWARE RIVER AT PORT JERVIS NY

Zoom period plot

Sunday Sep 13 2020 15:35



Explanation

129	☑	USGS 01433500
1730	☑	USGS 01434000
134	☑	USGS 01432110
--	☑	Measured discharge

Plot Courtesy of USGS

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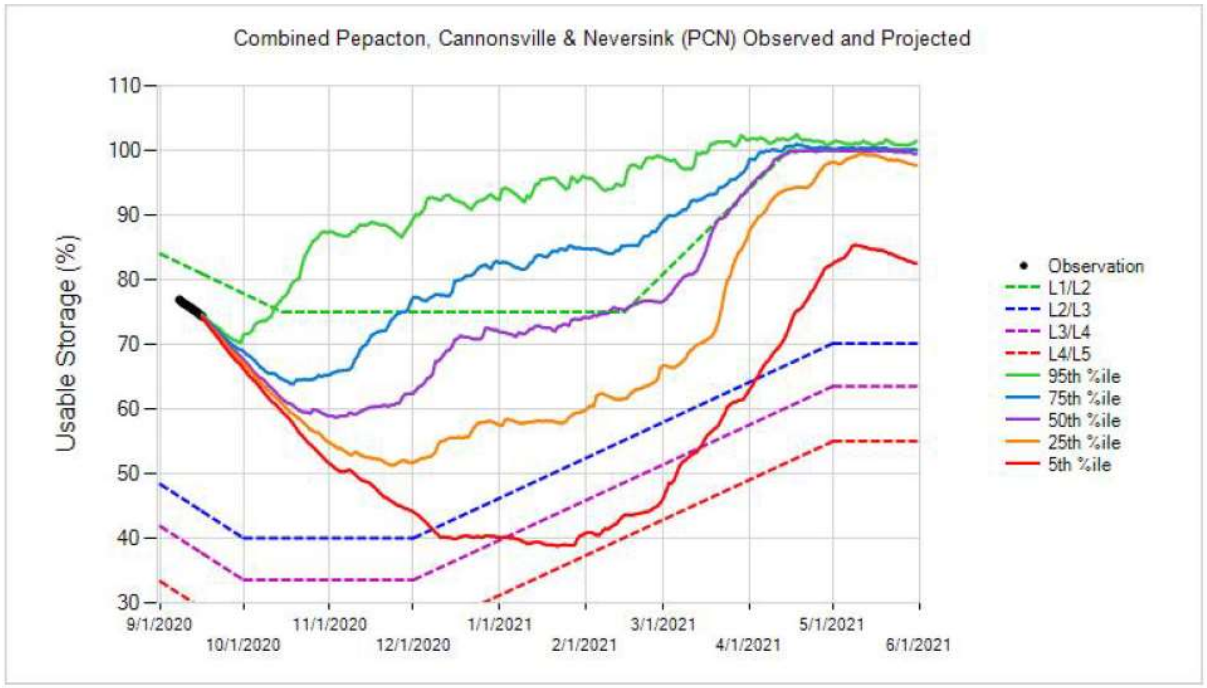
NYC Operations Support Tool



Example of FIRO

- Mass Balance Approach
- Today' Storage
- Expected Inflow until June 1 (forecasts)
- Expected Diversions
- Amount needed to be full on June 1
- Amount available to release
- Probability of Refill
- SELF-CORRECTING

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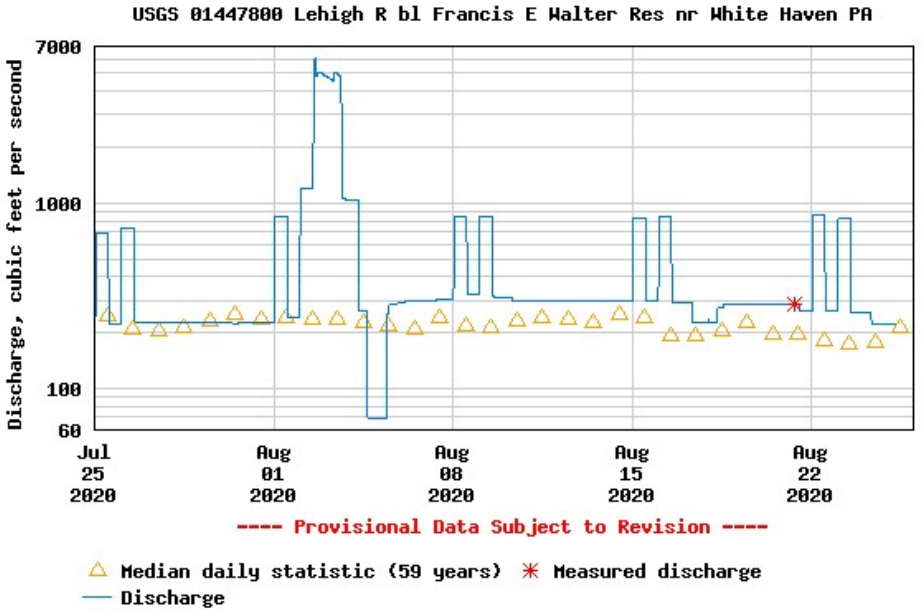
Example – FE Walter Reservoir – White Water

Photo: Kanvanagh



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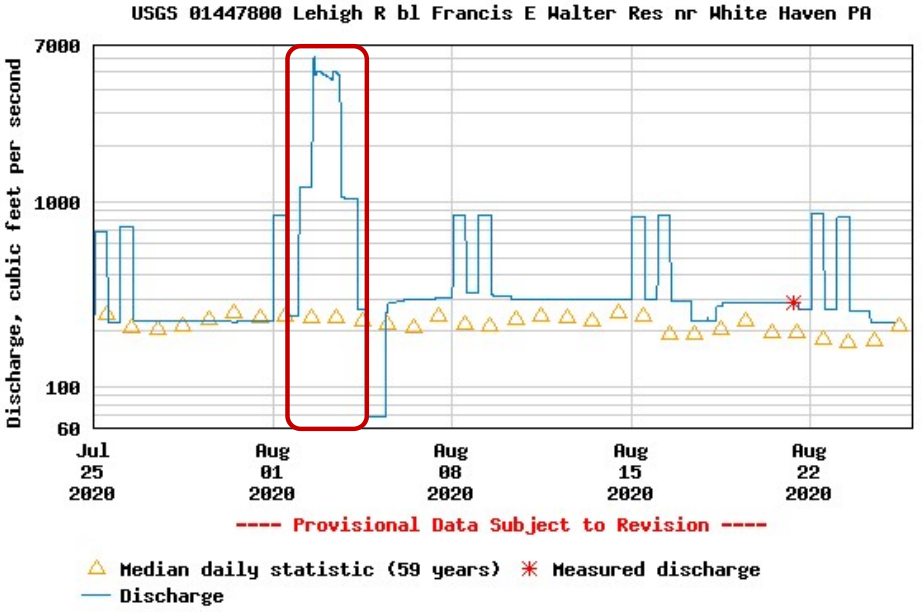
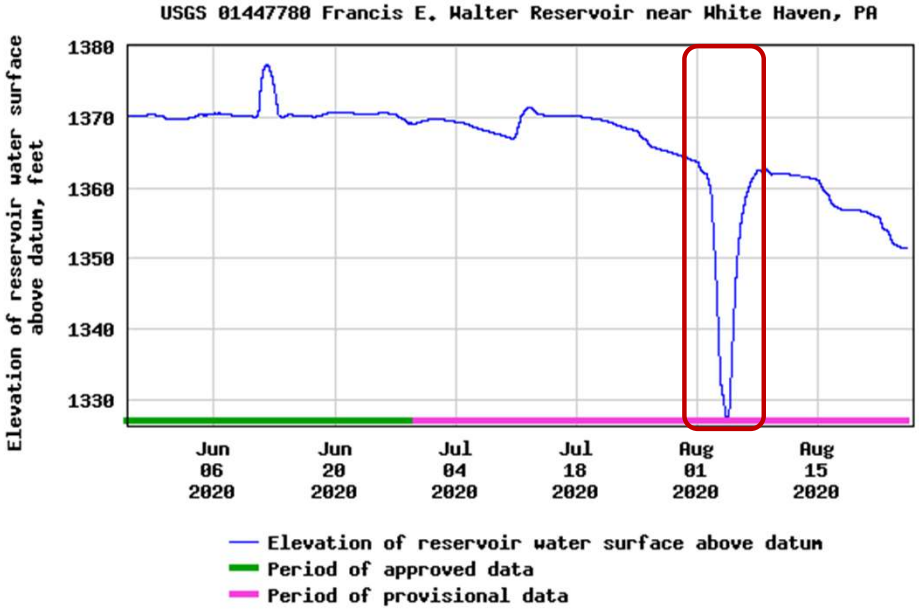
Example – FE Walter Reservoir – Flood Mitigation





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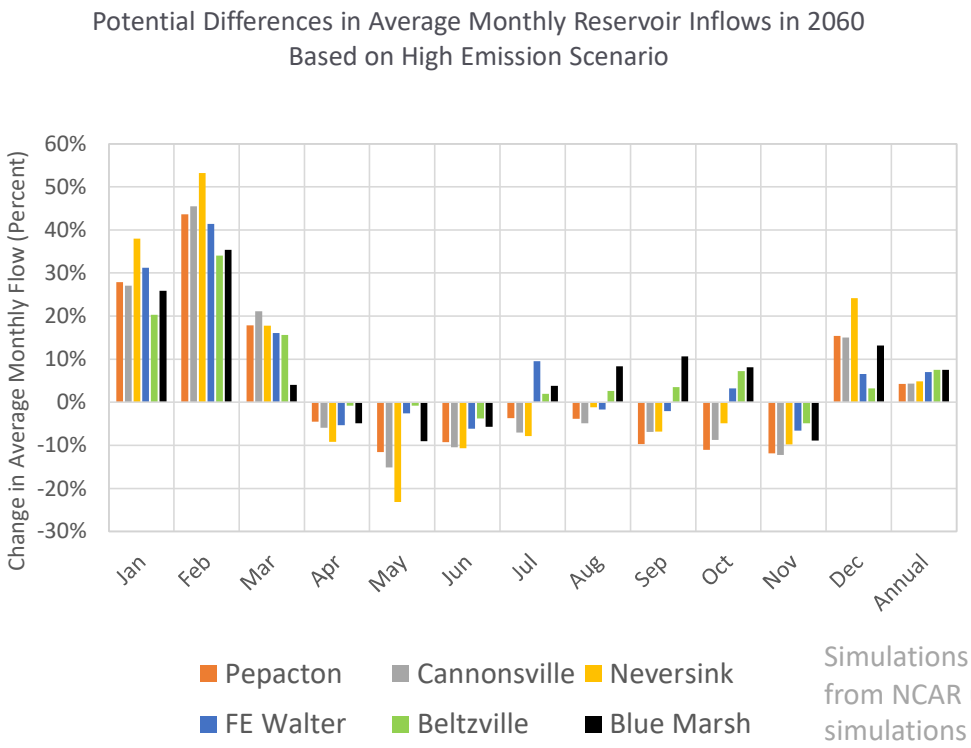
Climate Change Impacts to Flow



* Flows modestly increase
* Seasonality changes
* Higher temps means less snow
* Less snow means less snowmelt
* Increased evapotranspiration offsets increased precipitation

Simulations performed using WATER. Precipitation and Temperature from NCAR using change factor downscaling. Flows from DRB-PST simulations of 2011 Flexible Flow Management Plan.

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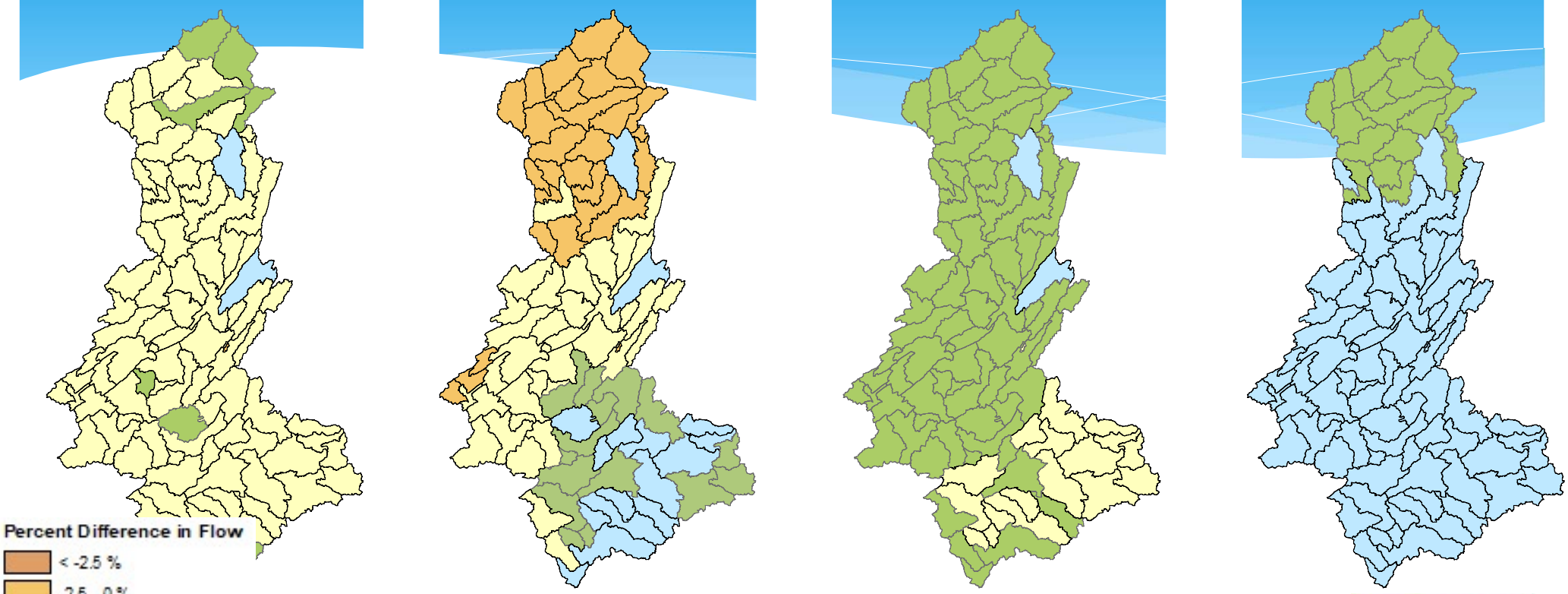
Simulated Percent Change in Average Annual Flow by 2060

RCP 2.6 Low Emissions

RCP 4.5 Medium Emissions

RCP 6.0 Med-Hi Emissions

RCP 8.5 High Emissions



Simulations performed using WATER. Precipitation and Temperature from NCAR using change factor downscaling.
Flows from DRB-PST simulations of 2011 Flexible Flow Management Plan.

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Sea Level Rise and Salinity

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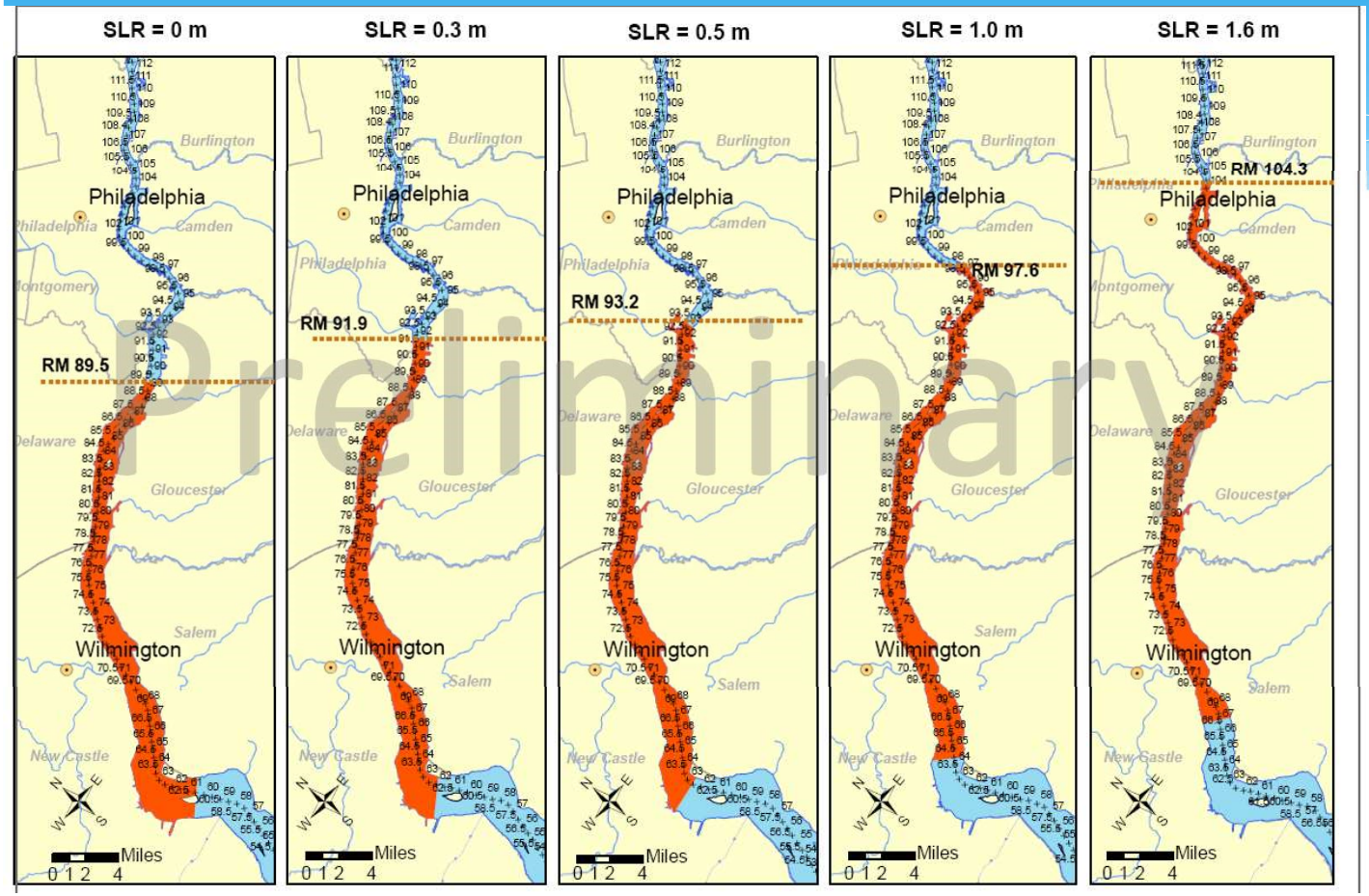
Range of Salt Front Movement

with dry conditions and different sea levels



DRBC. EFDC 3D Model - **Preliminary Results**

Simulated salt front range during 4-months of low flow conditions

With dry conditions similar to 2002 and SLR of 0.5 m or higher, salt front may move upstream of the Schuylkill River

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Flow Management

* Balancing of Goals Resources
* Evolves over time
* Consideration of a complex range of factors
* May be impacted by climate change

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QUESTIONS?

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