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Climate Change, Sea Level Rise and Drought Management in the DRB

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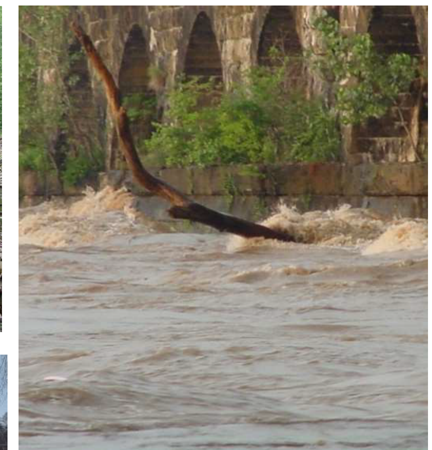
Advisory Committee on Climate Change
August 4, 2020



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Right to Left, Top to Bottom: AGU.org; NOAA, Phila.gov, Sea Grant Delaware, S. Mullholland, NOAA SLR Viewer, USGS, NYCDEP

Current Efforts on Climate Change

* Future Hydrology with Climate Change - Water Availability
* Flow Management Evaluations - Drought Resiliency
* Sea Level Rise Analyses - Water Suitability, Habitat
* Water demand projections – Needs Assessment
* Storage Studies (reservoir inventory, optimization, FE Walter) – Options
* Water Sustainability 2060 (Plan) - Adaptation
* Advisory Committee on Climate Change (AC3) - Guidance

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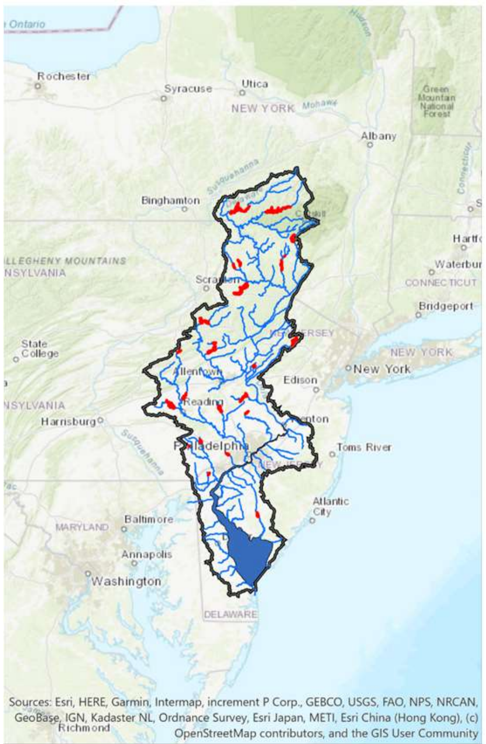
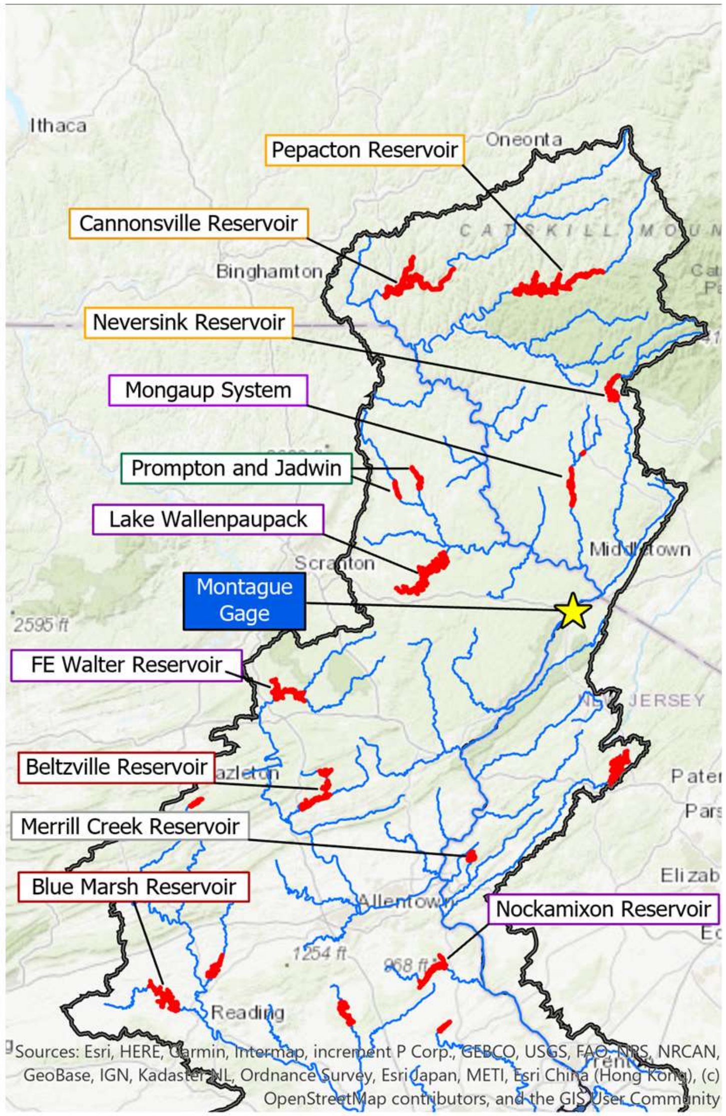
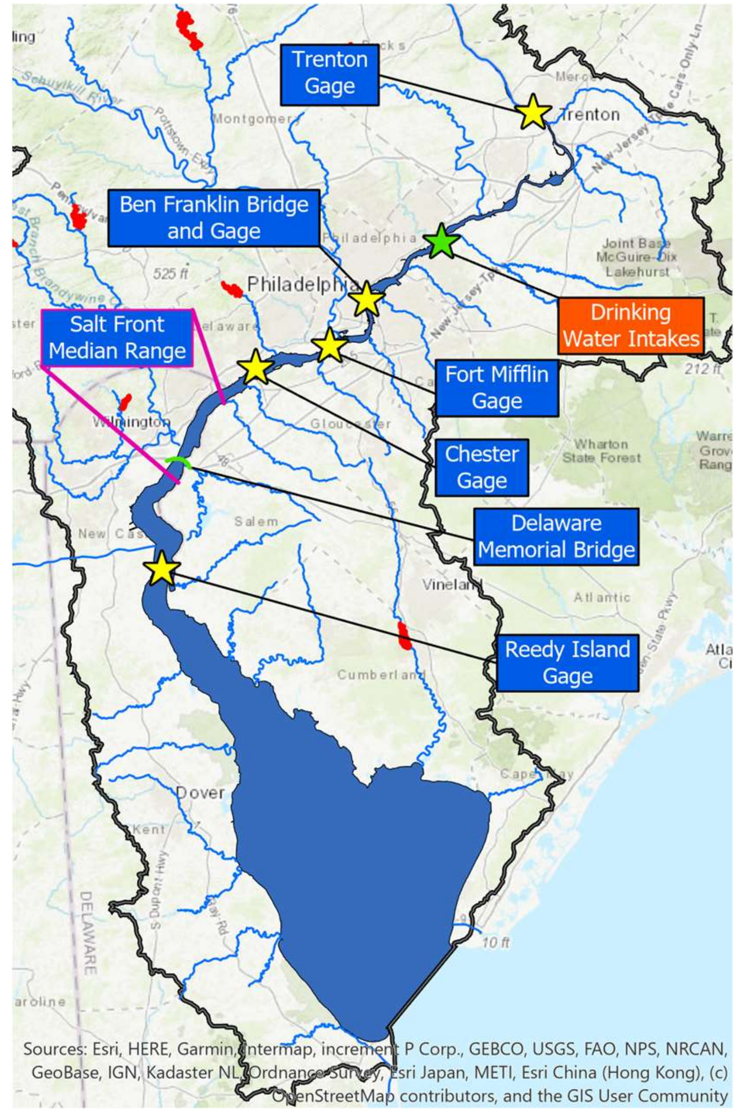
Delaware River Basin Tour

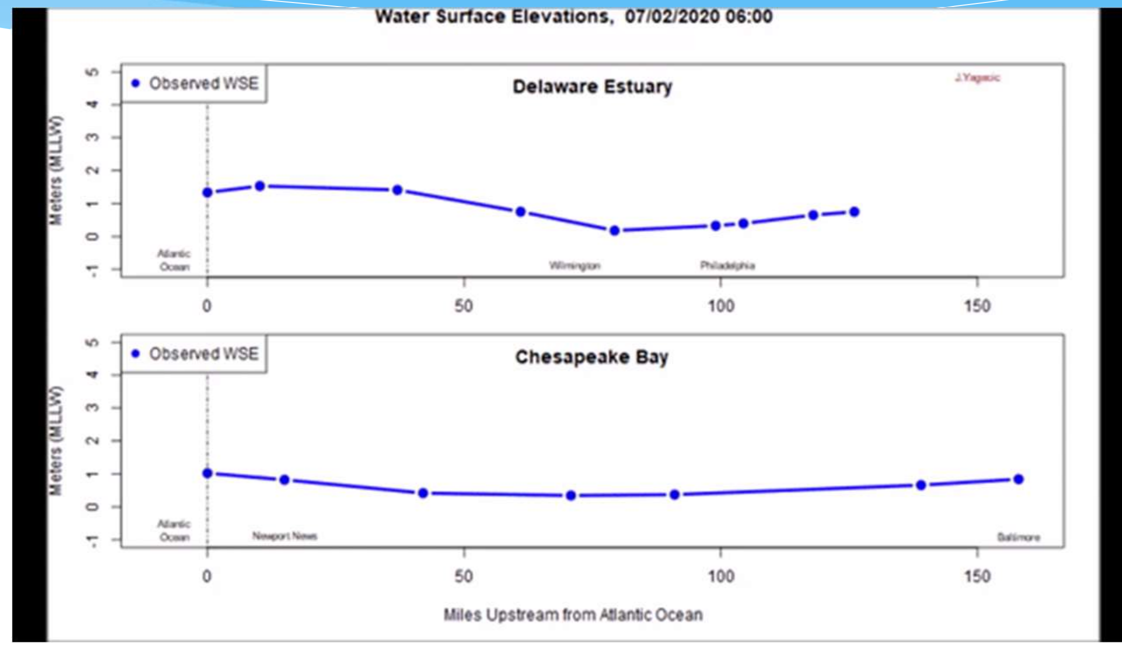


Basemap: ESRI, et. al.





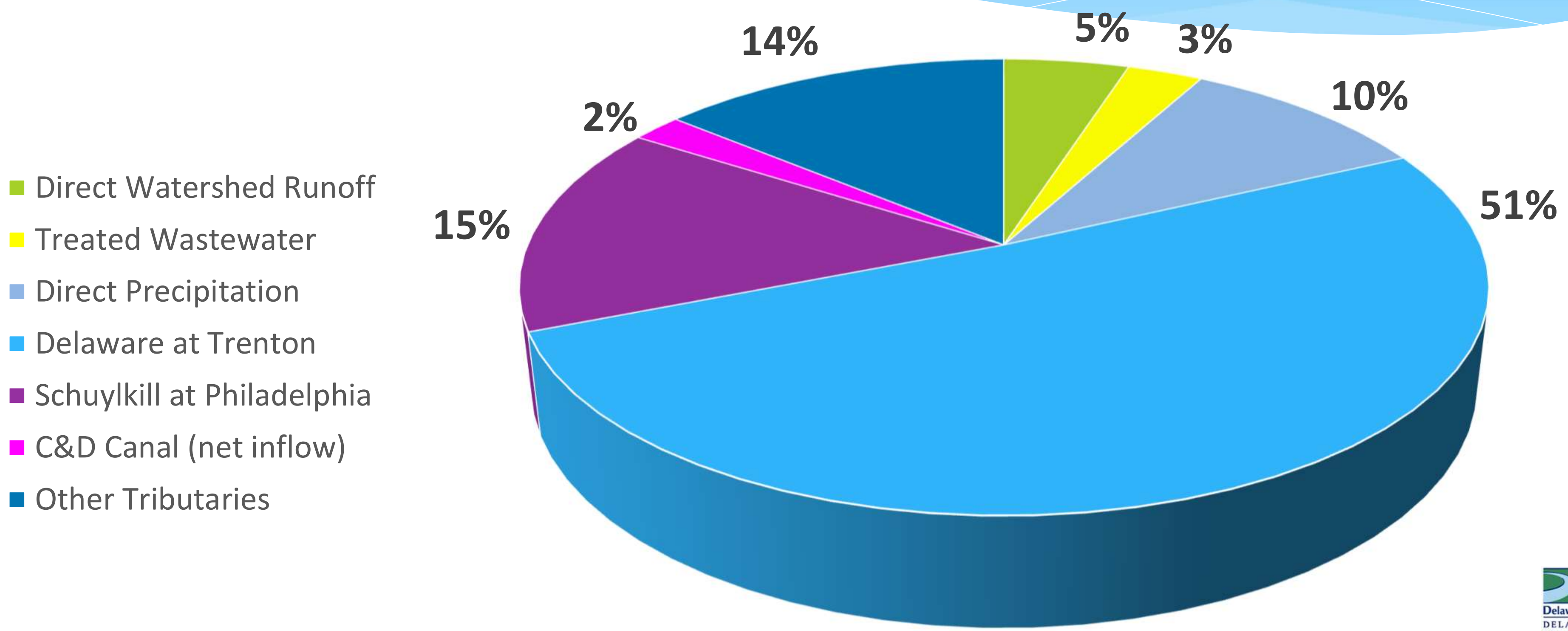
Chesapeake v. Delaware Bay/Estuary



Map: Google. Annimation: J. Yagecic.

Moving upstream, the DRB shoreline converges more quickly and the head of tide is like a wall which reflects the wave energy back downstream, unlike the Chesapeake bay and other estuaries.

Estuary Inflow Composition



Source: DRBC

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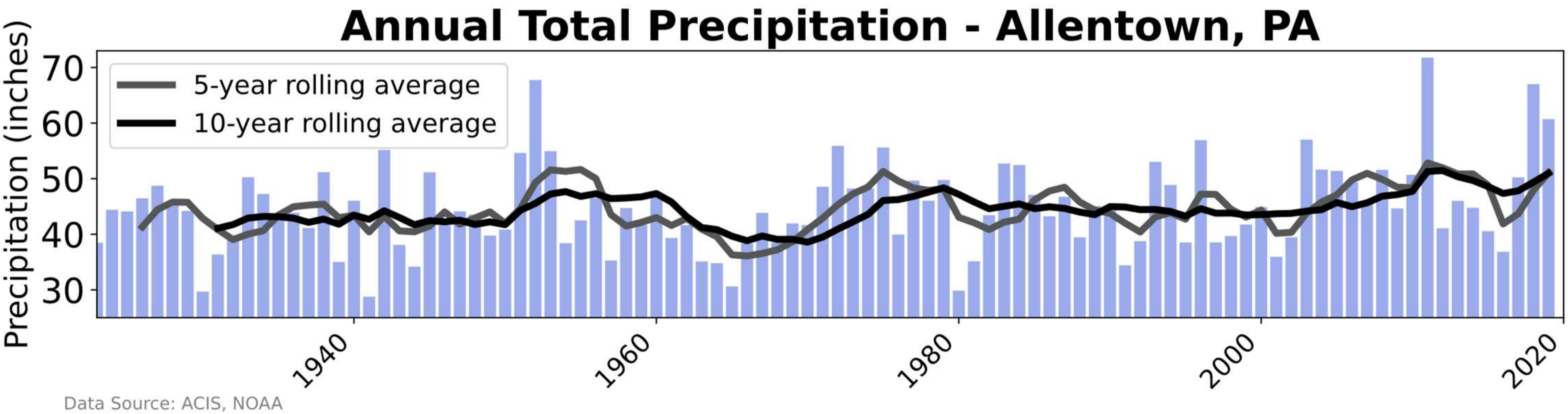
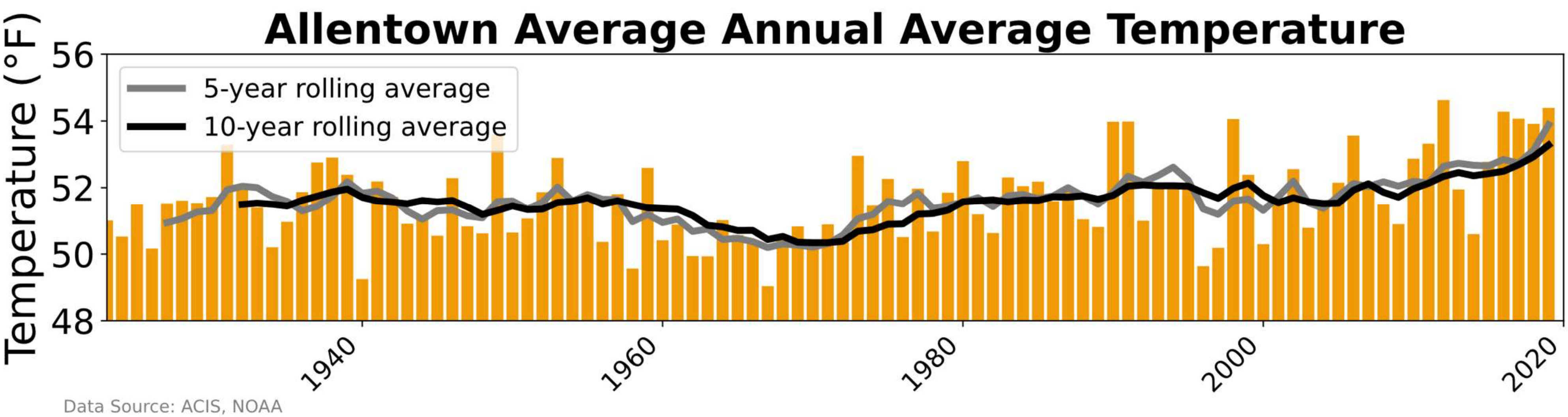
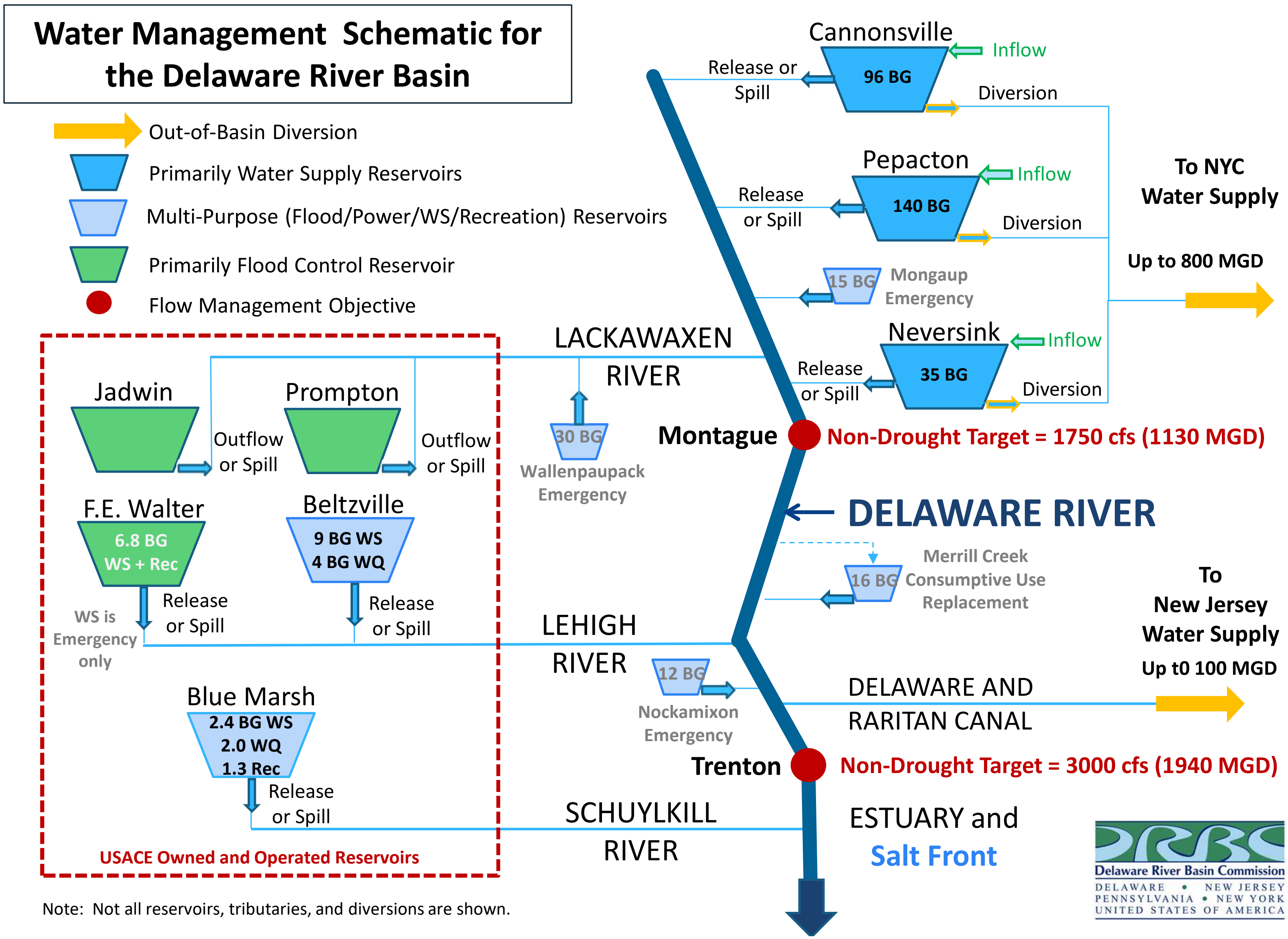


Annual Total Precipitation - Allentown, PA
Precipitation (inches)
70
60
50
40
30
5-year rolling average
10-year rolling average
1940
1960
1980
2000
2020
Data Source: ACIS, NOAA



Allentown Average Annual Average Temperature
Temperature (°F)
56
54
52
50
48
5-year rolling average
10-year rolling average
1940
1960
1980
2000
2020
Data Source: ACIS, NOAA


Water Management Schematic for the Delaware River Basin
Out-of-Basin Diversion
Primarily Water Supply Reservoirs
Multi-Purpose (Flood/Power/WS/Recreation) Reservoirs
Primarily Flood Control Reservoir
Flow Management Objective
Cannonsville
96 BG
Inflow
Release or Spill
Diversion
Pepacton
140 BG
Inflow
Release or Spill
Diversion
To NYC Water Supply
Up to 800 MGD
15 BG
Mongaup Emergency
Neversink
35 BG
Inflow
Release or Spill
Diversion
LACKAWAXEN RIVER
Jadwin
Outflow or Spill
Prompton
Outflow or Spill
30 BG
Wallenpaupack Emergency
Montague
Non-Drought Target = 1750 cfs (1130 MGD)
DELAWARE RIVER
16 BG
Merrill Creek Consumptive Use Replacement
F.E. Walter
6.8 BG WS + Rec
Release or Spill
WS is Emergency only
Beltzville
9 BG WS
4 BG WQ
Release or Spill
LEHIGH RIVER
To New Jersey Water Supply
Up t0 100 MGD
12 BG
Nockamixon Emergency
DELAWARE AND RARITAN CANAL
Blue Marsh
2.4 BG WS
2.0 WQ
1.3 Rec
Release or Spill
Trenton
Non-Drought Target = 3000 cfs (1940 MGD)
SCHUYLKILL RIVER
ESTUARY and Salt Front
USACE Owned and Operated Reservoirs
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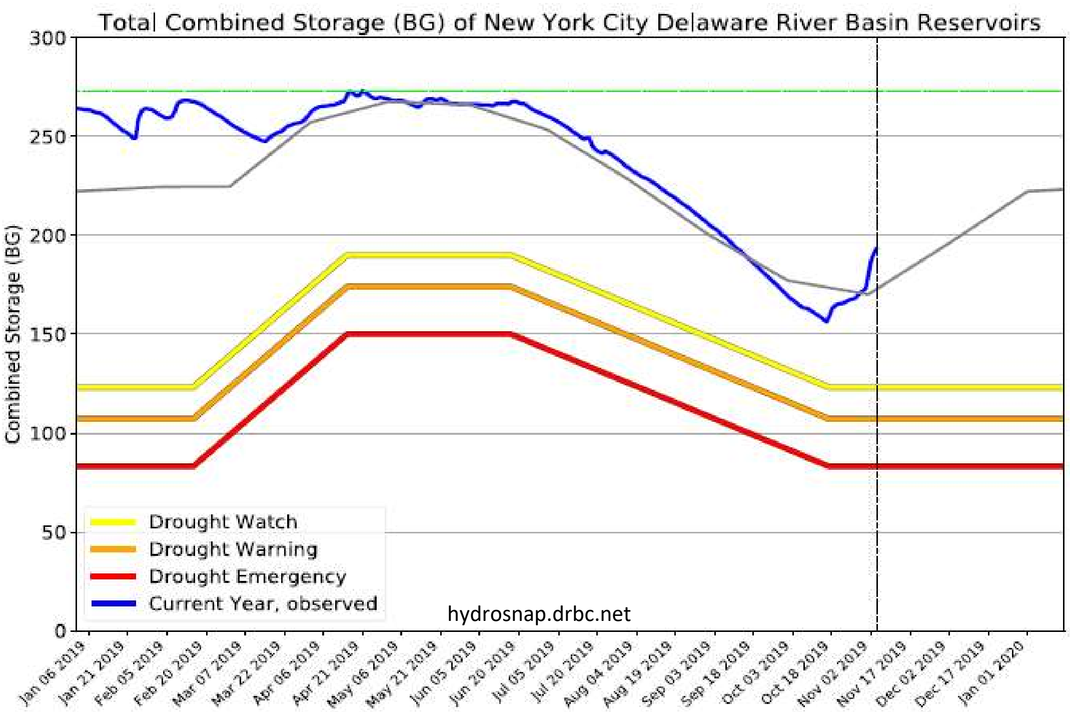
Note: Not all reservoirs, tributaries, and diversions are shown.

DRBC Drought Management



- Chloride Criteria
- Trenton Flow Objective
- Phased reductions
  - Flow Objectives
  - Diversions and Water Use
  - Releases
- Drought of Record Planning Scenario
- Conservation Requirements
- Depletive Use Management Plan
- Docket (permit) water allocation
- Plumbing Standards
- Water Audits

Basinwide plan is based on combined NYC storage. Lower Basin plan based on elevations in two lower basin reservoirs.

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Summary of the Setting

* Basin is vulnerable to flood and droughts
* Flow Management Programs were established to mitigate drought and build resiliency (after extensive studies) – adaptation
  * Basinwide and lower basin only drought management plan
  * water withdrawal permits (dockets)
  * water conservation
  * water audits
* Uncertainty about climate change related factors warrants a new assessment of basin resources and flow/drought management

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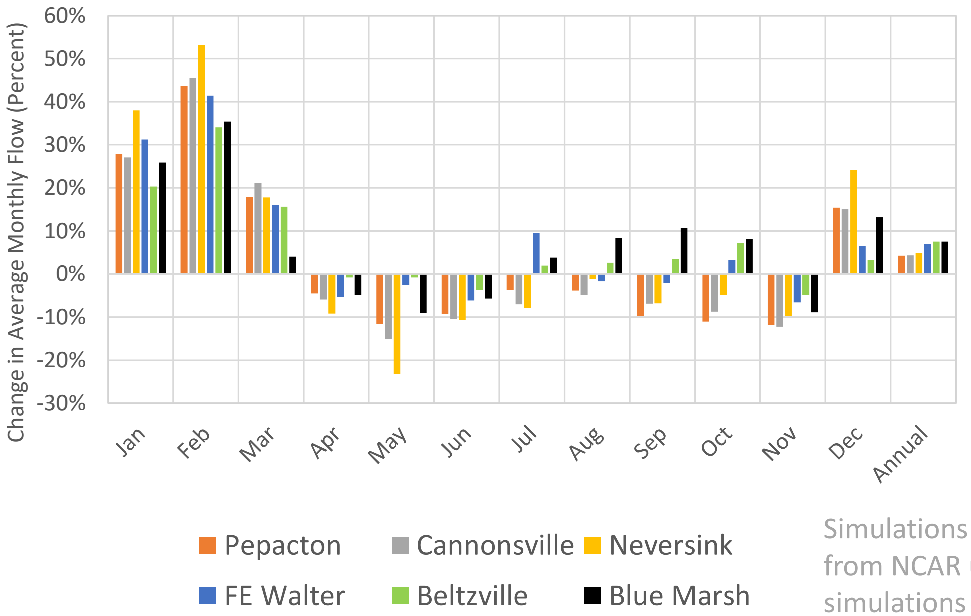
Climate Change Impacts to Flow

Potential Differences in Average Monthly Reservoir Inflows in 2060
Based on High Emission Scenario



- 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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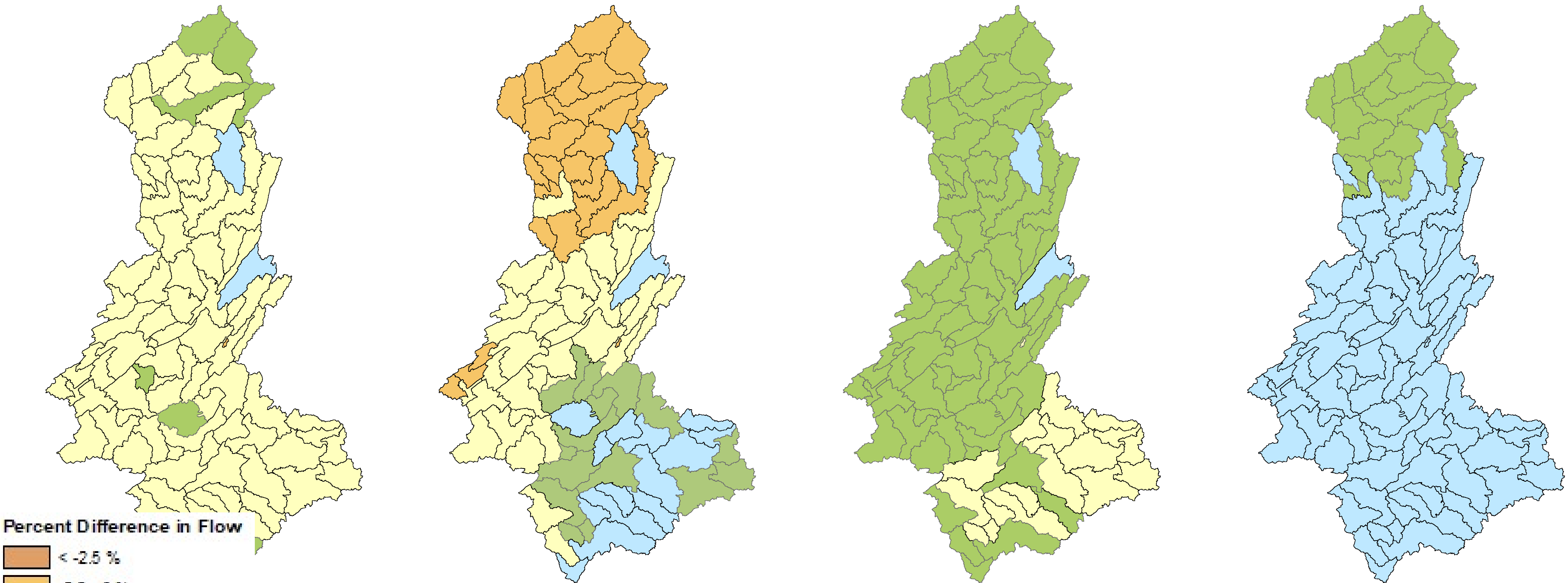
Simulated Percent Change in Average Annual Flow by 2060

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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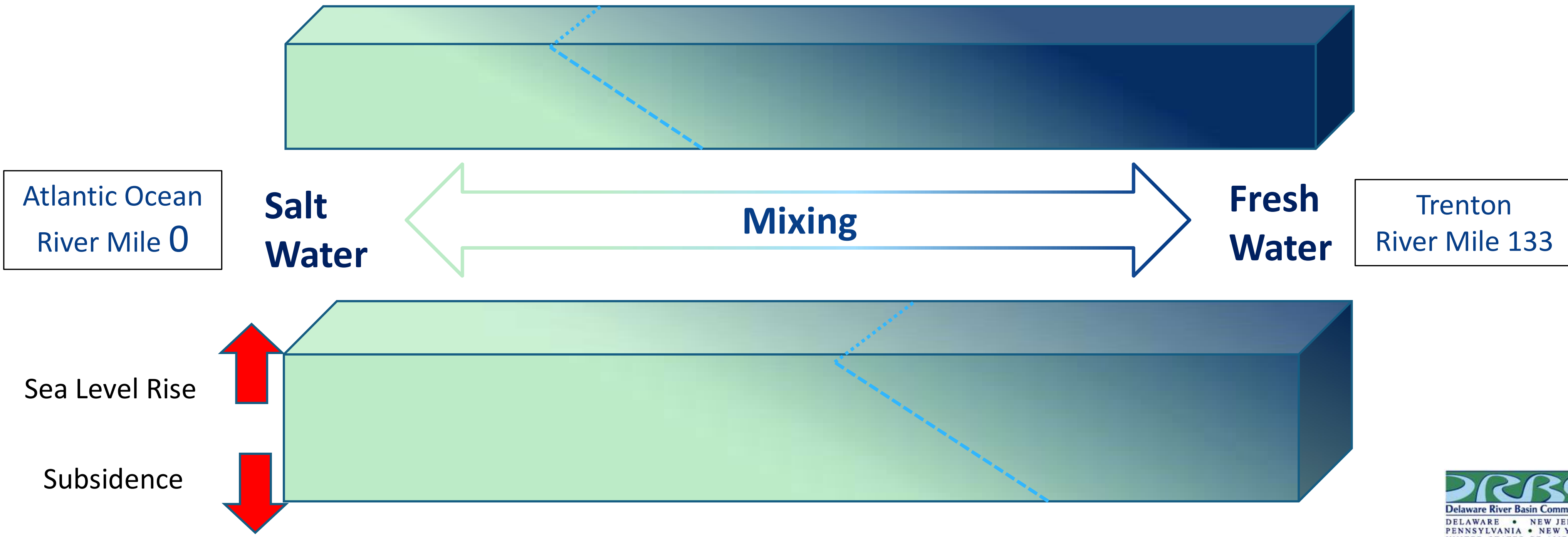
Sea Level Rise and Salinity



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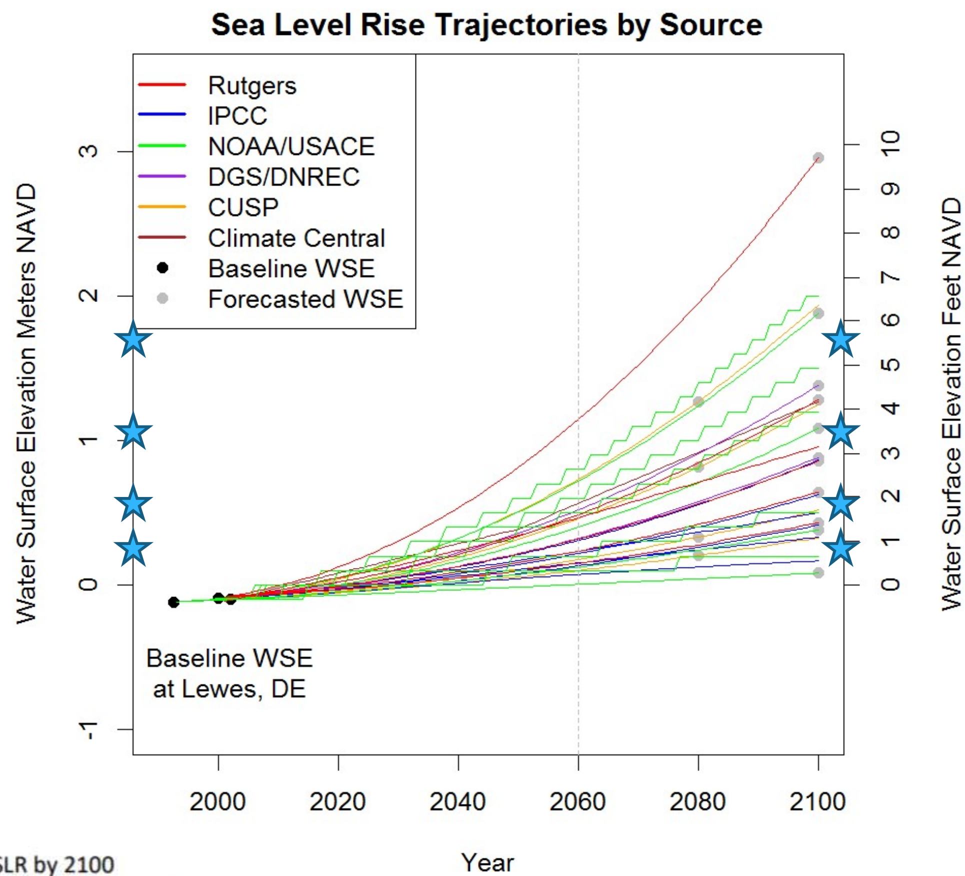


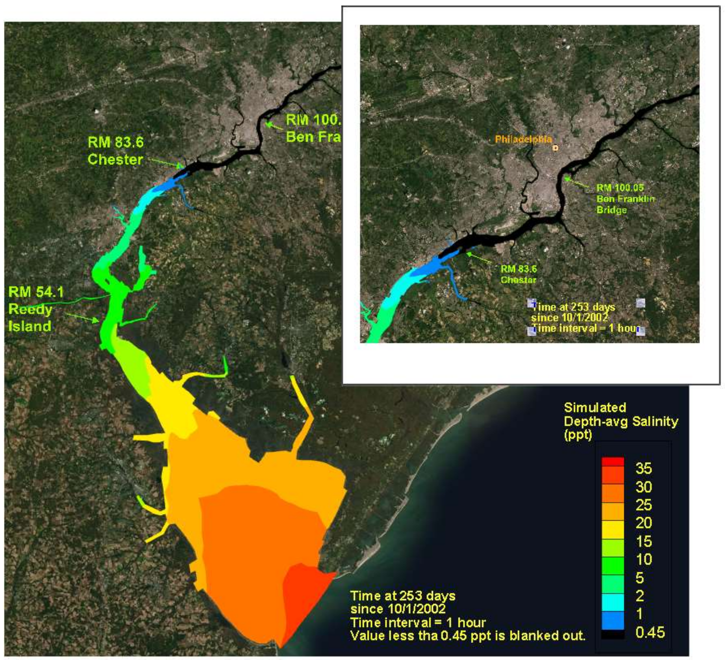
SLR Planning Scenario	SLR by 2100	
Low Scenario (5%)	**0.52 m**	**1.71 ft**
Intermediate Scenario (50%)	**0.99 m**	**3.25 ft**
High Scenario (95%)	**1.53 m**	**5.02 ft**

DRBC: Sea Level Trajectories by Source (2016). Delaware Geological Survey: SLR Planning Scenarios Table (2017). NJ: Rutgers STAP 2019, not shown.

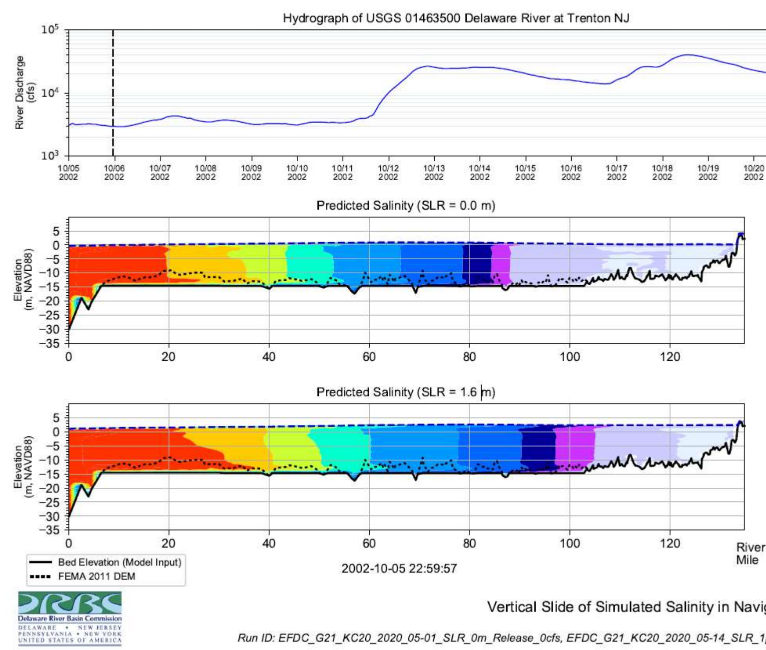
Animations

Simulation of 1.6 m of Sea Level Rise and with hydrological conditions from October 2002

Depth-averaged



Vertical Profile



Animations: DRBC/Dr. Fanghui Chen/ Preliminary Results

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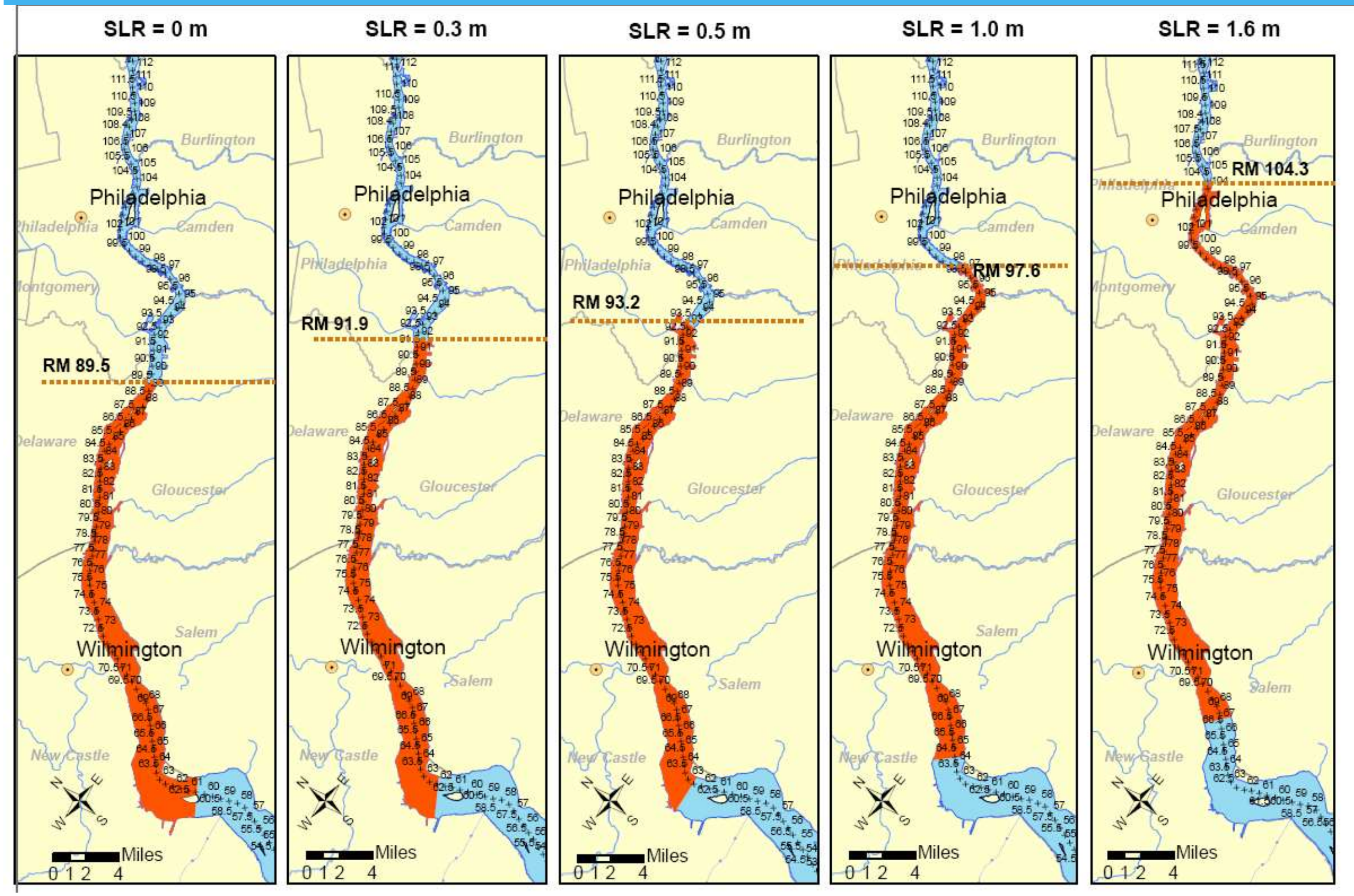
Range of Salt Front Movement
with dry conditions and different sea levels



DRBC. EFDC 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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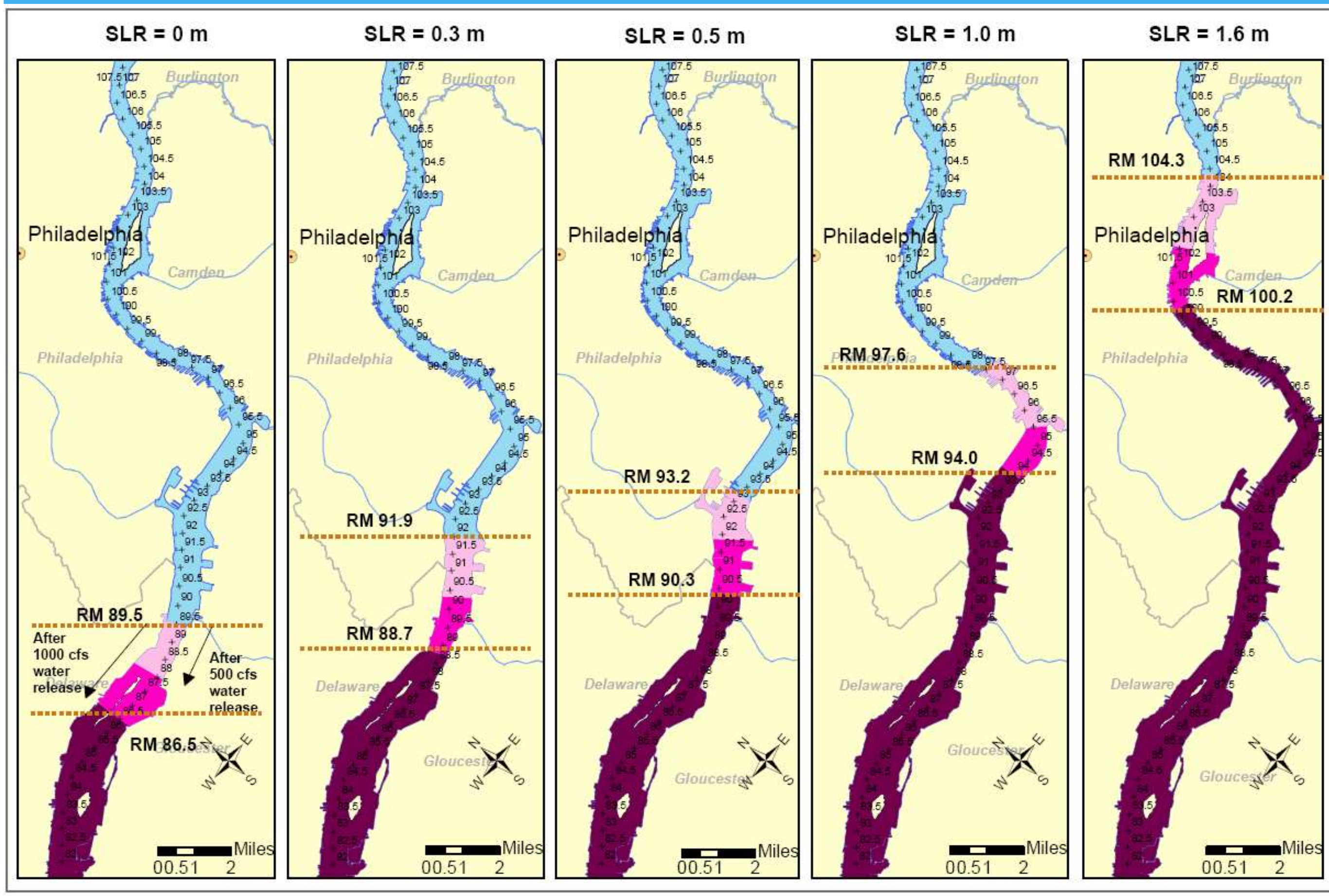
Range of Salt Front Movement

with dry conditions and different flow augmentation



Simulations of July-October 2002 conditions with additional water released in August and September. A significant amount of water may be needed to keep the salt front below RM 92.5.

DRBC. EFDC Model - Preliminary Results

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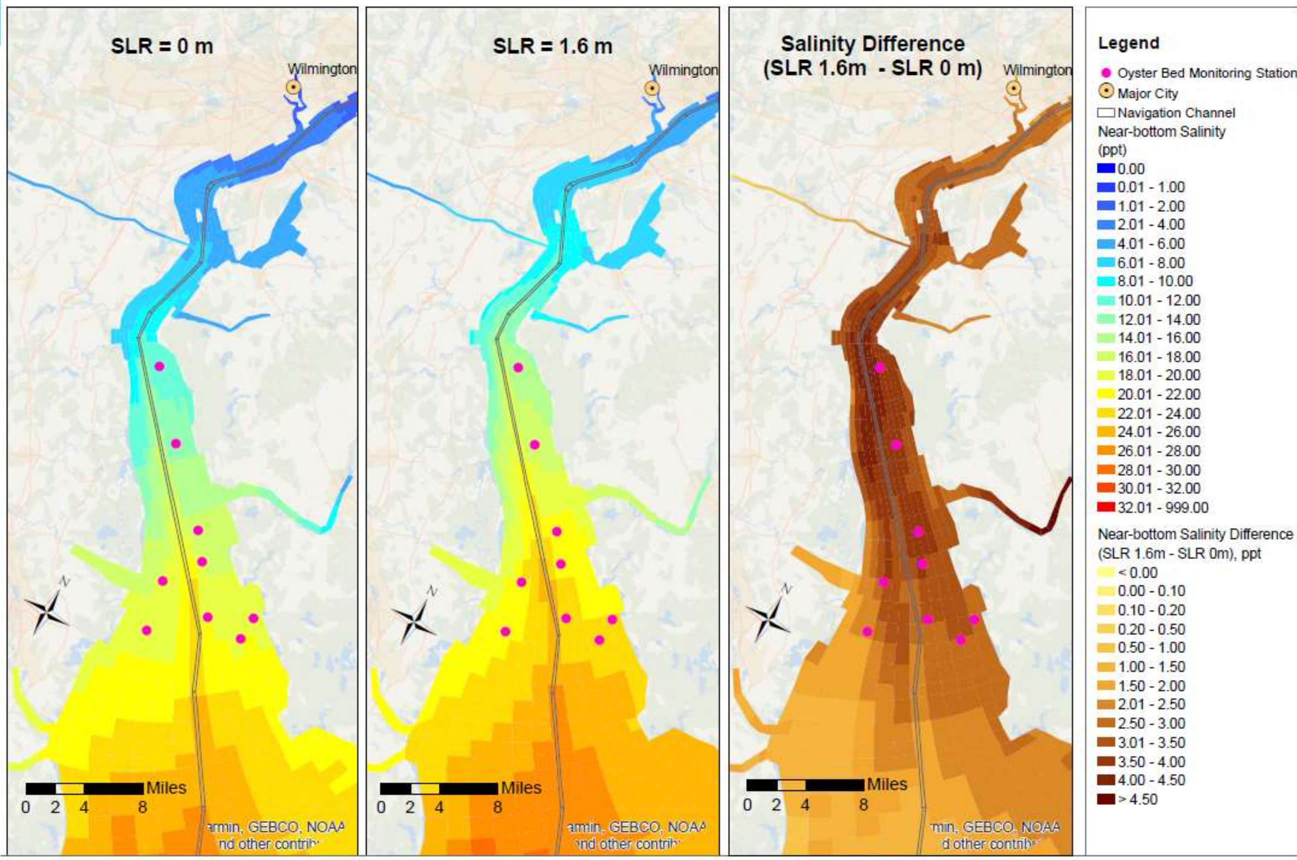
Impacts to Oysters

Preliminary



DRBC. EFDC Model - Preliminary Results

Simulated Average Salinity with July-October 2002 flows (a dry period)

- Oysters thrive with salinity of 14-28 psu; survive in 5-35 psu
- Parasites prefer and are more prevalent in higher salinity water
- Higher salinity water affects taste (mineral taste)

14.01 - 16.00
16.01 - 18.00
18.01 - 20.00
20.01 - 22.00
22.01 - 24.00
24.01 - 26.00
26.01 - 28.00

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Current Findings

* DRBC work is beginning to define climate change impacts related to hydrology, flow management and sea level rise - more work is planned
* **Water Availability:** changes in hydrology due to temperature and precipitation may be more impactful locally rather than basinwide
* **Water Suitability:** more frequent incidents of salinity intrusion may result in the need for alternative sources of water or [additional] treatment before use
* **Drought Resiliency:** more water will be needed to meet salinity management goals
* **Habitat:** with the increase in salinity from SLR, oysters are likely to be more susceptible to parasites, predators and disease and become less palatable
* AC3 assistance is needed to define scenarios, assumptions and planning criteria for future analyses

Next Steps

* Consult with the Advisory Committee on Climate Change (AC3)
  * Decide avenues of investigation
  * Identify knowledge gaps
  * Develop planning scenarios
  * Formulate and refine assumptions
  * Explore uncertainty
  * Gather stakeholder input
* DRBC will continue to use existing and developing tools
* Evaluate scenarios and alternatives (use existing and/or new models)
* Identify stressed areas
* Collaborate with other DRBC Advisory Committees
* Work with stakeholder to develop adaptation strategies

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