Delaware River Basin Commission

Planning Scenarios for Sea Level Rise Impacts to Drought Management

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with
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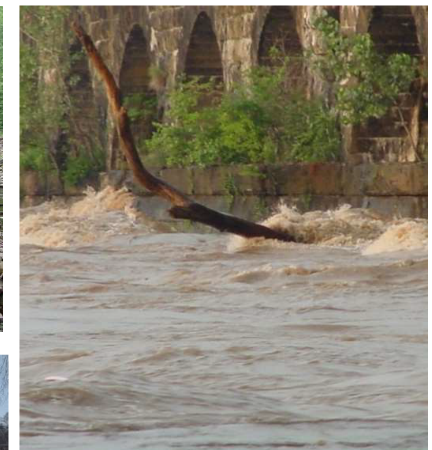
Anthony Preucil

Advisory Committee on Climate Change
December 17, 2020



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Objectives

* Inventory sea level rise (SLR) estimates for 2060 and 2100 in the Delaware Estuary using journal articles from major institutions. (NOAA, IPCC, USACE, Rutgers, others)
* Choose a range of SLR for planning projects
* Estimate impacts to the saltwater freshwater / interface (the salt front) during average and drought periods using SLR estimates
* Discuss choice of projections with the Advisory Committee on Climate Change

Water Users

Phila.gov

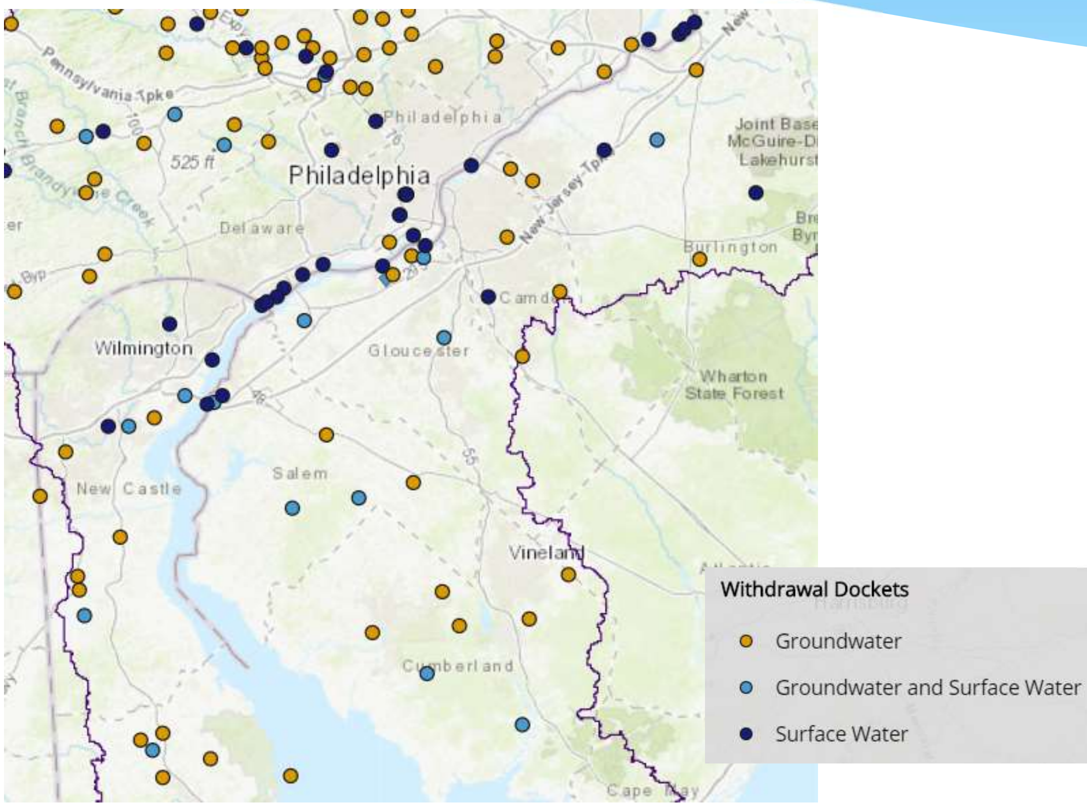
Suk

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

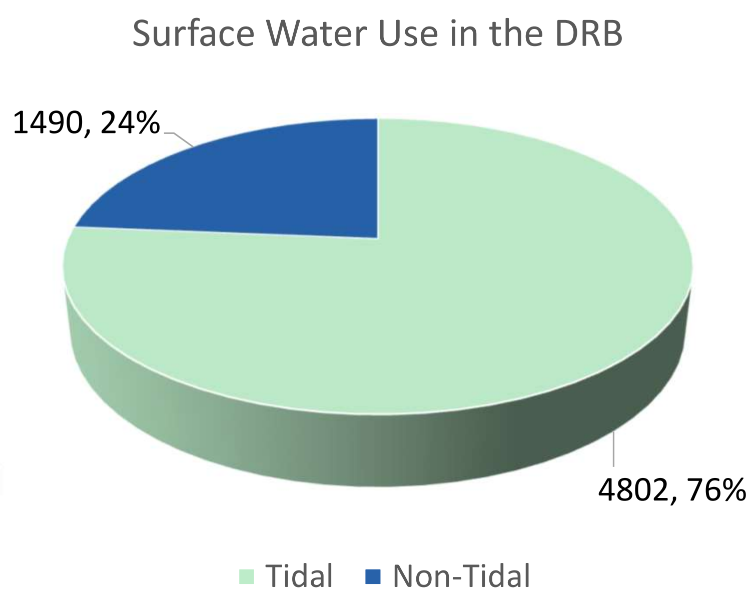
Photo: Peretz Partensky, https://www.flickr.com/photos/ifl/7238282472/in/album-72157629823114004/; unedited

- Drinking Water Providers
- Manufacturing
- Refining
- Energy Production

Estuary and Water Users



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



Total Withdrawals = 6,020 mgd

Based on 2015 Data

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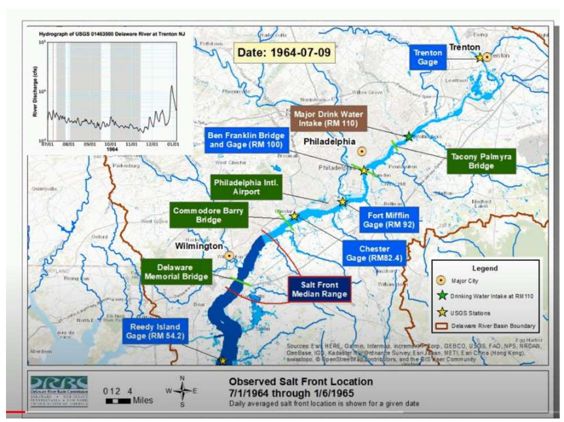
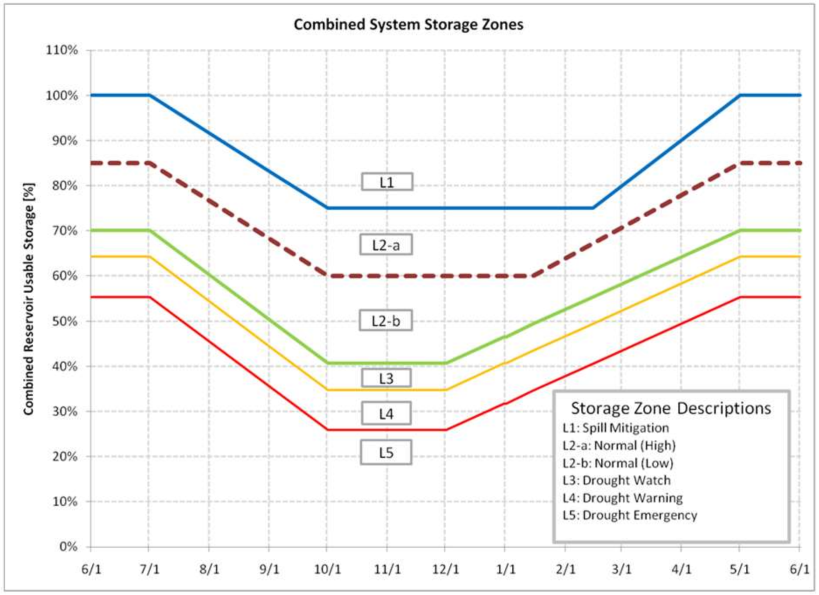
Animations

- https://www.youtube.com/user/DelRivBasinComm/videos
- https://www.nj.gov/drbc/hydrological/river/salt-front.html



DRBC Drought Management

Drought Zones based on NYC Combined Storage



- 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.

Water Management Schematic for the Delaware River Basin

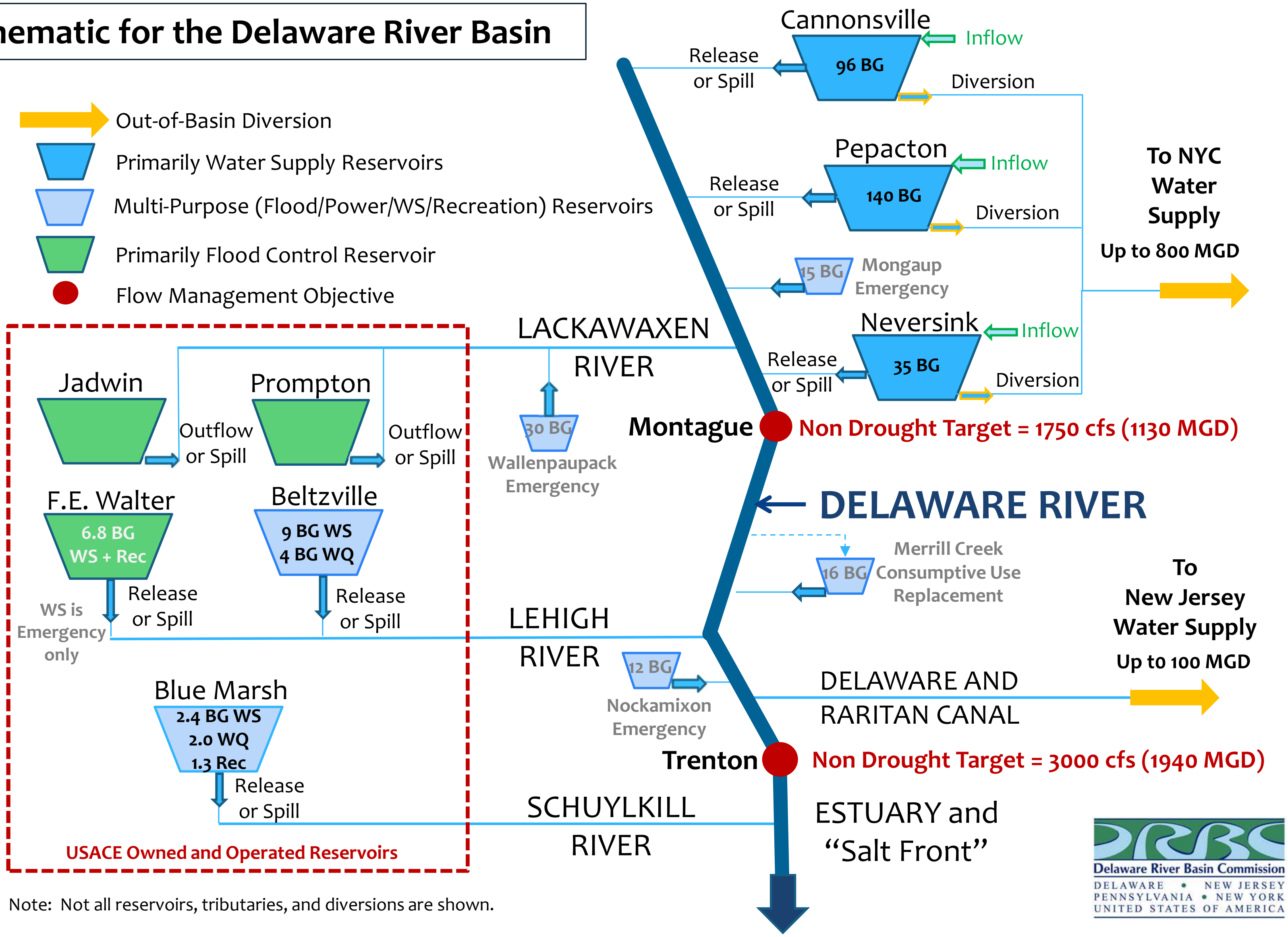
How everything came together:

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
- Montage Flow Objective
- Diversion Limits NYC/NJ

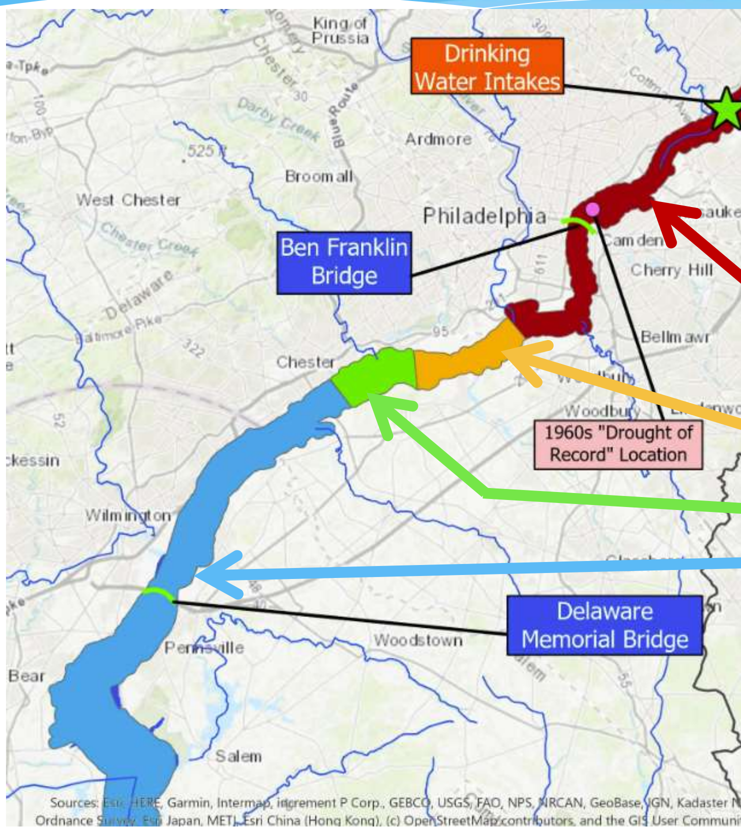
1955 Pepacton
1955 Hurricane Diane
1958 Nockamixon
1960s Drought
1960 Prompton and Jadwin
1961 FE Walter
1964 Cannonsville
1972 Beltzville
1977 Experimental Fisheries
1978 Blue Marsh
1983 Good Faith Agreement
- Trenton Flow Objective
- Phased Reductions

1988 Merrill Creek
2007 Flexible Flow Mgmt Plan



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

Trenton Flow Objective in Drought Emergency



Flow Objective During Drought Emergencies

7-day average location of Salt Front	Trenton Flow Objective (cubic feet per second)		
River Mile	Dec-Apr.	May-Aug.	Sept-Nov.
Upstream of R.M. 92.5	2,700	2,900	2,900
Between R.M. 87.0 and R.M. 92.5	2,700	2,700	2,700
Between R.M. 82.9 and R.M. 87.0	2,500	2,500	2,500
Downstream of R.M. 82.9	2,500	2,500	2,500

The location of the salt front determines the flow objective at Trenton during Basinwide Drought Emergency and **ANY** Lower Basin Drought Condition

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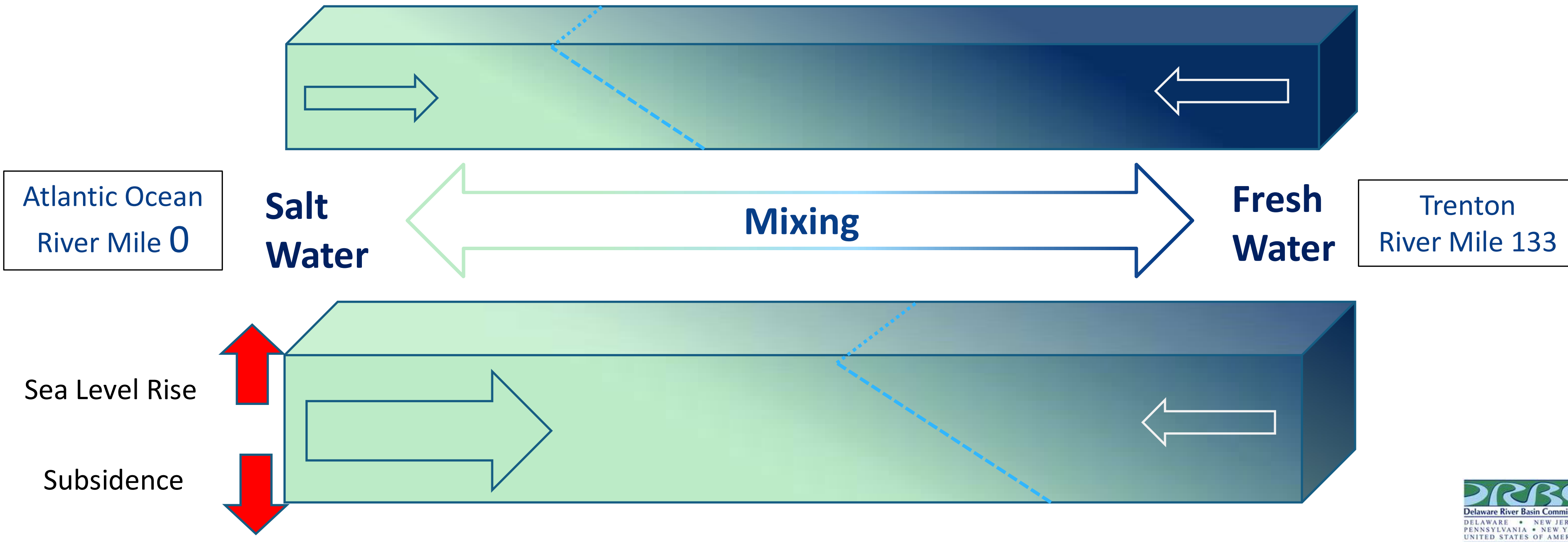
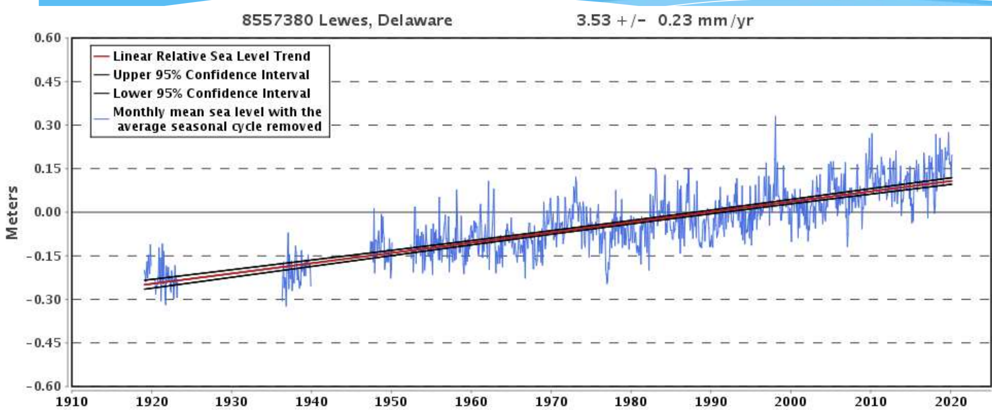
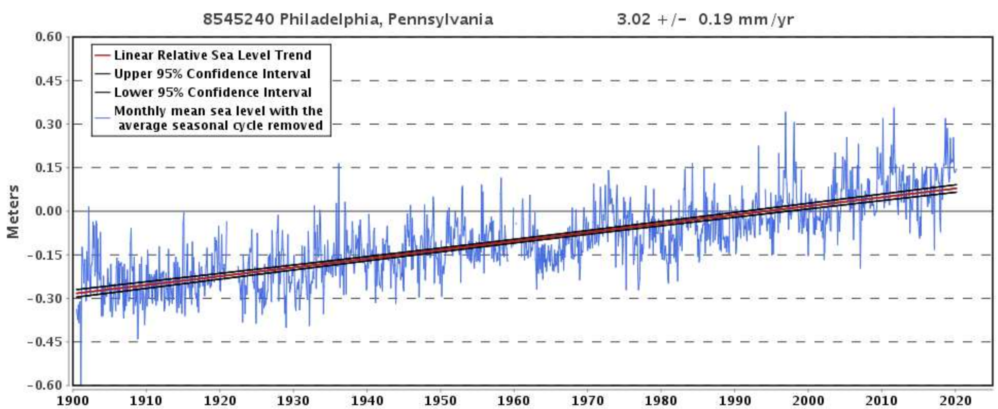
Sea Level Rise and Salinity



Historic





NOAA Station	Station Name	Period of Record	Number of Years	Linear Trend and 95% Confidence Interval (mm/yr)
8534720	Atlantic City, NJ	1911-2019	108	4.12 +/1 0.15
8536110	Cape May, NJ	1965-2019	54	4.73 +/- 0.49
8557380	Lewes, DE	1919-2019	100	3.53 +/ 0.23
8545240	Philadelphia, PA	1900-2019	119	3.02 +/- 0.19
8551910	Reedy Point, DE	1956-2019	63	3.69 +/- 0.46
8573927	Chesapeake City, MD	1972-2019	47	4.07 +/- 0.67

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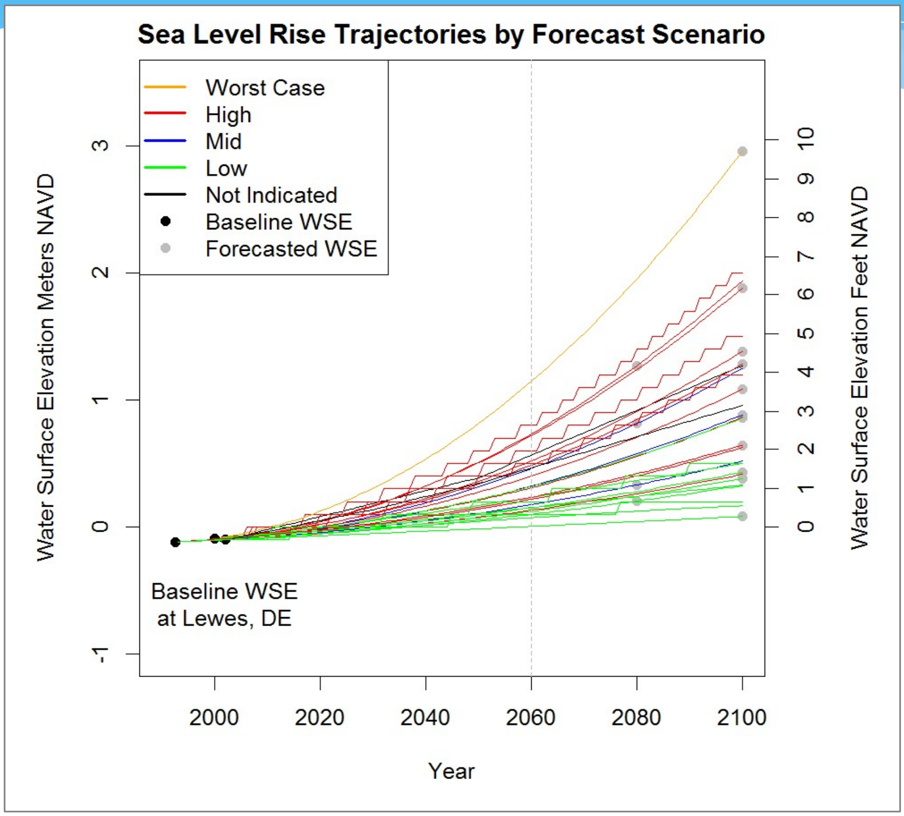
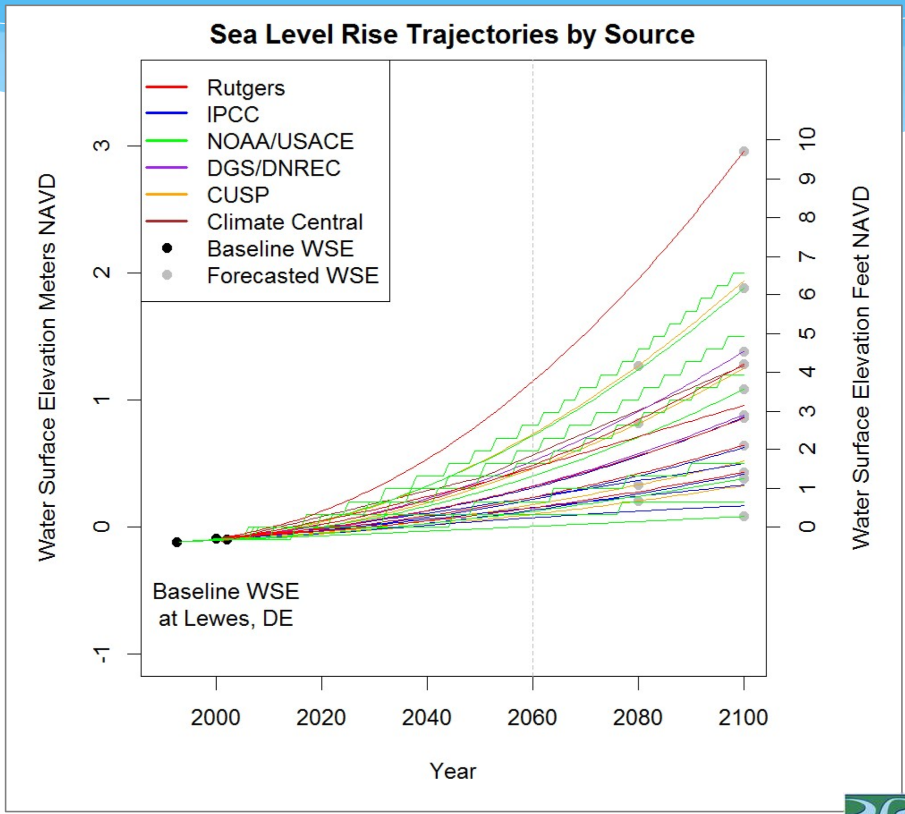
Projections





Original inventory based on 2016 literature review (Taylor Krovik, DRBC, 2016)

Proposed Modeling Assumptions

- Literature Review
  - STAP2016 – Probabilistic/Generic scenario based
  - DNREC 2017 - (University of Delaware) – RCP8.5
  - NOAA 2017 – Probabilistic Monte Carlo
  - USACE 2014 – Historic plus semi-empirical based on temperature
  - STAP 2019 (Rutgers) – Probabilistic/RCP-based/New Ice Melting Accounting
- Relative to Year 2000 (Baseline)
- Representative

Proposed Sea Level Rise Projections for Modeling Salinity						
Meters	0	0.3	0.5	0.8	1.0	1.6
Feet	0	1	1.6	2.6	3.28	5.3

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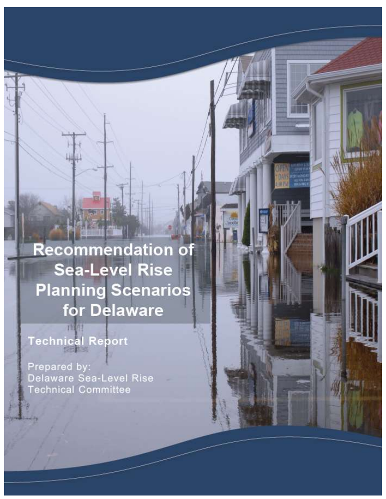
Local SLR Projections for Delaware Coast

DRNEC/DGS 2017

Technical Report (2017)
Prepared by:
Delaware Sea-Level Rise
Technical Committee



The Low, Intermediate and High planning scenarios correspond with the 5%, 50%, and 95% probability levels

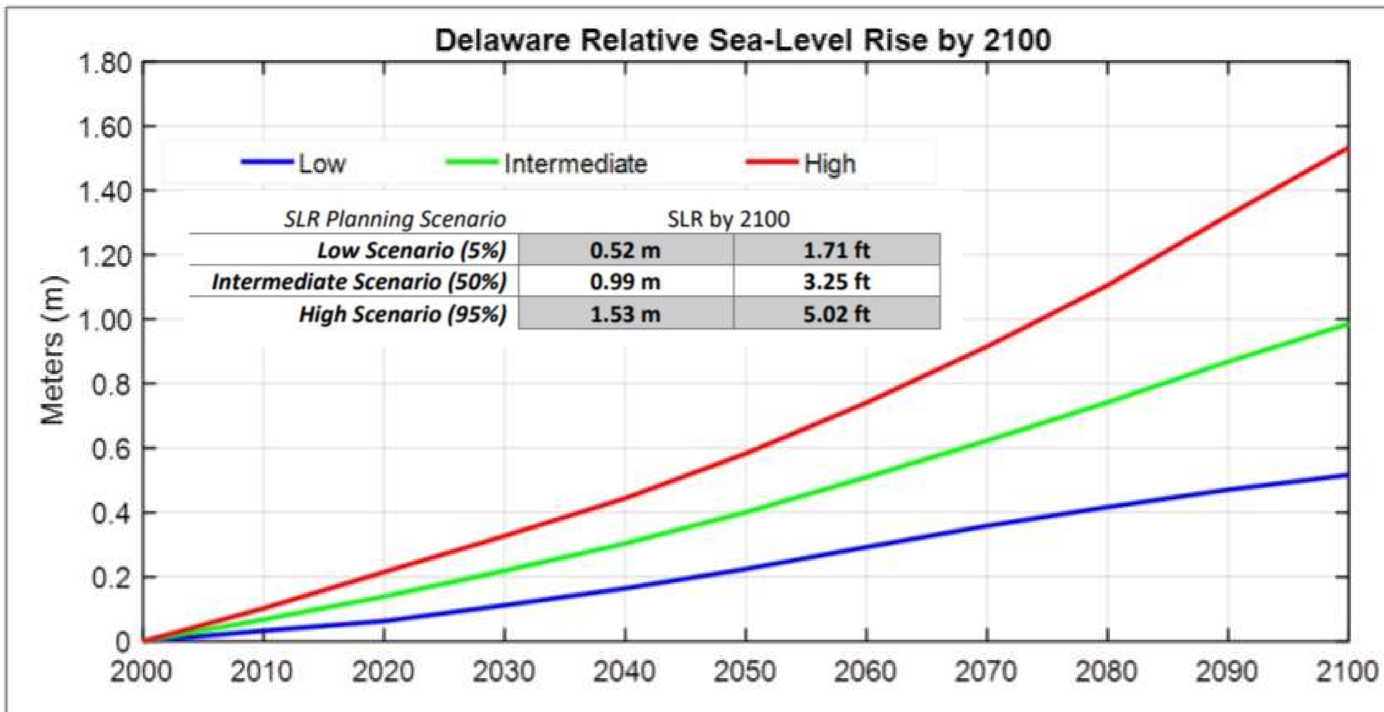


Figure ES-7. The 2017 Delaware SLR planning scenario curves to the year 2100. The Low, Intermediate and High planning scenarios correspond with the 5%, 50%, and 95% probability levels.

Local SLR Projections for NJ Coast

Rutgers/ STAP (2016)

Scenario Simulations – Sea Level Rise

Table ES-1: Projected SLR Estimates for New Jersey (ft.)

Year	Central Estimate *50% probability SLR meets or exceeds…*	Likely Range *67% probability SLR is between…*	1-in-20 Chance *5% probability SLR meets or exceeds…*	1-in-200 Chance *0.5% probability SLR meets or exceeds…*	1-in-1000 Chance *0.1% probability SLR meets or exceeds…*
2030	0.8 ft	0.6 – 1.0 ft	1.1 ft	1.3 ft	1.5 ft
2050	1.4 ft	1.0 – 1.8 ft	2.0 ft	2.4 ft	2.8 ft
2100 Low emissions	2.3 ft ~ 0.70 m	1.7 – 3.1 ft 0.5 ~ 0.9 m	3.8 ft ~ 1.15 m	5.9 ft	8.3 ft
2100 High emissions	3.4 ft ~ 1.04 m	2.4 – 4.5 ft 0.73 ~ 1.37 m	5.3 ft ~ 1.62 m	7.2 ft	10 ft

Estimates are based on Kopp et al. (2014). Columns correspond to different projection probabilities. For example, the 'Likely Range' column corresponds to the range between the 17th and 83rd percentile; consistent with the terms used by the Intergovernmental Panel on Climate Change (Mastrandrea et al., 2010). All values are with respect to a 1991-2009 baseline. Note that these results represent a single way of estimating the probability of different levels of SLR; alternative methods may yield higher or lower estimates of the probability of high-end outcomes.

Projection for 2100

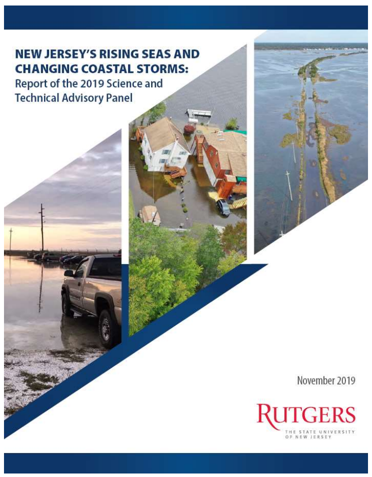
High probability Range (67%), most likely to happen

Low probability (5%)
Unlikely to happen

Cited form NJCAA STAP FINAL Report October 2016

Local SLR Projections for NJ Coast

Rutgers/ STAP (2019)



How Much Will Sea-Level Rise in New Jersey?

Table 3. New Jersey Sea-Level Rise above the year 2000 (1991-2009 average) baseline (ft)*

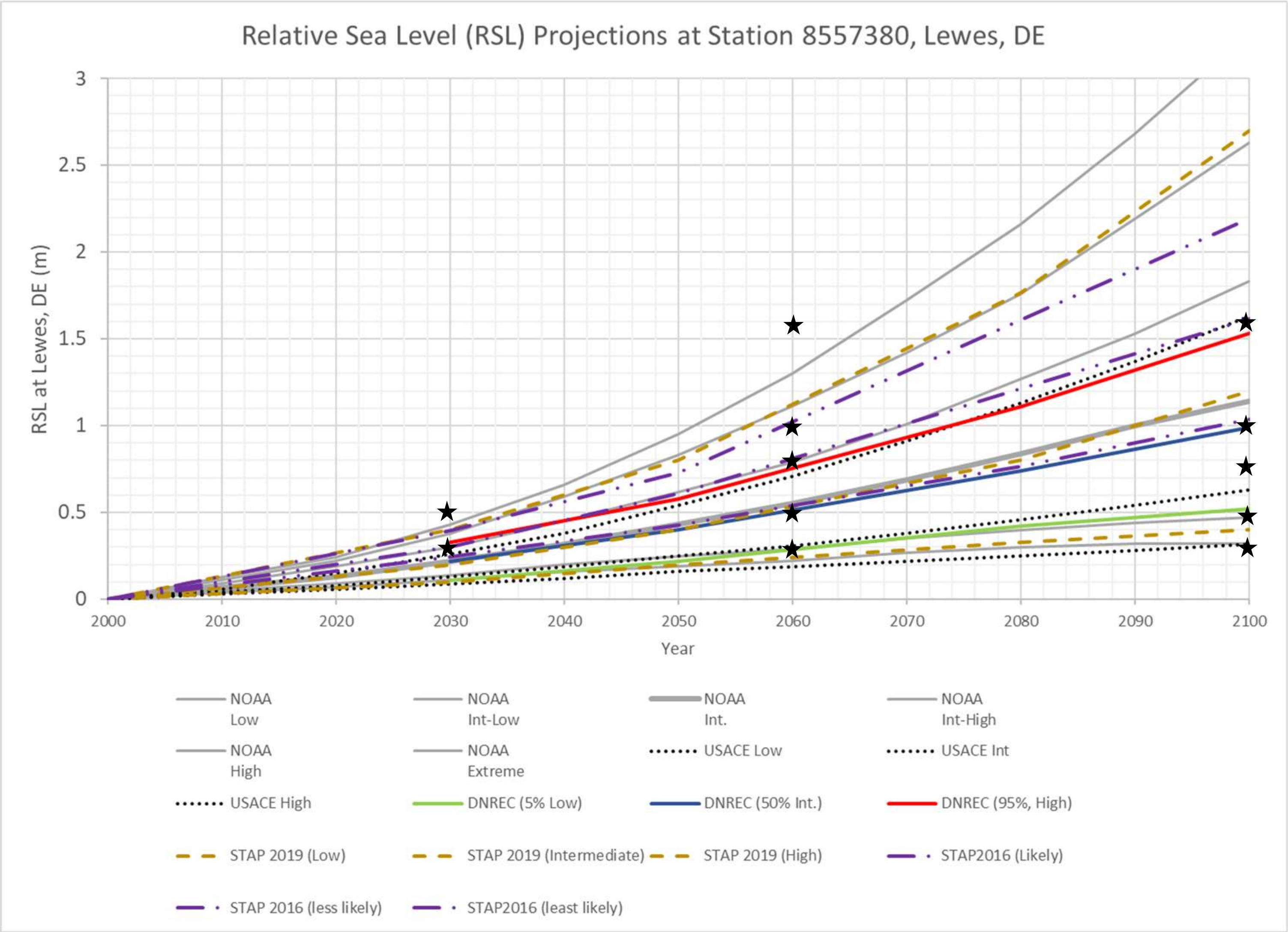
		2030	2050	2070			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.3	0.7	0.9	1	1.1	1.0	1.3	1.5	1.3	2.1	2.9
Likely Range	> 83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50 % chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	< 5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

**2010 (2001-2019 average) Observed = 0.2 ft*

New Jersey Science and Technical Advisory Panel (STAP) on Sea-Level Rise and Coastal Storms (Kopp et al., 2019)

It should be noted that LSRL for New Jersey coast is slightly higher than Delaware Coast.

Data source (solid lines):
Kopp, R.E., C. Andrews, A. Broccoli, A. Garner, D. Kreeger, R. Leichenko, N. Lin, C. Little, J.A. Miller, J.K. Miller, K.G. Miller, R. Moss, P. Orton, A. Parris, D. Robinson, W. Sweet, J. Walker, C.P. Weaver, K. White, M. Campo, M. Kaplan, J. Herb, and L. Auermuller. (2019) New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey. Prepared for the New Jersey Department of Environmental Protection. Trenton, New Jersey.



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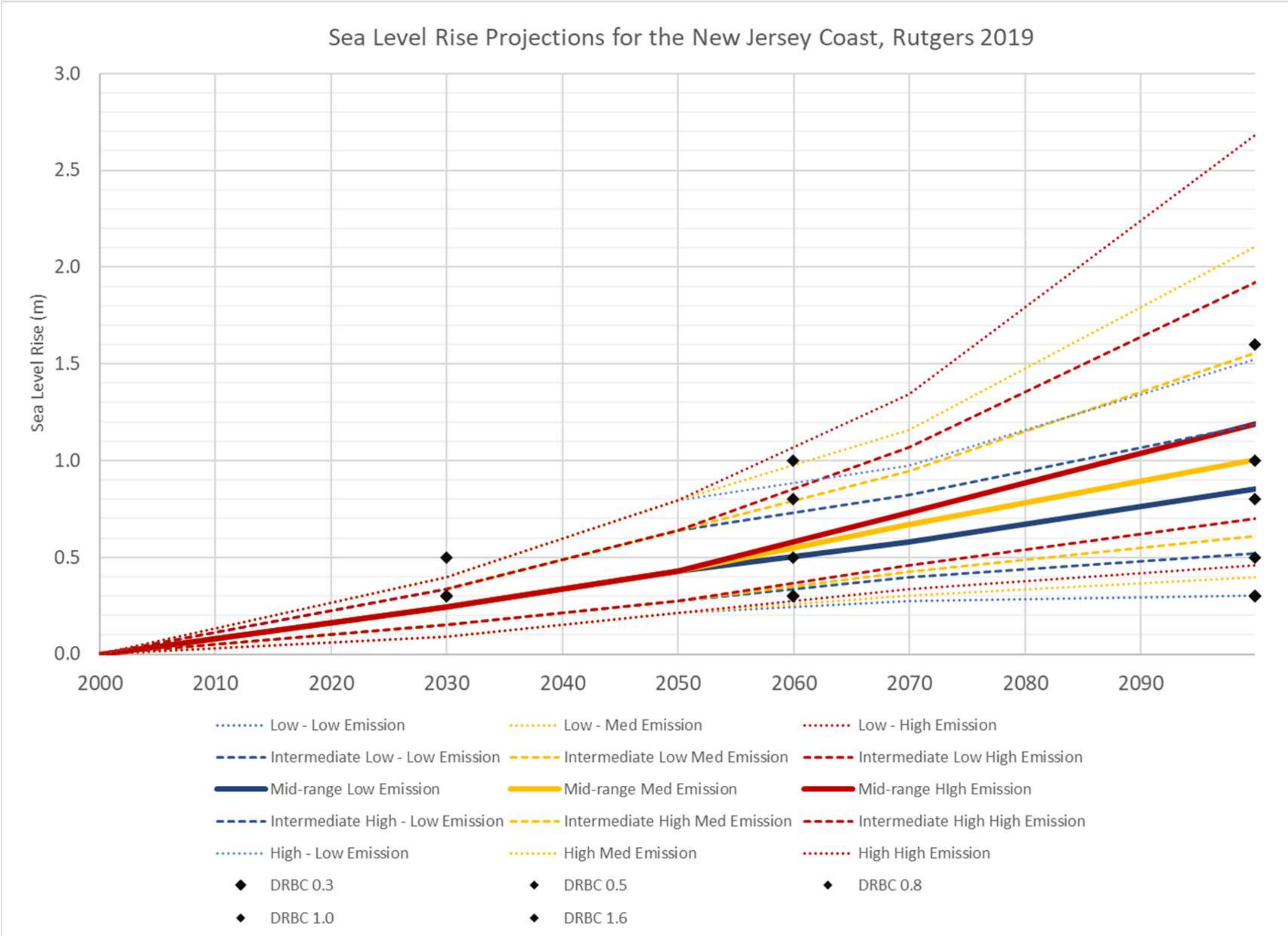

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Sea Level Rise Projections and Planning Examples

SLR (m/ft)	Description/Representation	Example Use
0.3m / 1 ft	**Near-term adaptation planning for risk adverse infrastructure ("you are almost here").** For the high emission scenario, 0.3 m represents a value that has a high probability of being exceeded **by 2030** (irrespective of emission scenario) *{95% probability for 2030}*	Operational changes, interconnections, re-examine salinity management goals, portable flood barriers (e.g., Muscle Wall, Port-a-dam or the like), personal property decisions (100-year flood has a 26 percent chance of occurring in 30-year mortgage), phasing construction
0.5 m / 1.6 ft	**Medium range planning ("I'm confident this will happen").** For the high emission scenario, 0.5 m represents a value that is likely to be exceeded **in 2060** (low and medium emission scenarios) and extremely likely to be exceeded in 2100. *{likely by 2050 (2060)}*	New small infrastructure (e.g., duck-bill gates), process changes (e.g., dry cooling); expandable levees (build to elevation in stages), alternative water sources (groundwater), abandonment/relocation (e.g., close factory, power plant)
0.8 m / 2.6 ft	**Medium range planning for risk-adverse infrastructure ("this might happen by the time I retire").** For the high emission scenario, 0.8 meters has a low probability of being exceeded by **2060** and will likely be exceeded by 2100 *{possible, but extremely unlikely by 2060}*	Regional water master plan, large scale infrastructure (move intake), water treatment (desalinization)
1.0 m / 3.3 ft	**Long-range planning ("this might happen a long time from now").** For the high emission scenario, 1.0 m (3.3 ft) has a low probability of being exceeded by **2075** and is likely to be exceeded by 2100. *{high end of the likely range by 2100 for low emission}*	Relocation of critical transportation infrastructure (e.g., airport. Port facilities); tidal barriers for low flow
1.6 m / 5.3 ft	**Conservative long-range planning for risk-adverse infrastructure ("who knows if this will really happen").** For the high emission scenario, 1.6 m has a low probability of being exceeded by **2100**. *{5% probability by 2100}*	Condemnation of shoreline areas from inhabitation

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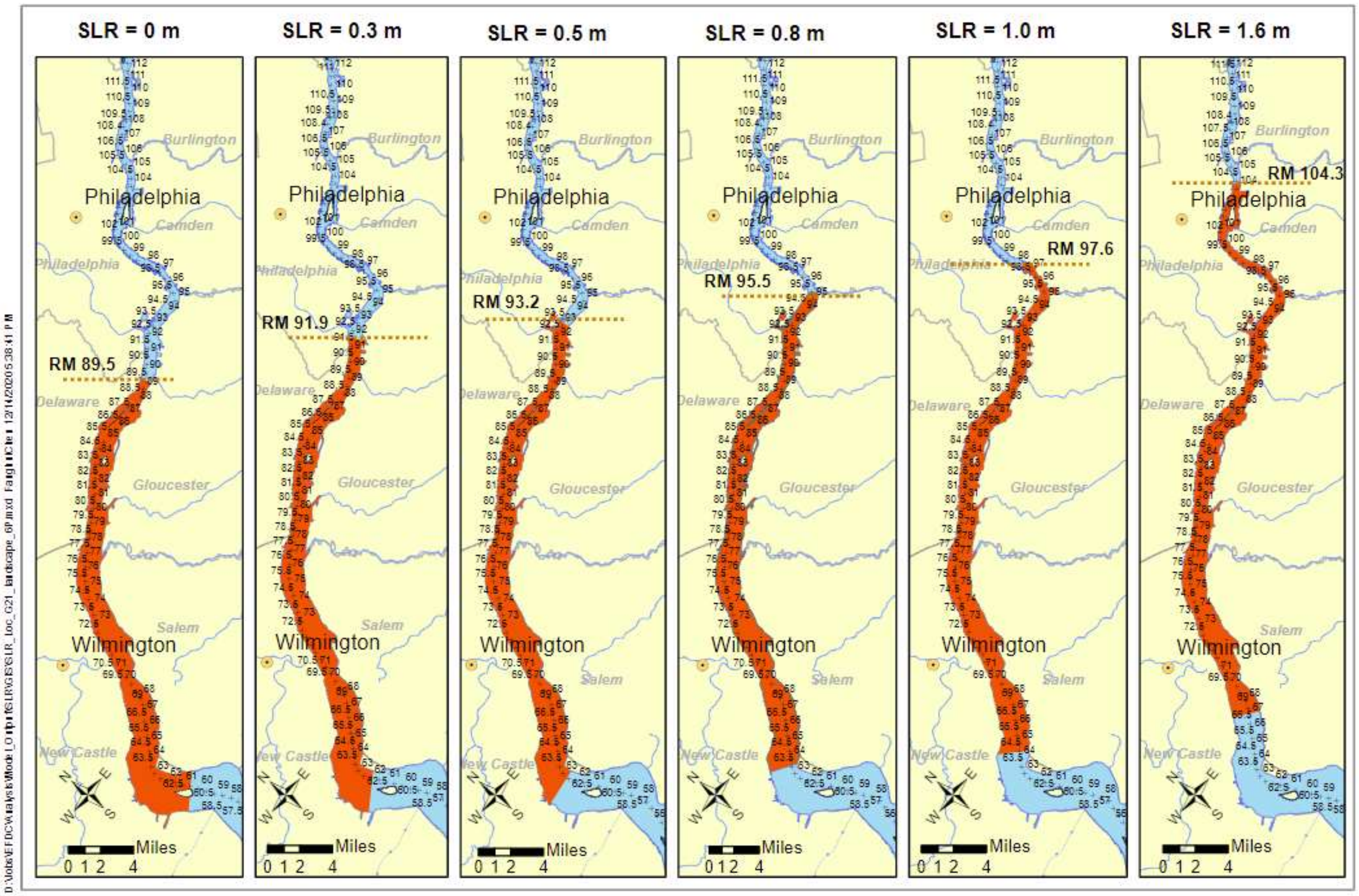
Salt Front Ranges with SLR



EDFC simulations using recent dry weather flows from July-October 2002

The salt front cannot be maintained below the Schuylkill River when SLR is greater than 0.3 m (1 ft)

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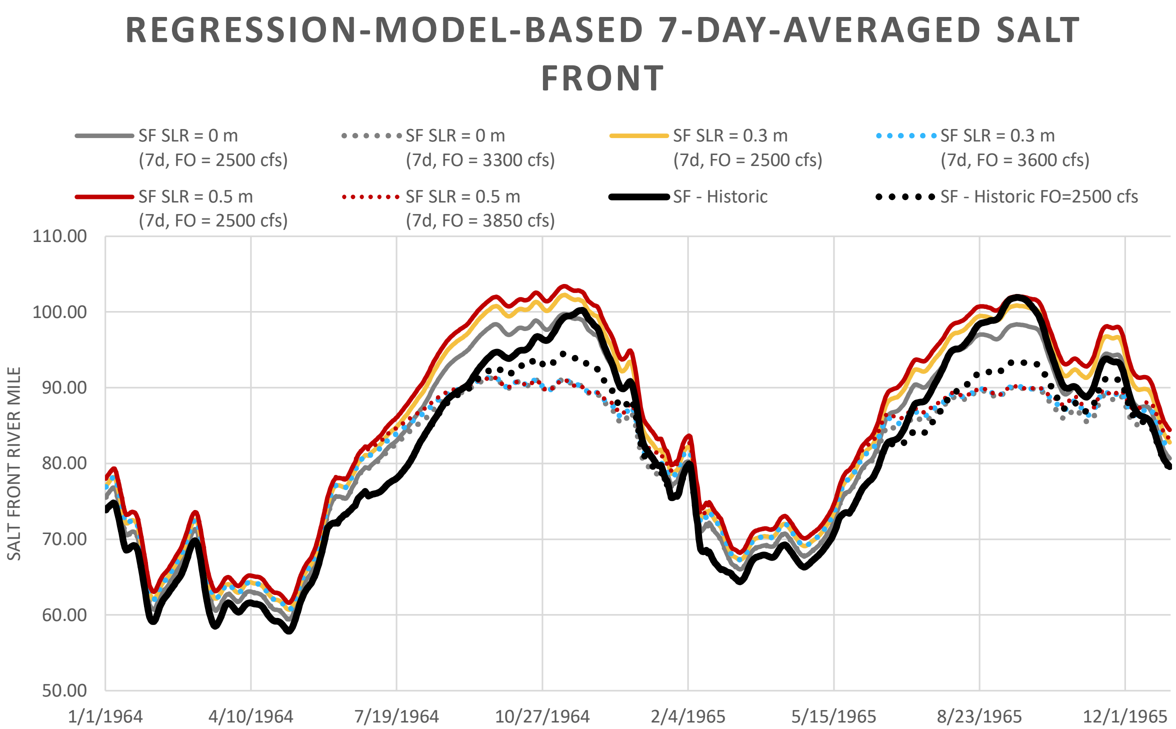
Possible Flow Requirements



Sea Level Rise	Possible Flow Objective (cfs) for Salt Front Below Schuylkill River 92.5
Historic	2500 – 3000
0 m	3300
0.3	3600
0.5	3850
1.0	4600
1.6	5100

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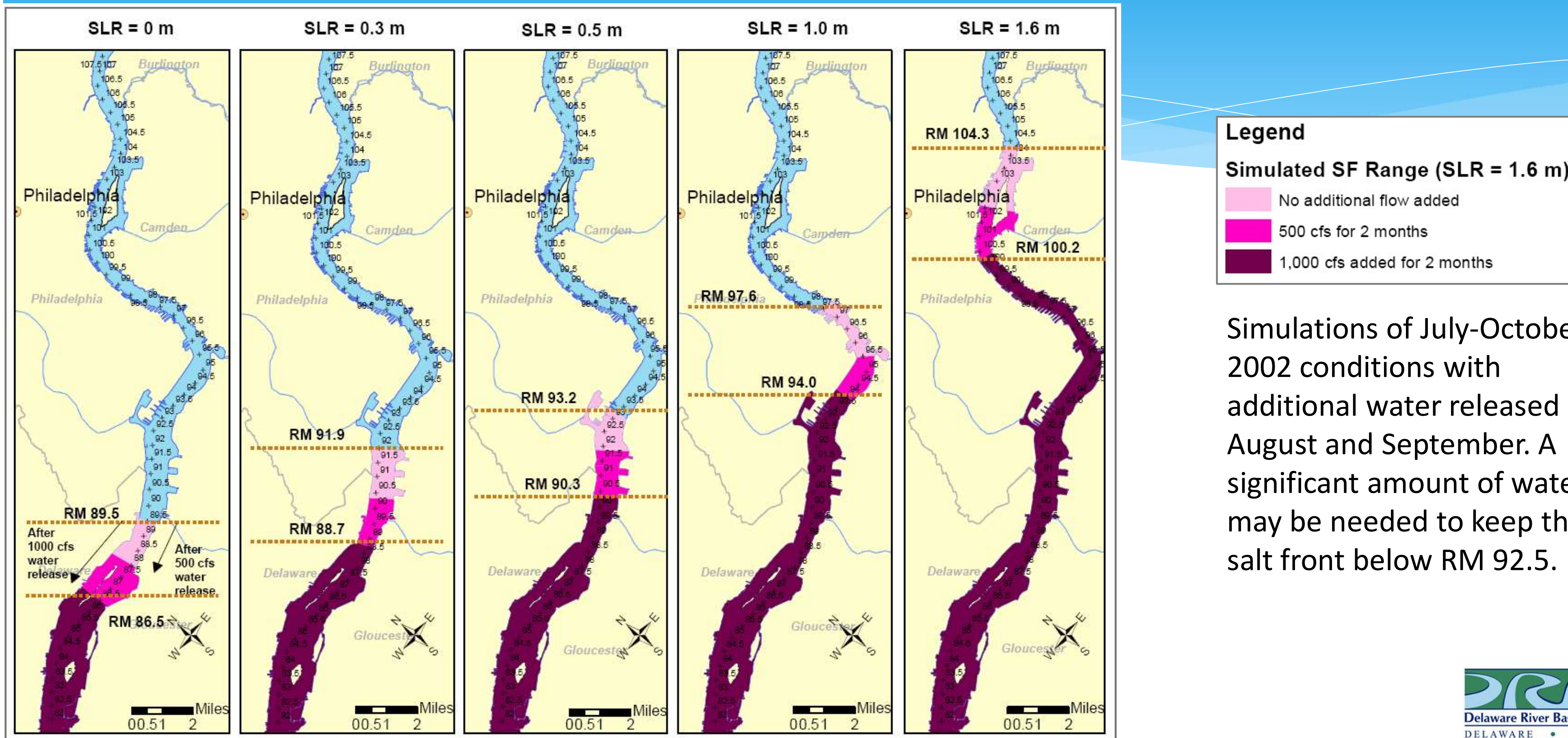
Based on EFDC-lite. Flow Objective determined by raising any flow below a certain value.

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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Summary

* Salinity intrusion is a threat to water users in the basin
* Sea Level Rise (SLR) is a significant driver of salinity intrusion and increases risk to water users
* Initial SLR range representative for most purposes
* Existing drought management program may not be protective during a repeat of the drought of record when adjusting for current SLR baseline considered (preliminary assessment)
* More water will likely be needed to meet salinity management objectives in the future

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Next Steps

* Verify and "finalize" assumptions for SLR analyses
* Incorporate flows from hydrologic model (not discussed) for changes in runoff and watershed yield
* Use flow management model to develop inflows for 3d hydrodynamic model (and develop alternative management programs)
* Use 3D model with input from flow management model
* Identify additional sources of water for new flow objectives
* Explore near-term adaptation options (flow management goals and measures)

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Questions for AC3

* Is a lower bound of 0.3 m (1 ft), which is “likely” to happen by 2060 low enough considering adaptation strategy implementation lead times? If not, why?
* Would you eliminate any of the values? If so, why?
* Are three intermediate SLR values enough? If not, why?
* Is the upper bound of 1.6 m (5.3 ft) high enough considering the “likelihood” of much higher values occurring before 2100 is small? What would be the advantage of adding a higher projection?
* Have you used SLR projections for purposes other than flood-related protection? If so, in what context?
* What other expressions of risk can be used to provide additional context for decision makers?