Evolution of Salinity Management in the Delaware River Estuary and Future Challenges

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Subcommittee on Source Water Protection
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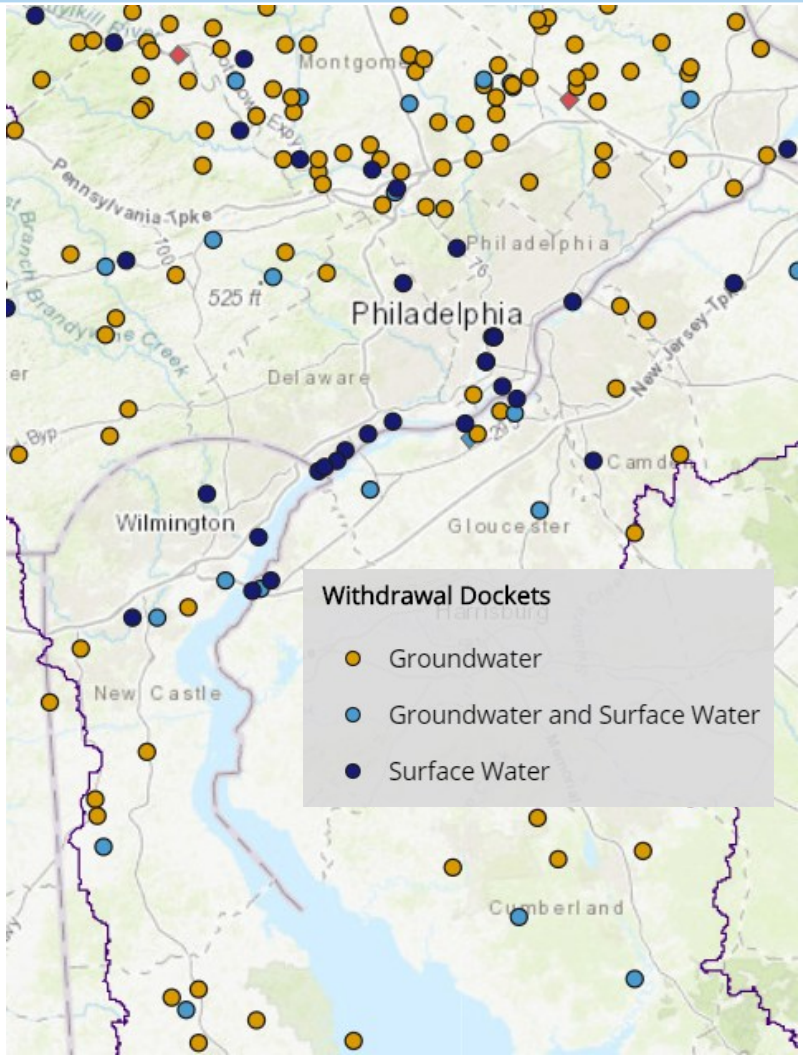
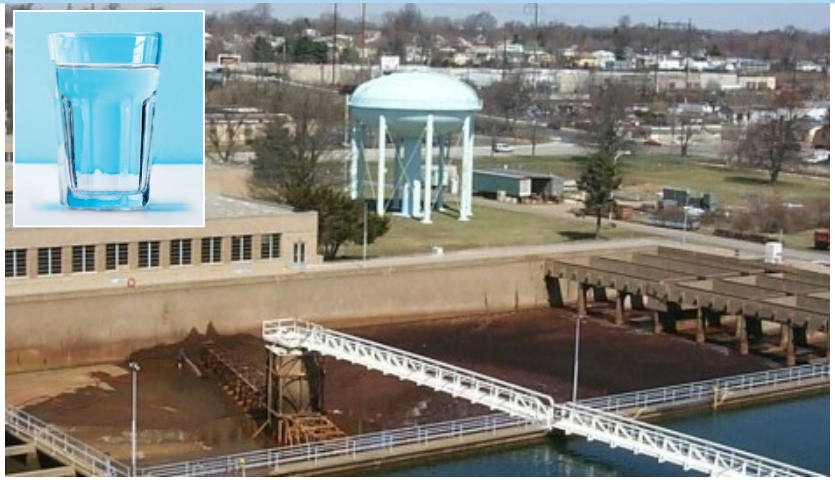
Tidal Water Users

Drinking Water Providers – Manufacturing – Refining – Energy Production



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



Phila.gov

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

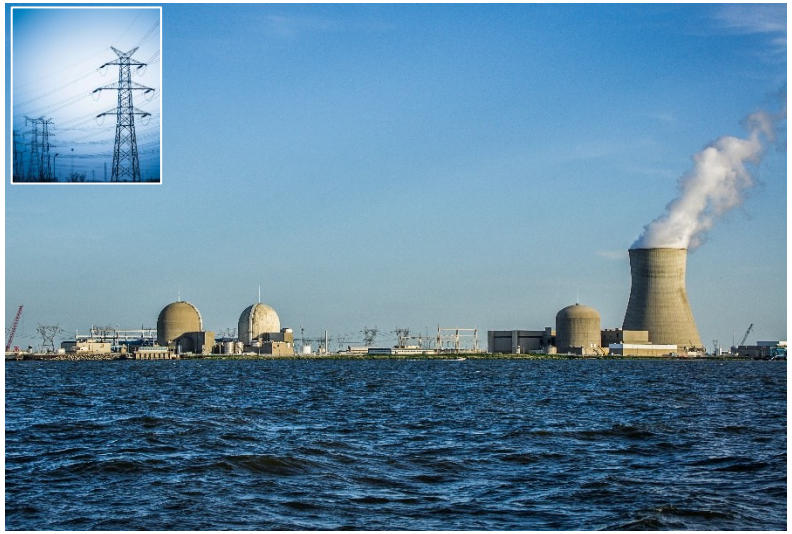
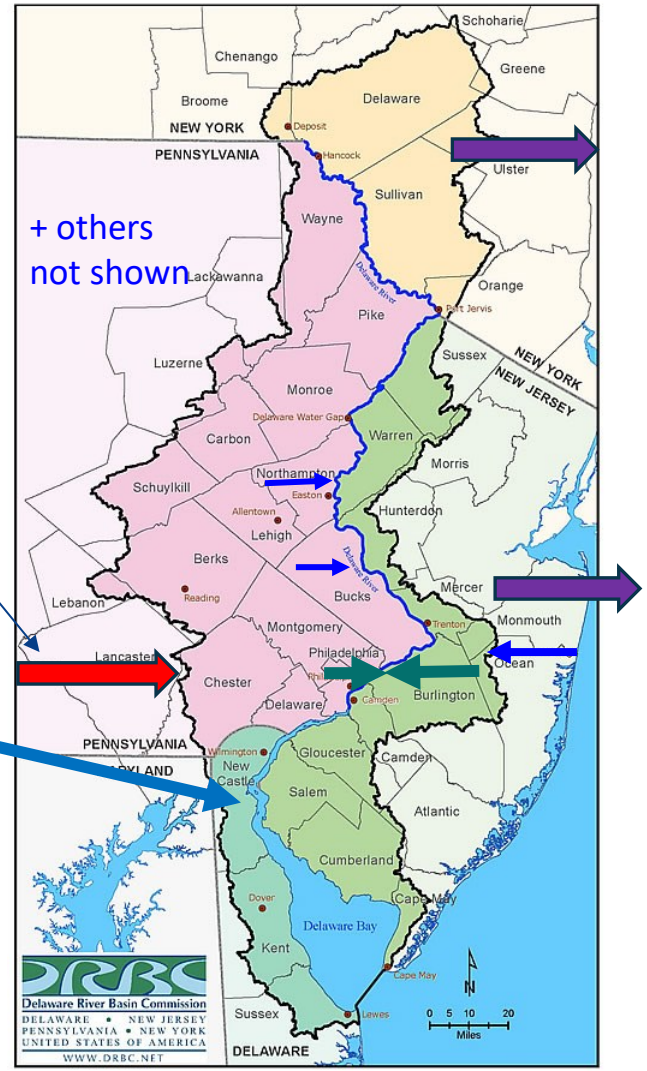


Photo: Peretz Partensky, https://www.flickr.com/photos/ifl/7238282472/in/album-72157629823114004/; unedited

Water Purveyors and Supplies

- Pennsylvania (in-basin):
  - Non-tidal
  - **Philadelphia (tidal)**
  - **Abandoned (1950s) -** *tidal intake:* Chester (now import)
- Delaware
  - New Castle County – tributary
  - **inflatable dam** for salinity and drought protection



- New York (exports):
  - **New York City**
  - Aqueduct communities
- New Jersey:
  - Exports (Non-tidal, out-of-basin)
  - **Tidal** (central and southern New Jersey)

Green = “Run-of-River”

Export
Import
Non-tidal
Major Tidal
Tidal Tributary

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Known impacts from high salinity

Drinking Water

- Taste and odor
- Health of sensitive populations
- Corrosion

Oysters

- Disease and predators
- Food types
- Taste
  - low salinity – “creamy”
  - Higher salinity – “bold and salty”

Manufacturing and Industry

- Pre-treatment of process water (RO)
- Performance of process chemicals
- Quality of product
- Cooling water fouling
- Equipment corrosion
- Permit compliance

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What is salinity intrusion?
Terrestrial salt vs. Ocean Salt

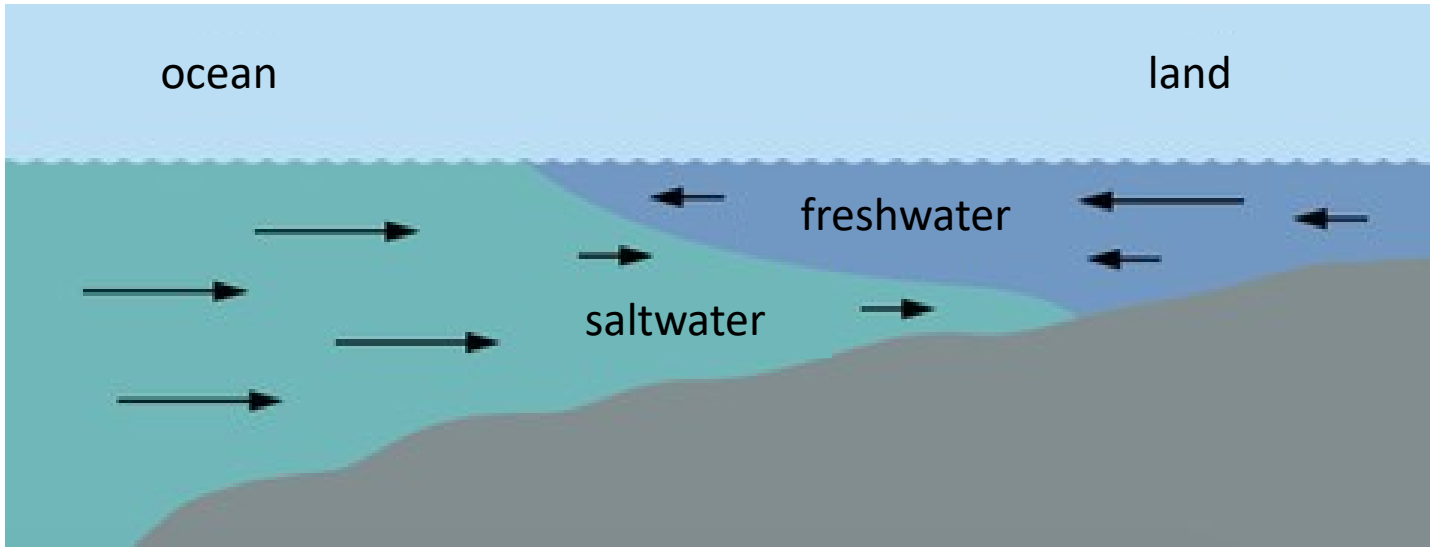
What is salinity?

- concentration of ions from salts

What are the sources?

- Runoff (terrestrial)
- ocean
- point sources

* What is salinity Intrusion?
  - upstream movement of salt



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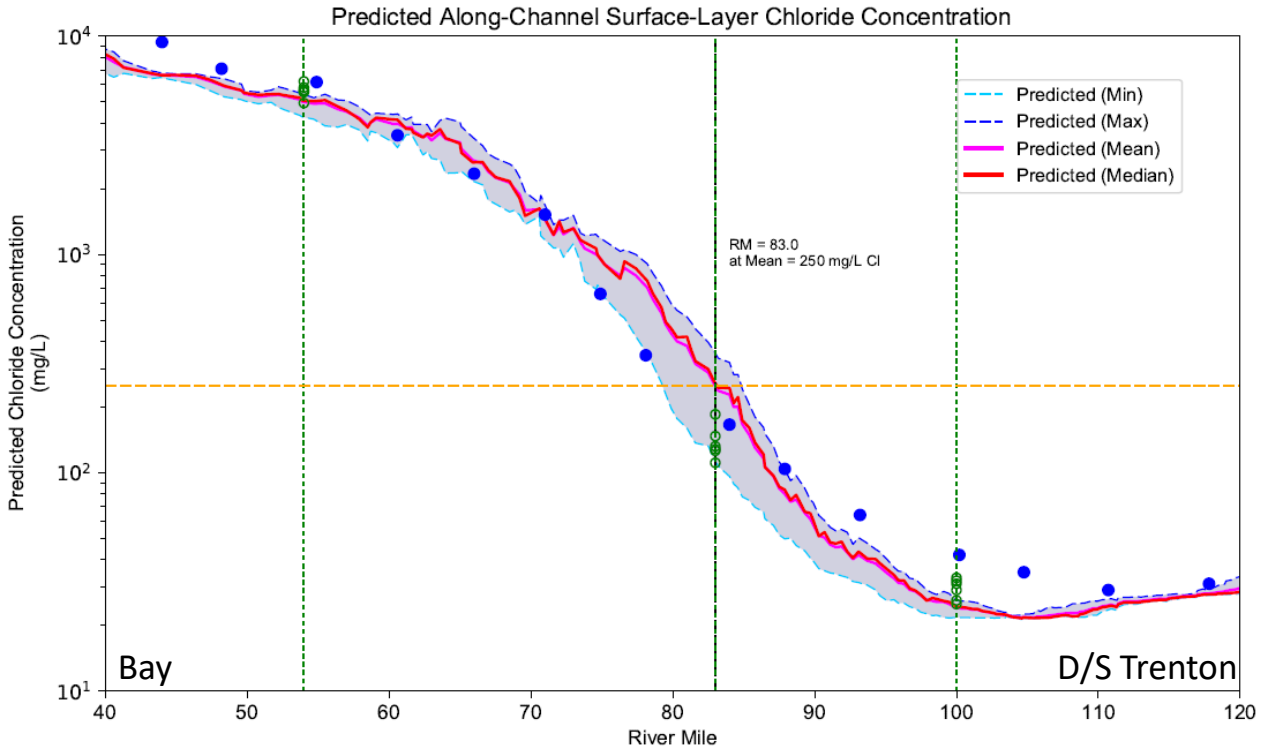
How does ocean salt get upstream?

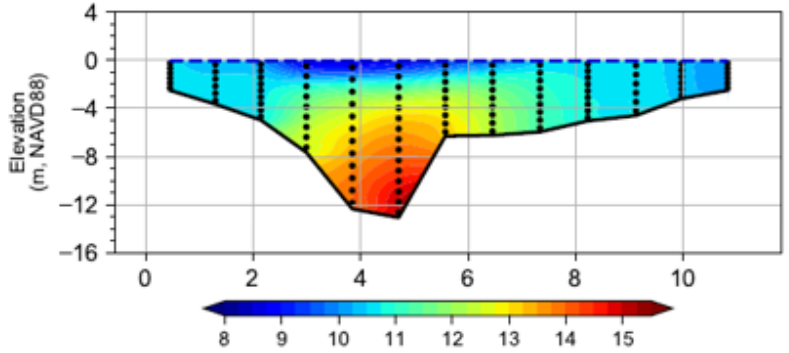
Forces pushing salt upstream

- tidal energy (pump)
- density-driven mixing
  - Colder
  - Saltier

Forces "pushing" salt downstream

- Freshwater inflows (dilution)
- Kinetic and potential energy





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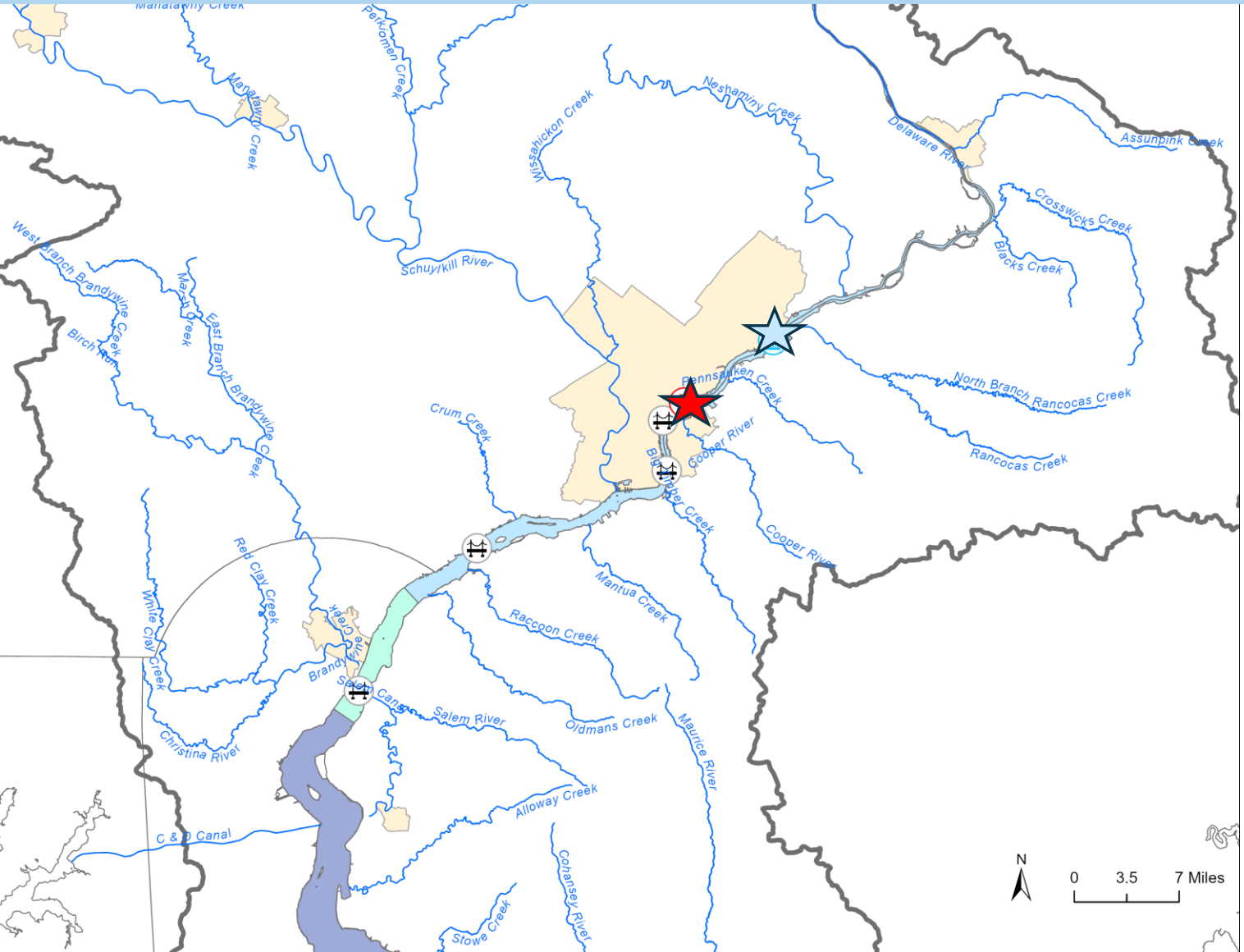
Where is the ocean salt?



- **Salt Front**
- location of the 250 mg/l isochlor
- 7-day moving average
- linear interpolation
- real-time specific conductance data (USGS)
  - Reedy Island
  - Chester
  - Fort Mifflin
  - Ben Franklin Bridge

Known Salinity Intrusion Events

Table 1. Peak Chloride Concentrations During Major Salinity Intrusions 1949-1966								
Location	DRBC RM	1966	1965	1964	1963	1957	1954	1949
Bridesburg (1)	106.1	79	127	174	109	140	91	--
Pier 4 S/11N (4)	100.0	147	340	340	202	--	--	--
Chester(2)	83.2	1474	1940	1940	1715	2030	2120	1540
Marcus Hook(3)	79.0	1198	1913	1913	1683	1708	1627	1523
Del Mem Bridge	68.7	4620	4200	4200	4120	4750	--	--
Reedy Island Jetty	54.1	7770	8360	7690	11600	7870	--	--
Max River Mile		96	101	102	98	101	99	na

(1) Data supplied by Rohm and Haas Company

Also, during the 1930s drought

(2) Data prior to 1966 provided by Scott Paper Company

(3) Data provided by Sun Oil Company

(4) Pier 4S/11N is at River Mile 100, also near the location of the Benjamin Franklin Bridge.

Source Data: 1966 ODRM Annual Report

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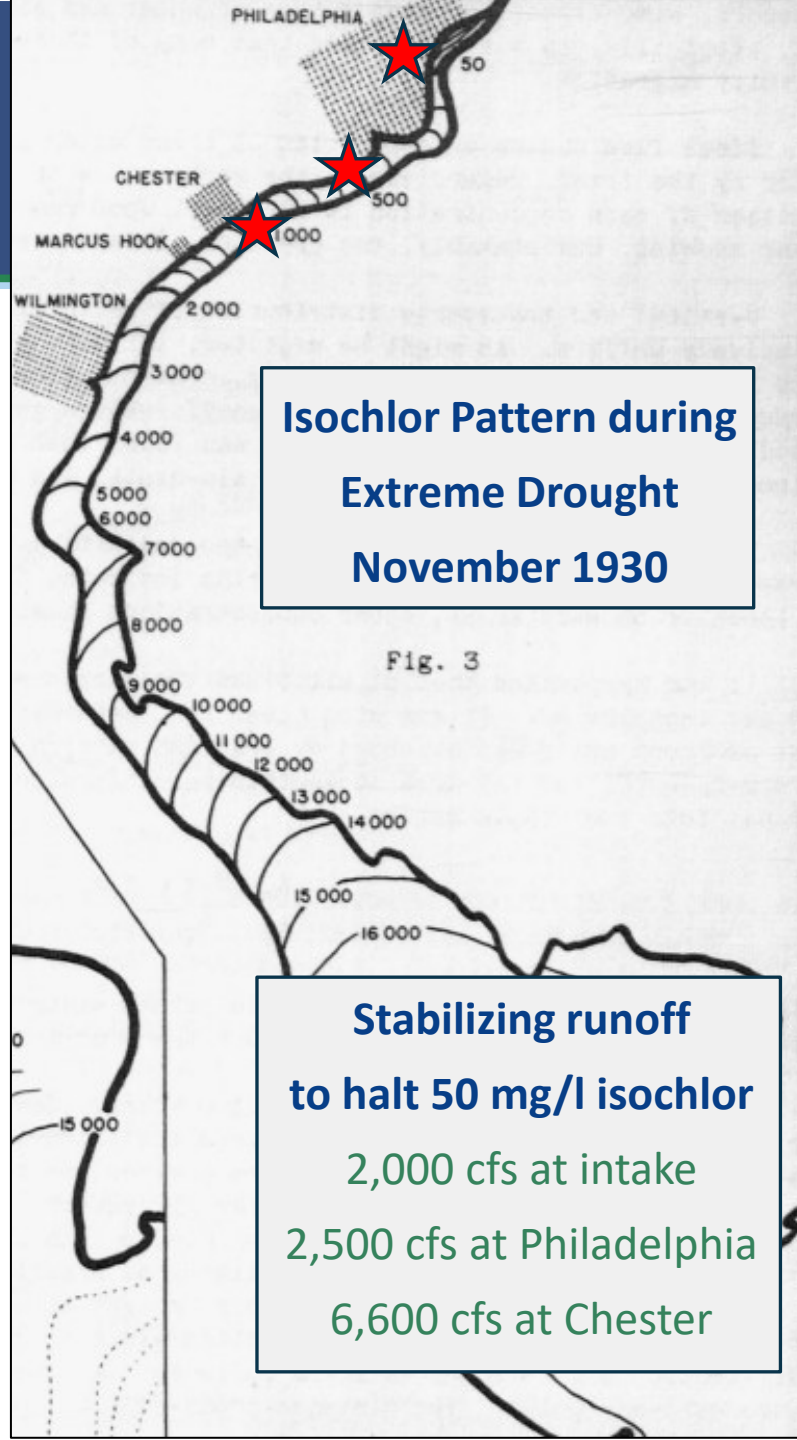
Salinity Intrusion in the 1930s

- Study of 1930s event
- Asserted – water “always fresh” between Philadelphia and Trenton
- Persistent low flow
- Concerns: NYC Reservoirs, Mainstem Flows, Drinking Water, Oysters, Salinity
- 10,000 samples collected
- Evaluation of the tidal prism



Mason, W. D. and Pietsch, W. H. 1940. Salinity Movement and its Causes in the Delaware River Estuary. Transactions, American Geophysical Union, Reports and Papers in Hydrology.

Salinity Intrusion in the 1960s

- Record-breaking low flows for four months
- Insufficient reservoir storage to meet demands (NYC)
- Chloride concentrations of 250 mg/l eight miles below intakes
- Five million dollars of equipment damage at Kimberly Clark (2019 $)

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What are we doing about it?

Flow and Drought Management Plans

preserve regional storage and repel salinity (balance upper and lower basin water supplies)

* Dockets - permitting (withdrawals, consumptive use)
* Phased reductions in flow objectives, exports, conservation releases
* Increase flow objectives with high salinity
* Water Conservation
* Additional Storage (DRBC co-funded and support)
* Planning standard (1960s Drought)

Cannonsville Reservoir (12/2001). Photo courtesy of NYCDEP

Competing Goals for Basin Waters and Storage

- **Goals**
  - Recreation
  - Flood Risk/Damage Reduction
  - Water Supply
  - Water Quality
  - Power Generation
- **Resources** (**FINITE**)
  - Nature
  - Storage
  - Direct from river

LIMITED RESOURCES

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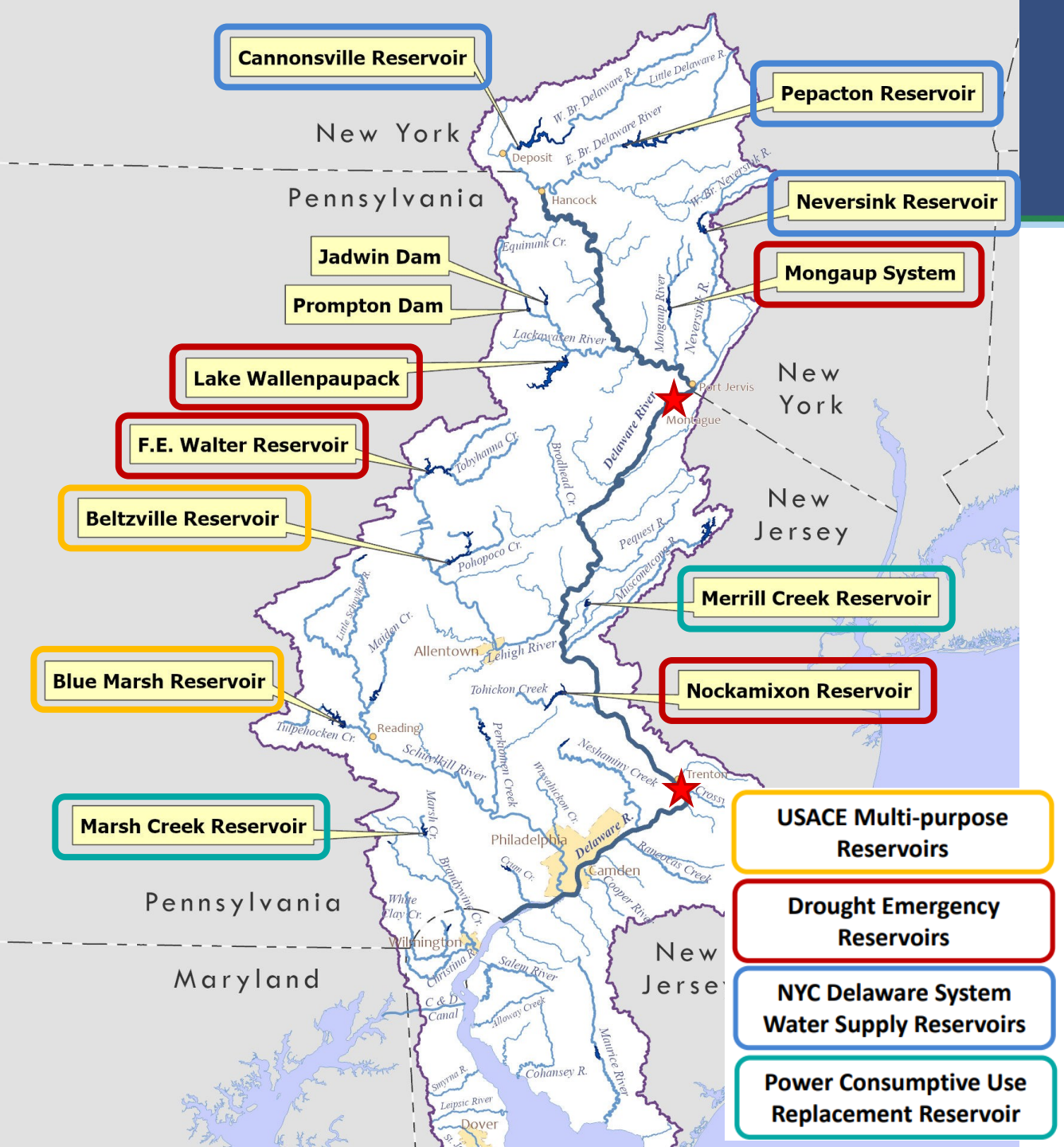

USACE Multi-purpose Reservoirs

Drought Emergency Reservoirs

NYC Delaware System Water Supply Reservoirs

Power Consumptive Use Replacement Reservoir

Meeting Goals

- Mother Nature (precipitation)
- Storage (different purposes)
- Minimum flow requirements
- Drought Management Programs
- Permitting programs
  - Water Use
  - Water Quality

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Water Management Schematic for the Delaware River Basin

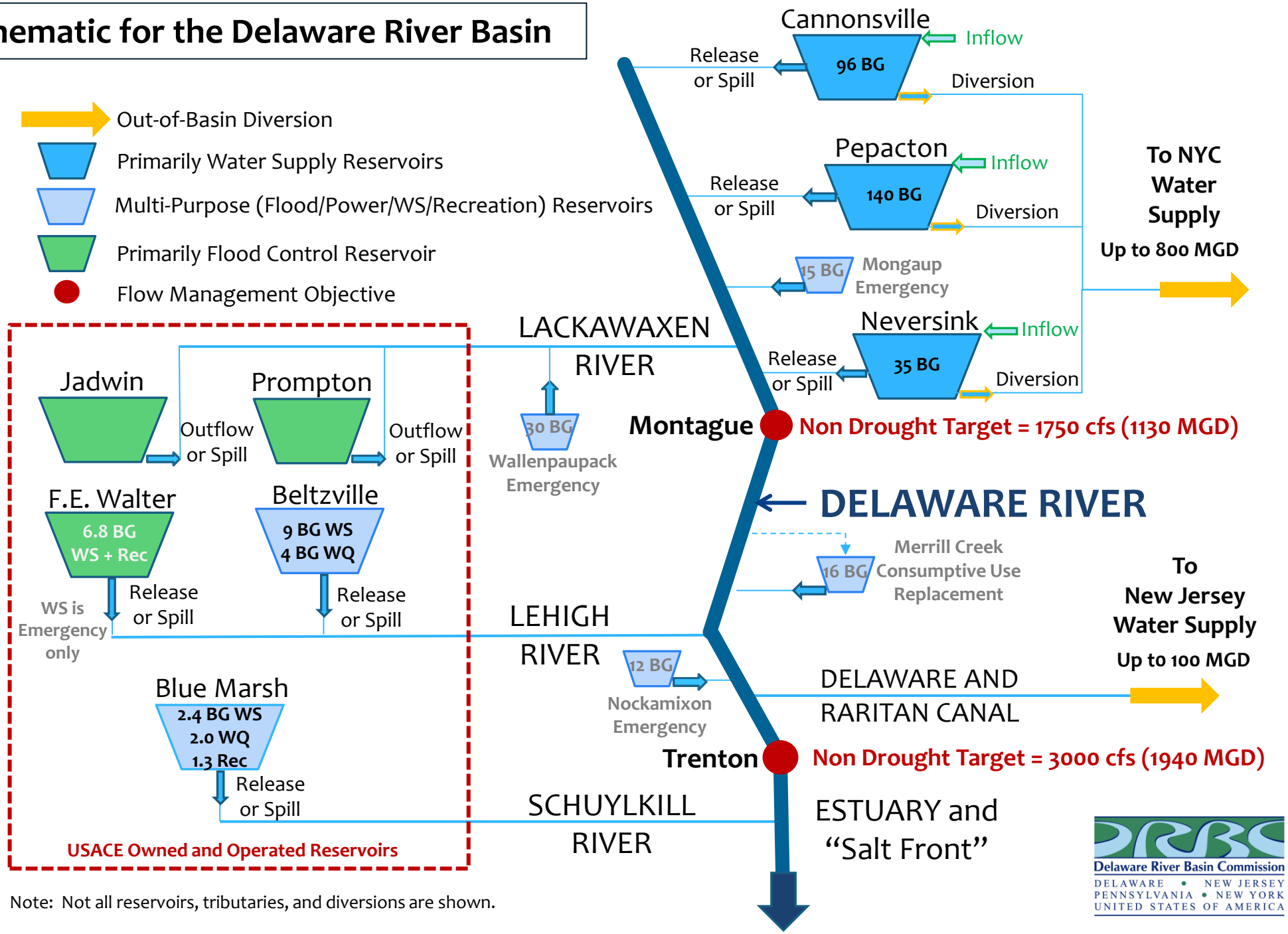
How everything came together:

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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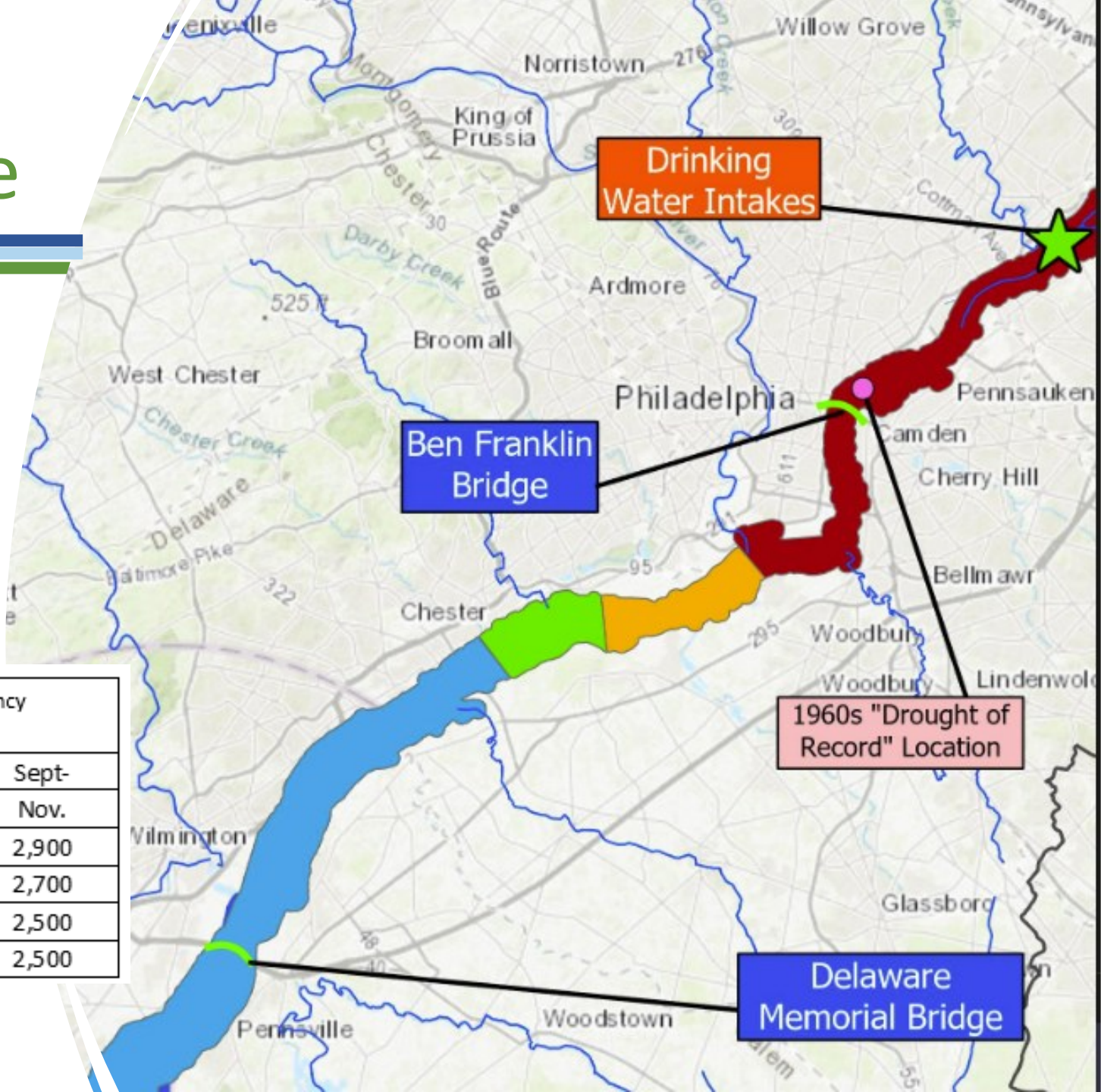
Trenton Flow Objective

- Preserve regional storage (upper basin)
- Repel salinity (lower basin)
- Structured incorrectly (IMO)

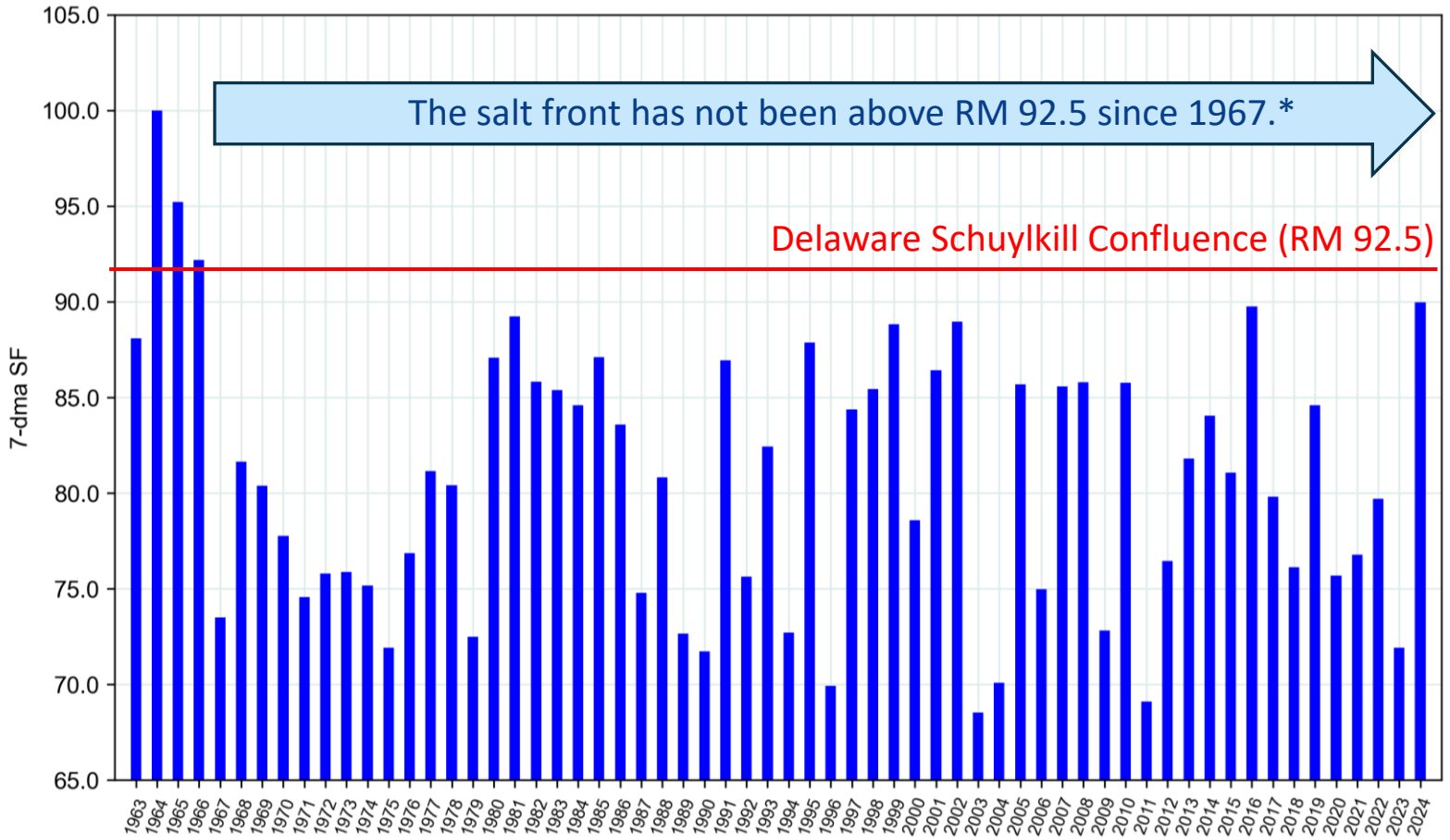
7-day average location of Salt Front	Trenton Drought Emergency Flow Objective (cfs)		
River Mile	Dec-Apr.	May-Aug.	Sept-Nov.
Upstream of R.M. 92.5	2,700	2,900	2,900
Between R.M. 87.0 and R.M. 92.5	2,700	2,700	2,700
Between R.M. 82.9 and R.M. 87.0	2,500	2,500	2,500
Downstream of R.M. 82.9	2,500	2,500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



Is the flow management program successful?

Goal: salt front below the Delaware Schuylkill confluence

YES



*The Trenton Flow Objective was not established until 1983. The 1970-1980 was a wet period.

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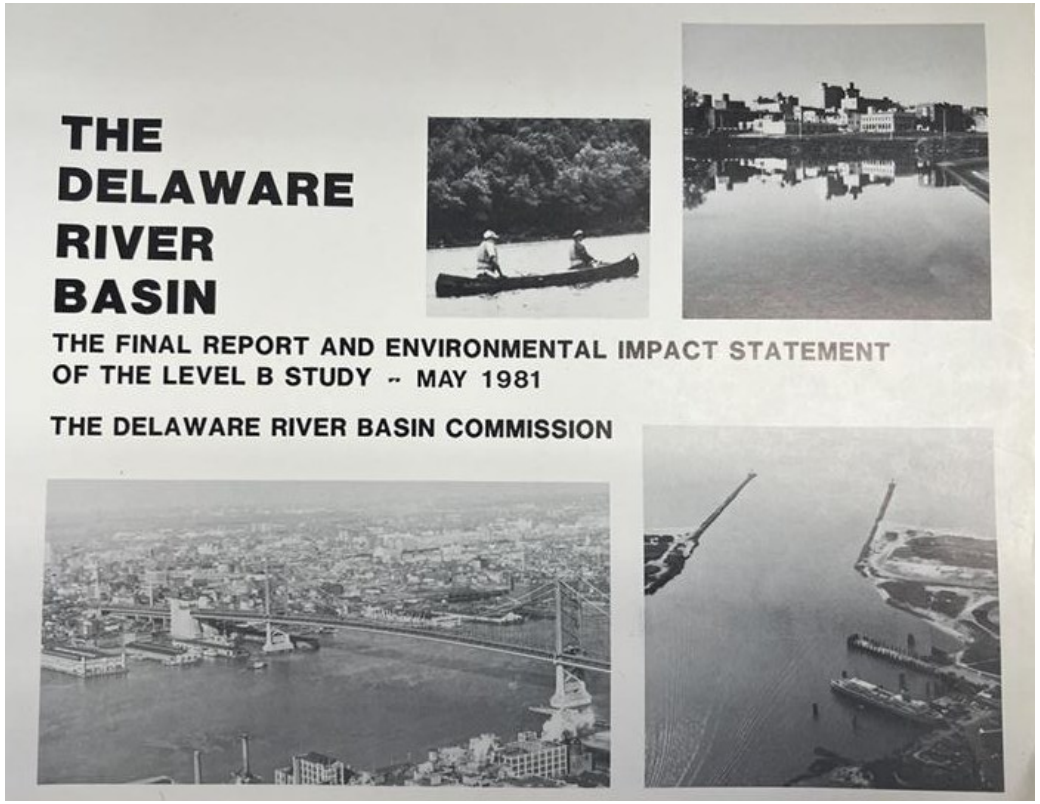
What are the future challenges?

- Drought management plans were established in the 1980s
- Assumptions
  - consumptive use
  - reservoir development
  - “sea level rise”
  - channel depth

What’s different?



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What has changed since the 1960s?

Assumptions	Changes since plan development
Sea Level Rise	Greater tidal energy pushing salt upstream Studies indicate TEFO may not be enough
Reservoir Development	Only 1 of 5 proposed constructed Aging infrastructure (30-100 years old)
Channel depth	Recently dredged from 40 – 45 ft. Salinity transport on the bottom Panamax?
Consumptive Use	Less than expected, but what about data centers?
Ambient chlorides	Not ocean salt, but still contributes salinity into the river

How do we address these challenges?

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Options to meet future challenges

- Maintain freshwater inflows
  - Studies are underway to re-evaluate Trenton flow objective (sea level rise, storage, weather and future hydrology)
  - Storage
- Infrastructure
  - Barries or baffles (sills)
  - Intake relocation (expensive, disruptive)
  - Interconnections (water chemistry)
  - Treatment (energy intensive, brine disposal)

My brainstorming.
List does not reflect the opinions of Commissioners or staff

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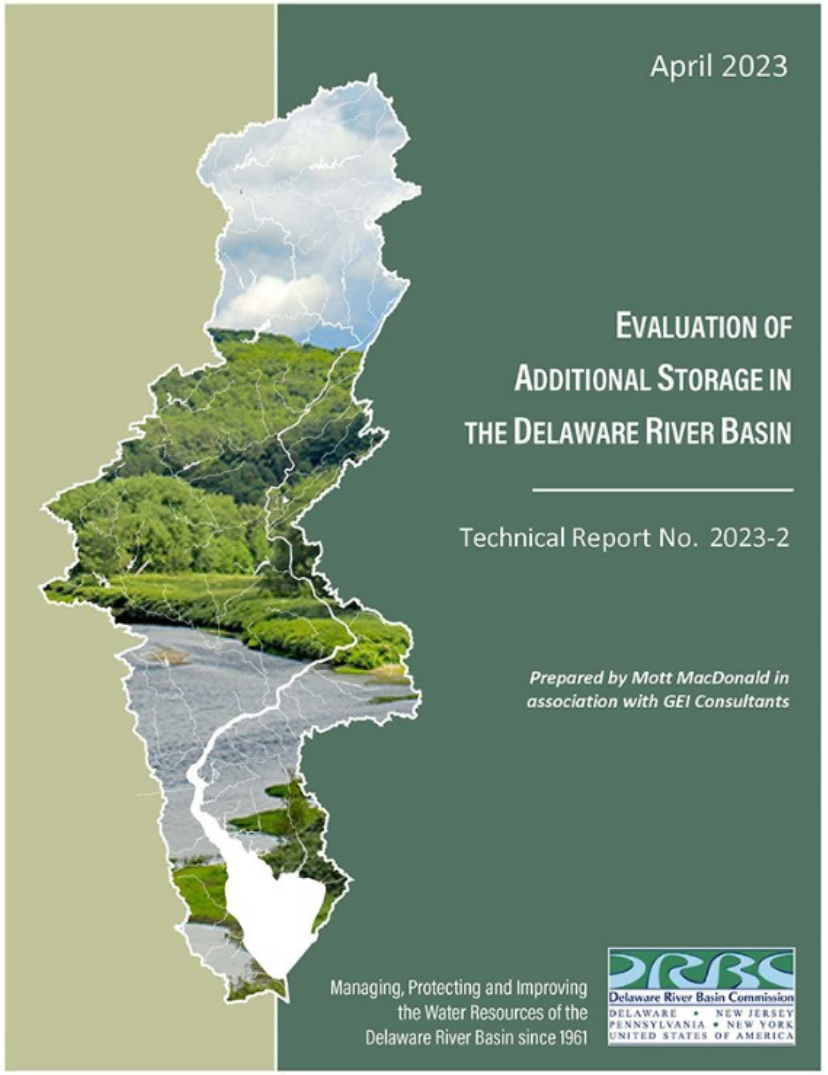
Maintain Freshwater Inflows - Storage



Expensive – long lead time – other desired uses

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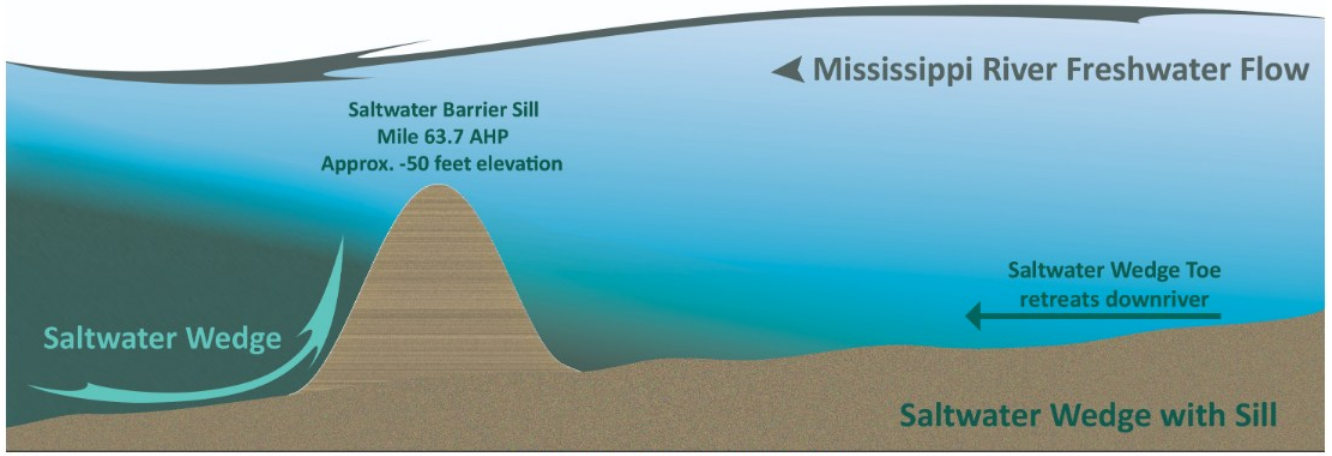
Sea Level Rise – Temporary Infrastructure

* Temporary infrastructure
* Permanent Infrastructure

- Costly
- Frequency of use
- Mobilization

Conservative estimates show that the sill would need to be constructed an average of about once every five years. Since completion of the 45-ft. channel, a sill has been constructed three times: in 1988, in 1999, and in 2012. Construction is currently underway for the 50-ft. channel.



Construction of the Saltwater Sill in the Mississippi River

Sea Level Rise – Permanent Infrastructure

- Navigation
- Habitat
- Costly

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Treatment

Desalinization

Energy Intensive – Brine Disposal - Costly

Rapid deployment reverse osmosis

Water Chemistry - Blending?

Salinity Management in the DRB

* Salinity intrusion events impact tidal water users
* Ocean salt movement – balanced between tides and freshwater inflows
* Trenton flow objective works (for now)
* Management plan is 40 years old – assumptions change
* Challenges can be addressed, but more information is needed

AP News Article: "Drought is causing saltwater to creep up the Delaware River. Here's what's being done about it."

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Questions and Discussion

Photo: DRBC Archives

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