

# Projections of self-supplied industrial sector water withdrawals in the Delaware River Basin

## Water Management Advisory Committee

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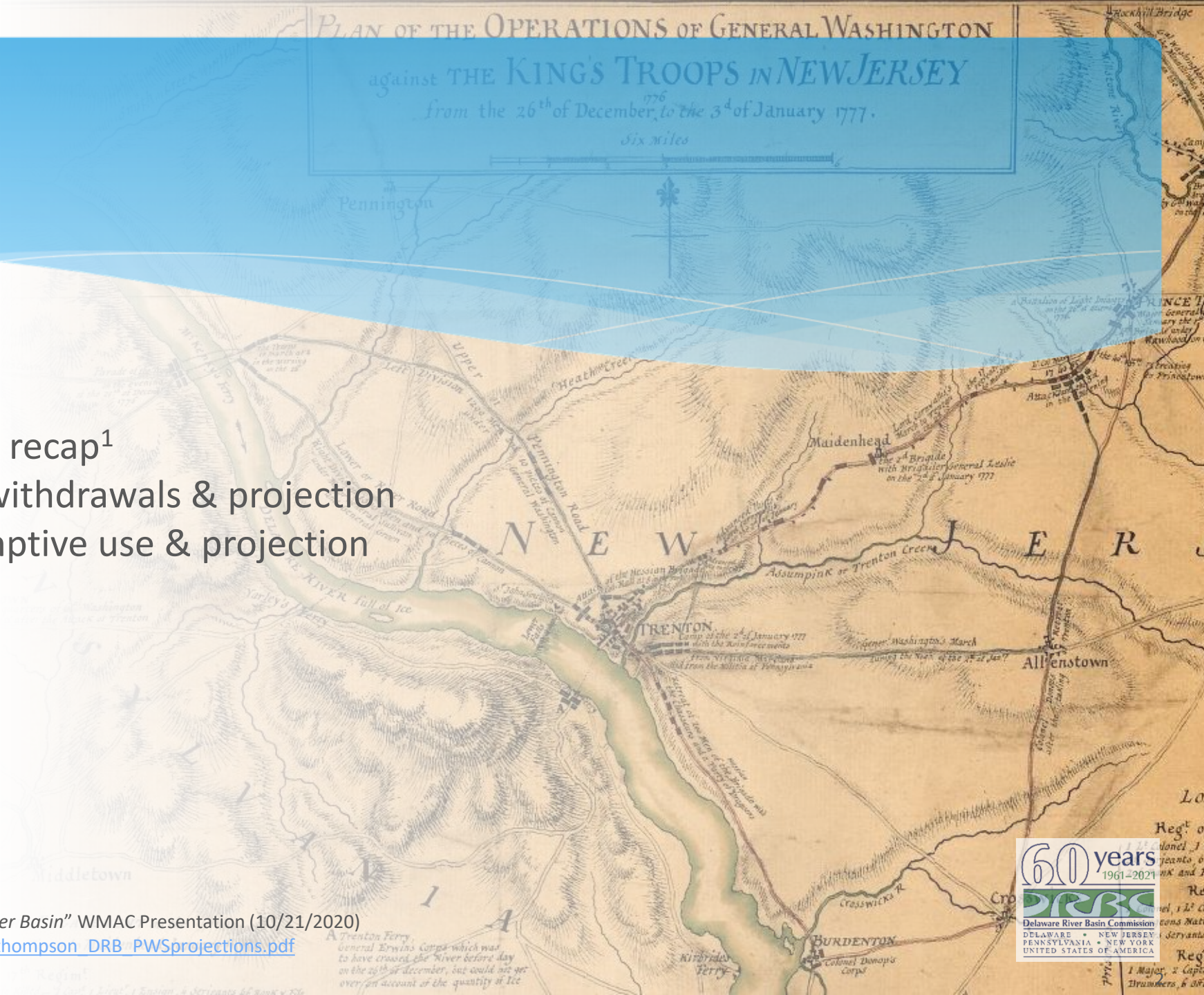
# Outline

1. Projection methodology recap<sup>1</sup>
2. Industrial sector water withdrawals & projection
3. Industrial sector consumptive use & projection
4. Next Steps

<sup>1</sup> "Projections of the Public Water Supply Sector in the Delaware River Basin" WMAC Presentation (10/21/2020)

[https://www.state.nj.us/drbc/library/documents/WMAC/102120/thompson\\_DRB\\_PWSprojections.pdf](https://www.state.nj.us/drbc/library/documents/WMAC/102120/thompson_DRB_PWSprojections.pdf)

Plan of the operations of General Washington against the King's troops in New Jersey, from the 26th of December to the 3d of January 1777. [1777] Map. <https://www.loc.gov/item/gm71000654/>.

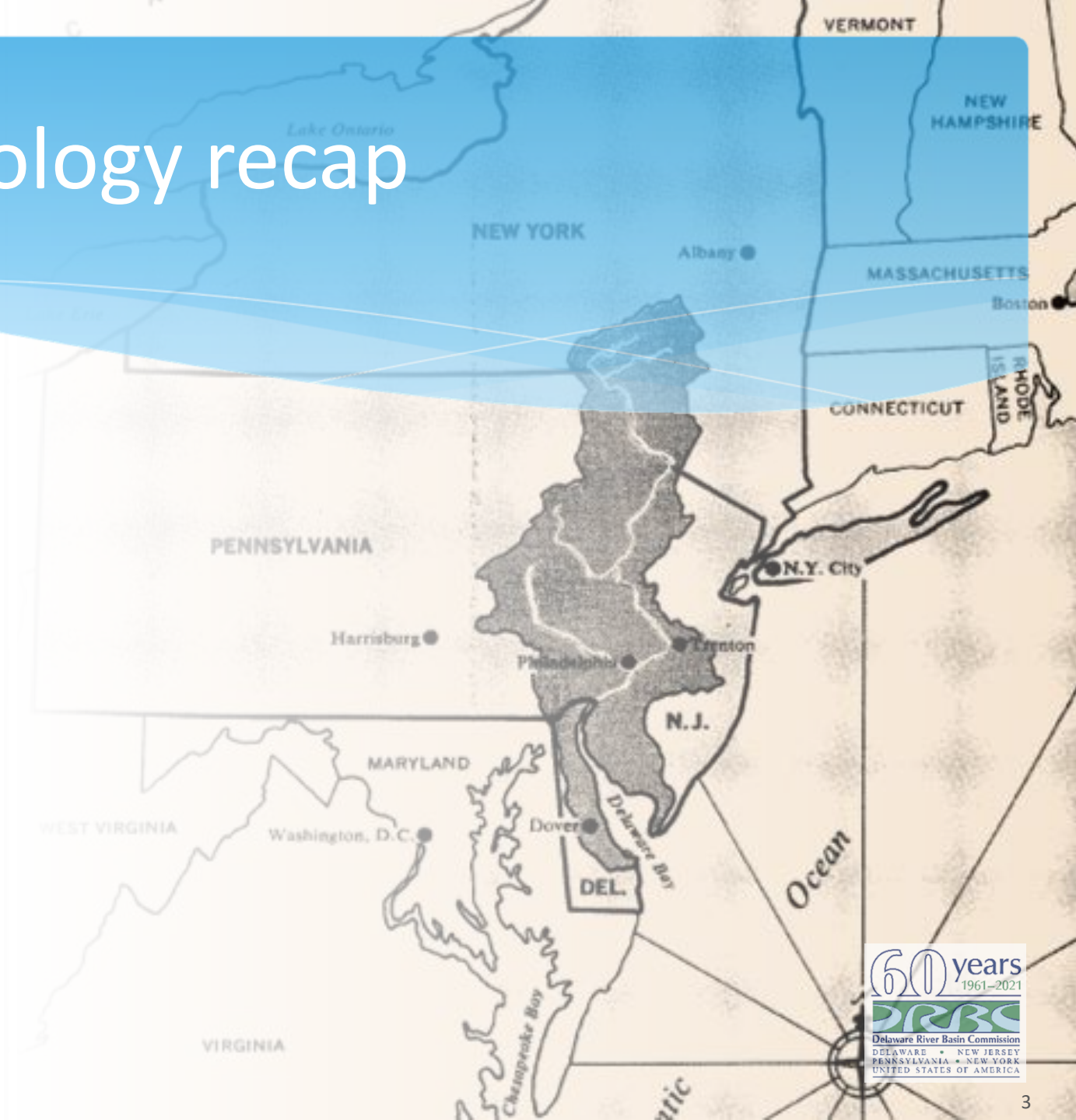




# 1. Projection methodology recap

*The planning process "...cannot be a grandiose fixed blueprint: rather it is a process involving continuing inputs from diverse programs, agencies, institutions, individuals and groups representative of every conceivable human and natural interest... The end product sought is a dynamic equilibrium serving the public interest."*

- DRBC Comprehensive Plan, 1973



# 1. Recap: What are the planning objectives?

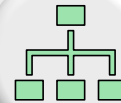


Provide projections of future average annual water withdrawals in the Delaware River Basin, through the year 2060, to be used in future planning assessments.

Represent each water withdrawal *sector* at the Basin-wide scale.



Apply GW results to the 147 sub-watersheds (Sloto & Buxton, 2006) and the 76 sub-watersheds of SEPA-GWPA.



Apply SW results at the source level for future availability analyses.



Relate results to regulatory approvals.

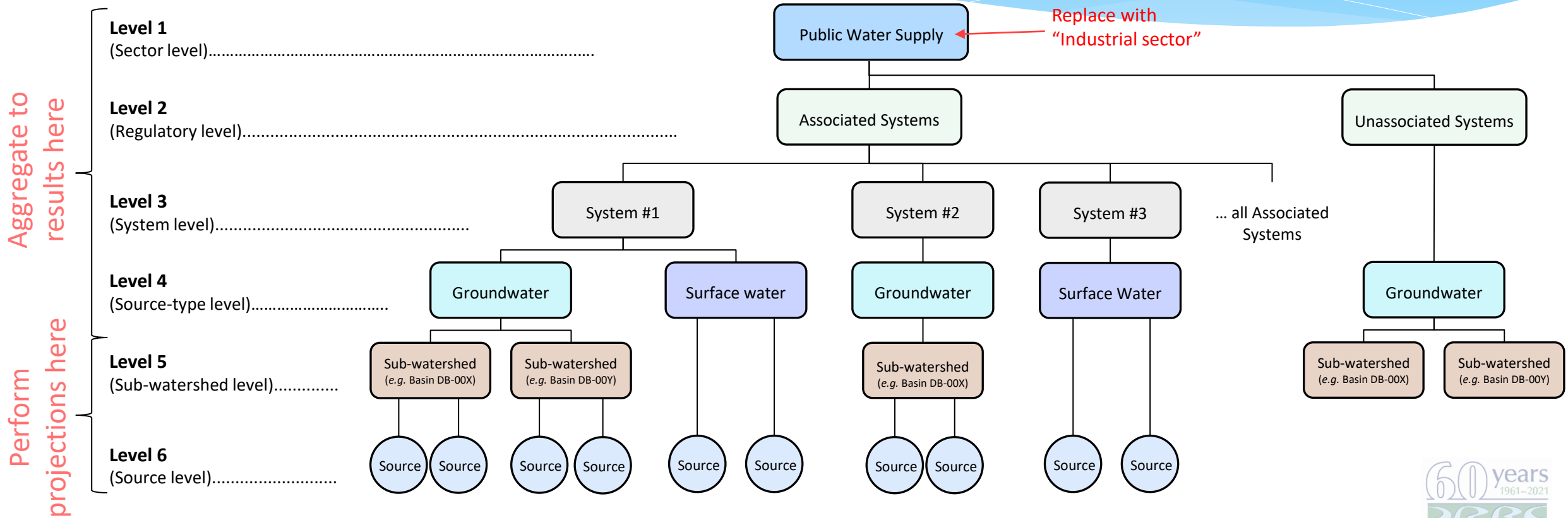


# 1. Recap: A plan for projecting data?



Where do we start?

## Time-series hierarchy



# 1. Recap: Tools in the toolbox



Prediction interval

$$\hat{y} \pm t_{\alpha, v} * \hat{\sigma}_e \sqrt{1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{(n - 1)s_x^2}}$$

“Metadata”



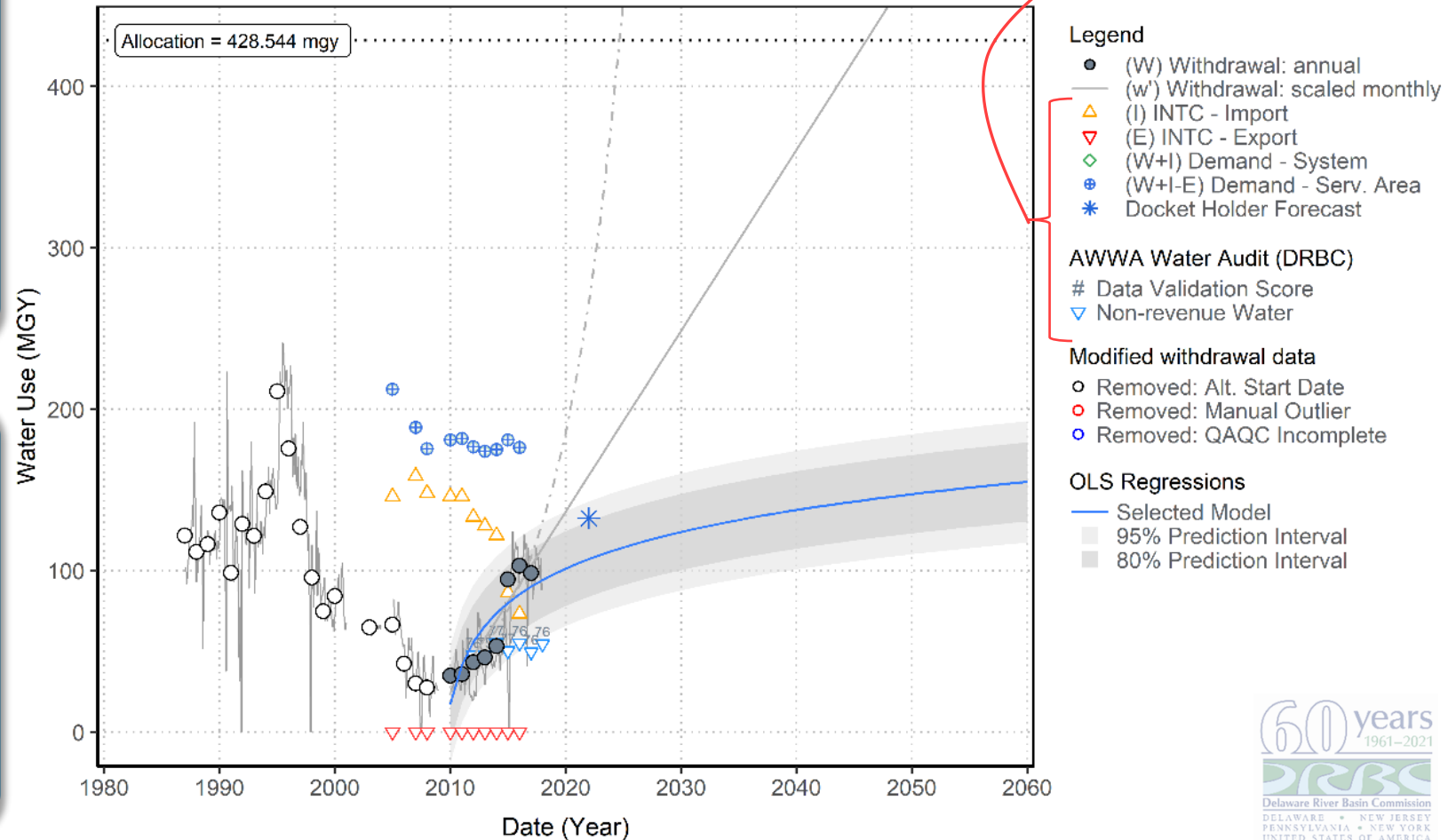
Methods of extrapolation

- Linear ordinary least-squares (OLS)
- Linear and non-linear transformations (i.e. LOG and EXP regressions)
- Mean value (zero-slope linear)
- Top-down equations
- Structural break / offset equations



QAQC of data

- **Outlier** – removal of individual point
- **Start date** – alter start of projection
- **Algorithm** checks annual completeness
- **Verifying sources** (in basin, duplicate...)
- **Best professional judgement (BPJ)** to check for capture of trends, metadata, outliers missed in algorithm





## 2. Industrial sector water withdrawals & projection

*“Today's 50-year projections are not the ones which will be used 10 to 40 years hence. The planning process is continuously building on the best information obtainable.”*

- DRBC Comprehensive Plan, 1973



# 3. Industrial sector context



Image obtained from: <https://www.pbfenergy.com/refineries/>

## Petroleum refining

Transformation of crude oil into usable products

- Water primarily used for cooling
- Water used for steam
- Sanitary purposes
- Fire protection
- Remediation



Image obtained from: <https://www.qualitymag.com/articles/95739-using-software-to-refine-the-steel-manufacturing-process>

## Steel/metal processes

Smelting, production & casting, rolling, sheet mills, rolling mills

- Water primarily used for cooling (furnace shell, quenching, casting)
- Cleaning furnaces & ovens
- Chemical treatments
- Emulsions for rolling, cleaning, degreasing, rinsing



Image obtained from: <https://new.abb.com/cpm/industry-specific-solutions/consumer-fine-chemicals>

## Chemical manufacturing

- Paints, pigments, coatings, sealants, lubricants, greases, components for engines & computers
- Water used for cooling & within the products
- Many scales of facilities throughout the DRB



Image obtained from: <https://www.innovusengineering.com/>

## Food processes

- Washing food prior to canning
- Cooling food / equipment
- Water used in canning
- Water used as bottled water
- Pet food production

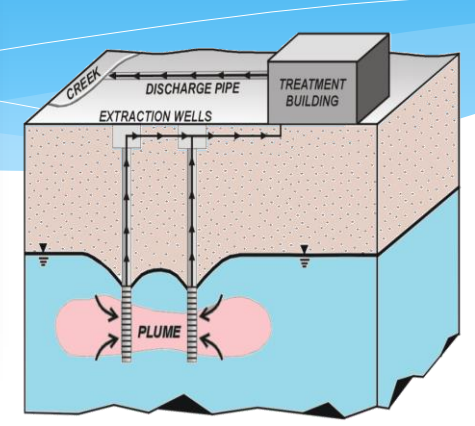


Image obtained from: [https://www.epa.gov/sites/production/files/2015-04/documents/gw\\_pump\\_treat\\_542r01021b\\_0.pdf](https://www.epa.gov/sites/production/files/2015-04/documents/gw_pump_treat_542r01021b_0.pdf)

## Remediation

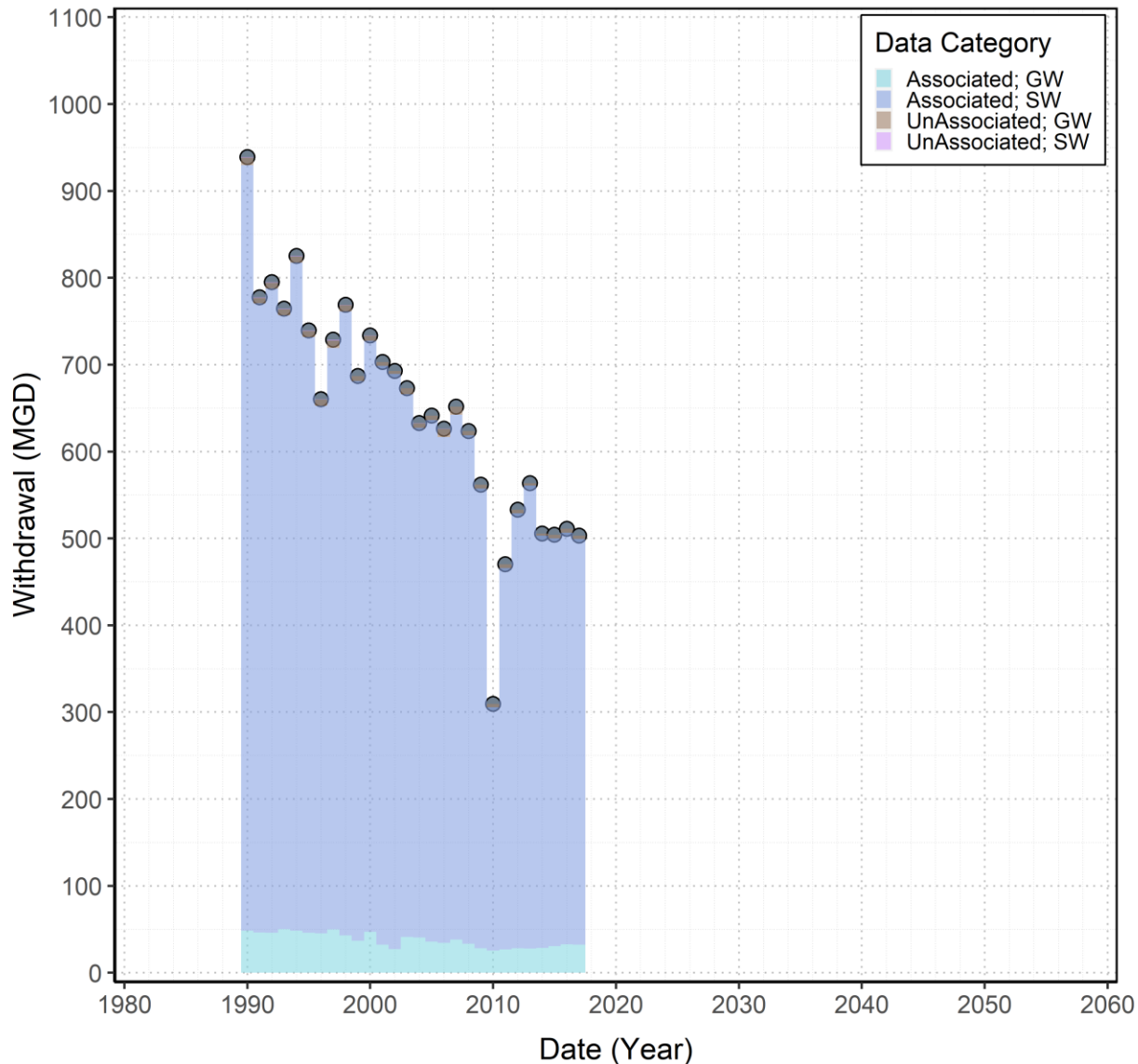
Generally, very small quantities but often related to current/former industrial facilities

- Groundwater pump and treat
- Controlling plume migrations
- Extraction & re-injection



# 3. Industrial sector withdrawals: characterization

Industrial Water Withdrawals in the Delaware River Basin

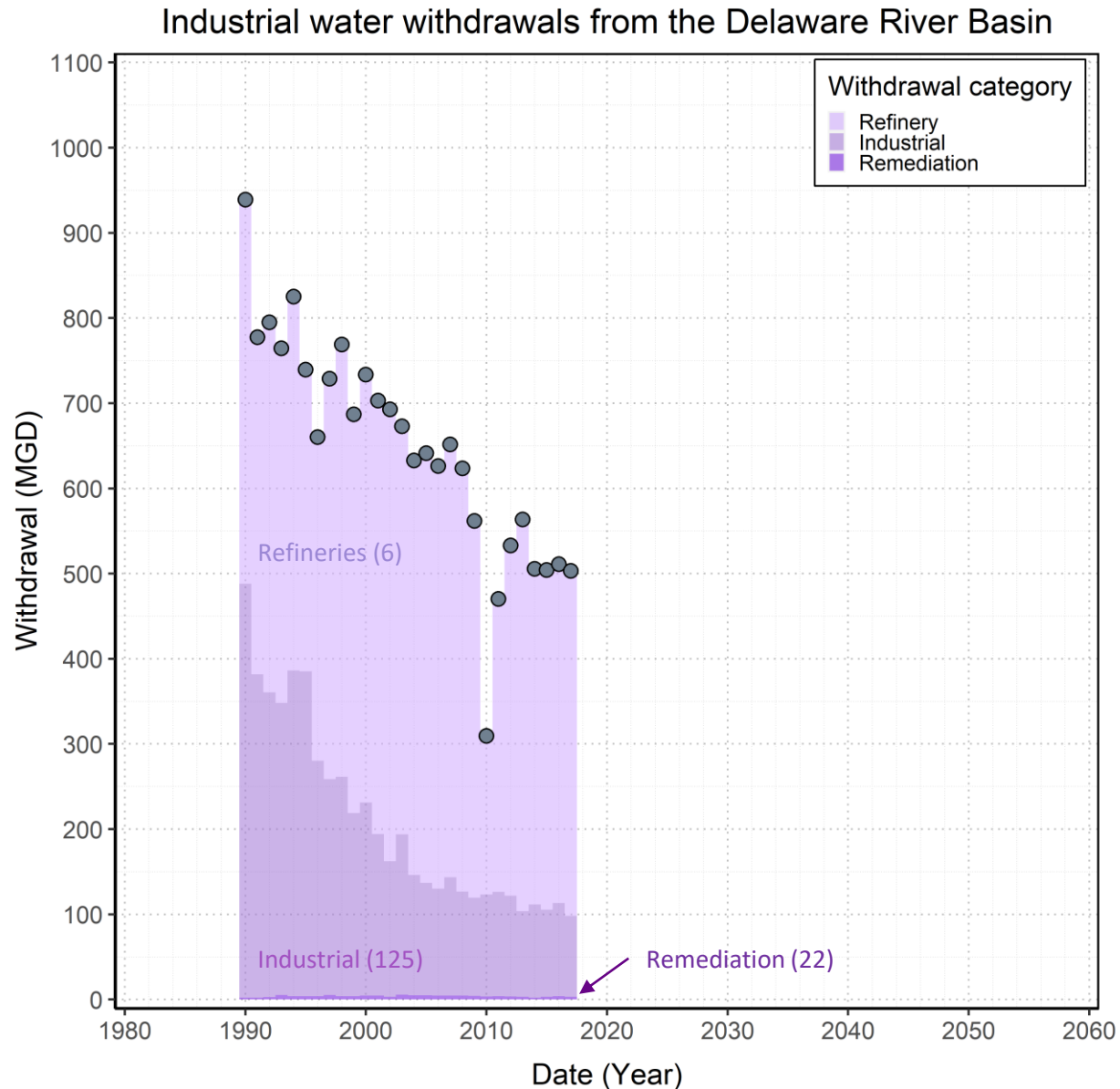


## KEY NOTES:

1. Withdrawals are **self-supplied**
2. Good picture of reporting from 1990-2017 based on QAQC of sources for 153 approvals
3. Reported data “unassociated” with regulatory approvals is about 1% by volume (assumed related to review thresholds etc.)
4. QAQC included review of many expired/terminated approvals to account for historic data
5. Unassociated data: only GW is projected

Data category	Systems (OAIDs)	Water type	Sources (WSIDs)	Average withdrawal (MGD)	Percent total withdrawal
Associated	165*	SW	97	597.082	93.2%
		GW	855	37.579	5.9%
Unassociated	215	SW	23	0.287	0.0%
		GW	509	5.611	0.9%
Totals:	380	--	1,484	640.558	100.0%

# 3. Industrial sector withdrawals: Basin-wide



## The data does include:

Three primary **categories of withdrawal based on facility:**

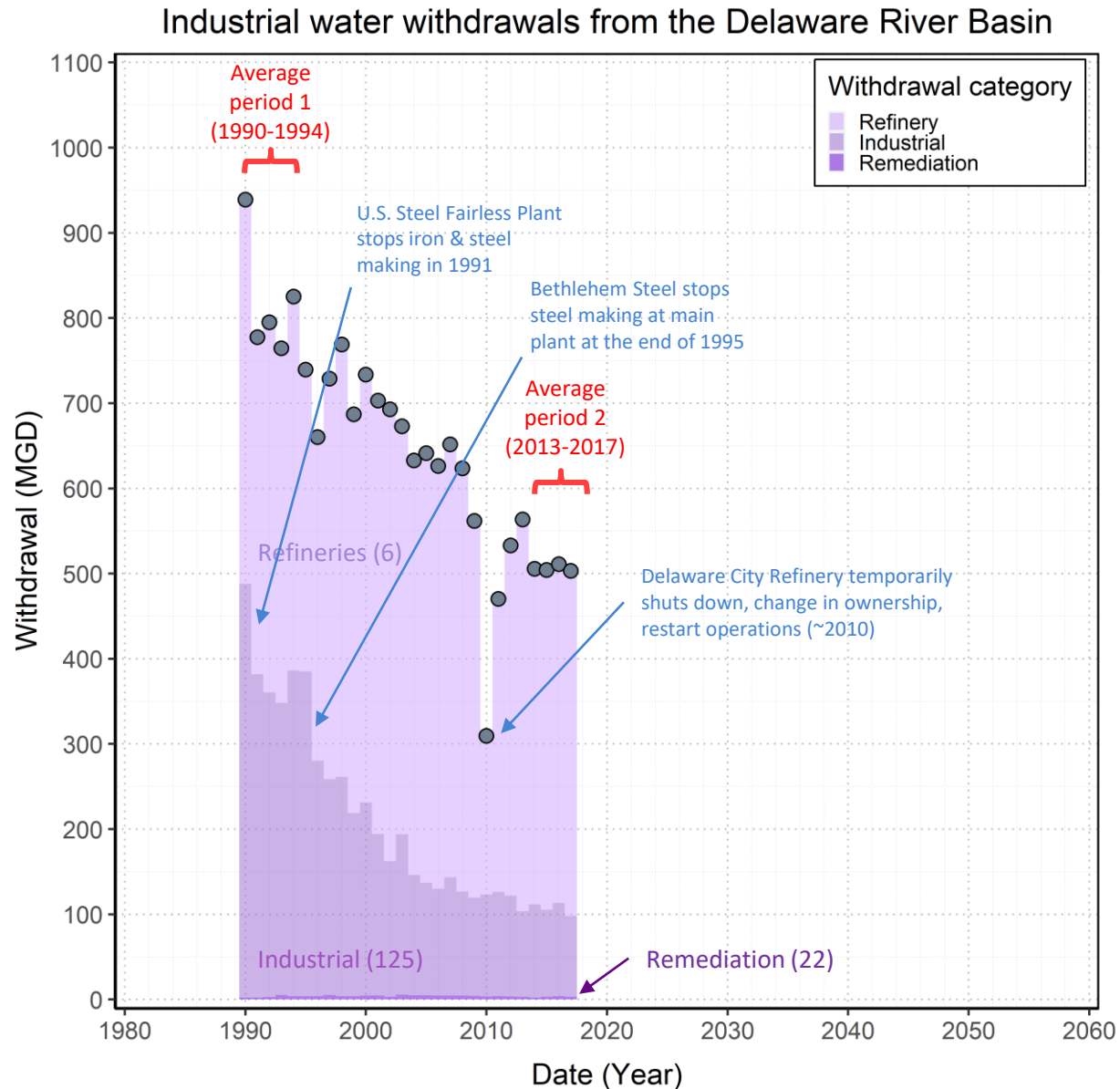
- **Refinery:** Withdrawals of water by facilities which are involved with the refining of petroleum products.
- **Industrial:** Includes withdrawals for industrial processes such as fabrication, processing, washing, canning and cooling.
- **Remediation:** An example is remediation of groundwater contamination which includes pump and treat or gradient control. Often associated with active or former industry.

## The data does not include:

- Non-self-supplied industrial facilities (*covered under PWS*)
- Mining withdrawals (*covered under mining sector*)
- Commercial withdrawals (*covered under "other" sector*)
- Thermoelectric withdrawals\* (*covered under power gen.*)



# 3. Industrial sector withdrawals: Basin-wide



## Key Notes:

- Drastic Basin-wide decreases over ~30 years:
  - 1990-1994: ~820 MGD
  - 2013-2017: ~520 MGD (-300 MGD, -36.9%)
- Looking at sectors, industrial withdrawals appear to account for most of the decrease
- Considering historic withdrawals on average:
  - (90%) about 20 facilities
  - (9%) about 130 associated facilities
  - (1%) about 200 unassociated facilities
- Remediation is comparatively small, and reporting at the state level is tricky (e.g., superfund sites)

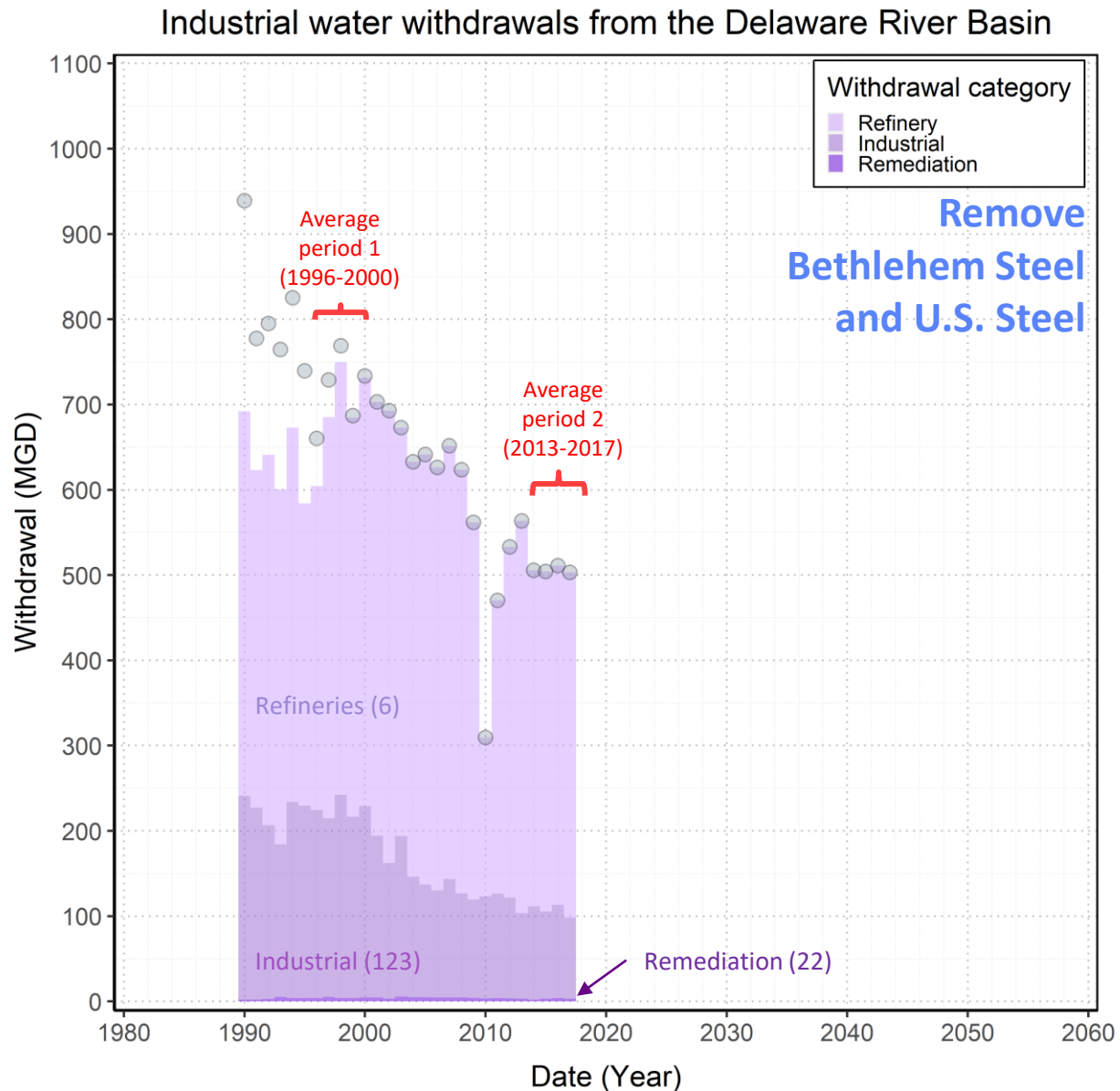
## Data including Bethlehem & U.S. Steel

State	Refinery		Industrial		Remediation	
	'90-'94	'13-'17	'90-'94	'13-'17	'90-'94	'13-'17
Delaware	312.146	293.453	41.322	5.913	0.855	0.066
New Jersey	18.352	7.963	80.470	26.847	0.937	1.878
New York	NA	NA	NA	1.586	NA	NA
Pennsylvania	96.676	109.693	267.840	68.948	1.487	1.160
Total	427.173	411.109	389.633	103.294	3.279	3.104

-16.064

-286.339

# 3. Industrial sector withdrawals: Basin-wide



## KEY NOTES:

1. Remove the two largest permanent facility shutdowns in the time-series
2. Adjust the first averaging period to 1996-2000
3. Refinery withdrawals decrease a little more, ~50 MGD
4. Industrial withdrawals decrease less, ~115 MGD

## What this analysis is not doing:

Not attempting to correlate withdrawal volumes with economics of the region. Economic value of DRB is complex (e.g., Kauffman, 2011)

## Data excluding Bethlehem & U.S. Steel

State	Refinery		Industrial		Remediation	
	'96-'00	'13-'17	'96-'00	'13-'17	'96-'00	'13-'17
Delaware	354.615	293.453	45.683	5.913	0.707	0.066
New Jersey	16.044	7.963	77.872	26.847	2.138	1.878
New York	NA	NA	NA	1.586	NA	NA
Pennsylvania	94.984	109.693	97.543	68.948	1.438	1.160
Total	465.642	411.109	221.099	103.294	4.284	3.104

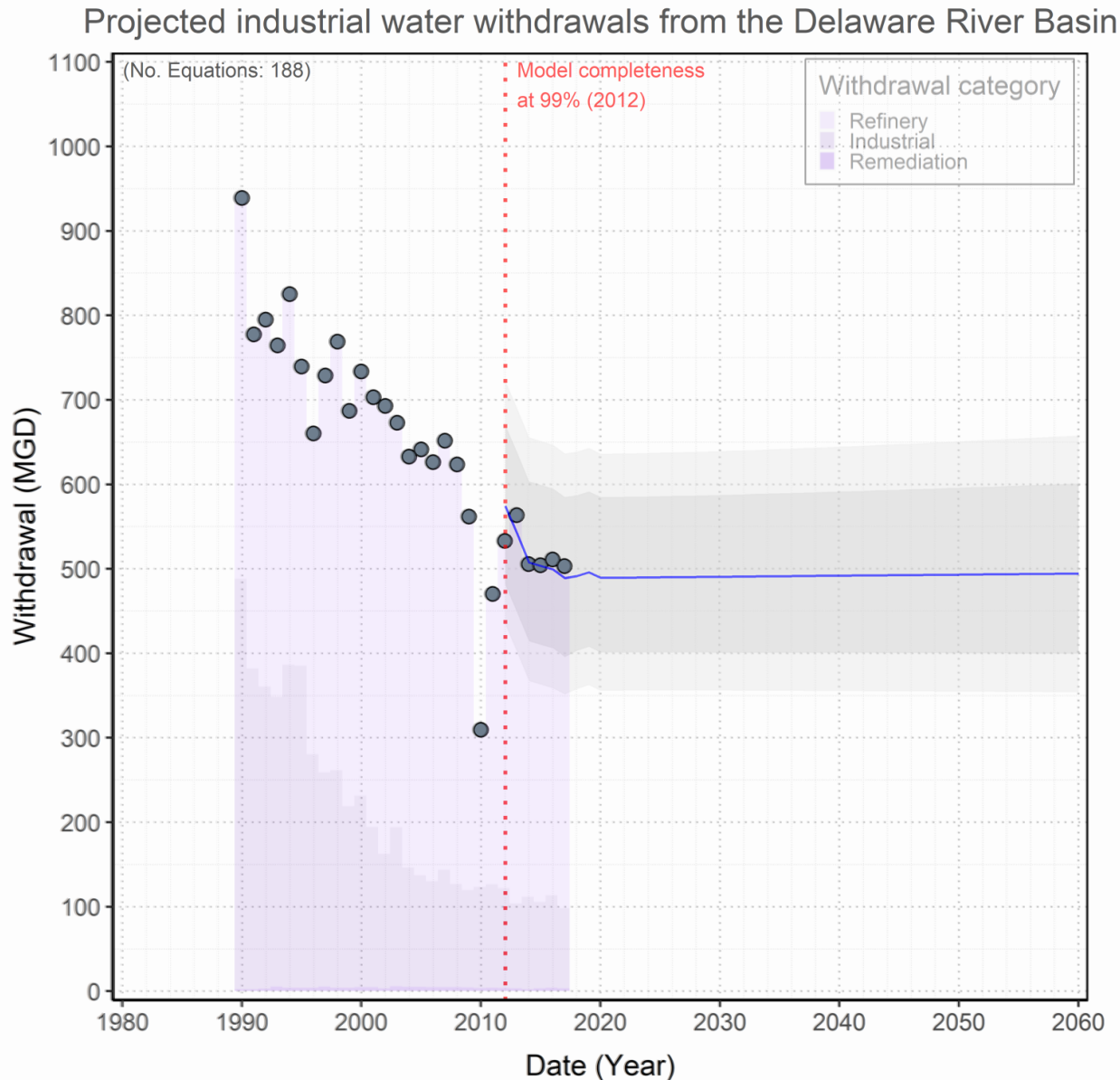
-54.553

-117.805





# 3. Industrial sector withdrawals: Basin-wide (projected)



## KEY NOTES:

1. Despite historic declines, aggregated projected trends suggest equilibrium reached
2. Modelled values:
  - **2020:** 489 MGD; (-88)(+95) 80%, (-133)(+147) 95%
  - **2060:** 494 MGD; (-95)(+107) 80%, (-140)(+163) 95%
3. Model does not account for future structural changes (i.e., facility shutdown like Bethlehem Steel)

Steel Mill in Claymont DE c.1927  
(Worth, Phoenix, CitiSteel, Evraz)  
Delaware River Intake



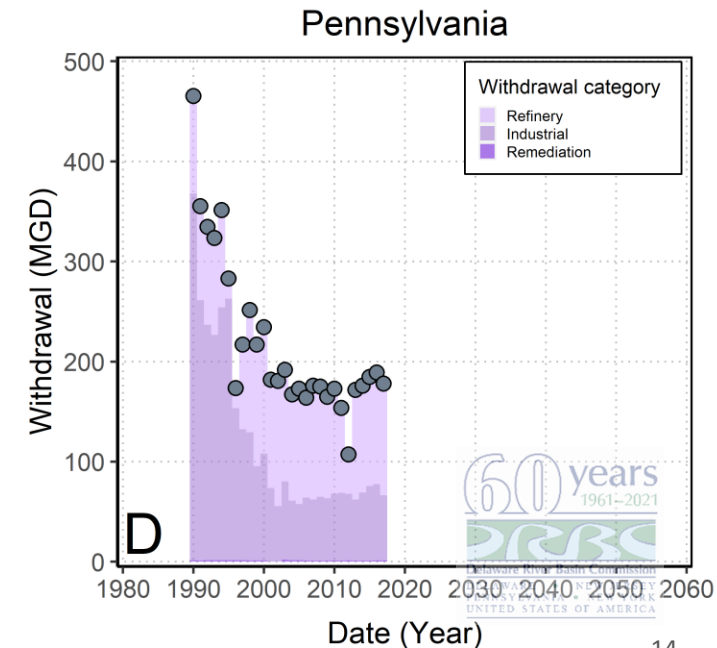
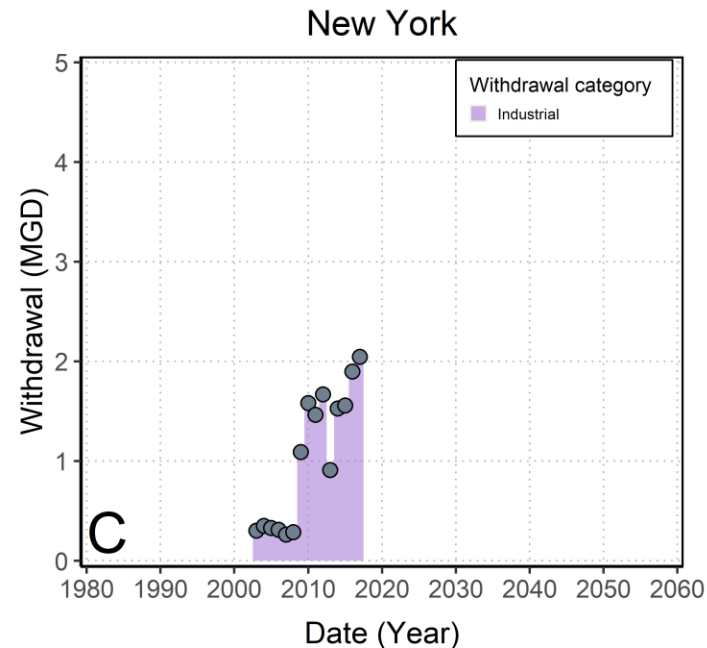
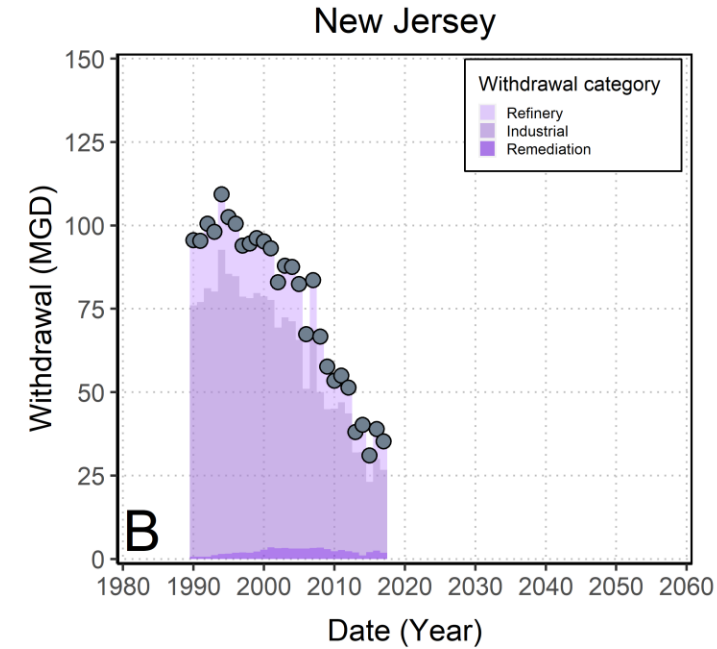
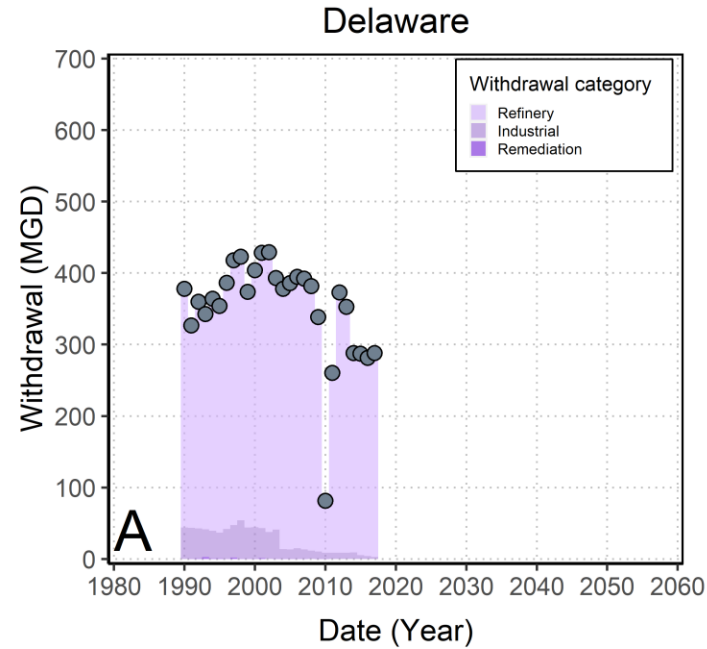
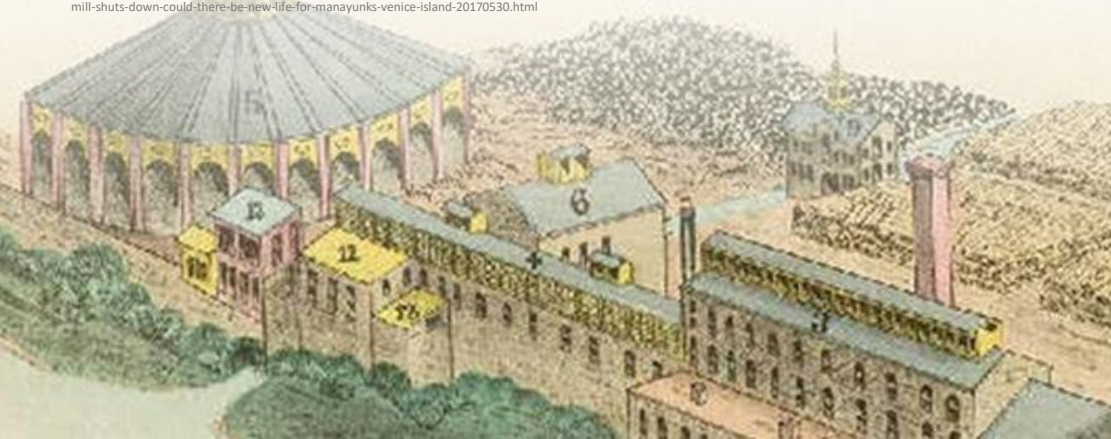
# 3. Industrial sector withdrawals: States

## KEY NOTES:

1. Large facilities can have substantial effects:
  - (PA-1991) US Steel stops steel prod.
  - (PA-1995) Bethlehem Steel stops steel prod.
  - (DE-2010) Refinery temporary shutdown, change ownership, restart
2. Other self-supplied industries:
  - (-75 MGD) 4 chemical/manufacturing facilities
  - (-8 MGD) 9 retirements of paper facilities

\*MGDs are difference between 1990-1994 and 2013-2017 averages

PaperWorks Mill in Manayunk, PA  
[https://www.inquirer.com/philly/business/real\\_estate/residential/after-historic-paper-mill-shuts-down-could-there-be-new-life-for-manayunks-venice-island-20170530.html](https://www.inquirer.com/philly/business/real_estate/residential/after-historic-paper-mill-shuts-down-could-there-be-new-life-for-manayunks-venice-island-20170530.html)





# 3. Industrial sector withdrawals: States

## KEY NOTES:

State level results @95% complete models appear coherent.

**DE** almost no change in total projection

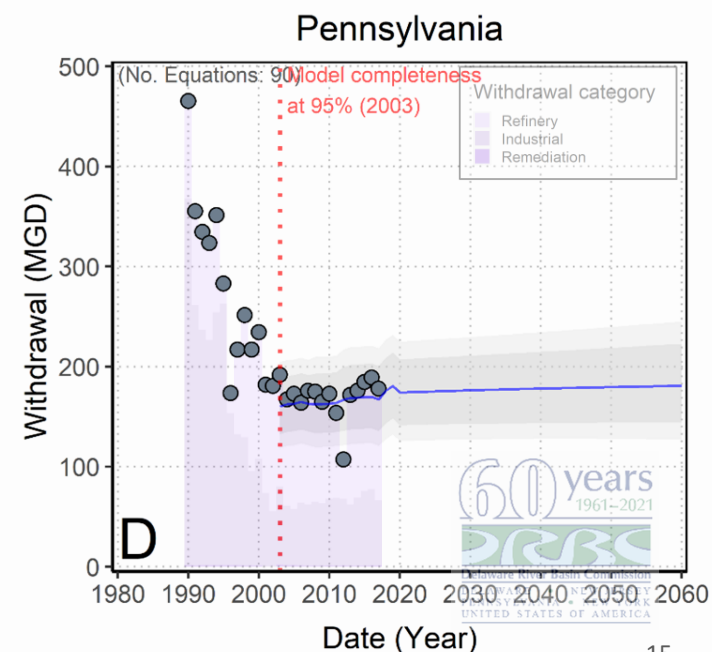
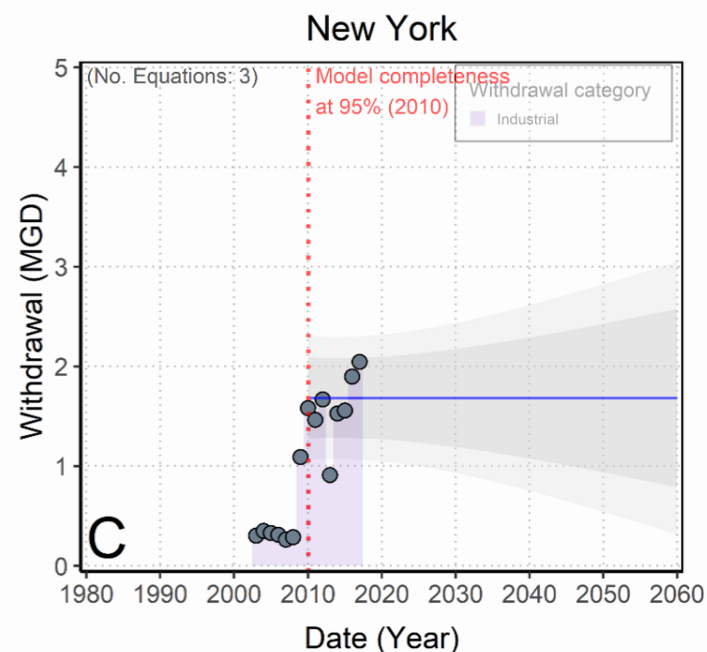
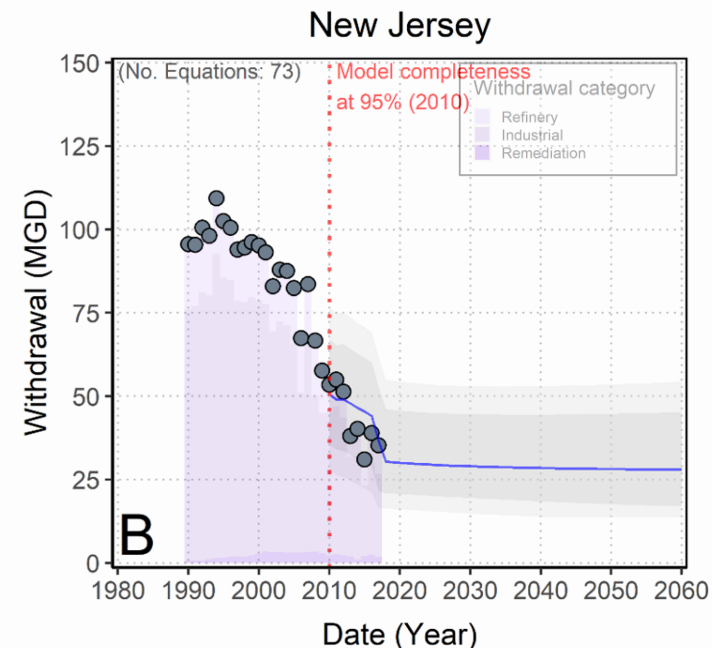
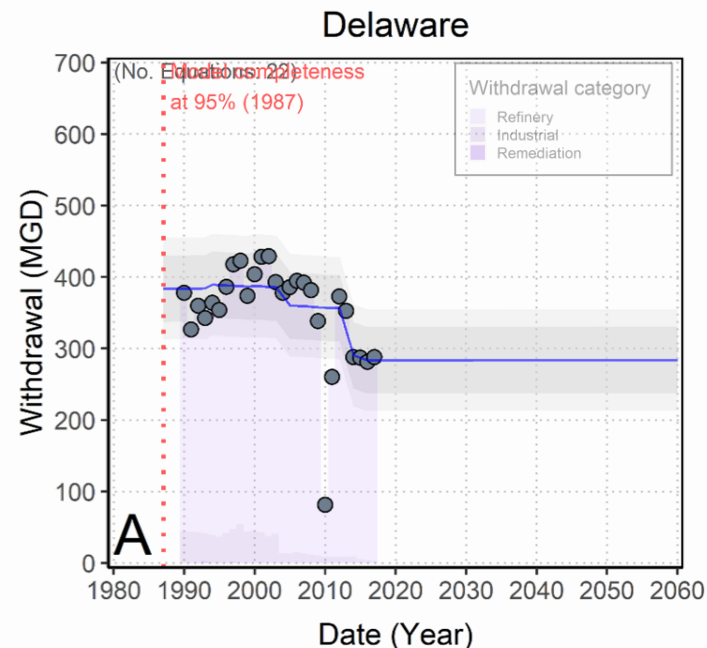
**NJ** slight decreasing trend (-2 MGD)

**NY** no change in total projection

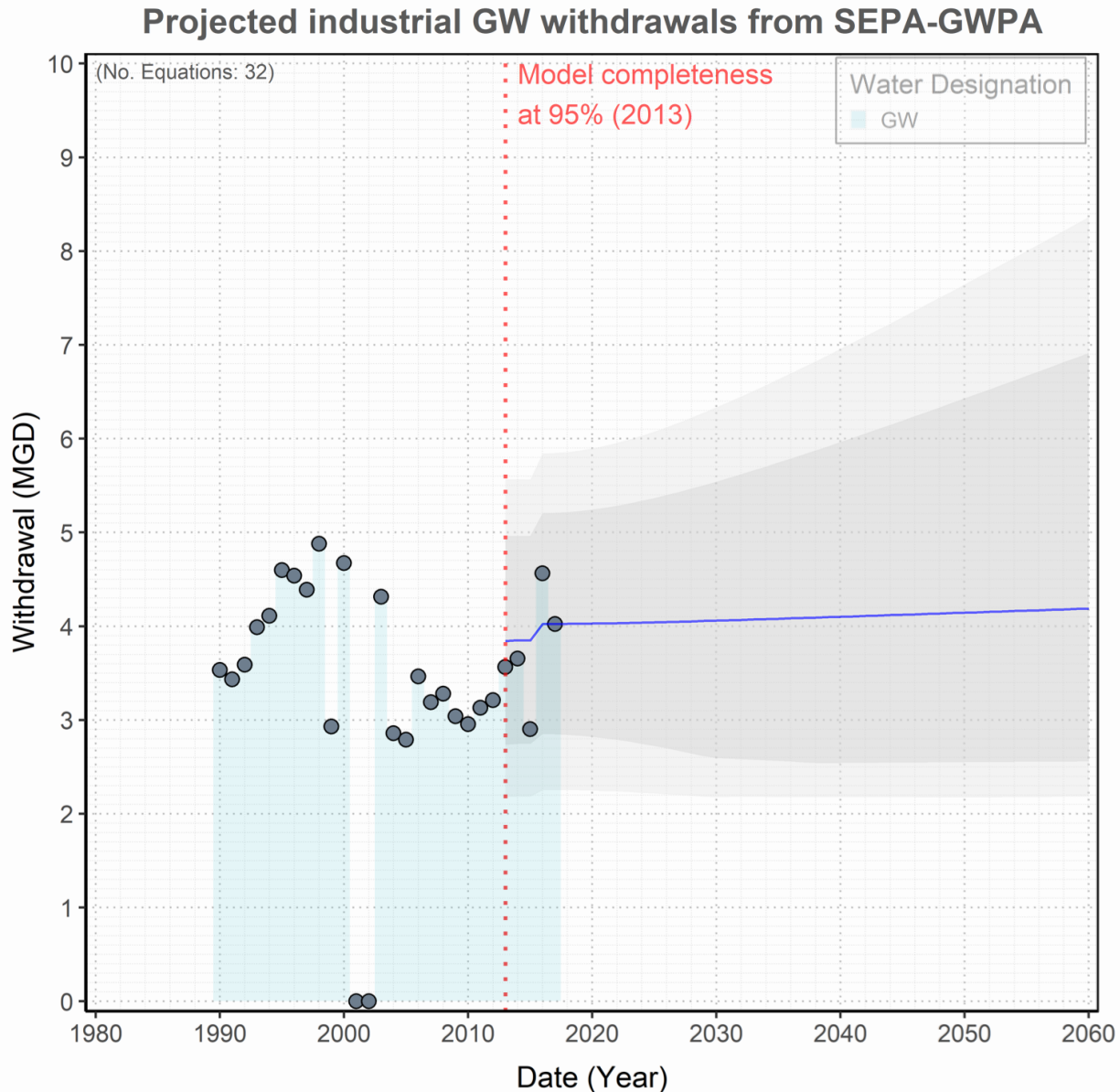
**PA** slight increasing trend (+6 MGD)

*Likely a fair assessment to say state trends are projected to be constant. Prediction intervals provide useful assessment of scale.*

De Laval Steam Turbine Co. in Trenton, NJ  
<http://www.vintagemachinery.org/mfgindex/detail.aspx?id=11234>



# 3. Industrial sector withdrawals: SEPA-GWPA (groundwater)



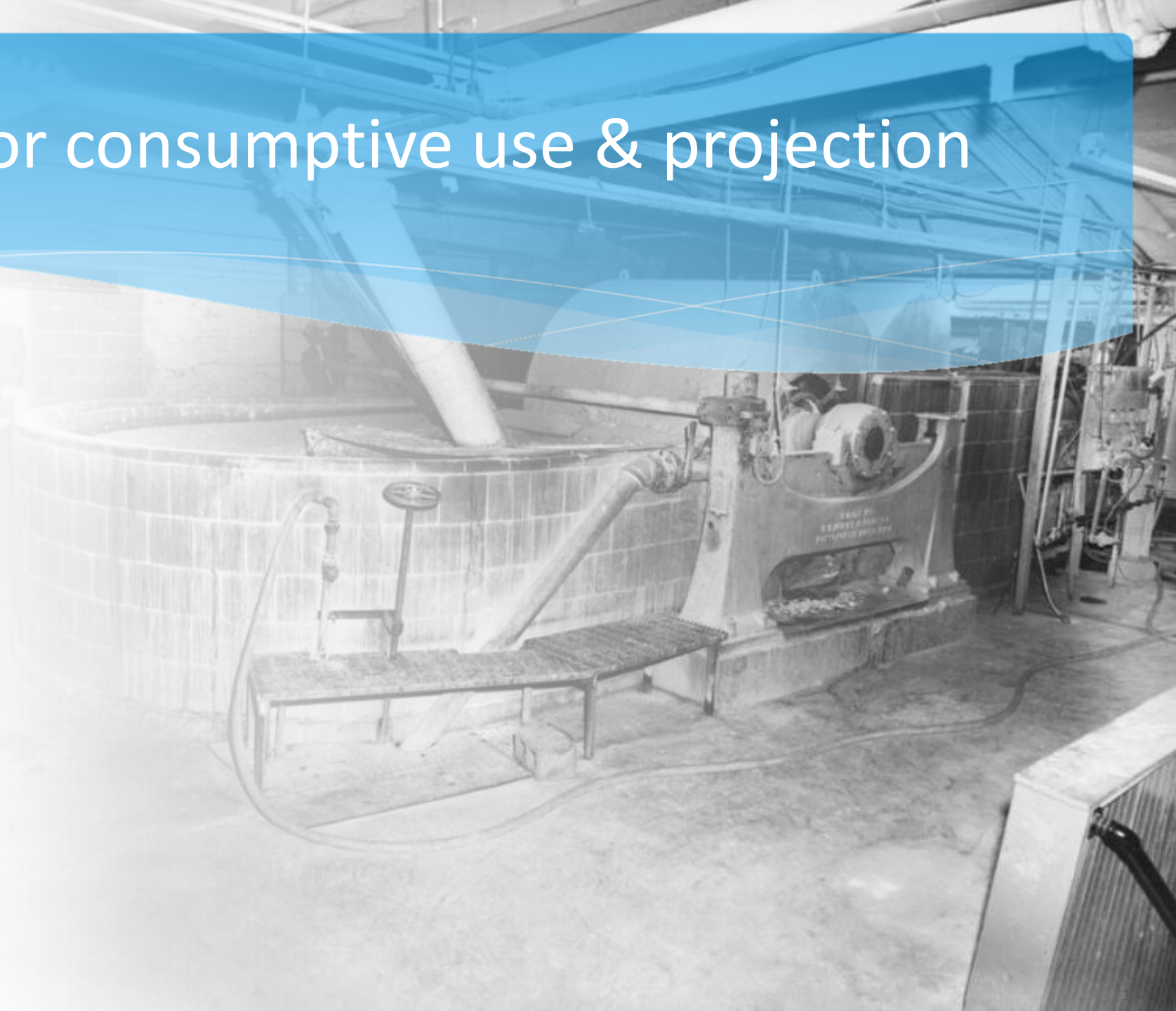
## KEY NOTES:

1. Only shows GW withdrawal from SEPA-GWPA
2. Smaller review threshold for associated systems
3. Model indicates likely status quo and uneven predictive interval:
  - 2020:** 4.0 MGD; (-1.2)(+1.2) 80%, (-1.8)(+1.9) 95%
  - 2060:** 4.2 MGD; (-1.6)(+2.7) 80%, (-2.0)(+4.2) 95%
4. Prediction interval suggests more likely to increase than decrease in future

# 3. Industrial sector consumptive use & projection

“We never know the Worth of Water,  
till the Well is dry”

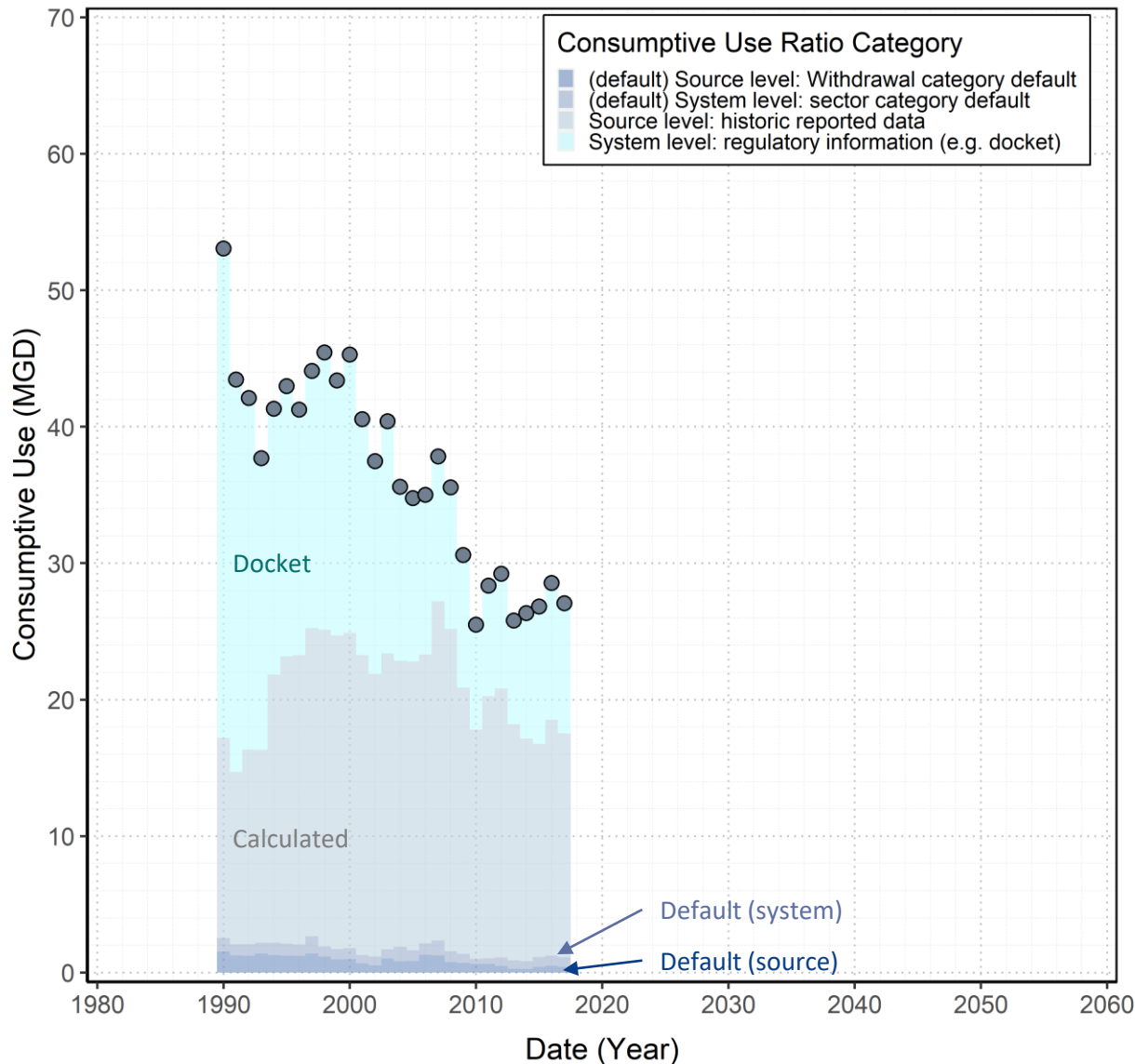
- Thomas Fuller, 1732  
(*Gnomologia*, #5451)





# 3. Industrial sector consumptive use: CURs

Industrial consumptive water use in the Delaware River Basin

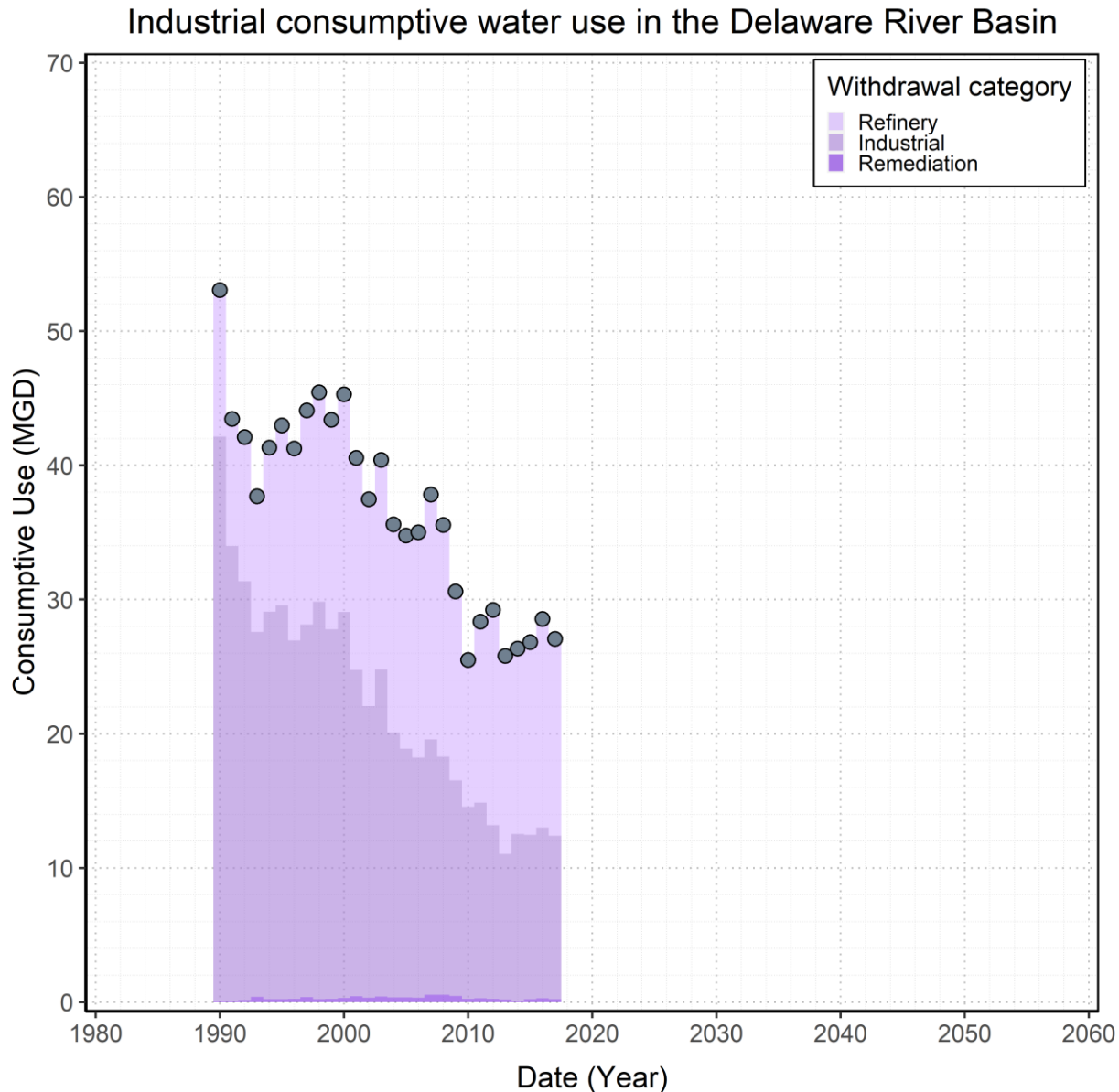


## KEY NOTES:

Used 4 methods in a preferential order:

- **Calculated:** DRBC Water Supply Charges Regulations data which contains reported CUR annually (specific facilities)
- **Docket:** Information contained within the docket outlining a percent consumptive use
- **Default (system):** A default value applied to all sources within an associated system based on facility category
- **Default (source):** A default value applied to unassociated source withdrawals based on source category

# 3. Industrial sector consumptive use: Basin-wide

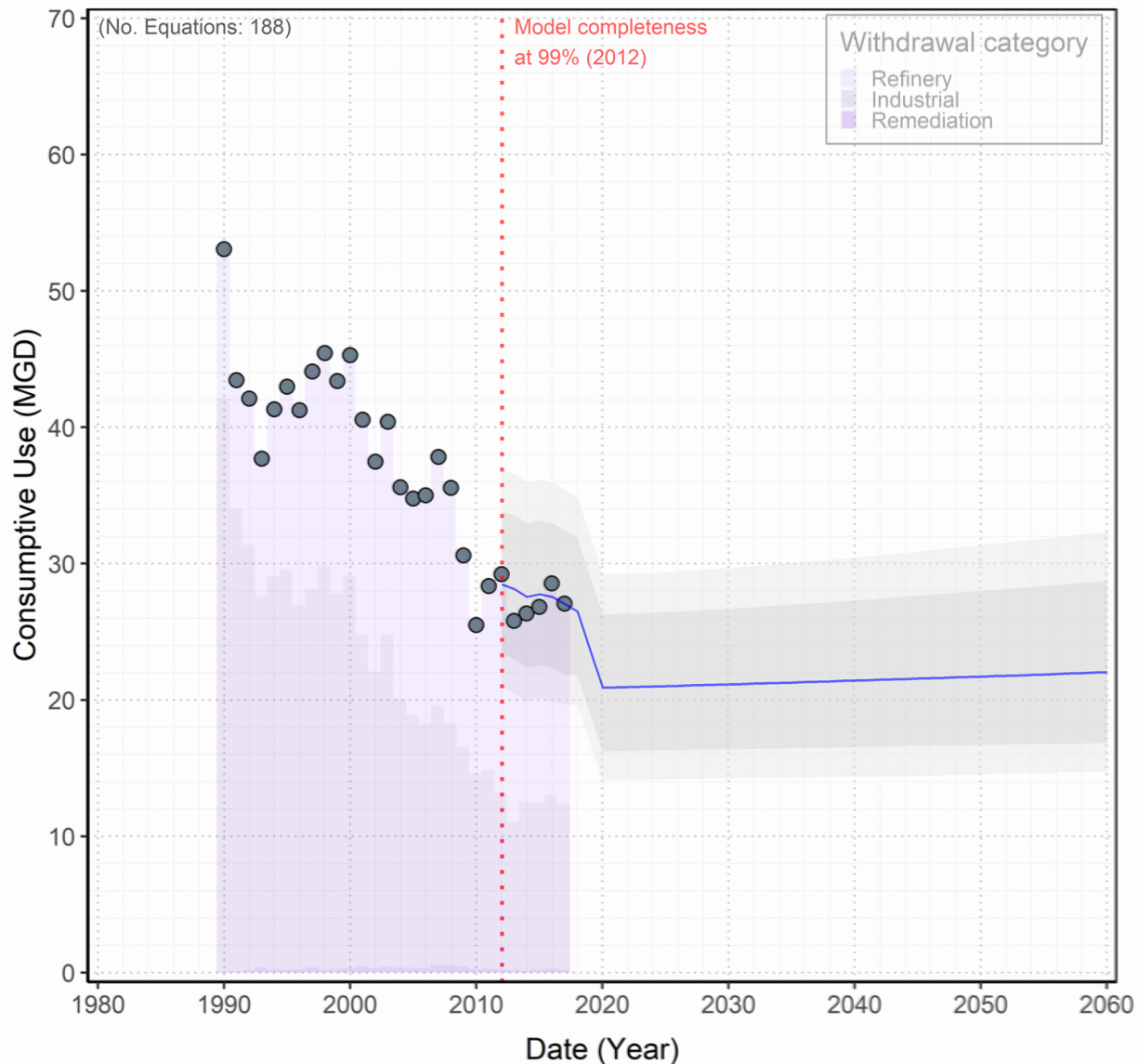


## KEY NOTES:

1. A single consumptive use ratio is applied to a system's entire historic dataset where possible (e.g., calculated values are a historic average)
  - Same method used for projecting consumptive use ( $CUR * \text{equation}$ ), small difference for unassociated withdrawals (~1% withdrawal)
2. Overall consumptive use has declined
  - ~40 MGD (1990-2000)
  - ~30 MGD (2010-2017)
3. Trends are similar to withdrawals, decreases are attributed to "industrial" facilities

# 3. Industrial sector consumptive use: Basin-wide (projected)

Projected industrial consumptive water use in the Delaware River Basin



## KEY NOTES:

1. Notable drop around 2019 is the closure of Philadelphia Energy Solutions (PES). Beyond general scope of study, known major withdrawer in the Basin (10-15 MGD) and operated about 40% consumptive
2. Projected similar trend to total withdrawal  
**2020:** 20.9 MGD; (-4.7)(+5.4) 80%, (-6.8)(+8.3) 95%  
**2060:** 22.1 MGD; (-5.2)(+6.7) 80%, (-7.3)(+10.3) 95%

Philadelphia Energy Solutions,  
Philadelphia, PA





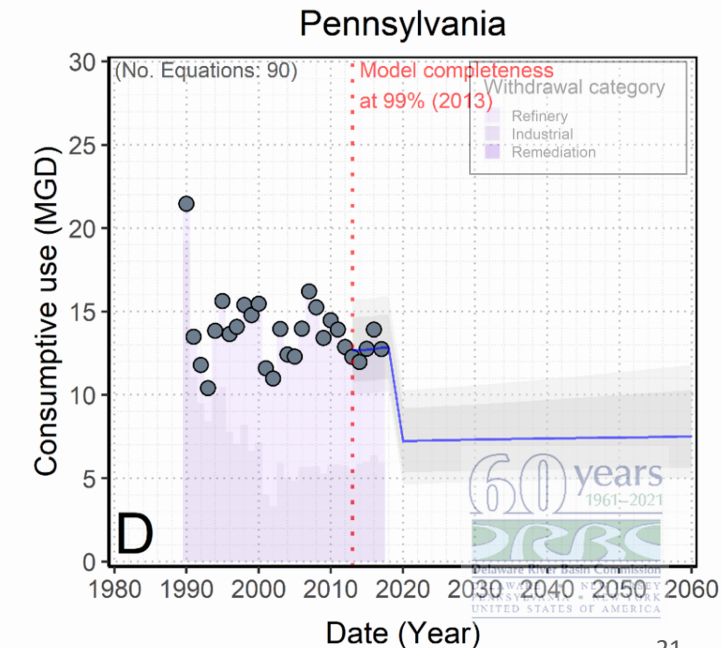
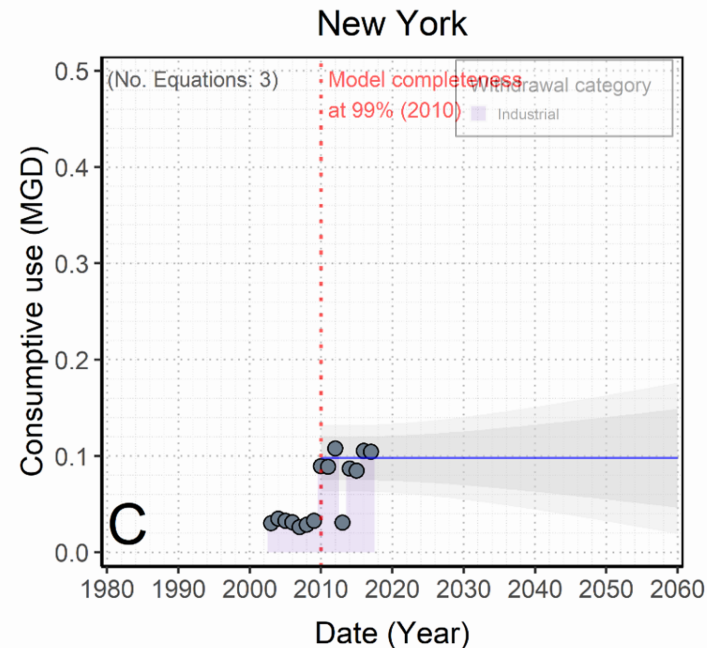
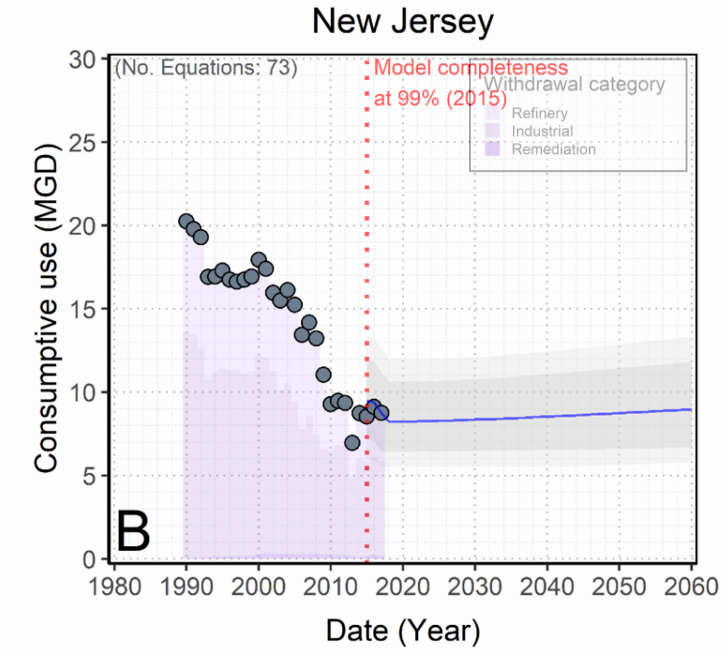
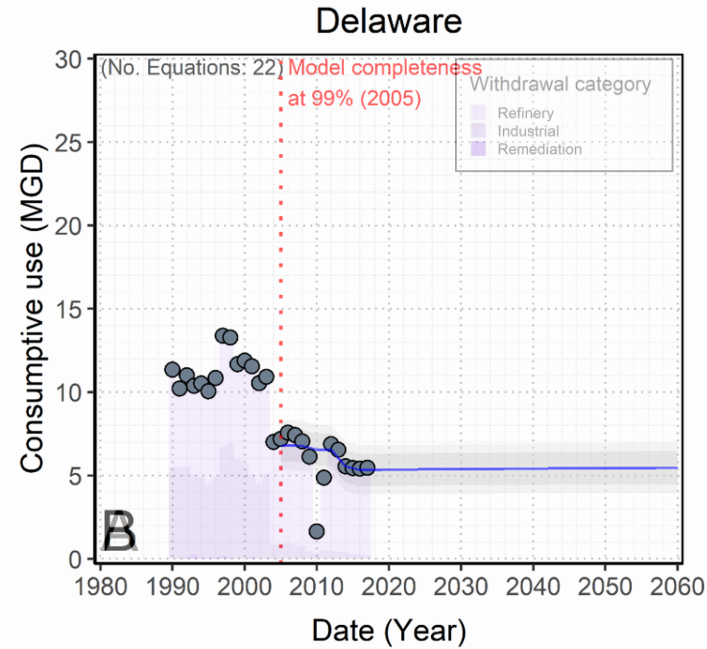
# 3. Industrial sector consumptive use: States

## KEY NOTES:

Same conclusions as the state-level analysis on total withdrawals.

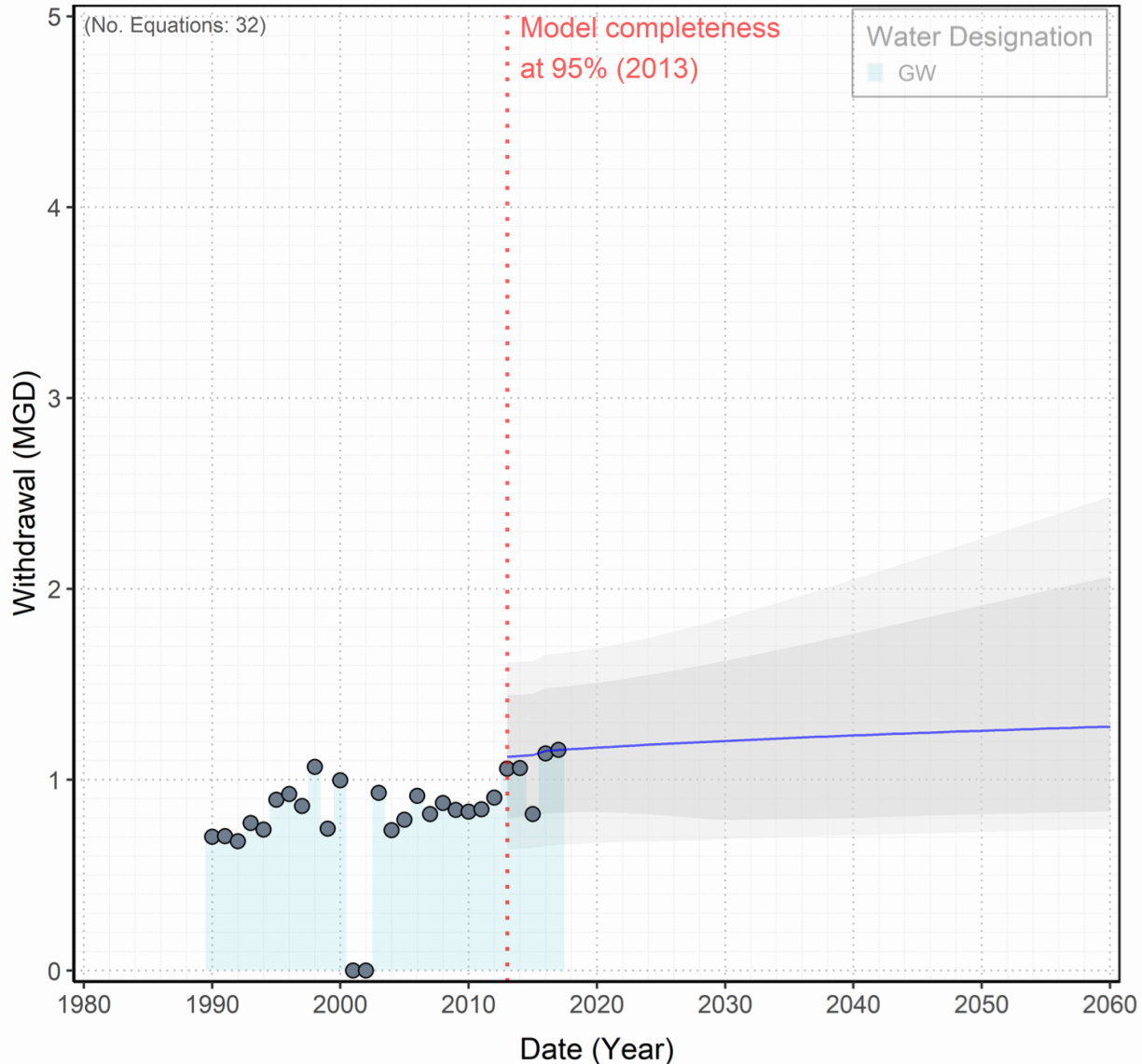
*Likely a fair assessment to say state trends are projected to be constant. Prediction intervals provide useful assessment of scale.*

Warren Glen Paper Mill on the Musconetcong River, New Jersey



# 3. Industrial sector consumptive use: SEPA-GWPA (groundwater)

Projected industrial GW consumptive use from SEPA-GWPA



## KEY NOTES:

1. Only shows GW withdrawal from SEPA-GWPA
2. Very similar results to the total withdrawal, with predictive interval suggesting more likely to increase than decrease in future

Van Reed Paper Mill c. 1875, recently owned by Federal Paperboard (Reading Paperboard)  
Cacoosing Creek diversion, Leesport, PA



# 4. Next steps in withdrawal projections



<u>TASK</u>	<u>STATUS</u>	<u>Presented at:</u>
• Public water supply	Substantially complete	Oct 2020
• Power generation sector analysis	Substantially complete	Feb 2021
• Industrial & Refinery sector analysis	Substantially complete	June 2021
• Discussions with docket holders	In progress	
• <i>Self-supplied domestic</i>	Substantially complete	Oct 2021
• <i>Mining sector</i>	Substantially complete	Oct 2021
• Irrigation sector	Substantially complete	Oct 2021
• Other sectors analysis	Substantially complete	Oct 2021
• Unassociated data projections	Substantially complete	
• Final report	In progress	



# Questions



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