Water Withdrawal and Consumptive Use Estimates for the Delaware River Basin (1990-2017) With Projections Through 2060

Schuylkill Action Network (SAN) Annual Meeting

November 5, 2021

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and

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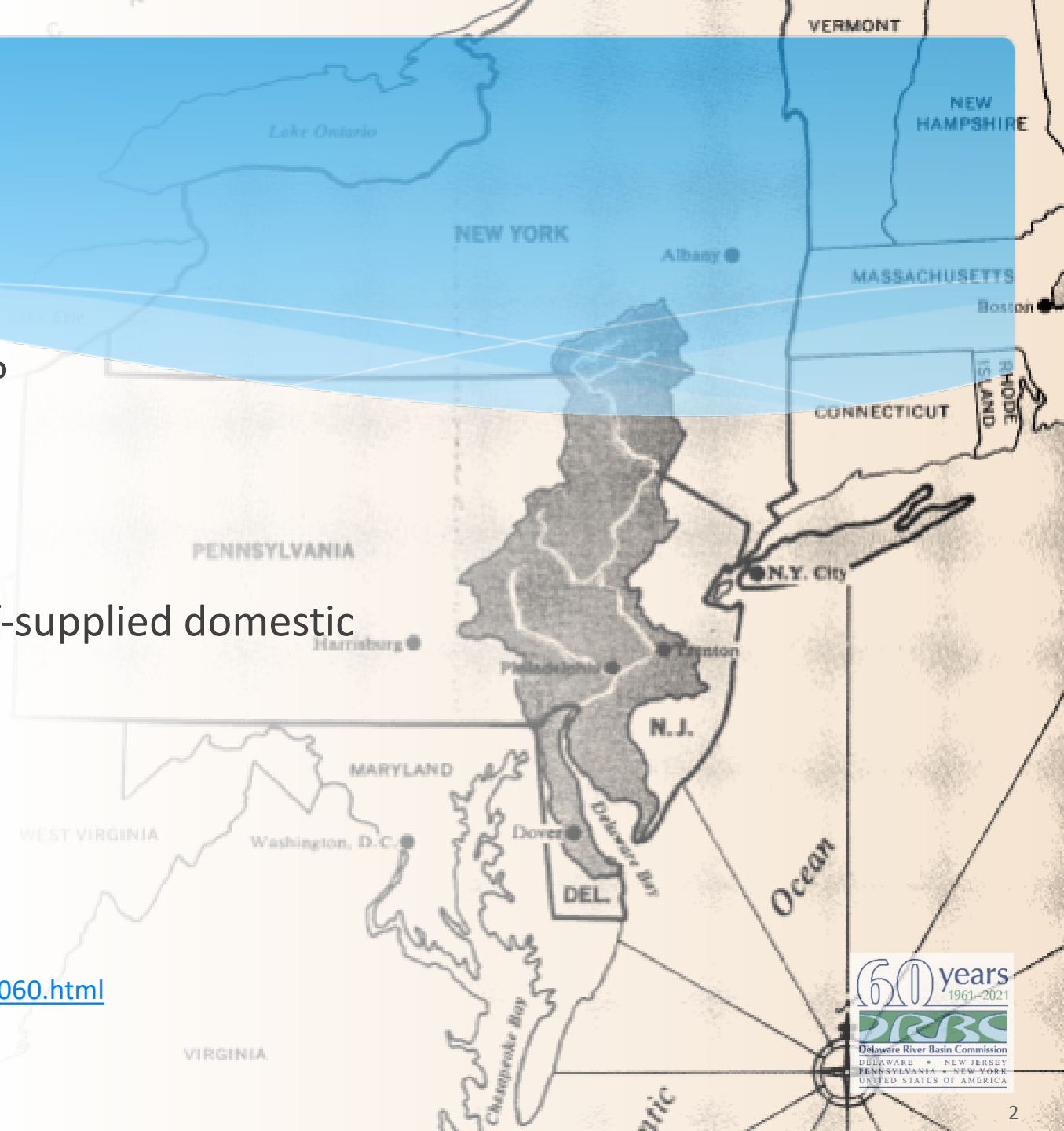
Outline

1. Water Supply Planning – Why and What?
2. Methodology
3. Results: All sectors
4. Supplemental analysis: irrigation
5. Supplemental analysis: population & self-supplied domestic
6. Next Steps
7. Publication & data deliverable overview
8. Interactive data visualization (demo)
9. Questions

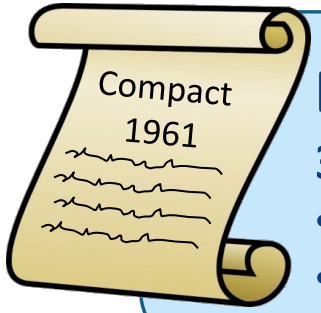
Report & data:
https://www.nj.gov/drbc/programs/supply/use-demand-projections2060.html



1. Water Supply Planning: Why are we projecting withdrawal data?

Is there enough water to meet future demands?

- What are the current/future demands?
- How does it compare against current allocations?
- What about a repeat of the Drought of Record?
- What about climate change?



DELAWARE RIVER BASIN COMPACT (1961)

3.6 General Powers.

- Conduct and sponsor research on water resources
- Collect, compile, correlate, analyze, report and interpret data on water resources and uses in the basin

1. Water Supply Planning: What are the planning objectives?

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

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

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

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

Relate results to regulatory approvals.

2. Recap: Methodology

Ontelaunee Reservoir Dam
near Reading, Pennsylvania.
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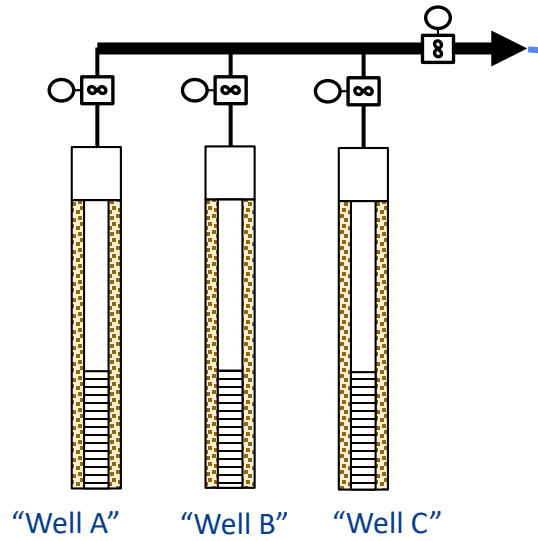
2. Methodology: What data are we looking at?

Withdrawals

Consumptive Use



"Well A" "Well B" "Well C"

Groundwater withdrawn from wells

Surface water withdrawn from stream, rivers and lakes

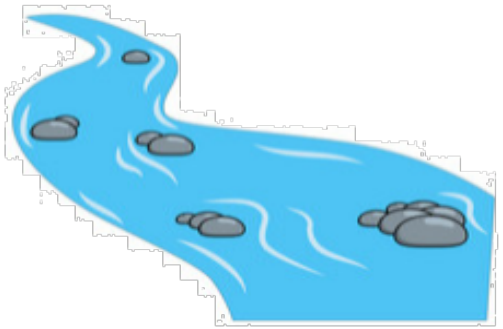
1000 gallons withdrawn

Insert specific use of water here.

Treatment if necessary.

200 gallons consumptively used (CUR = 20%).

800 gallons discharge back to river



Schuylkill River

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2. Methodology: Breakdown by sector… what's a sector?

(PWS) Public Water Supply
Water withdrawn by a facility meeting the definition of a public water supply system under the Safe Drinking Water Act (Pub. L. No. 93-523, 88 Stat. 1660), or subsequent regulations set forth by signatory parties.

(DIV) Out-of-Basin Diversions
Withdrawals of water for public water supply exported from the Delaware River Basin by the Decree Parties in accordance with a 1954 U.S. Supreme Court Decree (U.S. Supreme Court, 1954).

(SSD) Self-Supplied Domestic
Water withdrawal for domestic use for residents who are not served by a public water supply system; it is assumed in this study that all self-supplied groundwater withdrawals are groundwater.

(PWR) Power Generation
Water withdrawn/diverted by facilities associated with the process of generating electricity. Within the Delaware River Basin, this refers water withdrawn/diverted by both thermoelectric and hydroelectric facilities.

(IND) Industrial
Water withdrawals by facilities associated with fabrication, processing, washing, and cooling. This includes industries such as chemical production, food, paper and allied products, petroleum refining (i.e., refineries), and steel. Due to the generally close relationship, water withdrawn for groundwater remediation purposes are also included in this sector.

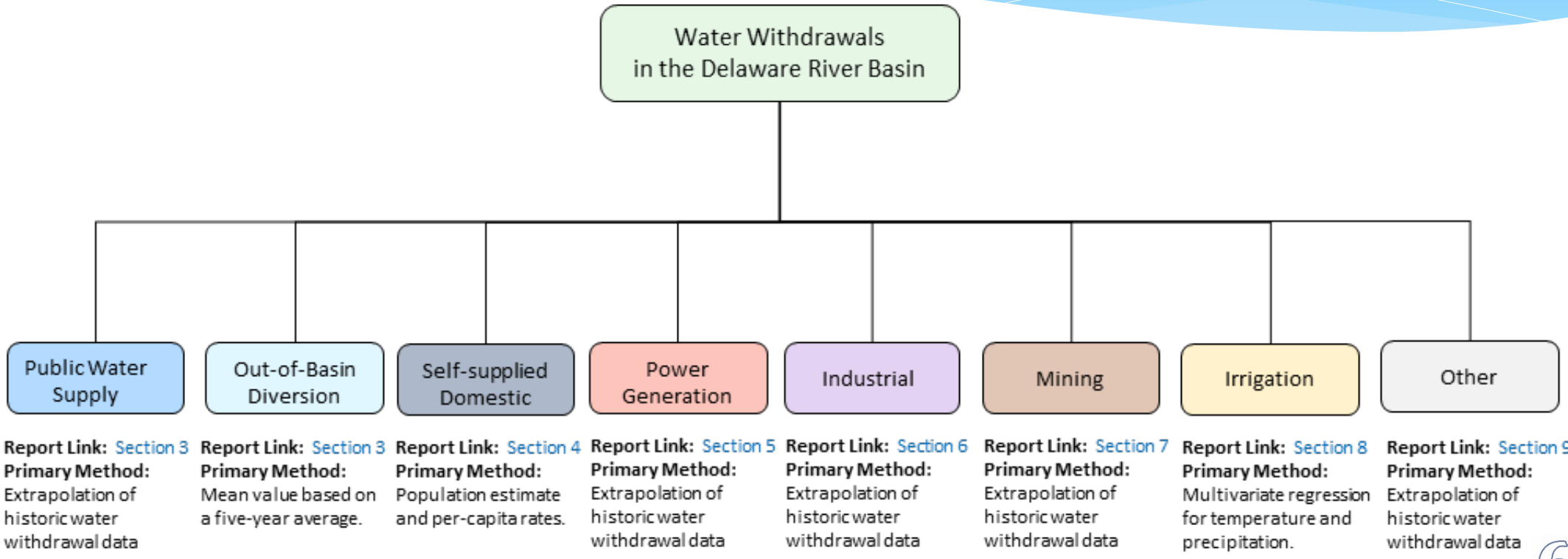
(IRR) Irrigation
Water withdrawals which are applied by an irrigation system to assist crop and pasture growth, or to maintain vegetation on recreational lands such as parks and golf courses. This does not include withdrawals/ diversions associated with aquaculture.

(MIN) Mining
Water withdrawals by facilities involved with the extraction of naturally occurring minerals. This includes operations such as mine dewatering, quarrying, milling of mined materials, material washing and processing, material slurry operations (e.g. sand), dust suppression and any other use at such facilities.

(OTH) Other
Facilities not categorized by previous sectors, including but not limited to aquaculture, bottled water, commercial (e.g. hotels, restaurants, office buildings, retail stores), fire suppression, hospital/health, military, parks/recreation, prisons, schools, and ski/snowmaking.

2. Methodology: Breakdown by sector

The primary method is extrapolation of historic reported withdrawal data



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2. Methodology: Primary data scale to analyze?

Analysis at the system level (mostly)[1]

Projections at a scale finer than the system level…

Pertinent metadata is often at the system level (e.g., regulatory)

Reporting inconsistencies disguised as trends

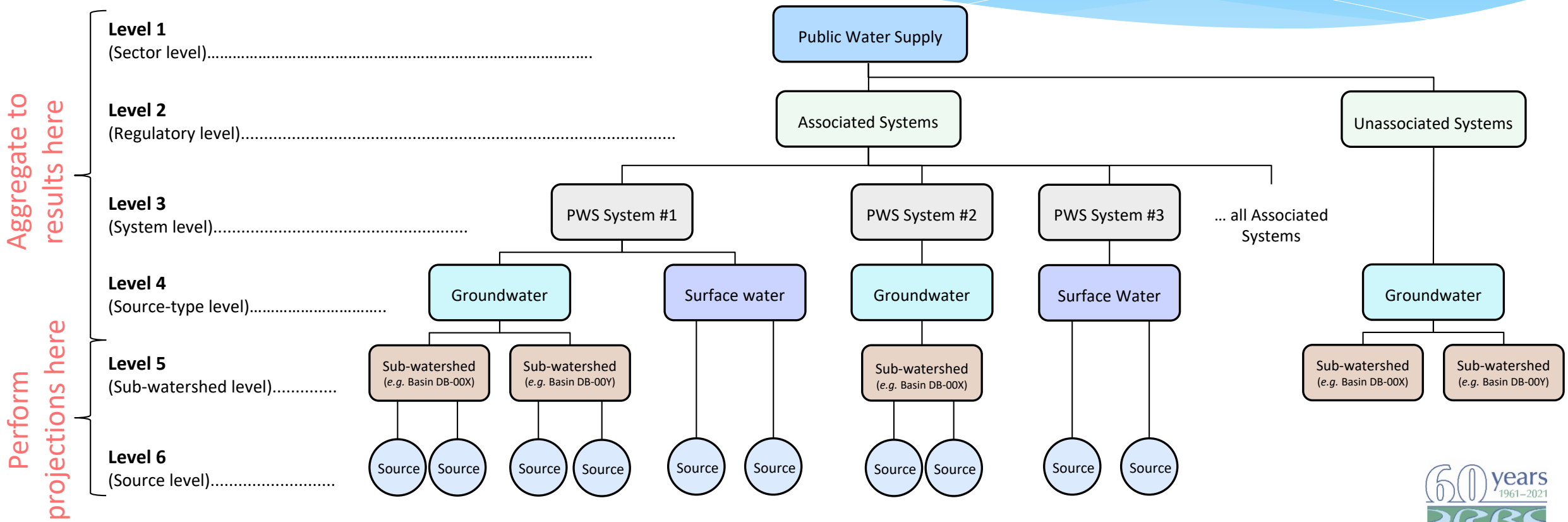
System sources show cause-and-effect relationships

[1] Self-supplied domestic and Irrigation used different methodologies

2. Methodology: A plan for projecting data?

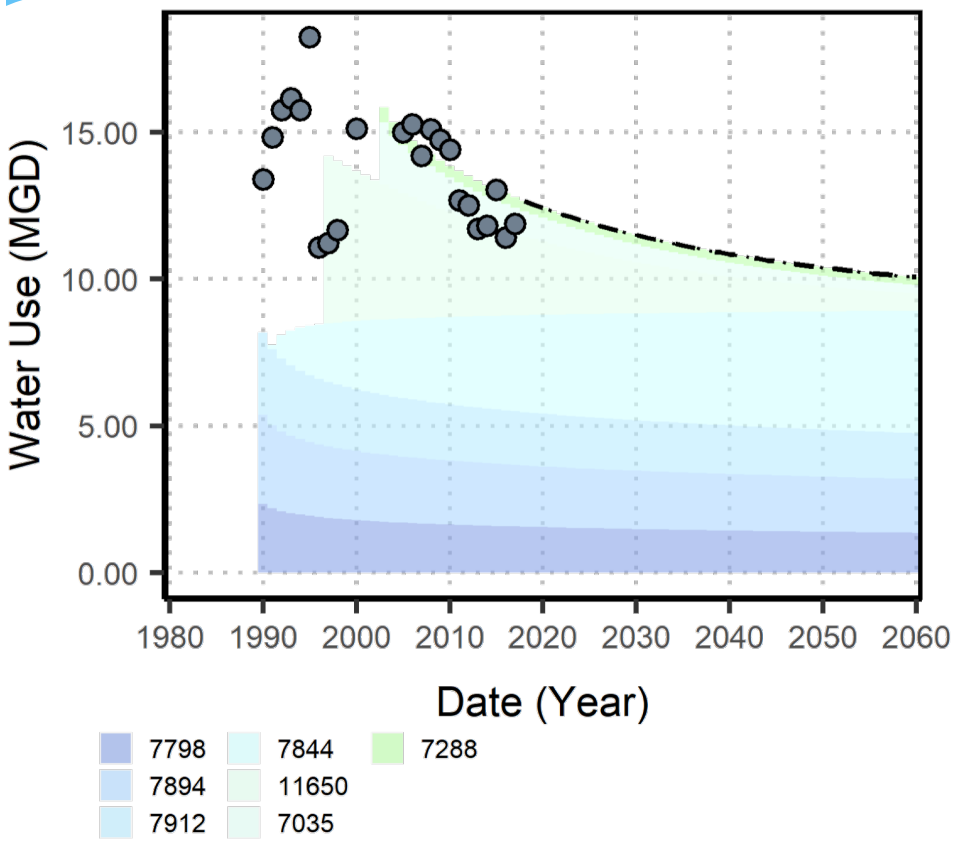
Where do we start?

Time-series hierarchy



Hyndman, R., & Athanasopoulos, G. (2018). *Forecasting: principles and practice* (2nd ed.). Melbourne, Australia: OTexts. https://otexts.com/fpp2/

2. Methodology: How do analyze results?



"Bottom-up approach"

$$\boldsymbol{Total} = \underbrace{f_{1,1}(x) + f_{1,2}(x) + f_{1,3}(x) + f_{1,4}(x)}_{\text{PWS System \#1}} + \underbrace{f_{2,1}(x)}_{\text{PWS System \#2}} + \underbrace{f_{3,1}(x) + f_{3,2}(x)}_{\text{PWS System \#3}} + \ldots$$

DB-00X, DB-00Y, SW 1, SW 2

DB-00X, "System Level"

SW 1, SW 2

Do projections aggregate in a manner consistent with the time series?

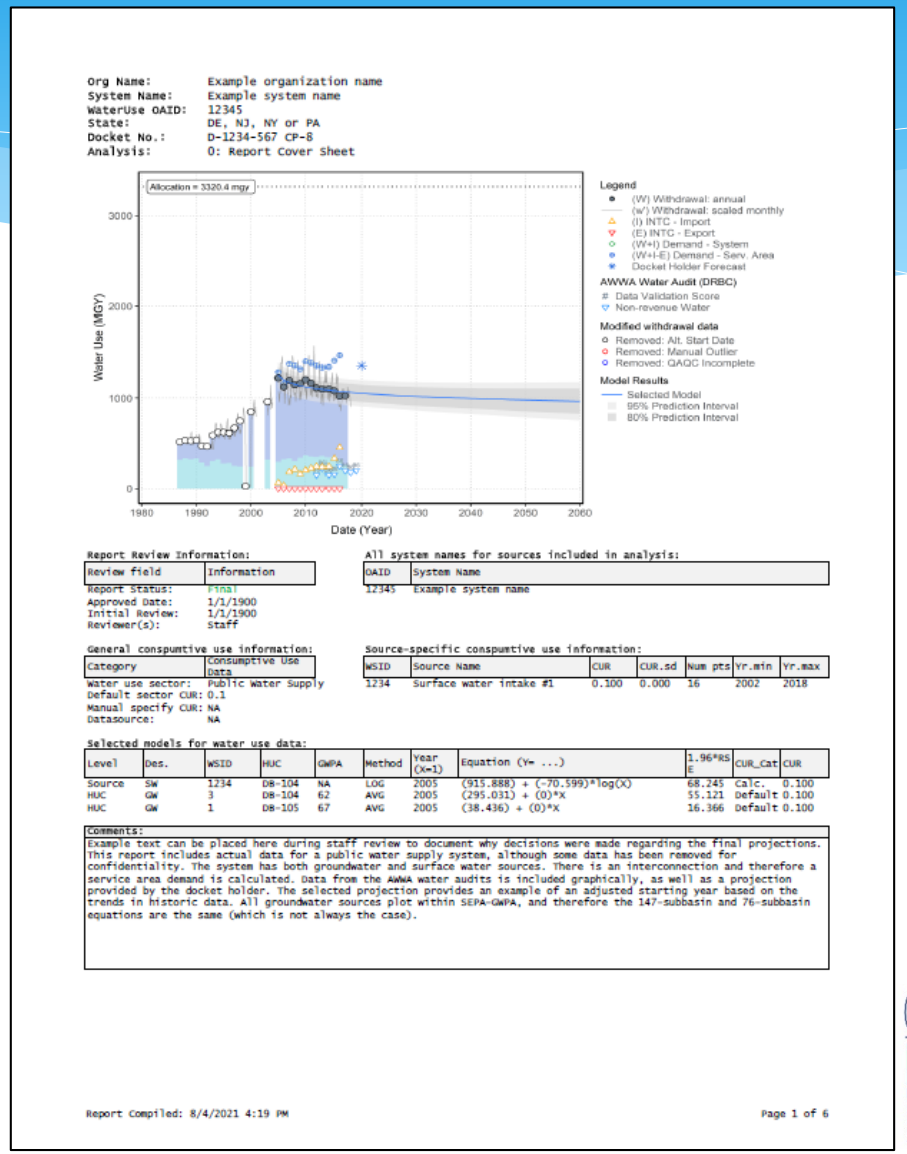
2. Methodology: A plan for projecting data?

The main model is based on extrapolating historic withdrawal data.

- Significant QAQC of historic data
- 600+ system reports
- 1,100+ equations
- Describe withdrawal & consumptive use

Method		Associated		Unassociated		Subtotal
		GW	SW	GW	SW	
Mean Value		218	71	147	0	436
OLS	Exponential	72	17	36	0	125
	Linear	83	11	11	0	105
	Logarithmic	250	74	69	0	393
Other		62	48	4	0	114
Subtotal		685	221	267	0	1,173

- OLS = Ordinary Least Squares
- Associated means system operate above review thresholds and has allocation regulatory approval.
- Does not include agriculture and self-supplied domestic analyses



Org Name: Example organization name
System Name: Example system name
WaterUse OAID: 12345
State: DE, NJ, NY or PA
Docket No.: D-1234-567 CP-8
Analysis: 0: Report Cover Sheet

Report Review Information:

Review field	Information
Report Status:	Final
Approved Date:	1/1/1900
Initial Review:	1/1/1900
Reviewer(s):	Staff

All system names for sources included in analysis:

OAID	System Name
12345	Example system name

General consumptive use information:

Category	Consumptive Use Data
Water use sector:	Public Water Supply
Default sector CUR:	0.1
Manual specify CUR:	NA
Datasource:	NA

Source-specific consumptive use information:

WSID	Source Name	CUR	CUR.sd	Num pts	Yr.min	Yr.max
1234	Surface water intake #1	0.100	0.000	16	2002	2018

Selected models for water use data:

Level	Des.	WSID	HUC	GWPA	Method	Year (X=1)	Equation (Y= ...)	1.96*RSE	CUR_Cat	CUR
Source	SW	1234	DB-104	NA	LOG	2005	(915.888) + (-70.599)*log(X)	68.245	Calc.	0.100
HUC	GW	3	DB-104	62	AVG	2005	(295.031) + (0)*X	55.121	Default	0.100
HUC	GW	1	DB-105	67	AVG	2005	(38.436) + (0)*X	16.366	Default	0.100

Comments:
Example text can be placed here during staff review to document why decisions were made regarding the final projections. This report includes actual data for a public water supply system, although some data has been removed for confidentiality. The system has both groundwater and surface water sources. There is an interconnection and therefore a service area demand is calculated. Data from the AWWA water audits is included graphically, as well as a projection provided by the docket holder. The selected projection provides an example of an adjusted starting year based on the trends in historic data. All groundwater sources plot within SEPA-GWPA, and therefore the 147-subbasin and 76-subbasin equations are the same (which is not always the case).

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3. Results: All sectors

Wing Dam on The Delaware River
Lambertville New Jersey on the left and
New Hope Pennsylvania on the right.
Credit: © James Loesch
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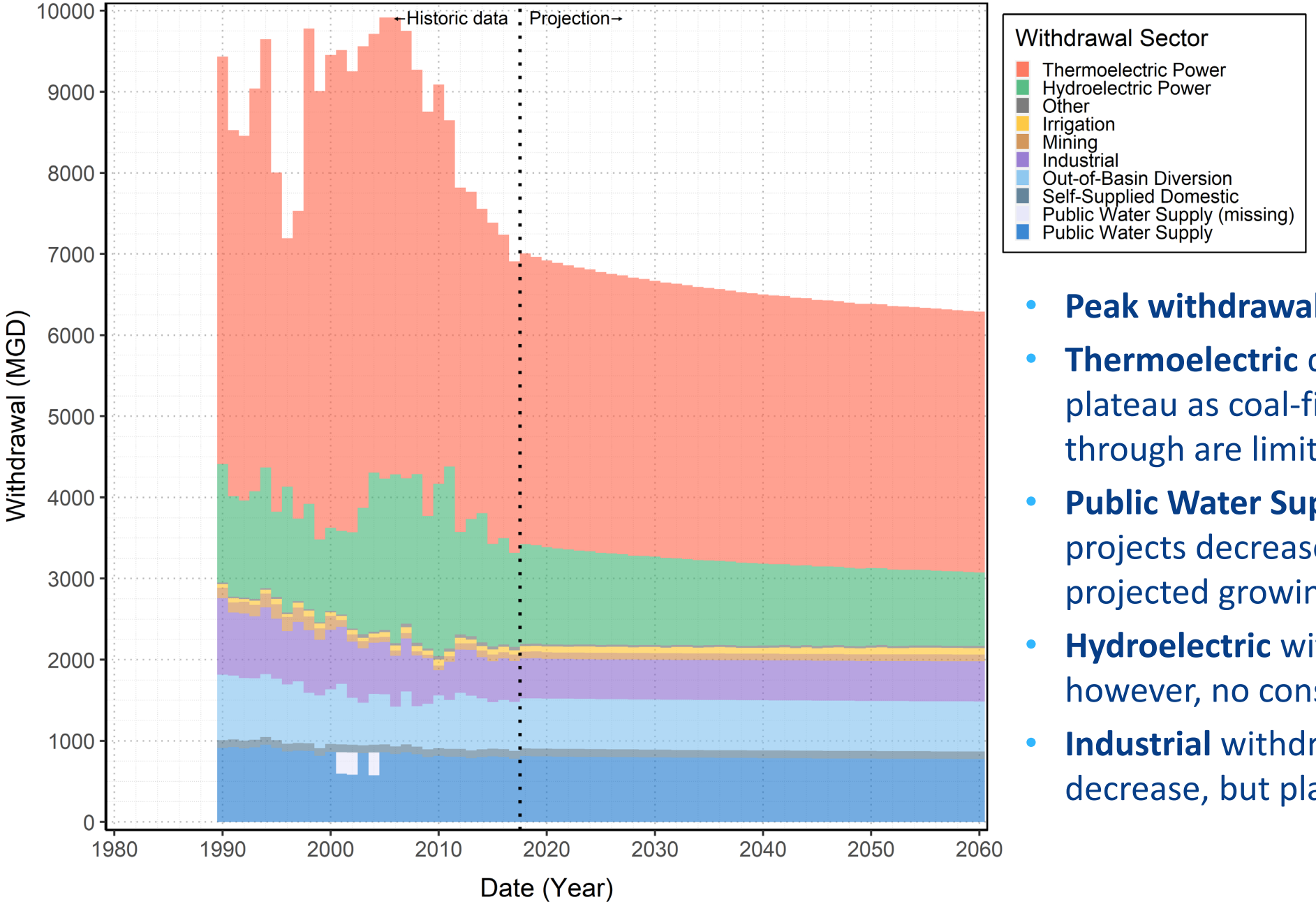
Historic and projected water withdrawals from the Delaware River Basin



- **Peak withdrawals have occurred**
- **Thermoelectric** decreases since 2007 will plateau as coal-fired facilities using once-through are limiting
- **Public Water Supply** has shown and projects decreases despite historic and projected growing in-Basin population
- **Hydroelectric** withdrawals are significant; however, no consumptive use
- **Industrial** withdrawals historically decrease, but plateau

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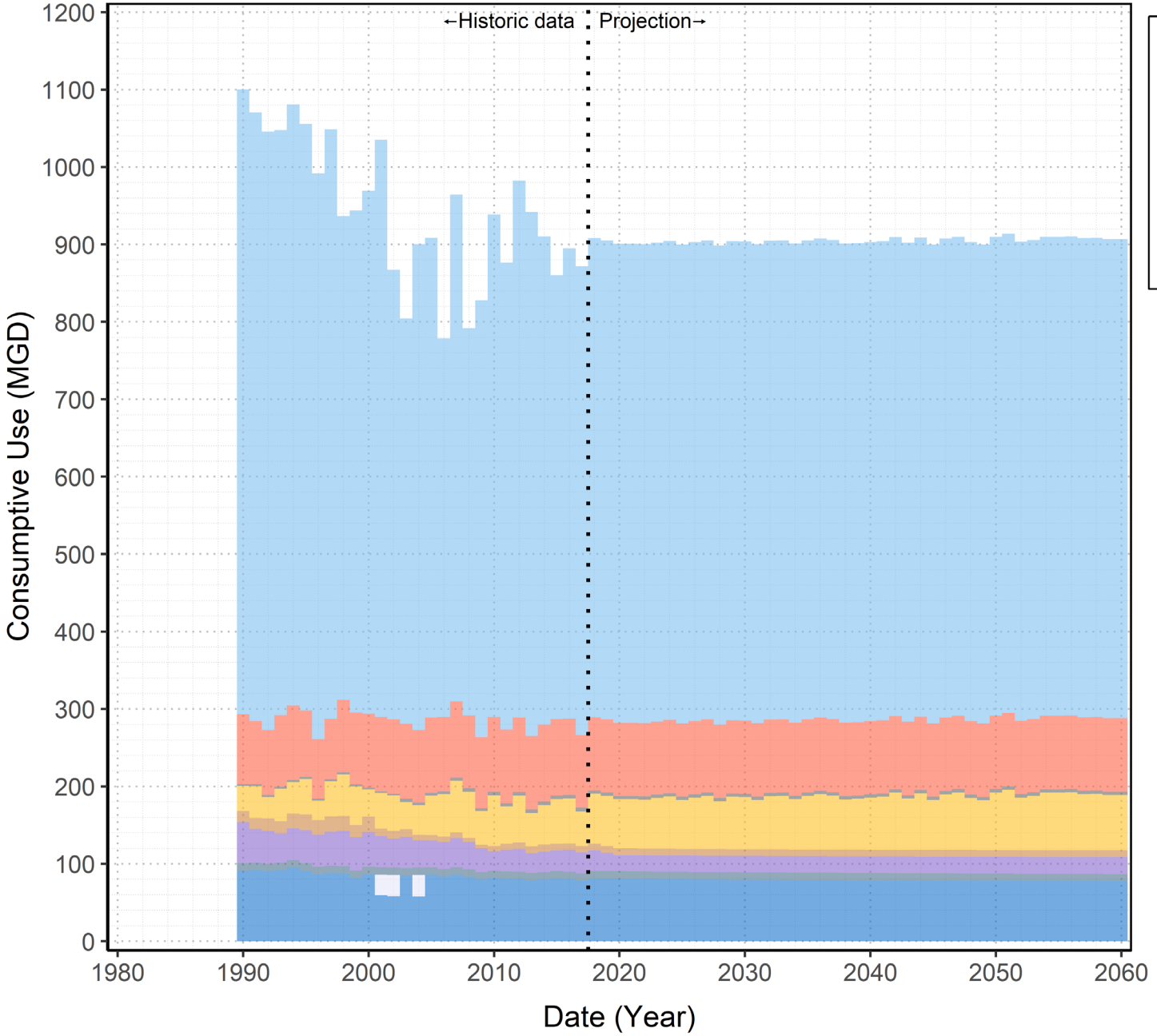
Historic and projected consumptive water use in the Delaware River Basin



- **Consumptive use projected to remain relatively constant**
- **Largest consumptive use is Out-of-Basin Exports under a U.S. Supreme Court Decree**
- **Thermoelectric** consumptive use constant despite decreased withdrawals due to changes in technology
- **Irrigation** is significant and shows slight increases related to projected changes in climatic variables
- Significant **spatial variation** in terms of both withdrawal and consumptive use
- Comparison against previous DRBC estimates (next slide)

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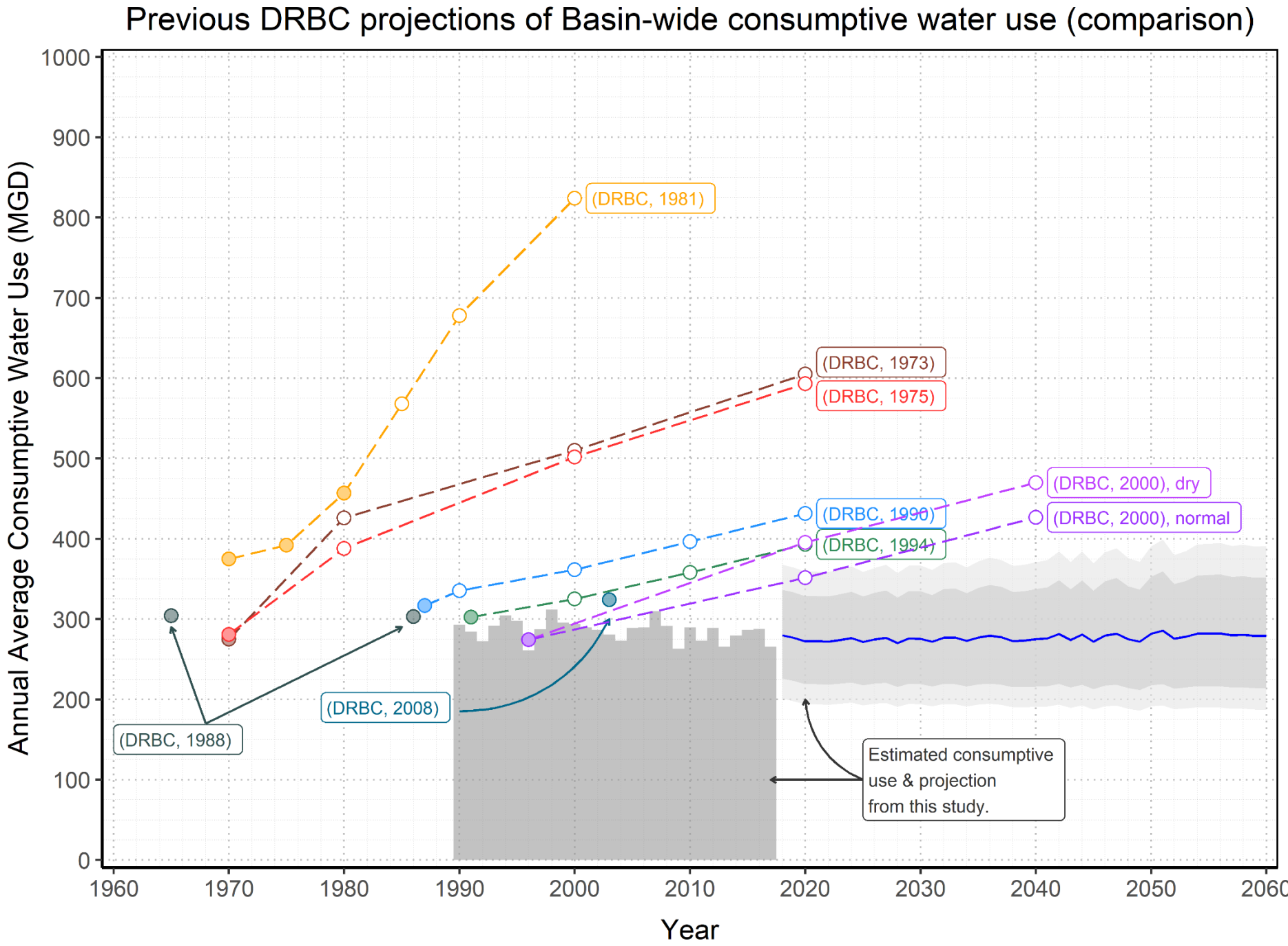

Prior projections often:

- Work from one estimated year of withdrawal data
- Are performed indirectly (e.g., applying population projections)
- May have considered/ accounted for planned facilities (e.g., power)

This study:

- Almost 30 years of data
- Aligns with previous *estimates*
- Most conservative projection

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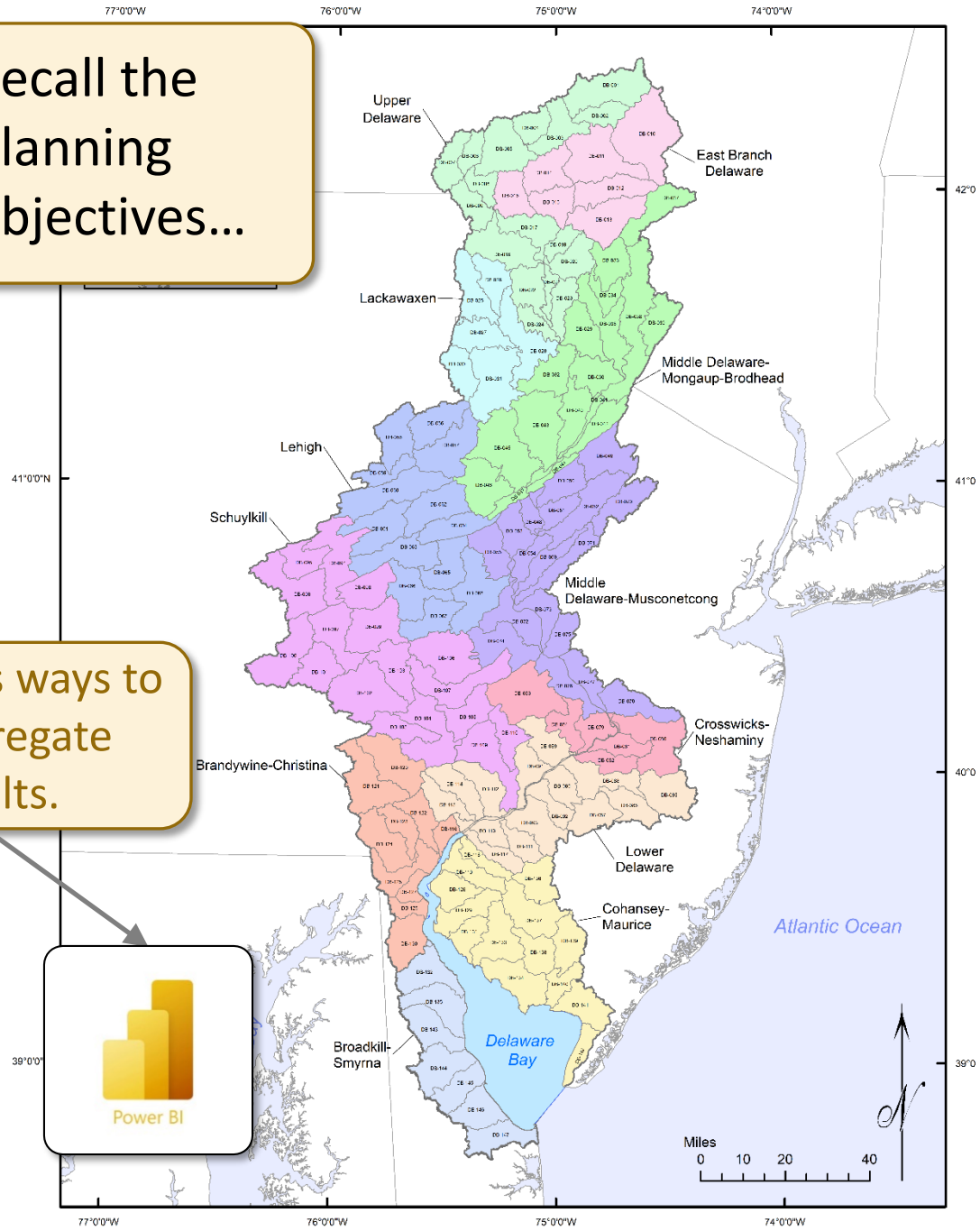
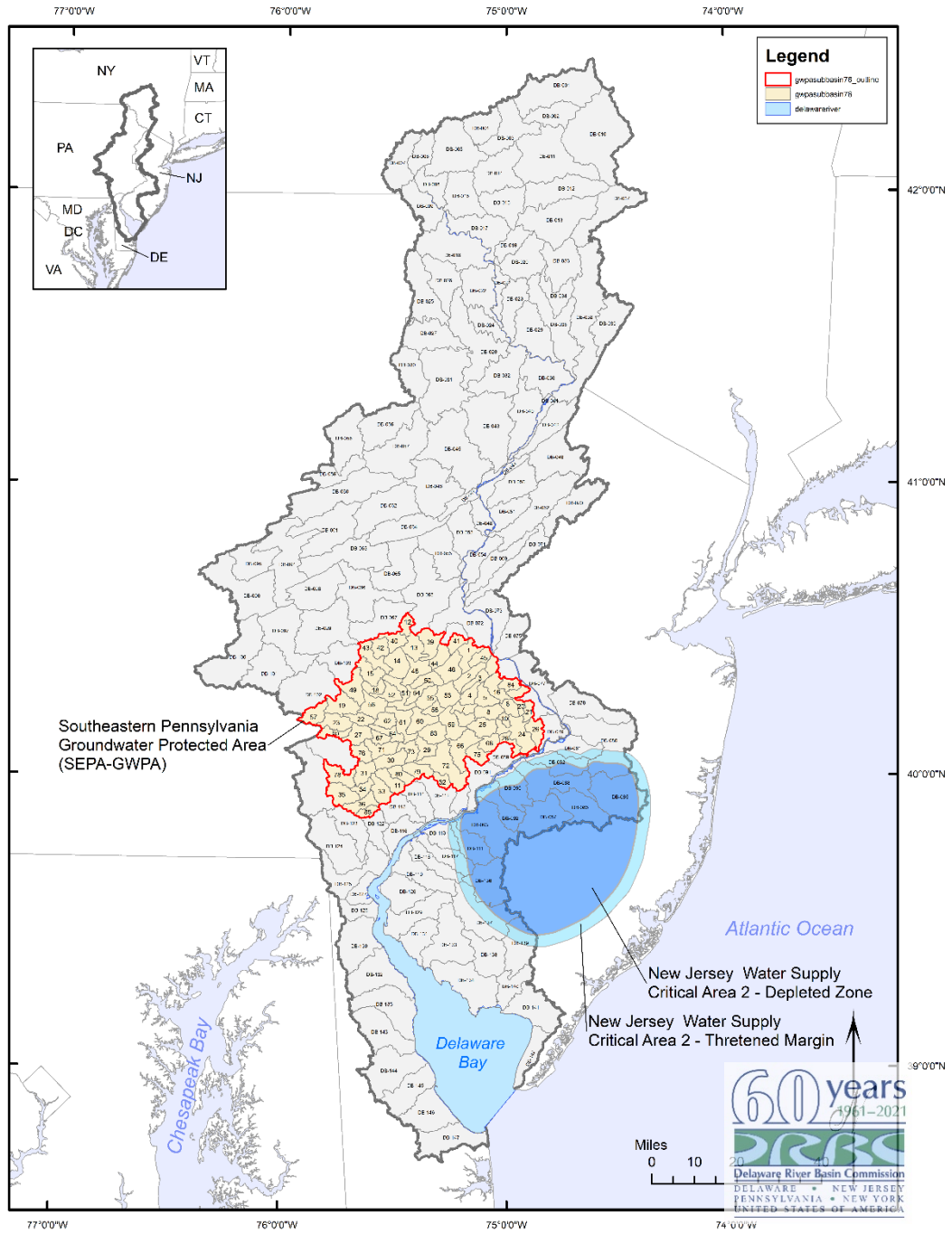
Recall the planning objectives…

Countless ways to re-aggregate results.

Highlight some in the report.

Power BI





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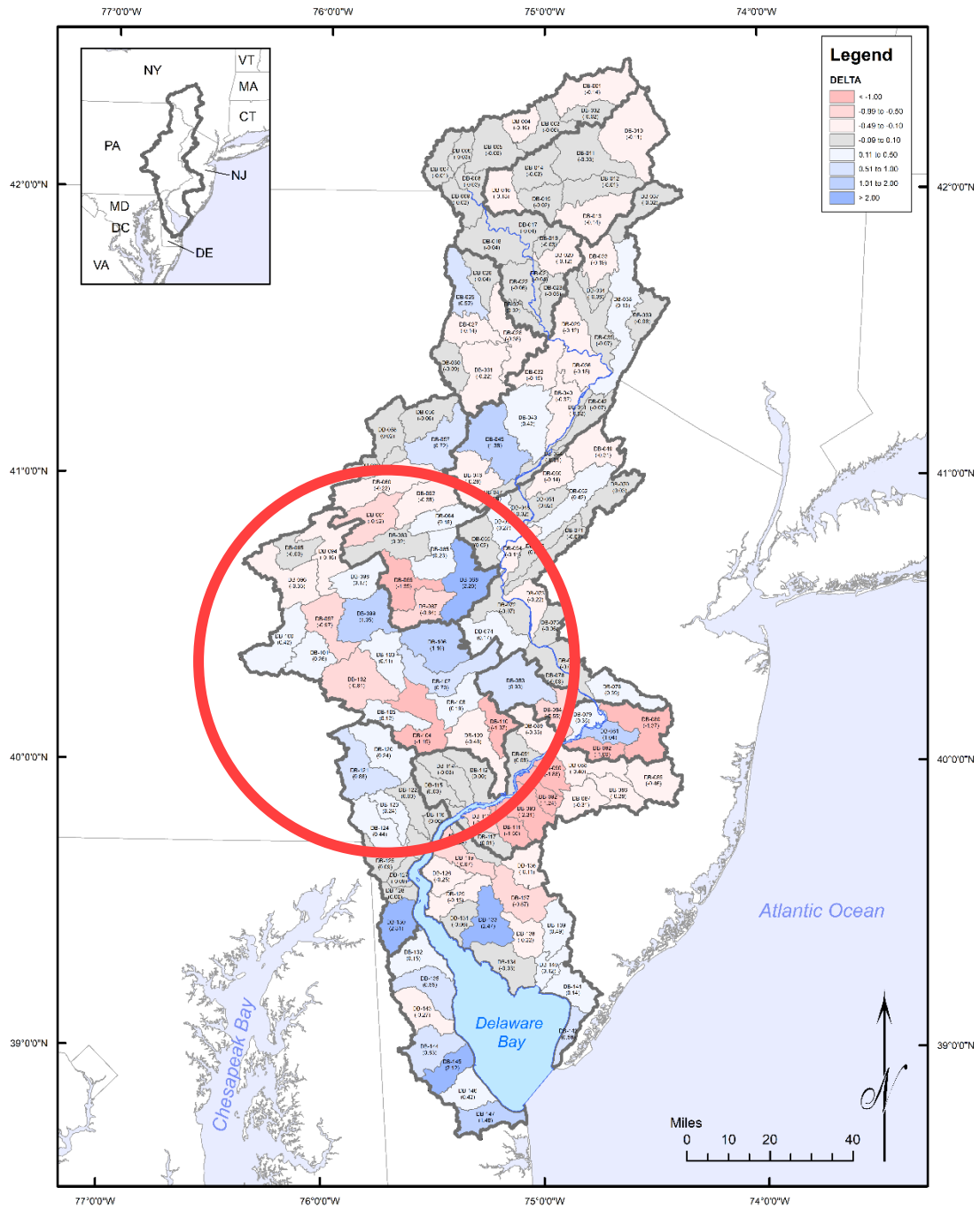

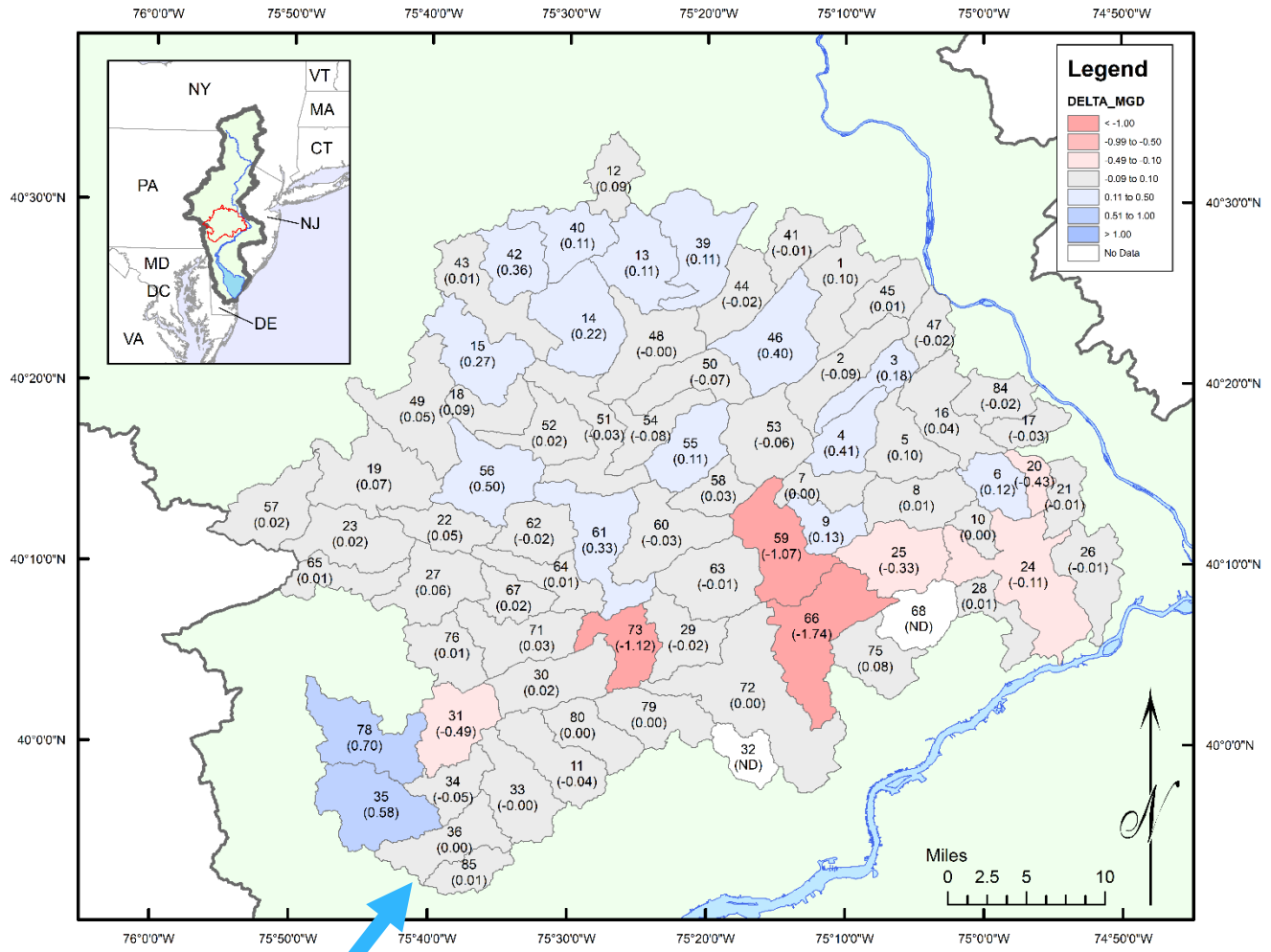

SEPA-GWPA:

- Decreasing (Δ < -0.10 MGD) 7 subbasins (-5.273 MGD)
- Neutral (-0.10 < Δ < 0.10 MGD) 51 subbasins (+0.325 MGD)
- Increasing (Δ > 0.10 MGD) 16 subbasins (+4.629 MGD)

147 Subbasins:

- Decreasing (Δ < -0.10 MGD) 51 subbasins (-26.500 MGD)
- Neutral (-0.10 < Δ < 0.10 MGD) 56 subbasins (-1.451 MGD)
- Increasing (Δ > 0.10 MGD) 40 subbasins (+26.930 MGD)

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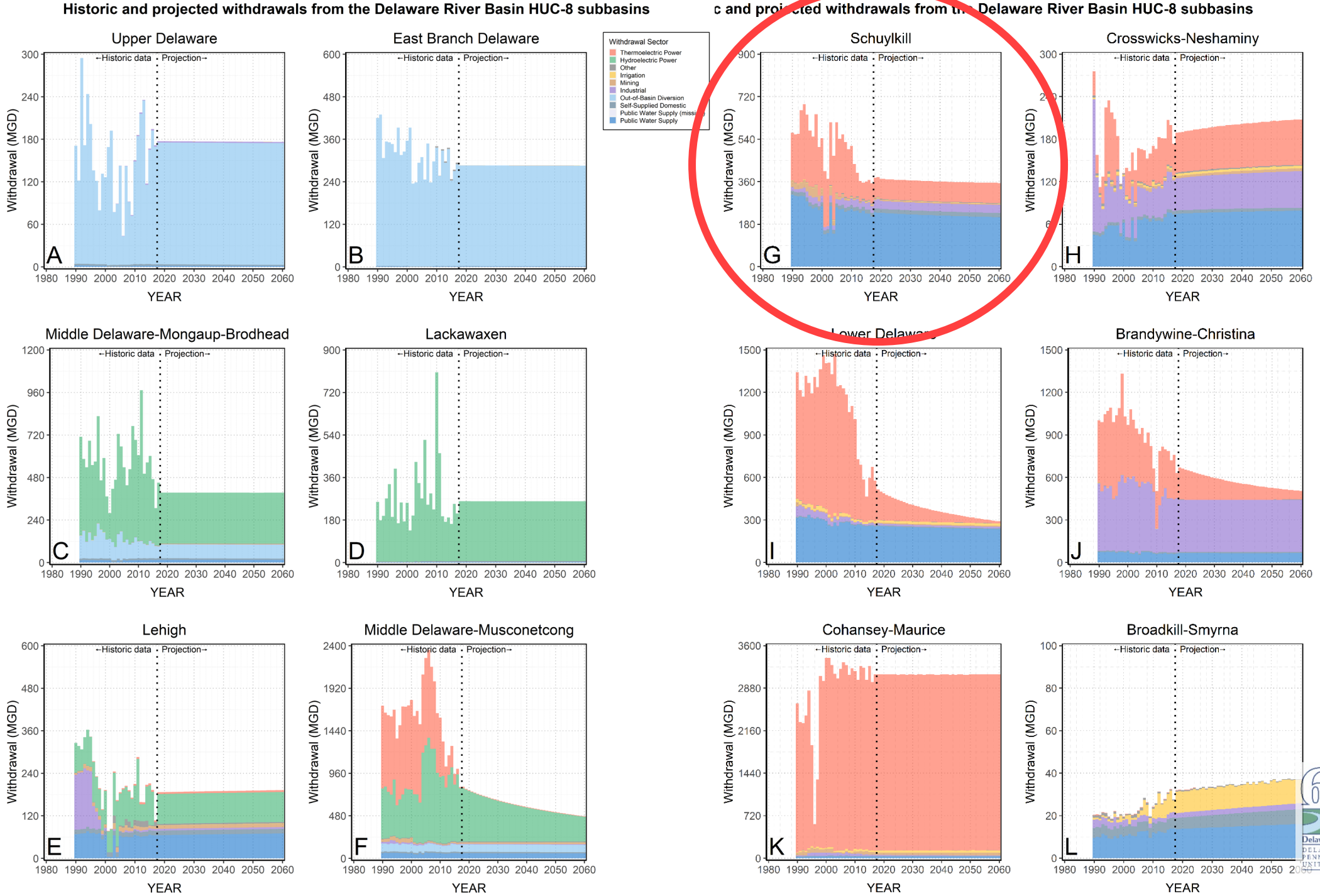

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4. Results: What about the Schuylkill?

Wing Dam on The Delaware River
Lambertville New Jersey on the left and
New Hope Pennsylvania on the right.
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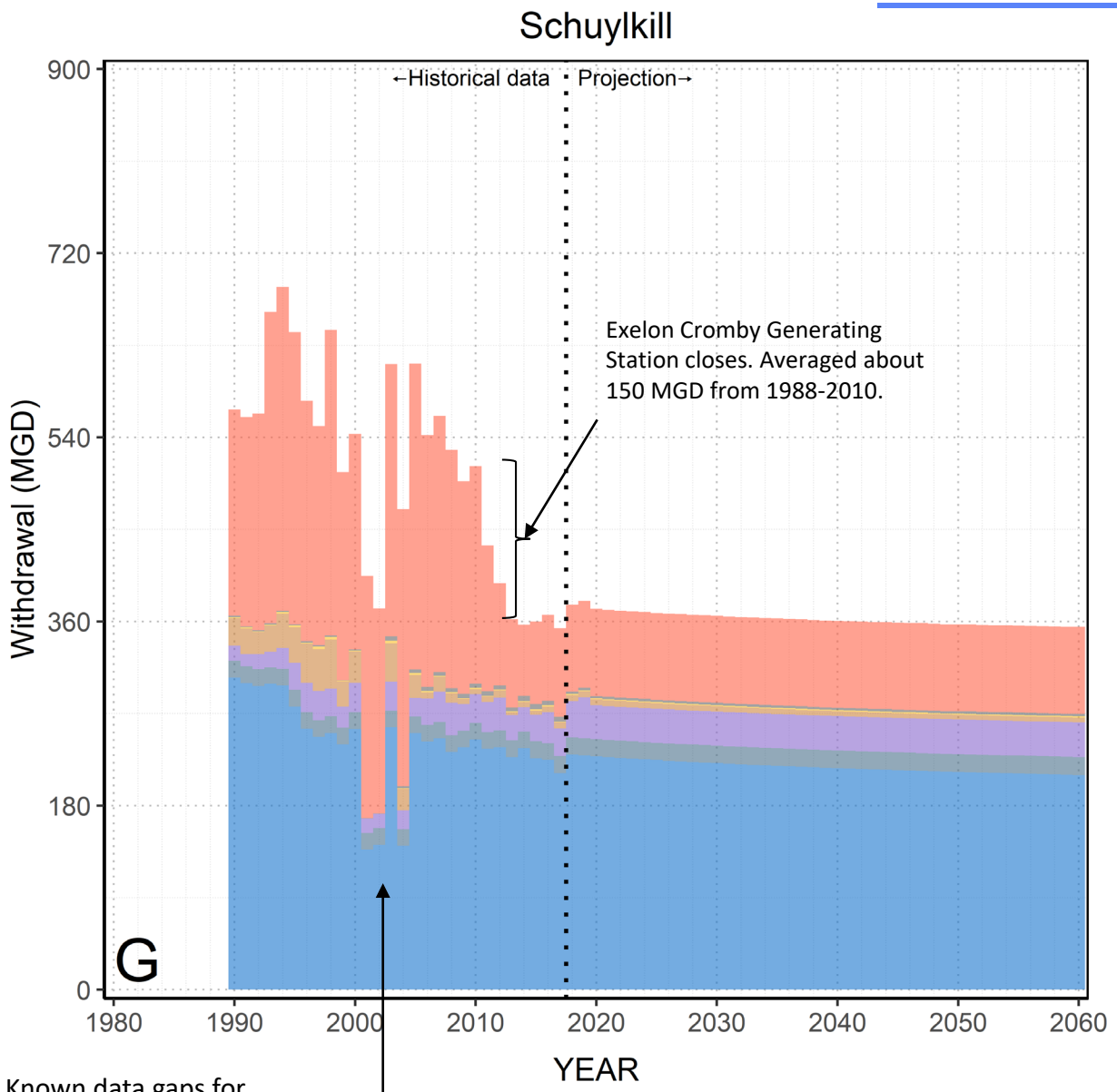
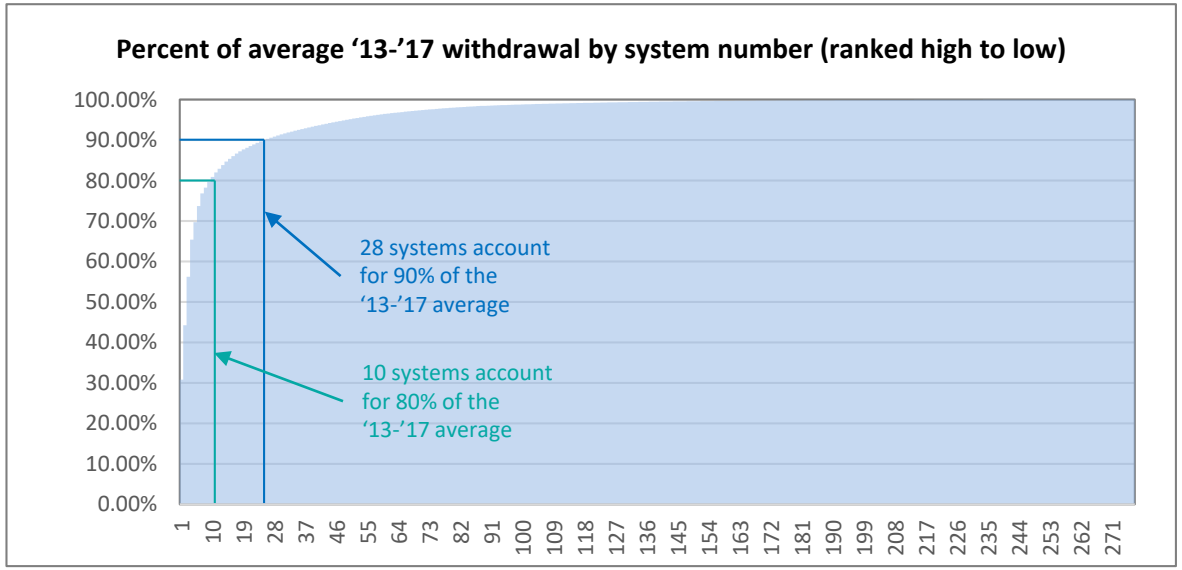
WITHDRAWALS



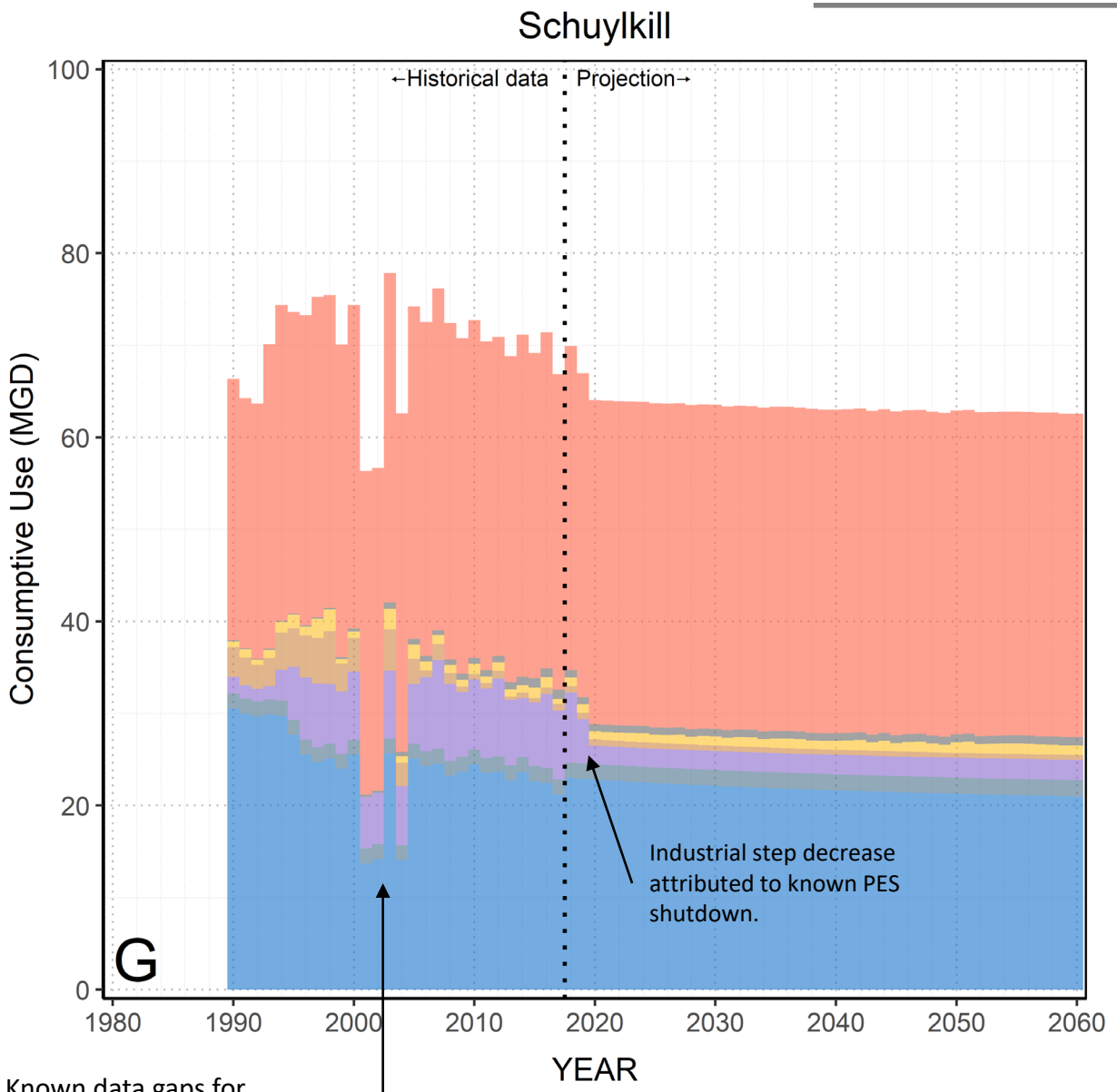
Known data gaps for Public Water Supply in 2001, 2002 and 2004

Breakdown by sector:

Sector	Average Withdrawal (MGD) 2013-2017	Percentage
Public Water Supply	225.221	62.6%
Thermoelectric Power	81.369	22.6%
Industrial	26.294	7.3%
Self-Supplied Domestic	16.510	4.6%
Mining	4.687	1.3%
Other	4.627	1.3%
Irrigation	0.967	0.3%
Subtotal:	359.675	100.0%

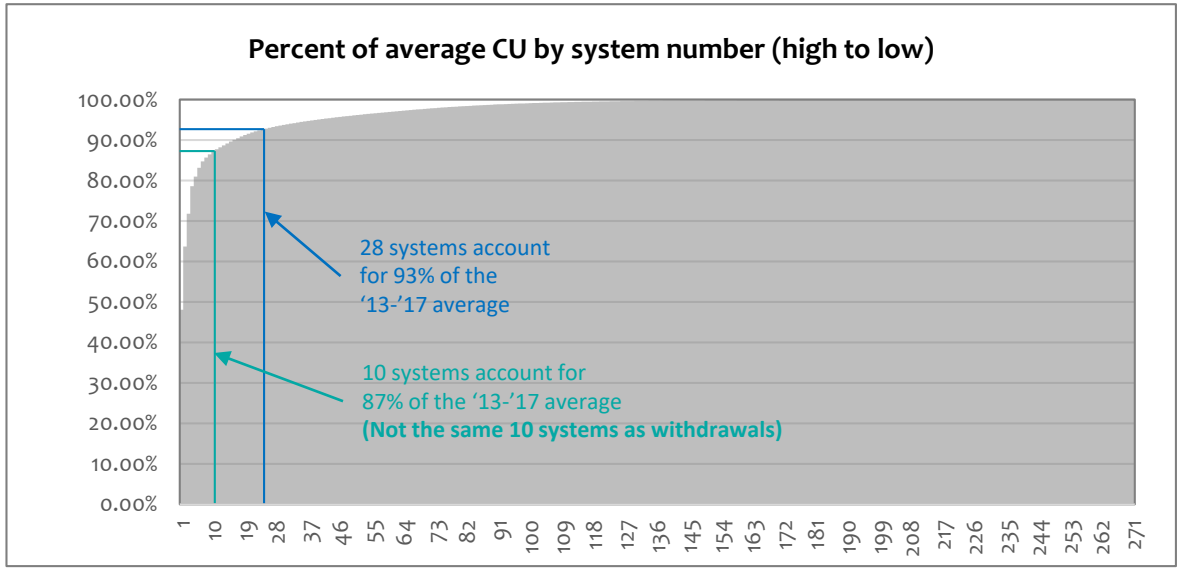


CONSUMPTIVE USE

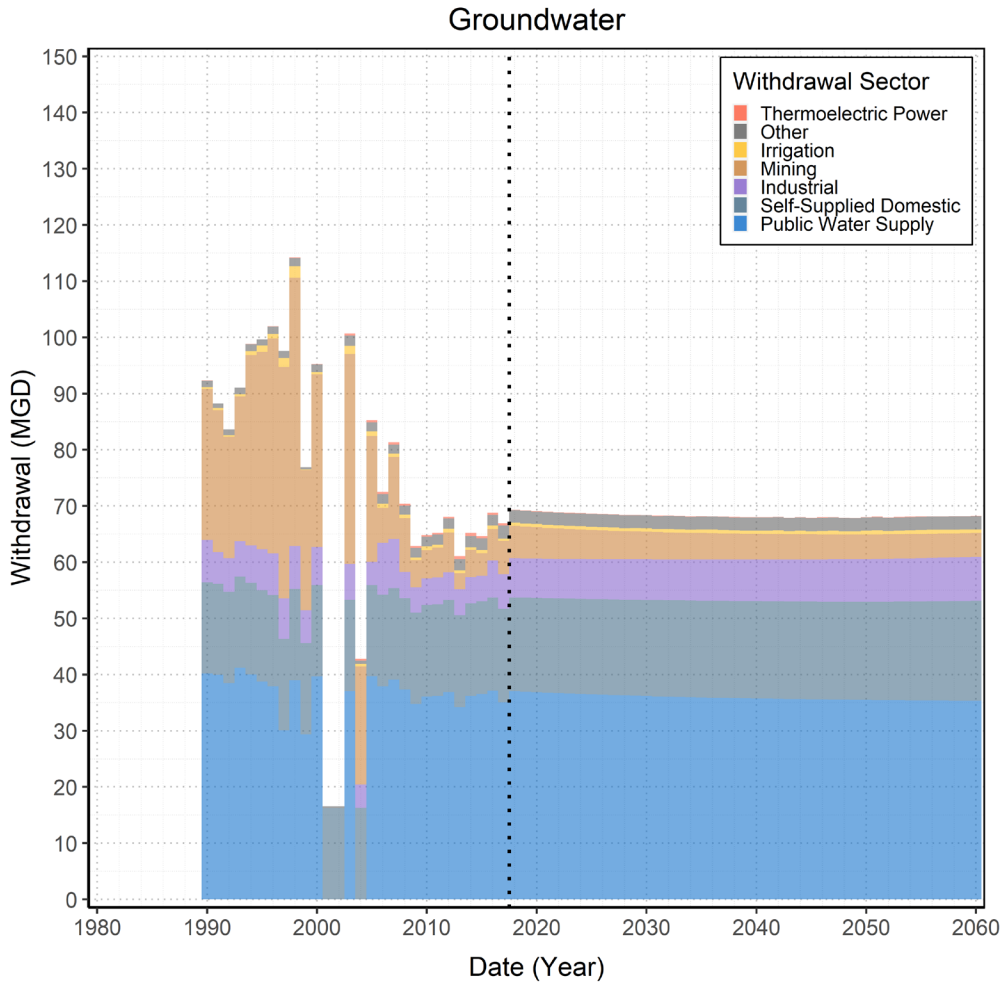


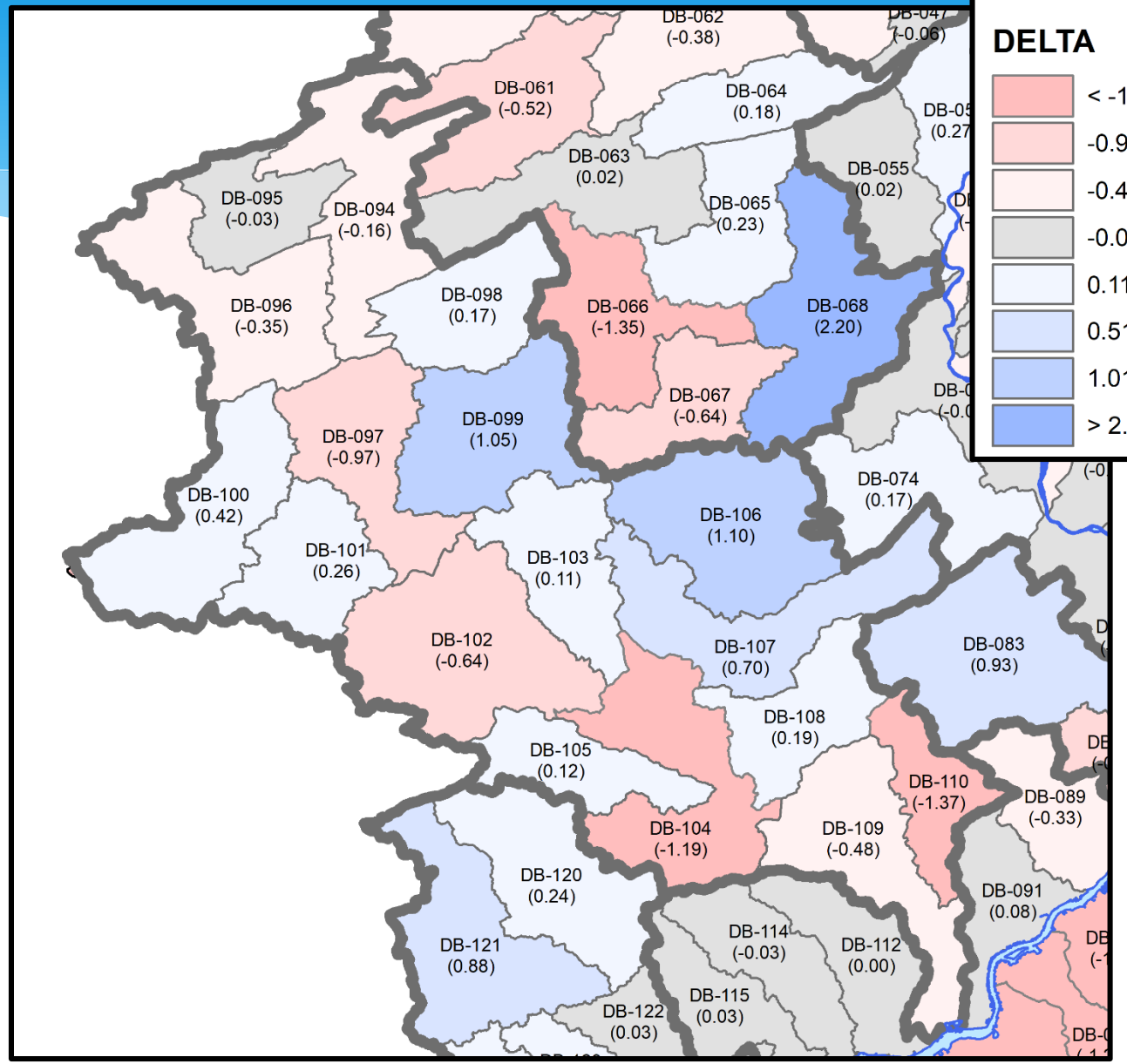
Breakdown by sector:

Sector	Average Withdrawal (MGD) 2013-2017	Percentage
Thermoelectric Power	35.746	51.4%
Public Water Supply	22.522	32.4%
Industrial	7.191	10.3%
Self-Supplied Domestic	1.651	2.4%
Other	0.938	1.3%
Irrigation	0.870	1.3%
Mining	0.562	0.8%
Subtotal:	69.479	100.0%



4. Sub-trends: GW





4. Supplemental analysis: population & self-supplied domestic

The Delaware River flowing under the Benjamin Franklin Bridge with the Philadelphia skyline behind.
Credit: © Chris Boswell
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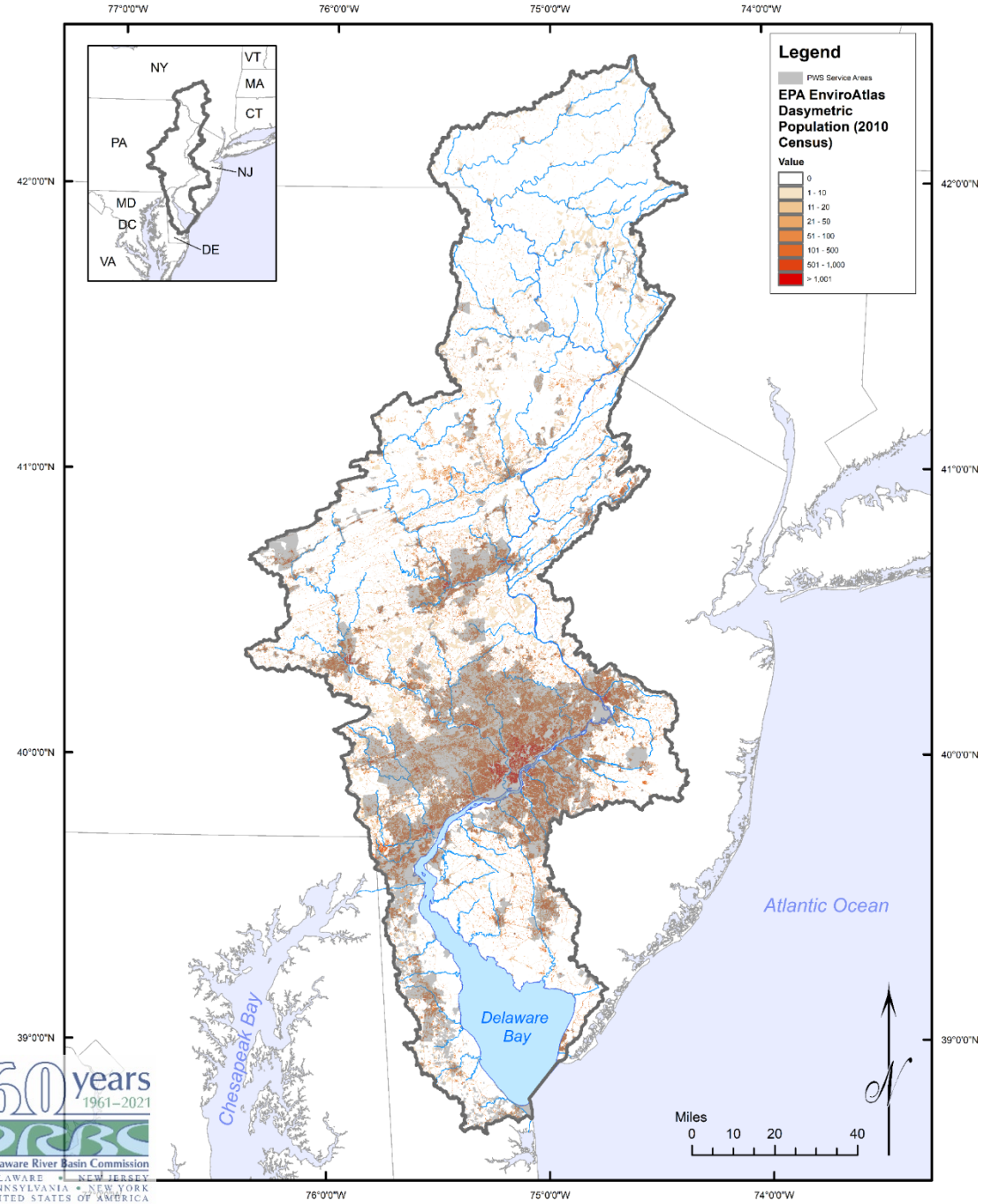

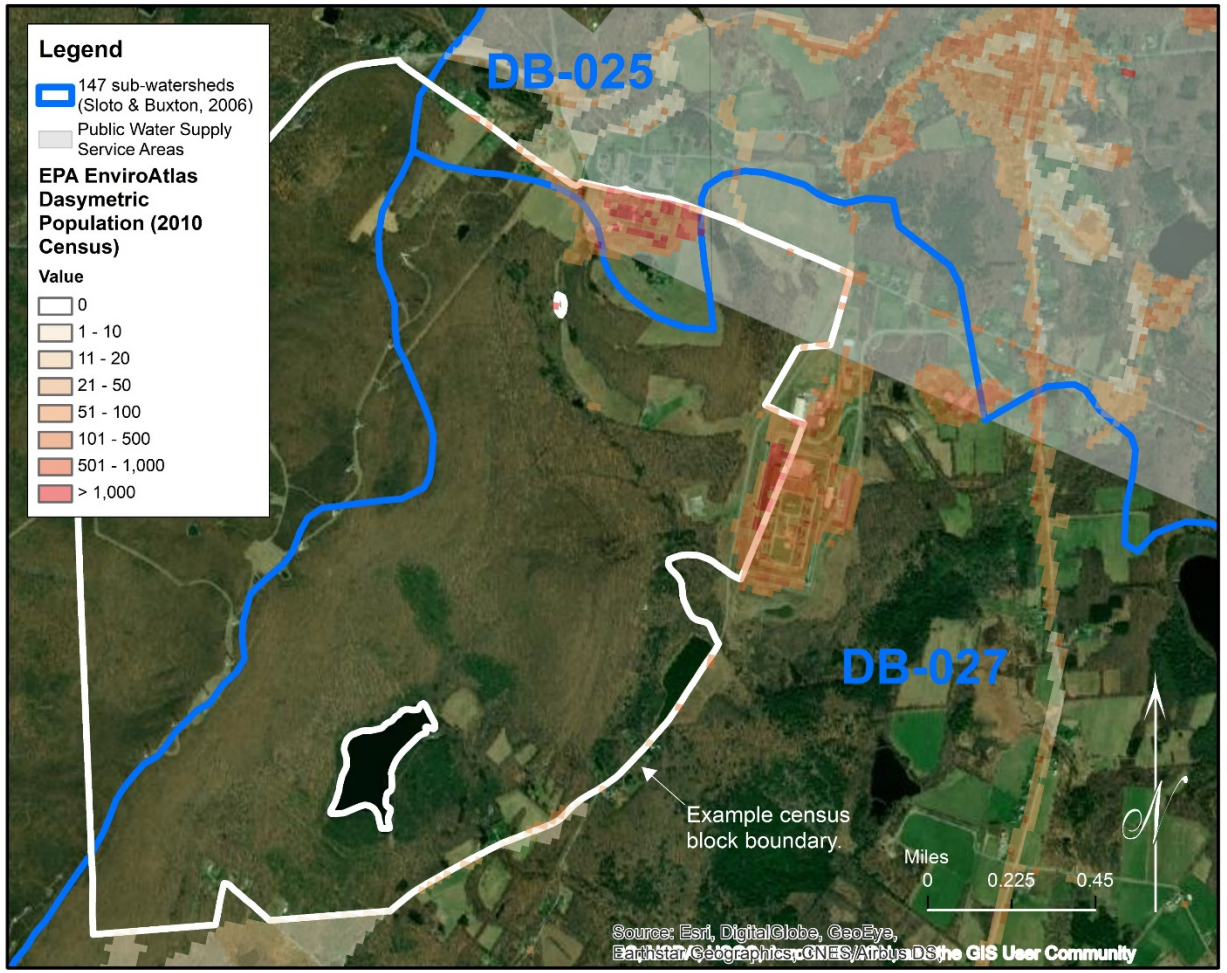

- EPA EnviroAtlas dasymetrically mapped 2010 population to 30x30m pixels
- Public water supplier service areas
- Raster analyses show 2010 population: ~8.252 MM people
  - 1.146MM (~14%) reside outside services areas

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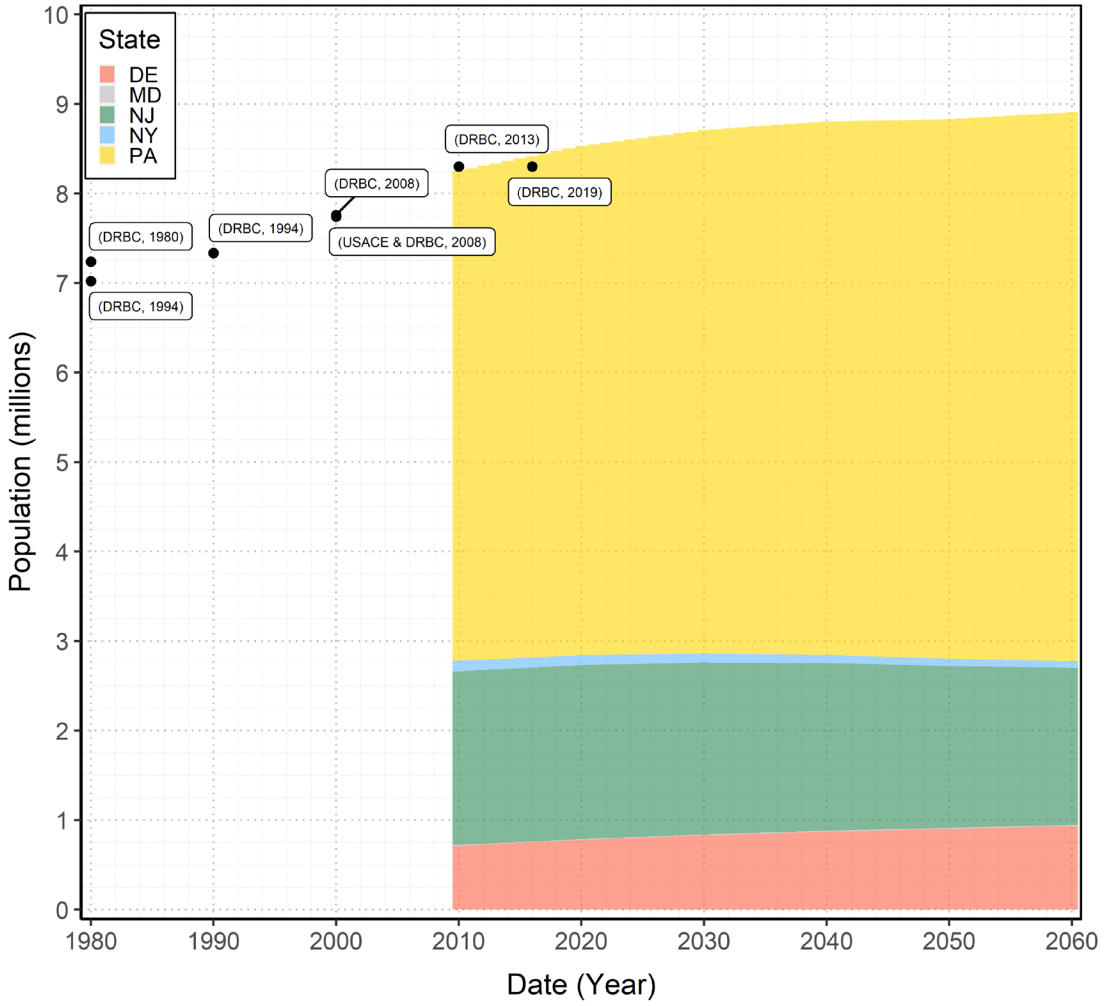
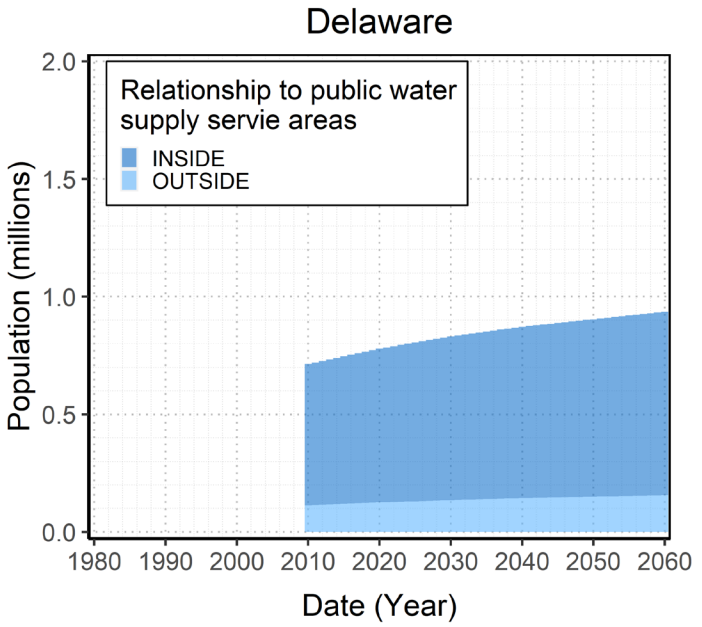
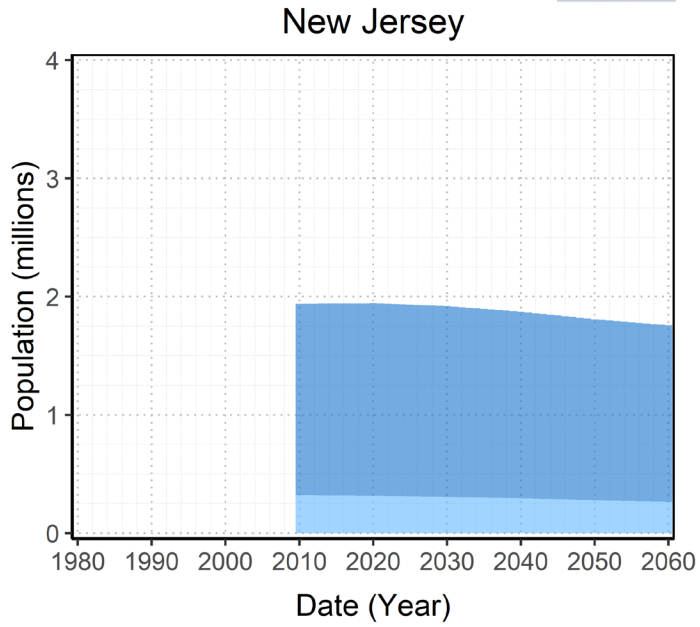
Delaware River Basin population estimate (2010) and projections based on Hauer & CIESIN, 2021 (scenario SSP2)

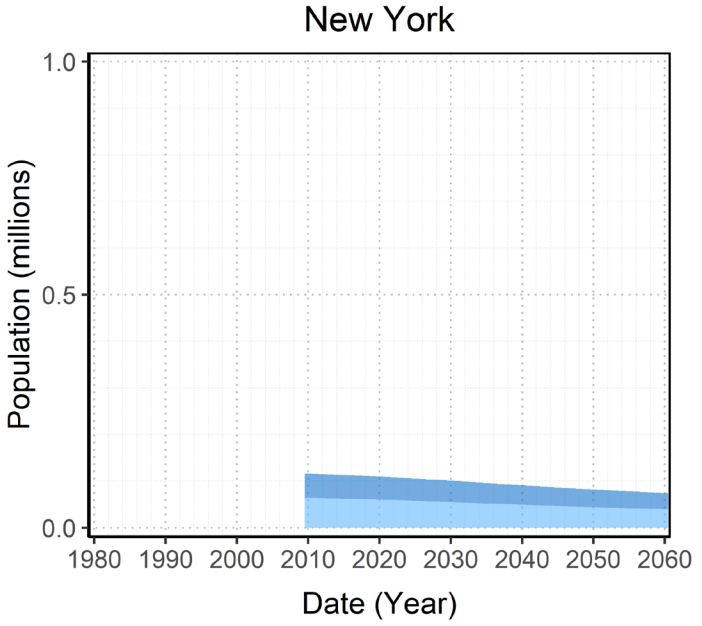


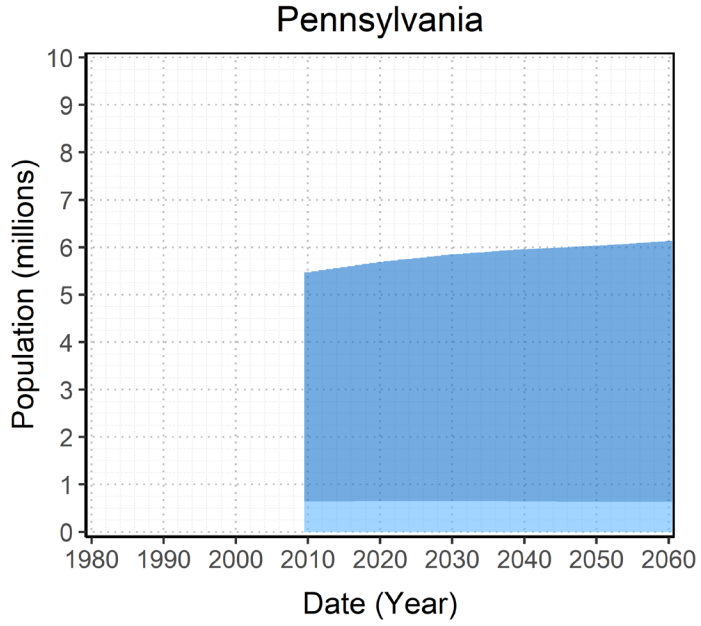
Projected populations were calculated by applying the county-level annual percent changes determined from **M. Hauer & CIESIN, 2021 ; SSP2**

Delaware River Basin state population estimates (2010) and projections based on Hauer & CIESIN, 2021 (scenario SSP2)









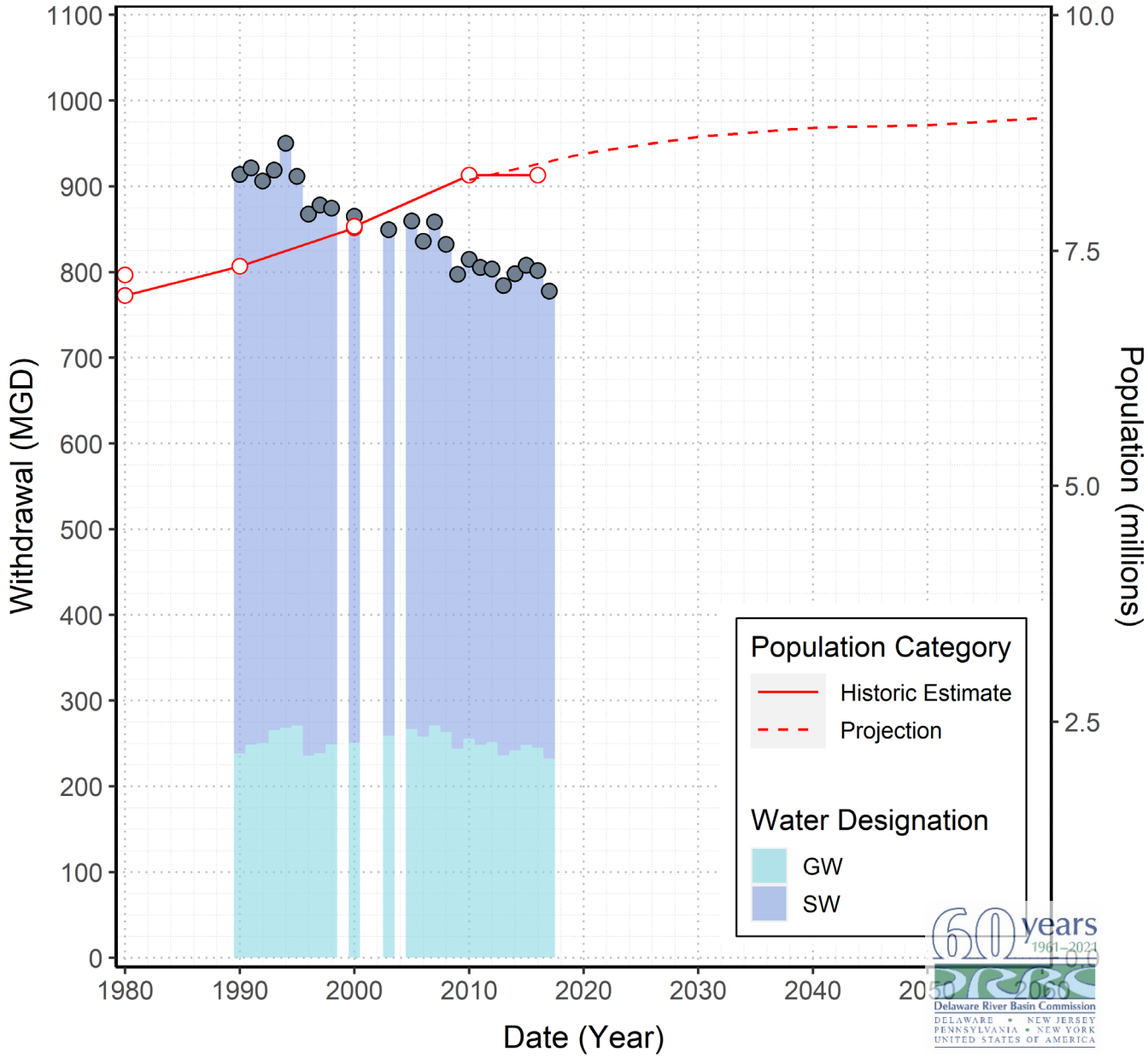
Self-Supplied Groundwater Withdrawal Projections

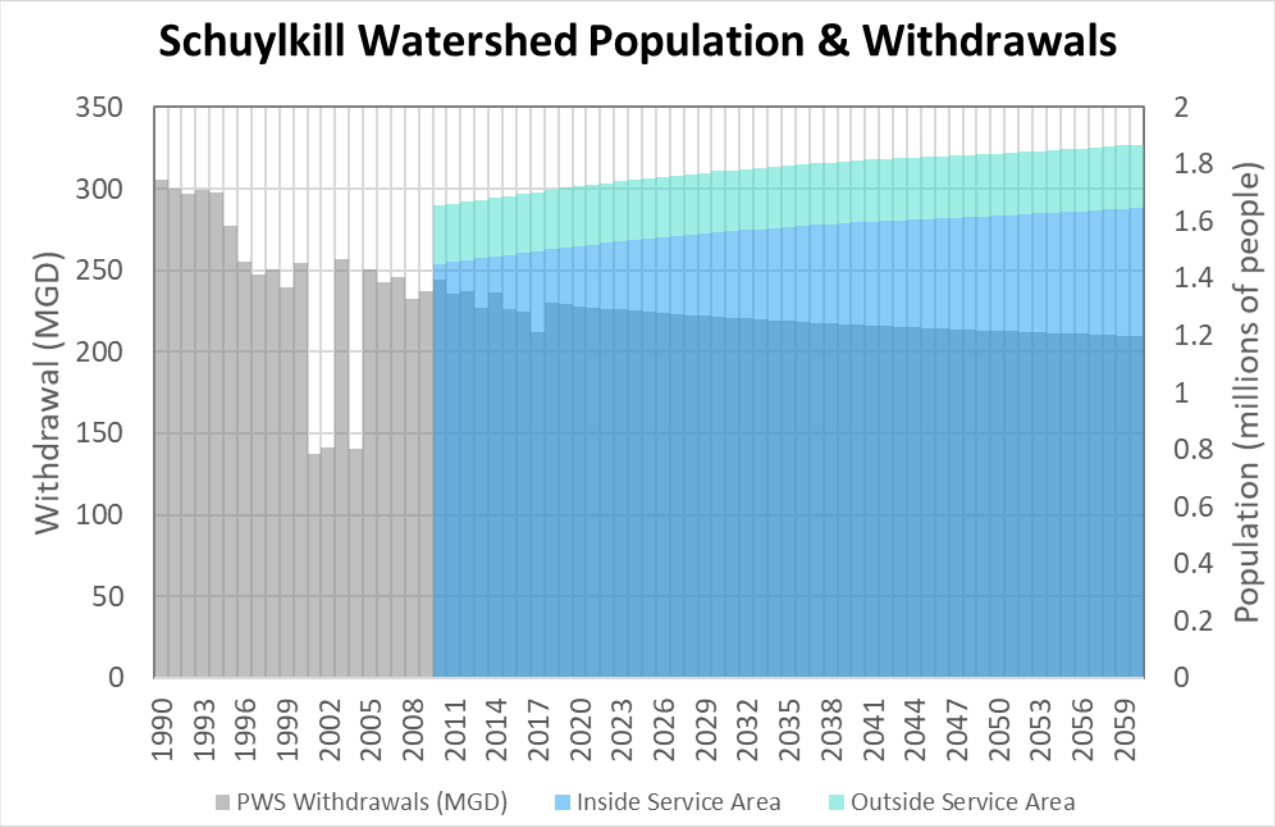
Year	Delaware River Basin Population (estimate)	Inside public water supply service areas		Outisde public water supply service areas		Self-supplied domestic withdrawal (MGD)	Self-supplied domestic consumptive use (MGD)
		Population	%	Population	%		
2010	8,251,815	7,105,813	86.1%	1,146,002	13.9%	95.224	9.522
2020	8,530,210	7,371,663	86.4%	1,158,547	13.6%	96.159	9.616
2030	8,708,203	7,551,844	86.7%	1,156,359	13.3%	95.865	9.586
2040	8,804,505	7,664,729	87.1%	1,139,776	12.9%	94.387	9.439
2050	8,830,378	7,715,283	87.4%	1,115,095	12.6%	92.242	9.224
2060	8,907,241	7,803,099	87.6%	1,104,142	12.4%	91.238	9.124

- SSD withdrawals calculated based on per-capita rates (1 number per state).
  (MD population excluded from calculations)
- Population growth weighted inside PWS Service Areas; declining SSD population & withdrawal

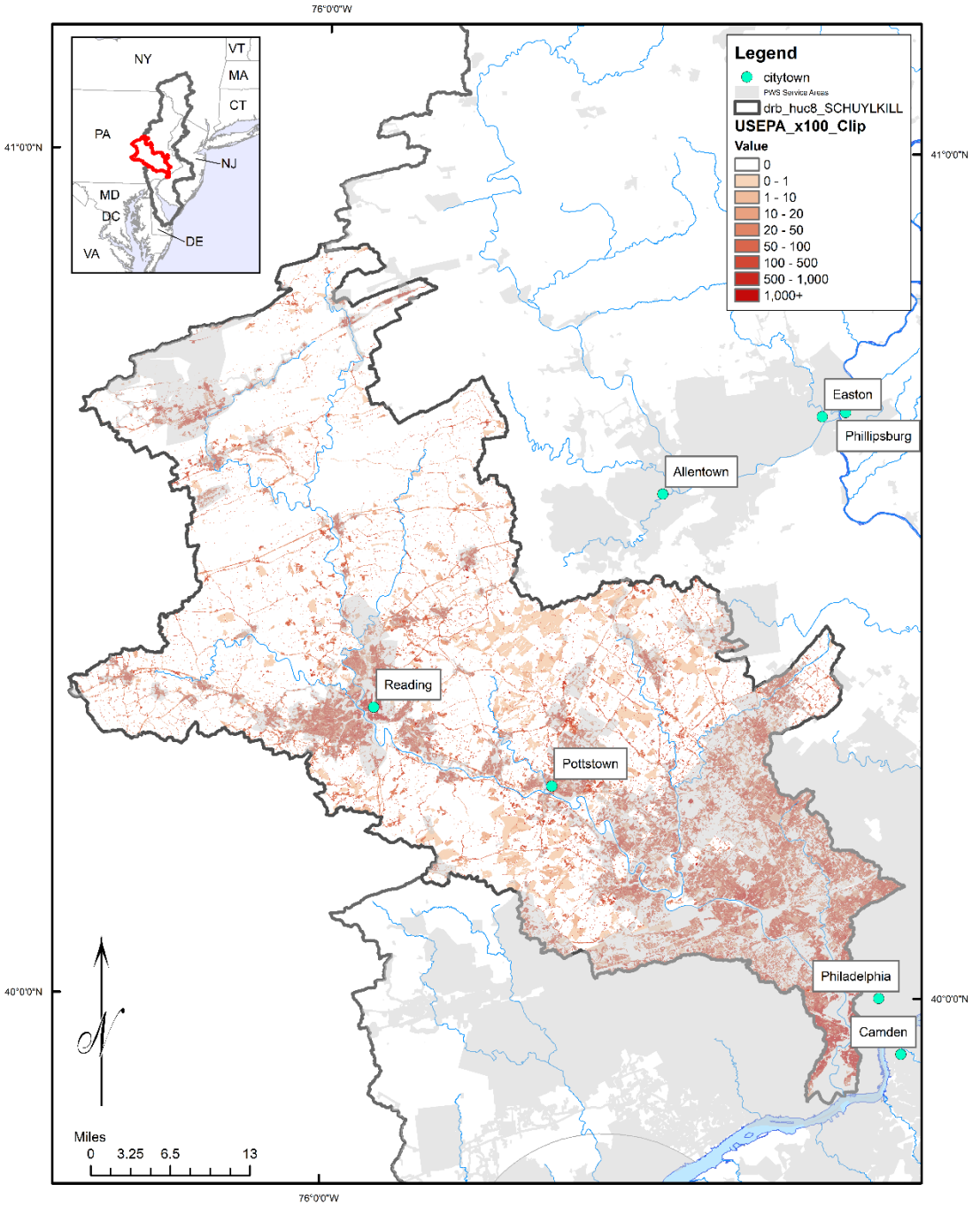
- Population had increased, projected to continue increasing.
- Withdrawals by public water suppliers have decreased, projected to continue decreasing.

Public water supply withdrawals from the Delaware River Basin with comparison to the in-Basin population





YEAR	Population						PWS Withdrawal	
	INSIDE	DELTA	OUTSIDE	DELTA	TOTAL	DELTA	MGD	DELTA
2010	1.452	--	0.203	--	1.655	--	244.6458	--
2020	1.515	4.33%	0.210	3.15%	1.724	4.19%	228.1679	-6.74%
2030	1.562	3.10%	0.214	2.08%	1.776	2.98%	221.4329	-2.95%
2040	1.598	2.31%	0.216	1.17%	1.814	2.17%	216.5714	-2.20%
2050	1.619	1.35%	0.218	0.72%	1.837	1.27%	212.8261	-1.73%
2060	1.647	1.68%	0.222	1.73%	1.868	1.69%	209.8103	-1.42%



NOTES:

- Watershed Population ≠ “Population Served”.
- Self supplied domestic calculated based on population, assumed to be groundwater.

7. Next Steps

* Interactive online data platform (Power BI)
* Groundwater availability
  * 147 HUC scale
  * SEPA GWPA scale
* Surface Water availability
  * Consider effects of climate change
  * Consider reservoir operations
  * Consider the Drought of Record

60 years 1961–2021
Delaware River Basin Commission
DELAWARE • NEW JERSEY
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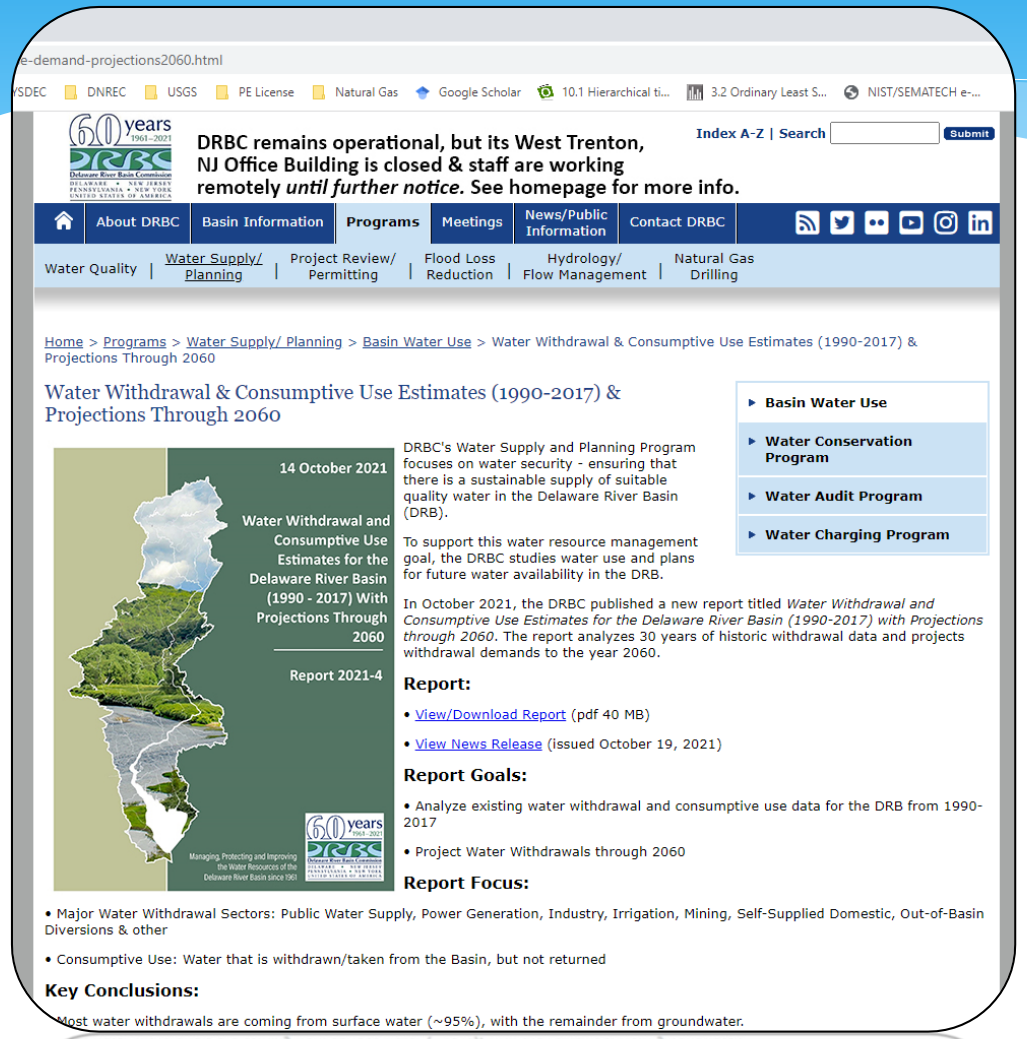
8. Publication & Data Deliverable



Report webpage:

https://www.nj.gov/drbc/programs/supply/use-demand-projections2060.html

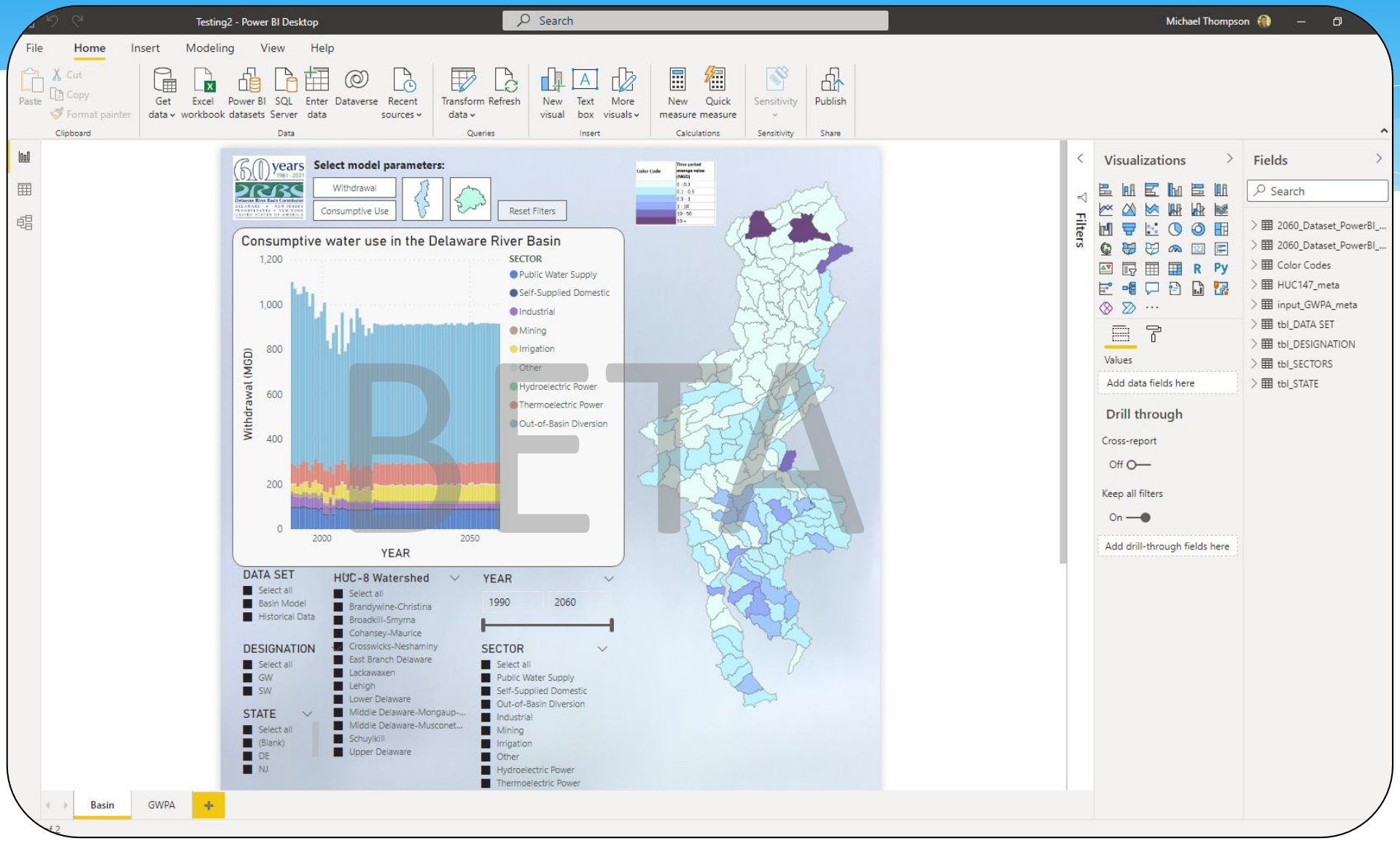
You can:

Download the report (~40 MB)
266 page PDF
(Best viewed with Adobe)

Download the dataset (~10 MB)
MS Excel File (no macros)

Download high resolution versions of report maps

8. Interactive data visualization (demo)



8. Questions

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