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

Delaware Water Supply Coordinating Council

January 20, 2022

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and

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60 years 1961–2021
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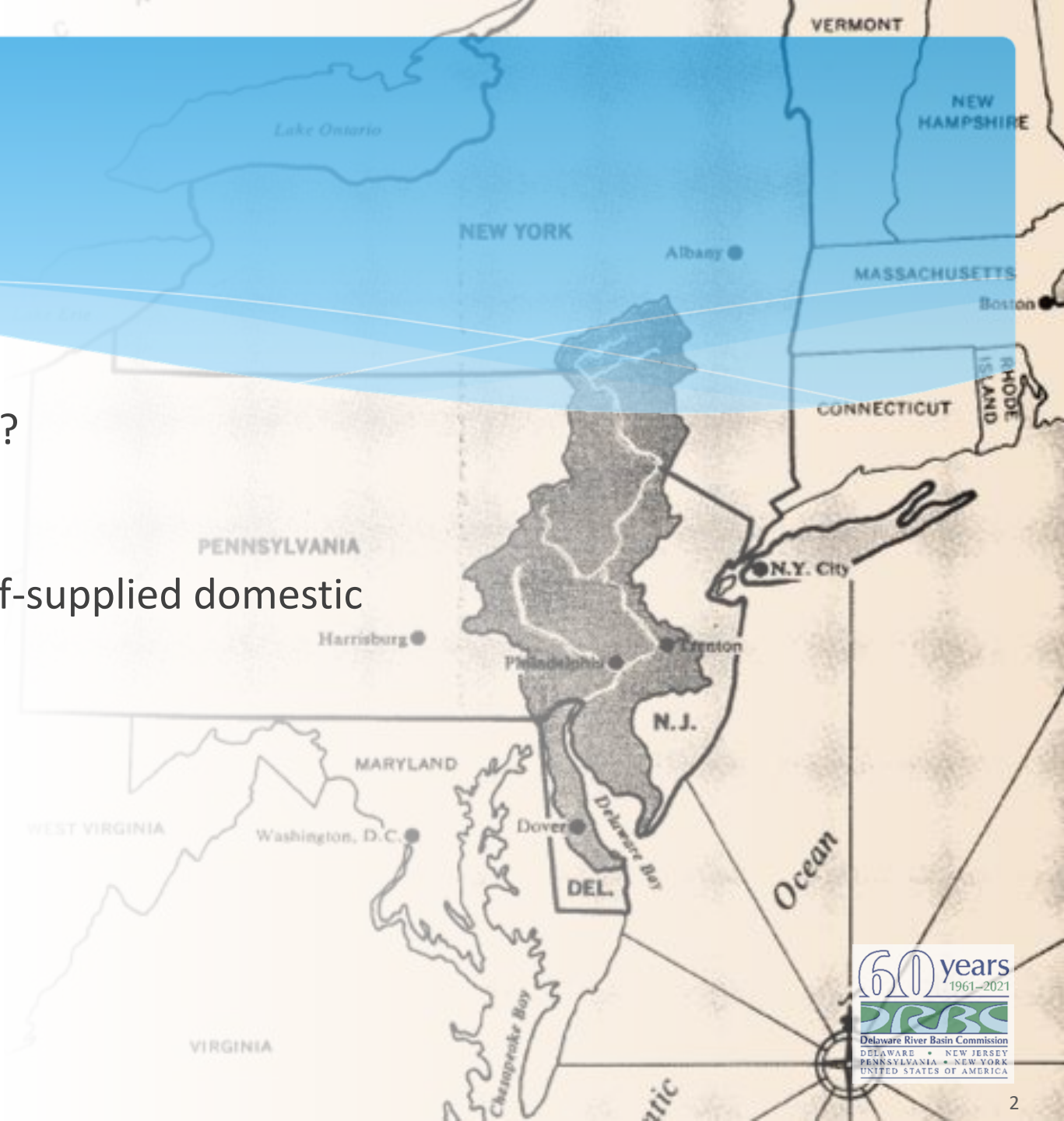
Outline

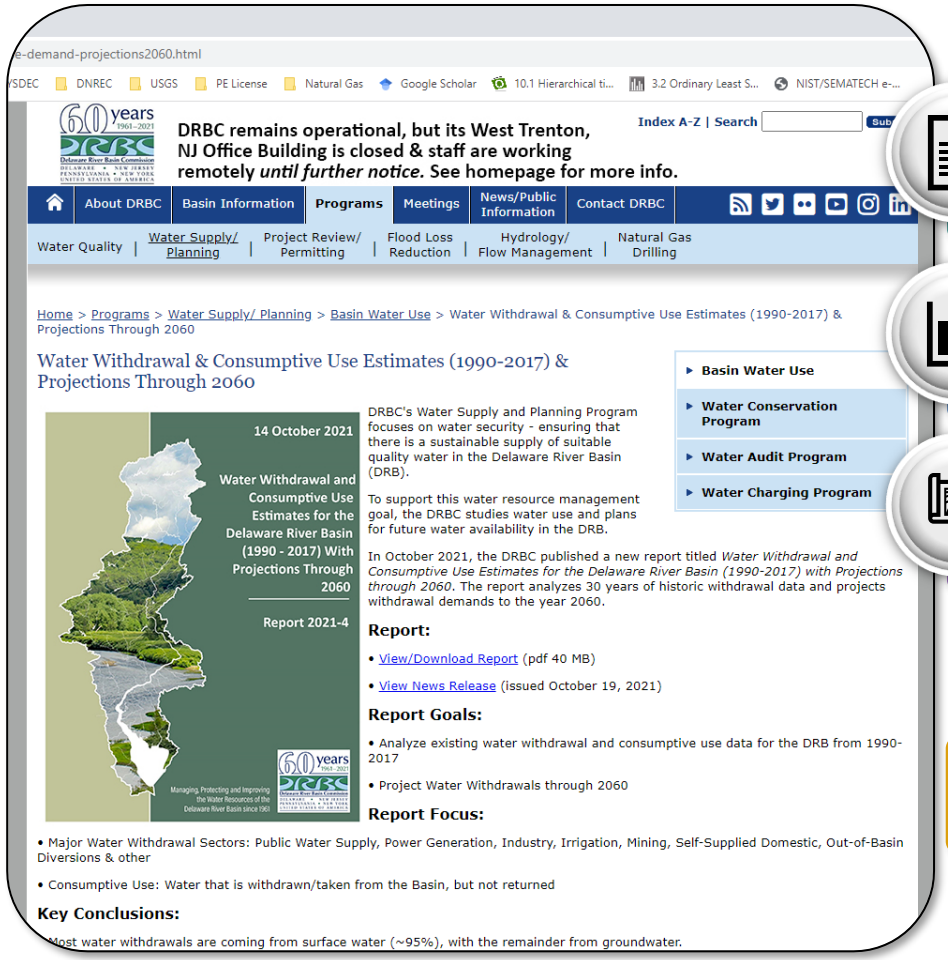
1. Publication and data deliverables
2. Water Supply Planning – Why and What?
3. Methodology
4. Results
5. Supplemental analysis: population & self-supplied domestic
6. Supplemental analysis: irrigation
7. Next Steps
8. Questions



1. Publication & Data Deliverable

Report webpage:

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



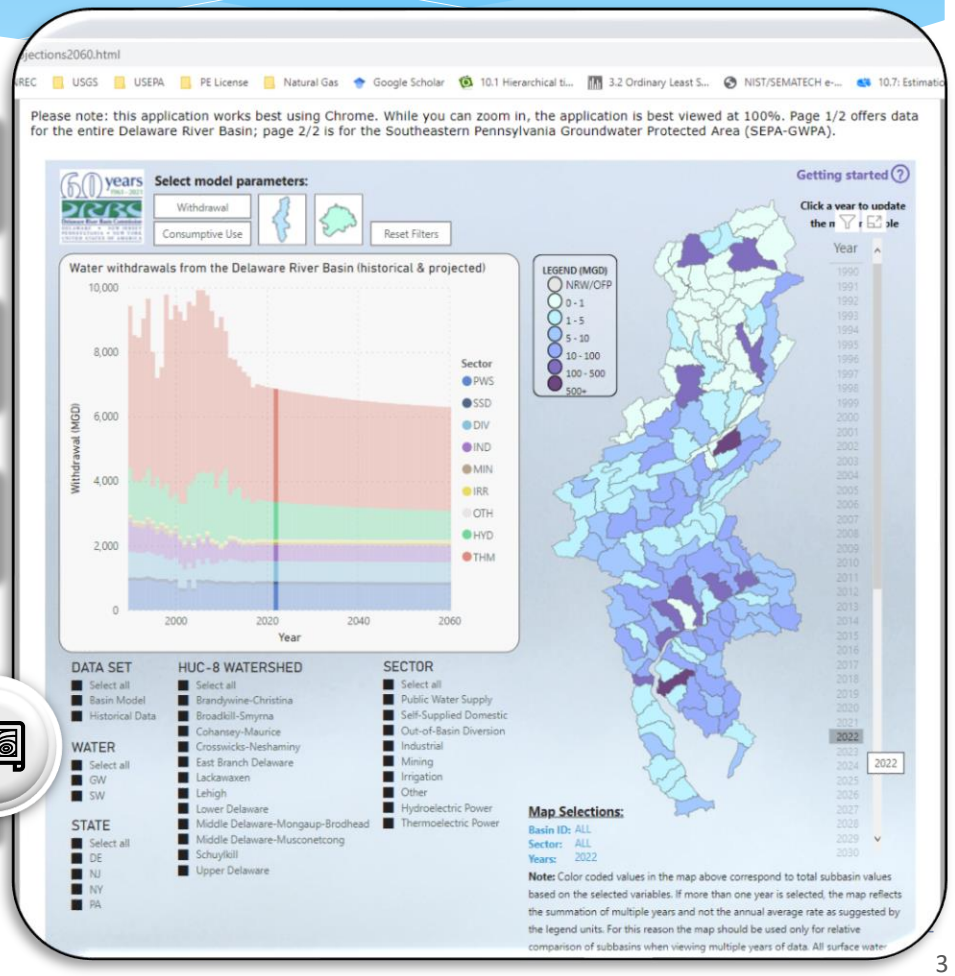
You can:

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

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

Download high resolution maps from the report

Interact with the Power BI data visualization tool



2. Water Supply Planning – Why and What?

Hoopes Reservoir in
New Castle County, Delaware.
Credit: © Michael Gatti
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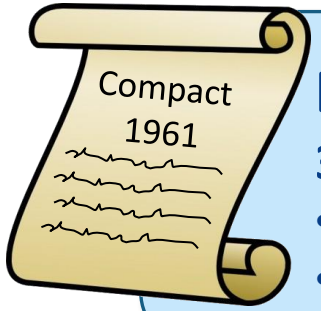
2. Water Supply Planning: Why are we projecting withdrawal data?

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

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2. 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.

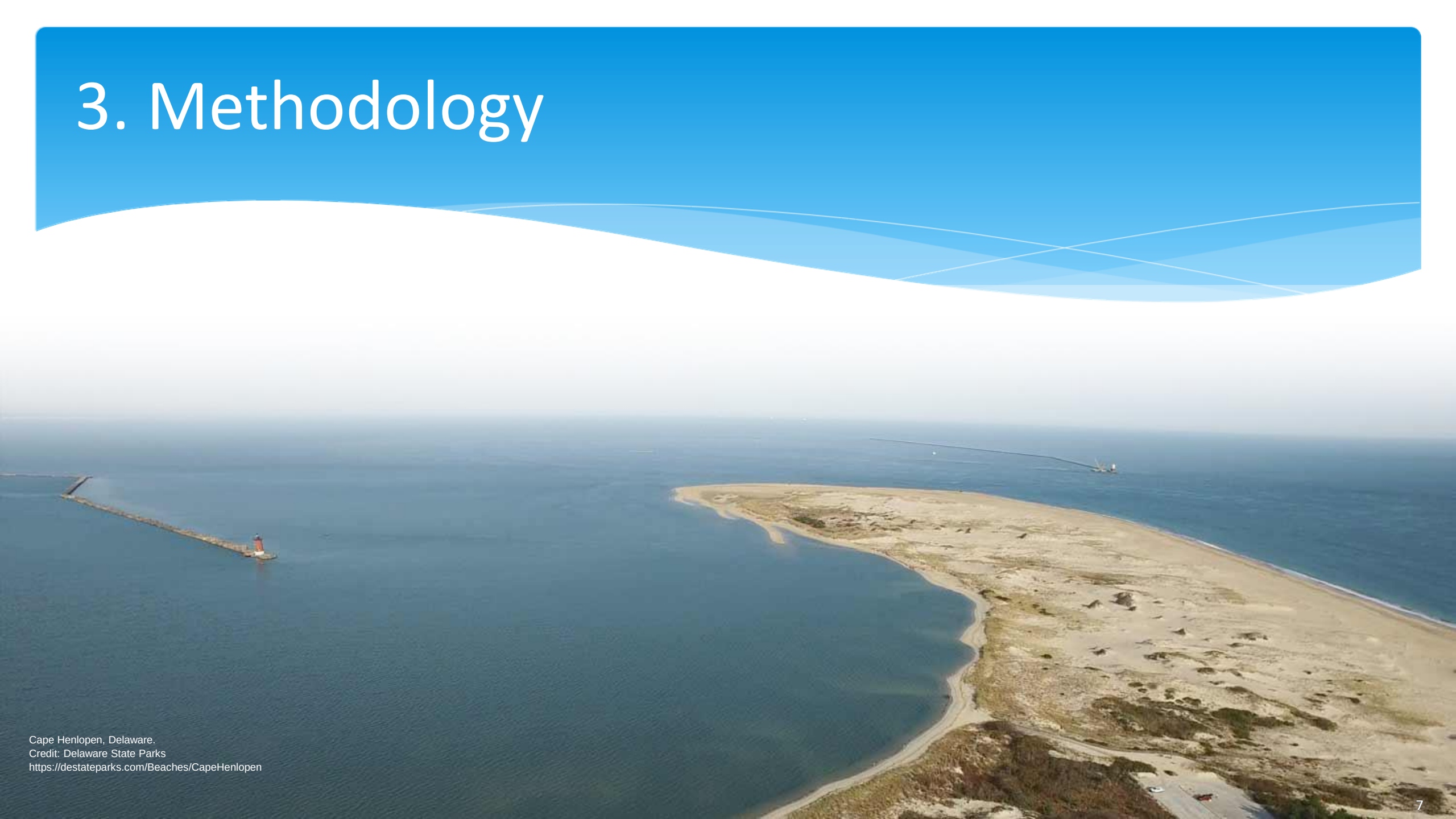
Represent each water use *sector* at the Basin-wide scale.

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.

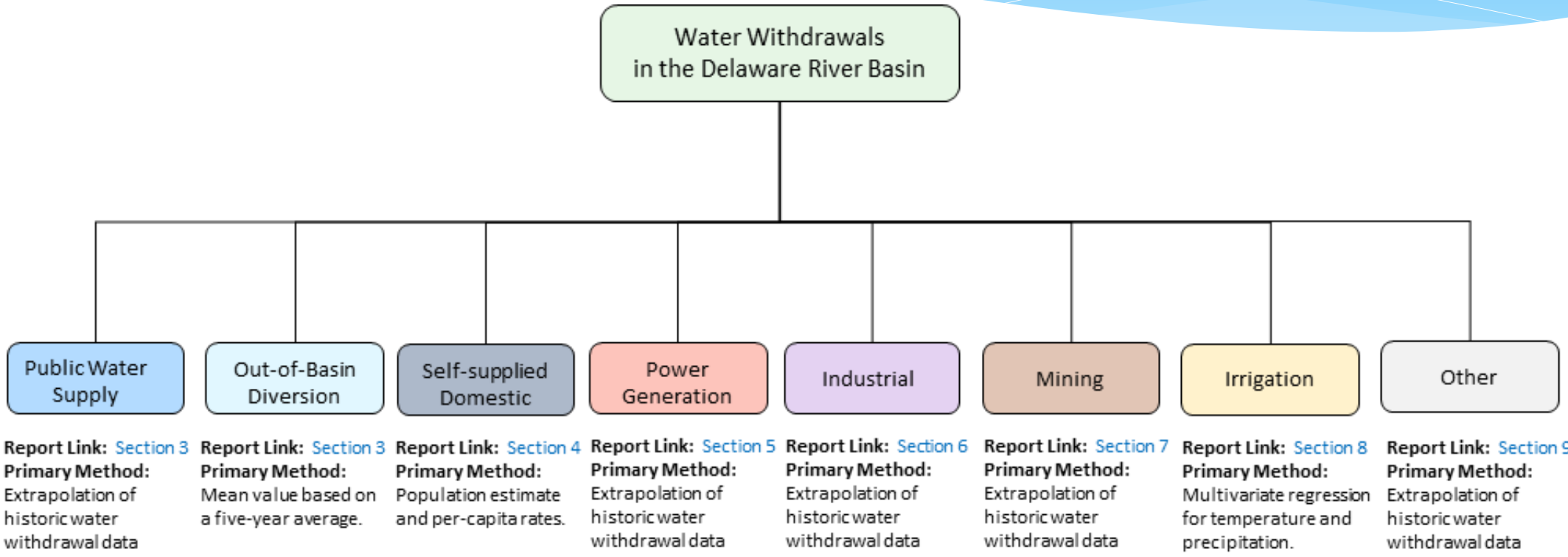
3. Methodology



Cape Henlopen, Delaware.
Credit: Delaware State Parks
https://destateparks.com/Beaches/CapeHenlopen

3. Methodology: Breakdown by sector

The primary method is extrapolation of historic reported withdrawal data



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3. Methodology: A plan for projecting data?

NOTE:
Not the method for self-supplied domestic withdrawals, and irrigation withdrawals

Where do we start?

Time-series hierarchy

Aggregate to results here

Perform projections here

Level 1
(Sector level)……

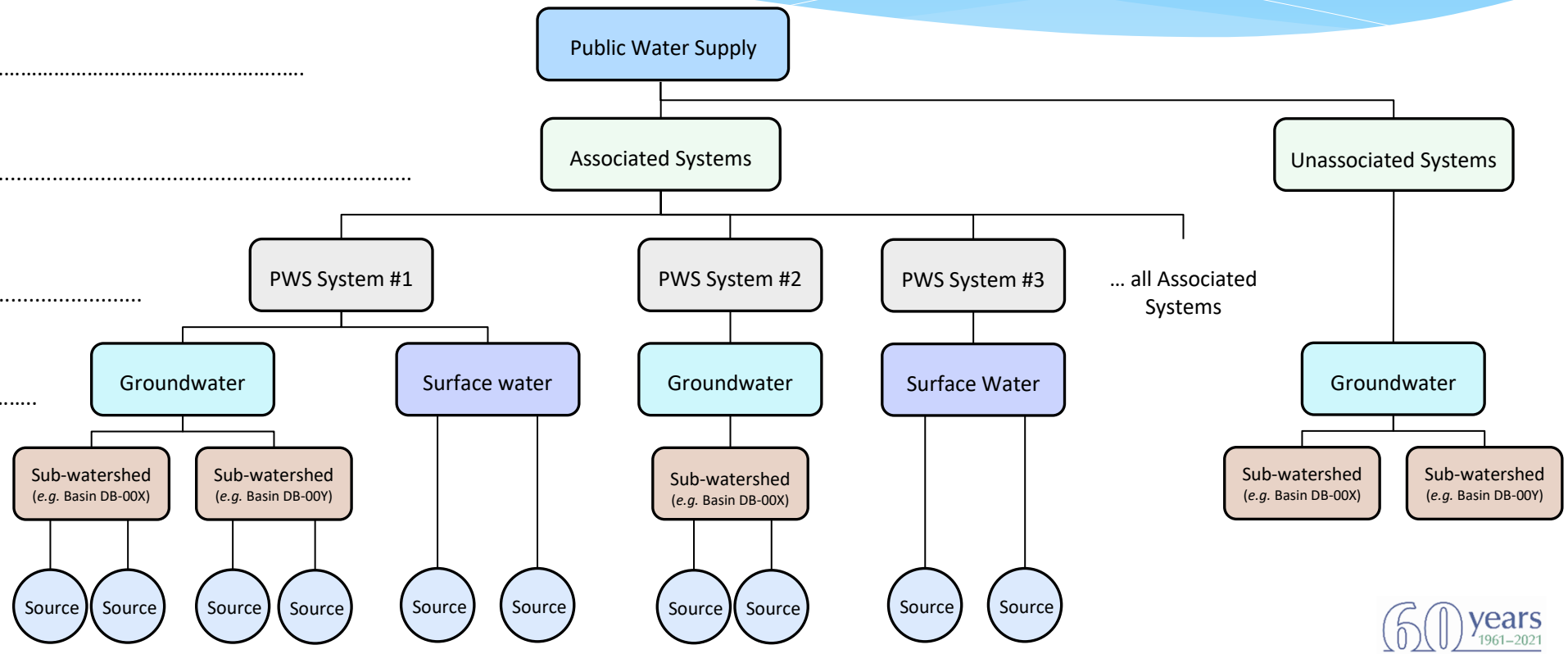
Level 2
(Regulatory level)……

Level 3
(System level)……

Level 4
(Source-type level)……

Level 5
(Sub-watershed level)……

Level 6
(Source level)……



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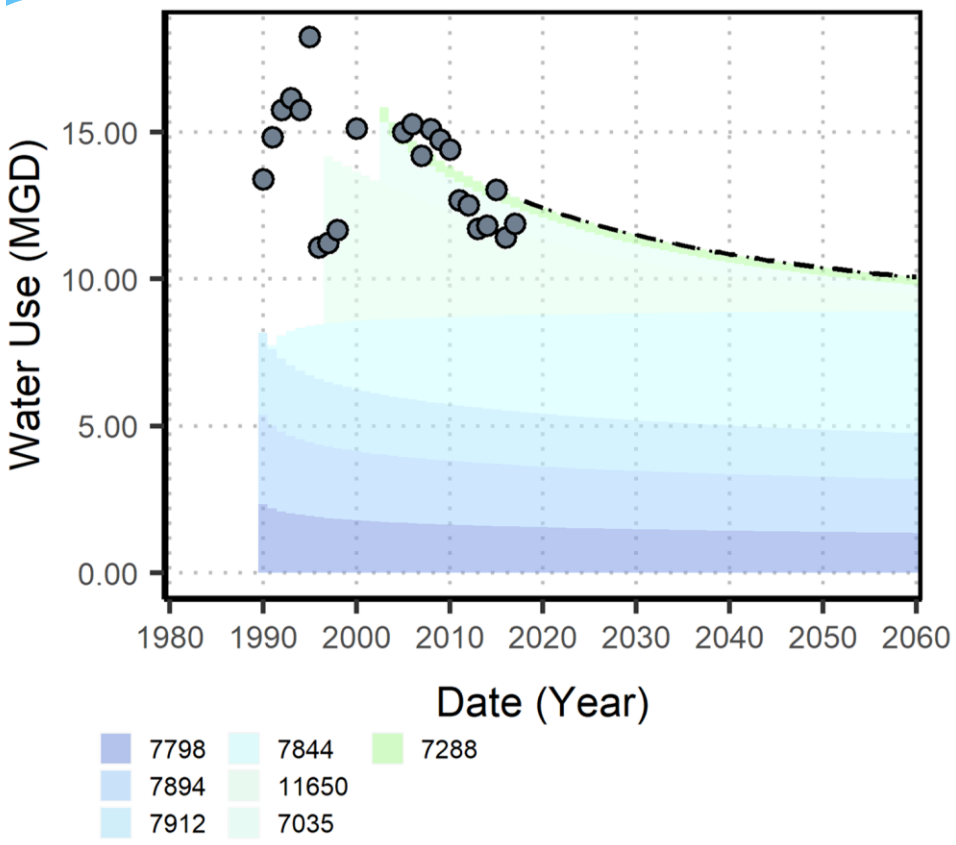
Hyndman, R., & Athanasopoulos, G. (2018). *Forecasting: principles and practice* (2nd ed.). Melbourne, Australia: OTexts. https://otexts.com/fpp2/

3. Methodology: How do you aggregate projections?



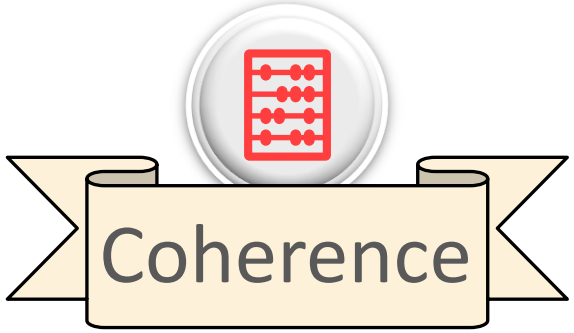
"Bottom-up approach"

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

PWS System #1: DB-00X, DB-00Y, SW 1, SW 2

PWS System #2: DB-00X, "System Level"

PWS System #3: SW 1, SW 2



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

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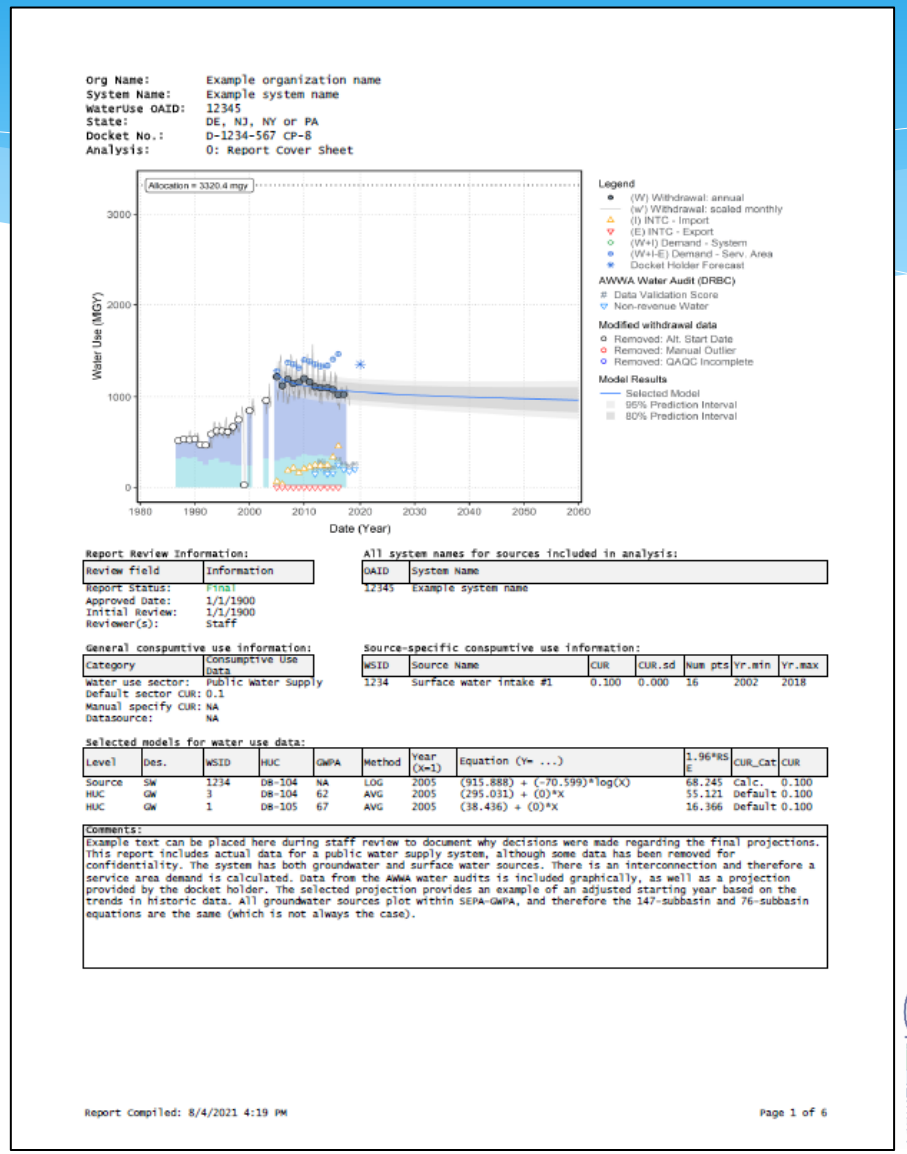
3. Methodology: A plan for projecting data?

The main model is based on extrapolating historic withdrawal data.

- Significant QAQC of historic data
- 600+ system reports
- 1,100+ equations

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).

Report Compiled: 8/4/2021 4:19 PM

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4. Results

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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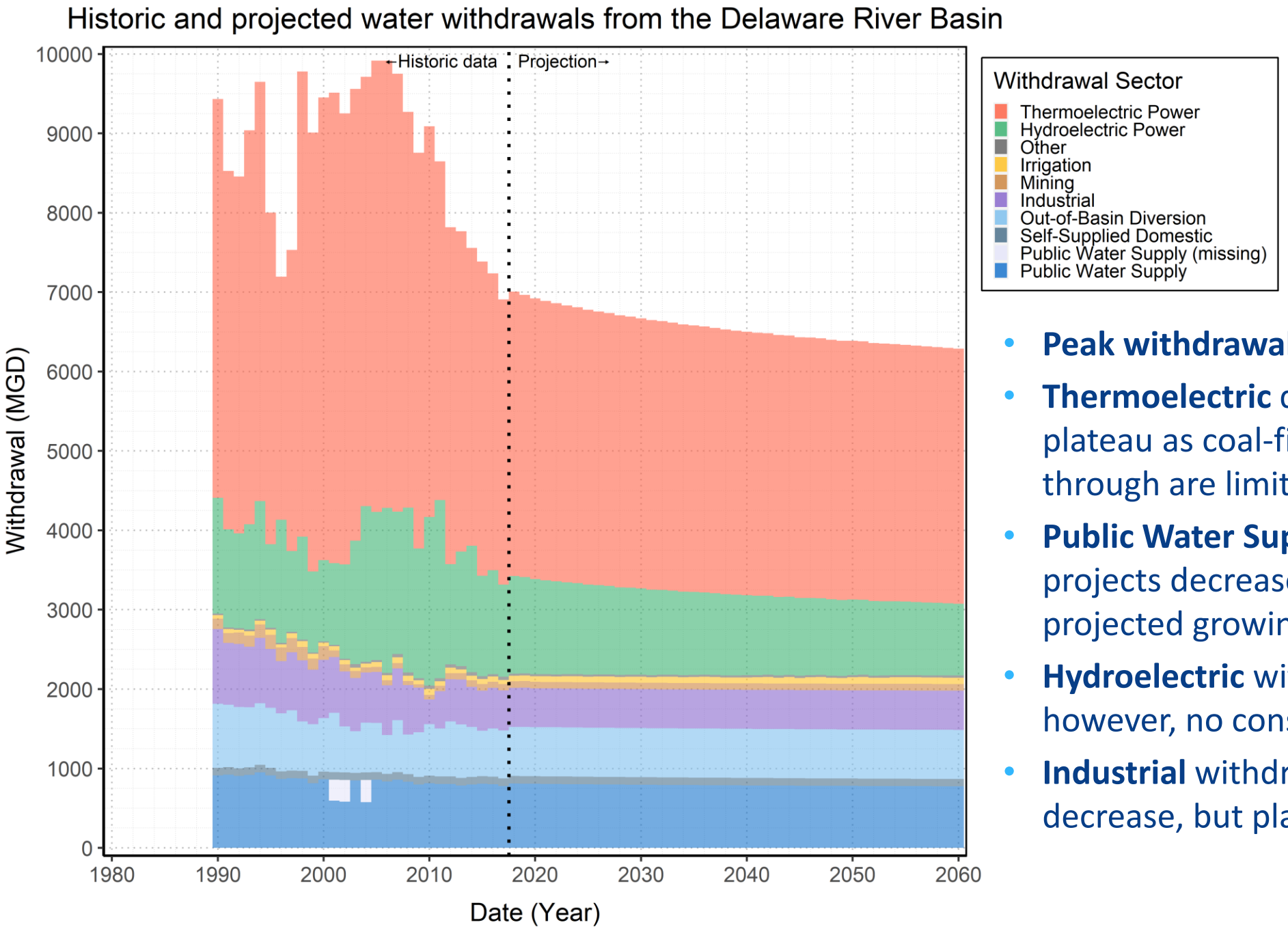

- **Peak withdrawals have occurred**
- **Thermoelectric** decreases since 2007 will plateau as coal-fired facilities using once-through are limiting
- **Public Water Supply** has shown and projects decreases despite historic and projected growing in-Basin population
- **Hydroelectric** withdrawals are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

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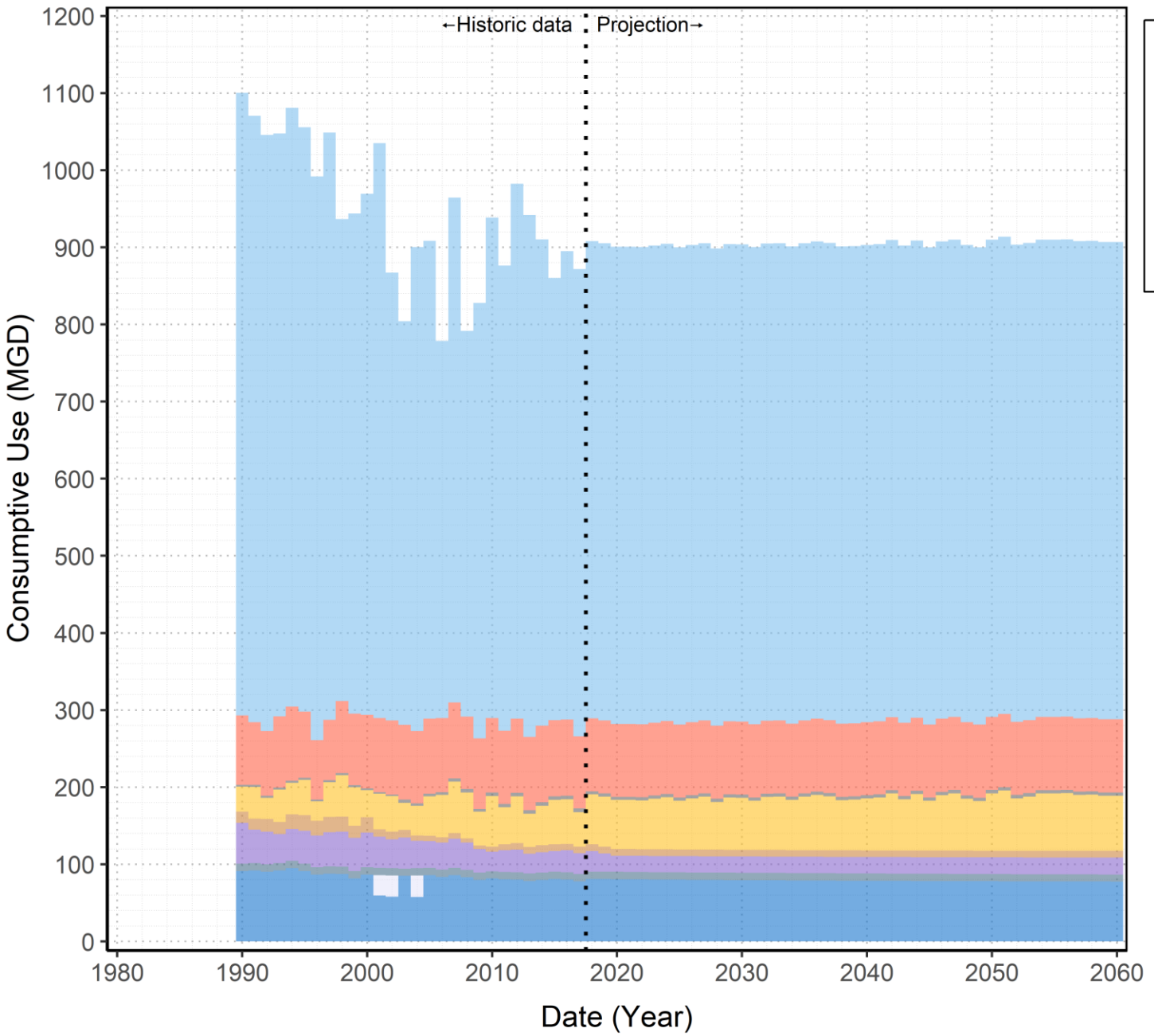
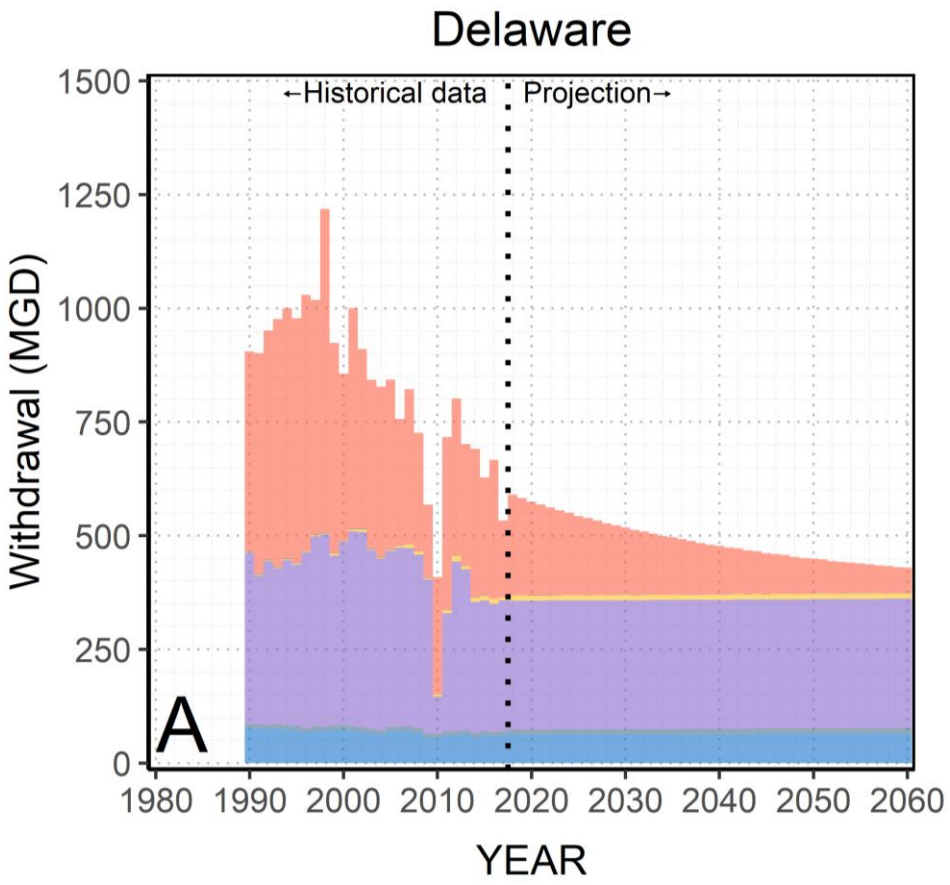
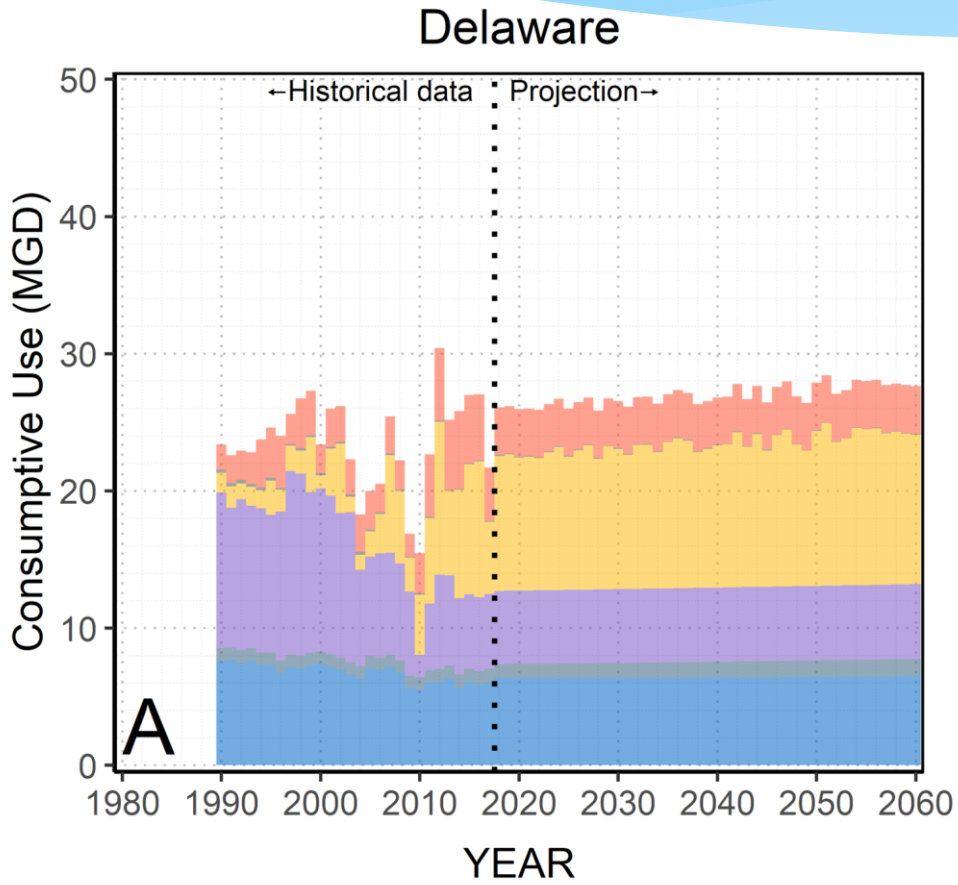
Historic and projected consumptive water use in the Delaware River Basin

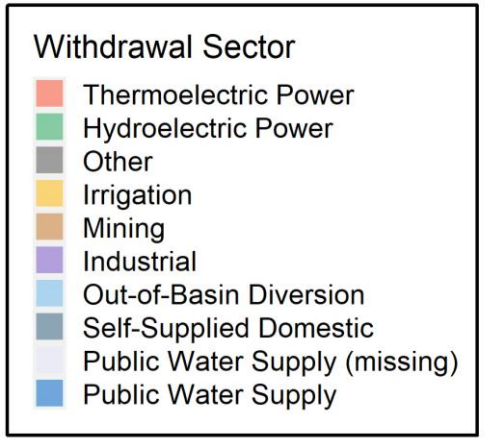


- **Consumptive use projected to remain relatively constant**
- **Largest consumptive use is Out-of-Basin Exports under a U.S. Supreme Court Decree**
- **Thermoelectric** consumptive use constant despite decreased withdrawals due to changes in technology
- **Irrigation** is significant and shows slight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

4. Results: Withdrawals and consumptive use in Delaware

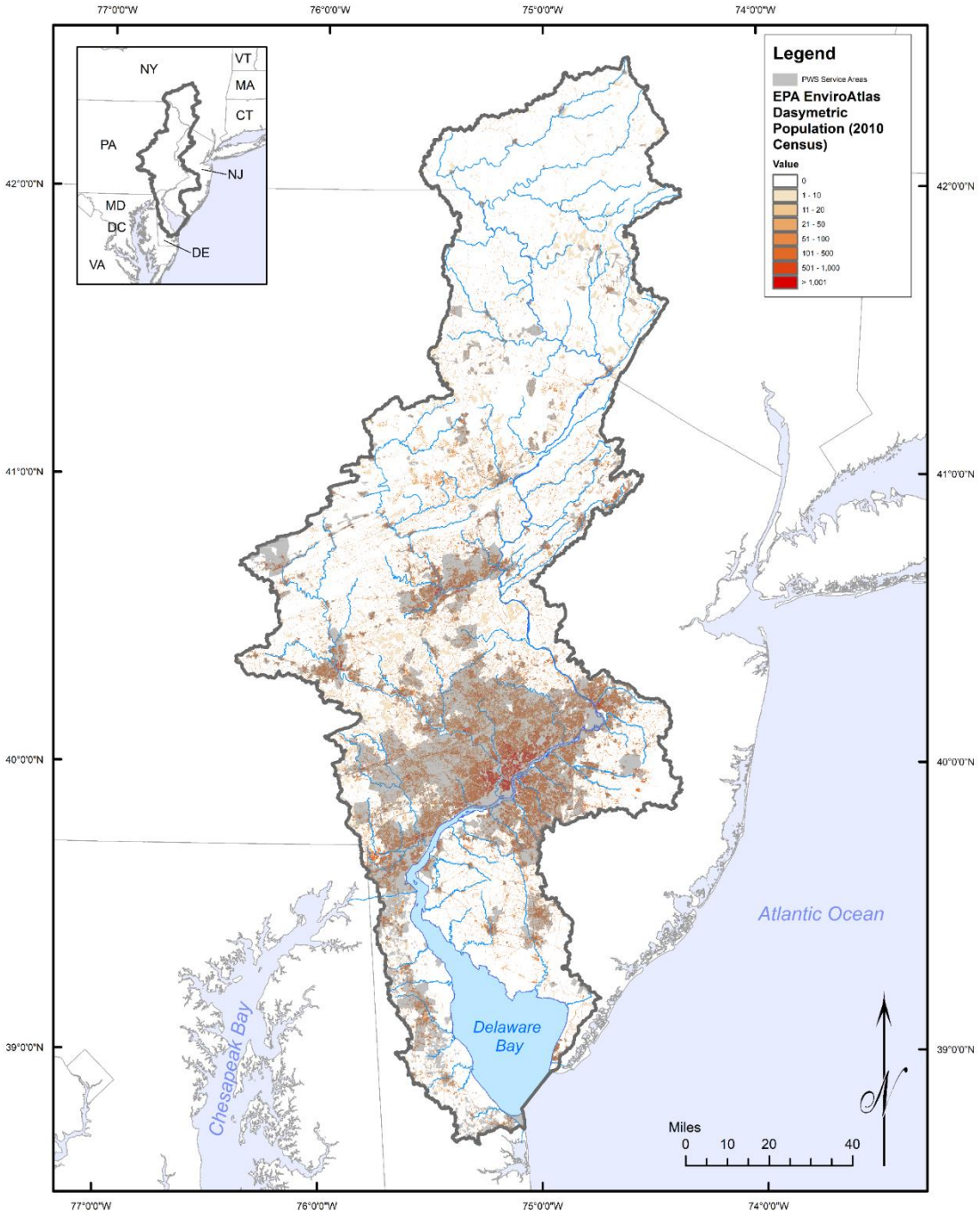


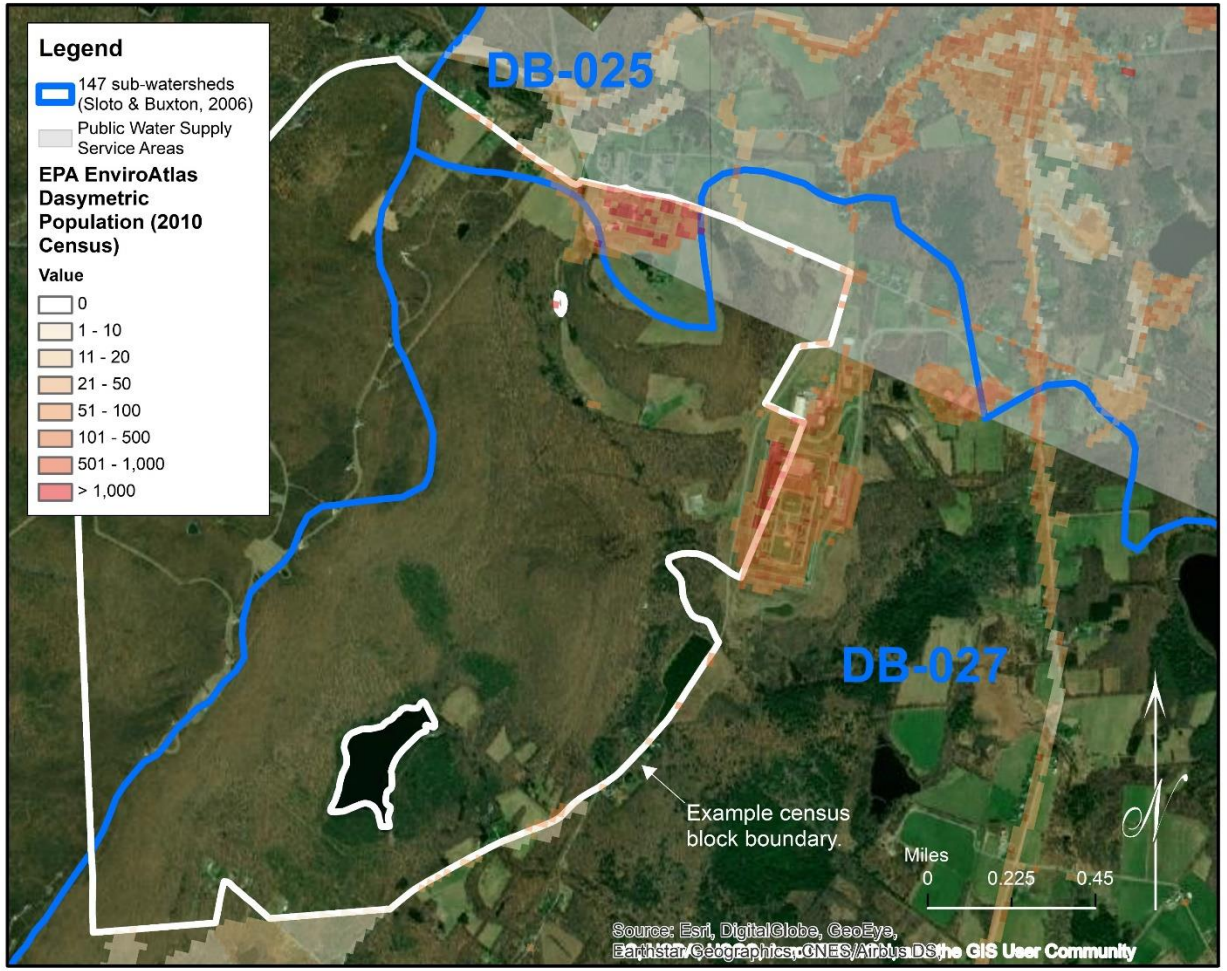




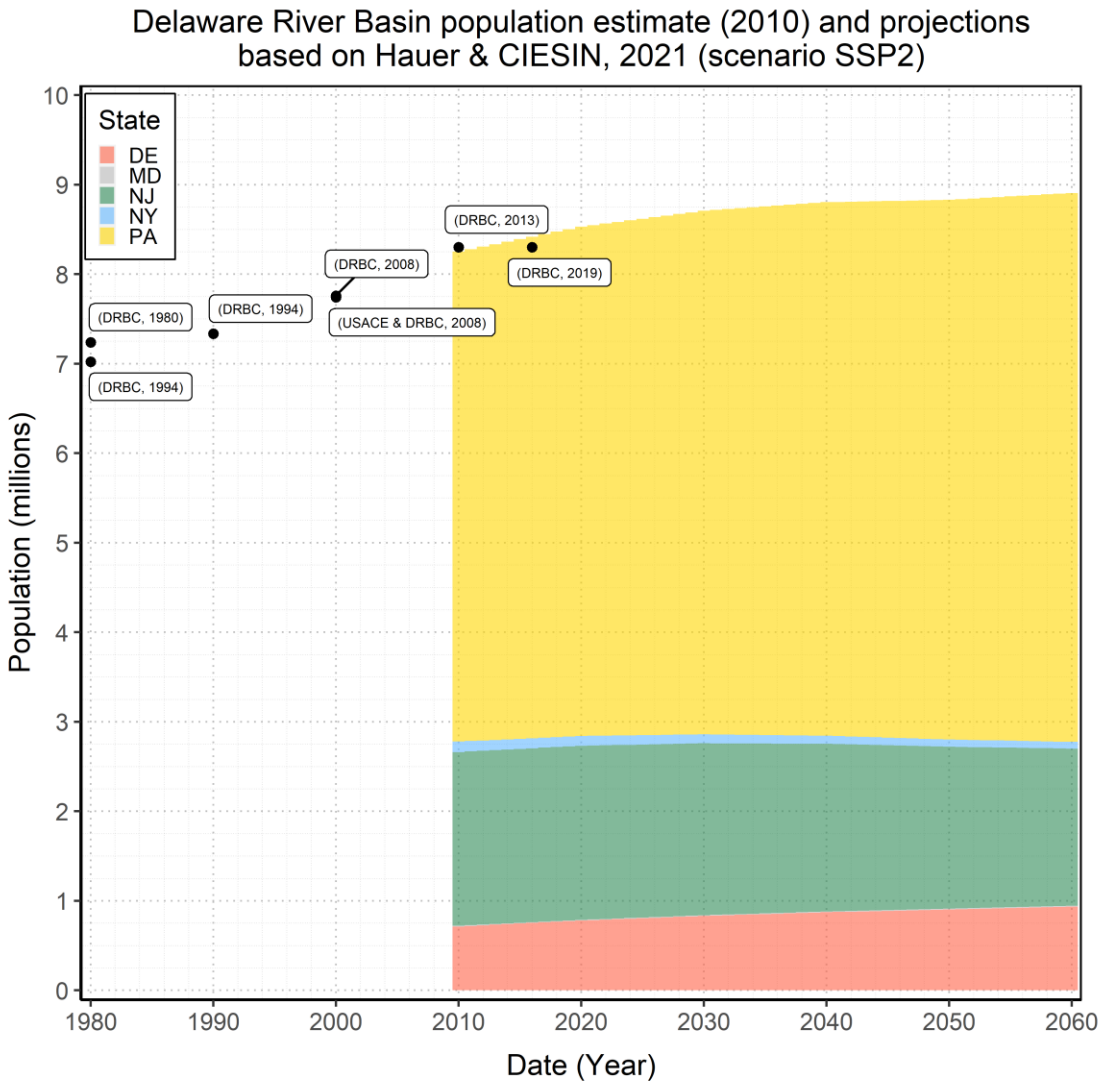
5. Supplemental analysis: population & self-supplied domestic

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



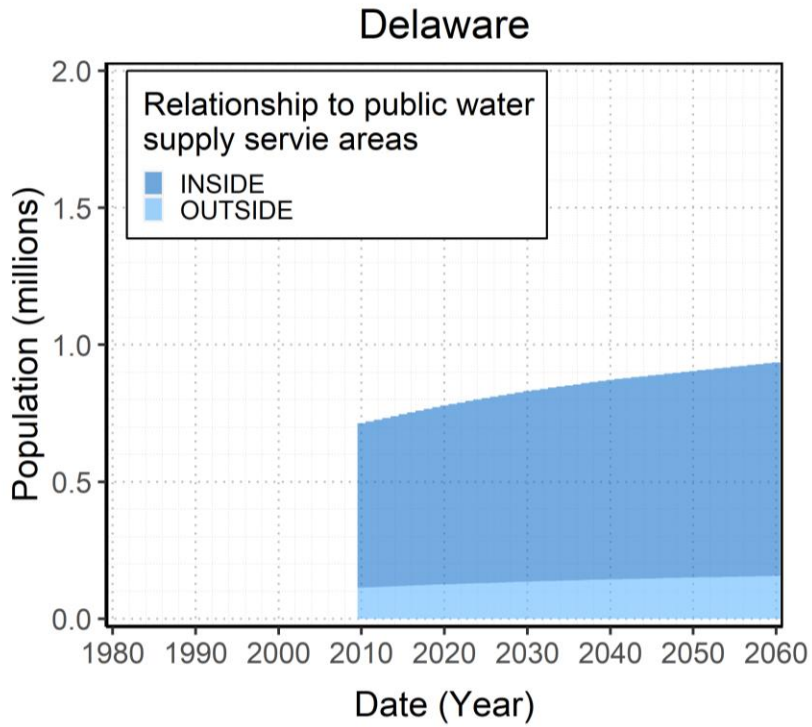


- EPA EnviroAtlas dasymetrically mapped 2010 population to 30x30m pixels
- Public water supplier service areas
- Raster analyses show 2010 population: ~8.252 MM people
  - 1.146MM (~14%) reside outside services areas



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

Breakdown projections by state, county, service area, watershed boundary…



SSP2 for Delaware projects continued population growth, at a decreasing rate for all counties.

Year	Kent				New Castle				Sussex				Grand Total	
	INSIDE	OUTSIDE	SUBTOTAL	%Δ	INSIDE	OUTSIDE	SUBTOTAL	%Δ	INSIDE	OUTSIDE	SUBTOTAL	%Δ	Population	%Δ
2010	109,155	35,907	145,062	--	466,840	57,052	523,892	--	24,584	19,938	44,522	--	713,476	--
2020	123,923	40,767	164,690	14%	500,762	61,197	561,959	7%	28,987	23,508	52,495	18%	779,144	9%
2030	136,101	44,772	180,873	10%	526,705	64,367	591,072	5%	32,496	26,355	58,851	12%	830,796	7%
2040	146,997	48,357	195,354	8%	545,859	66,707	612,566	4%	35,457	28,757	64,214	9%	872,134	5%
2050	155,914	51,291	207,205	6%	560,084	68,447	628,531	3%	37,768	30,631	68,399	7%	904,135	4%
2060	164,250	54,031	218,281	5%	575,367	70,314	645,681	3%	39,691	32,191	71,882	5%	935,844	4%

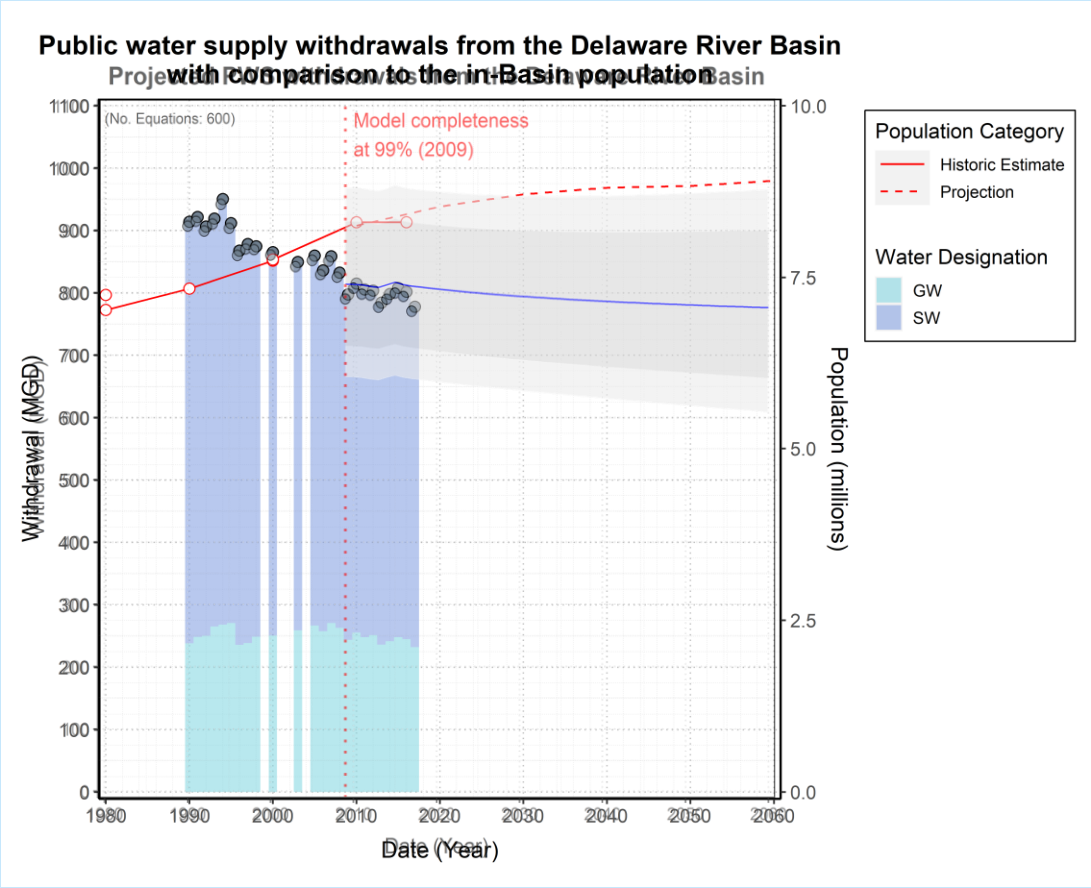
PWS & SSD Withdrawal Projections (Delaware)

Year	Outside Service Areas		Inside Service Areas			
	Population	Self-supplied withdrawal	Population	PWS withdrawals (MGD)		
				GW	SW	TOTAL
2010	112,897	9.032	600,579	22.992	32.031	55.022
2020	125,472	10.038	653,672	28.091	35.750	63.841
2030	135,494	10.840	695,302	29.167	34.602	63.769
2040	143,821	11.506	728,313	30.235	33.760	63.995
2050	150,369	12.030	753,766	31.301	33.093	64.394
2060	156,536	12.523	779,308	32.370	32.541	64.911

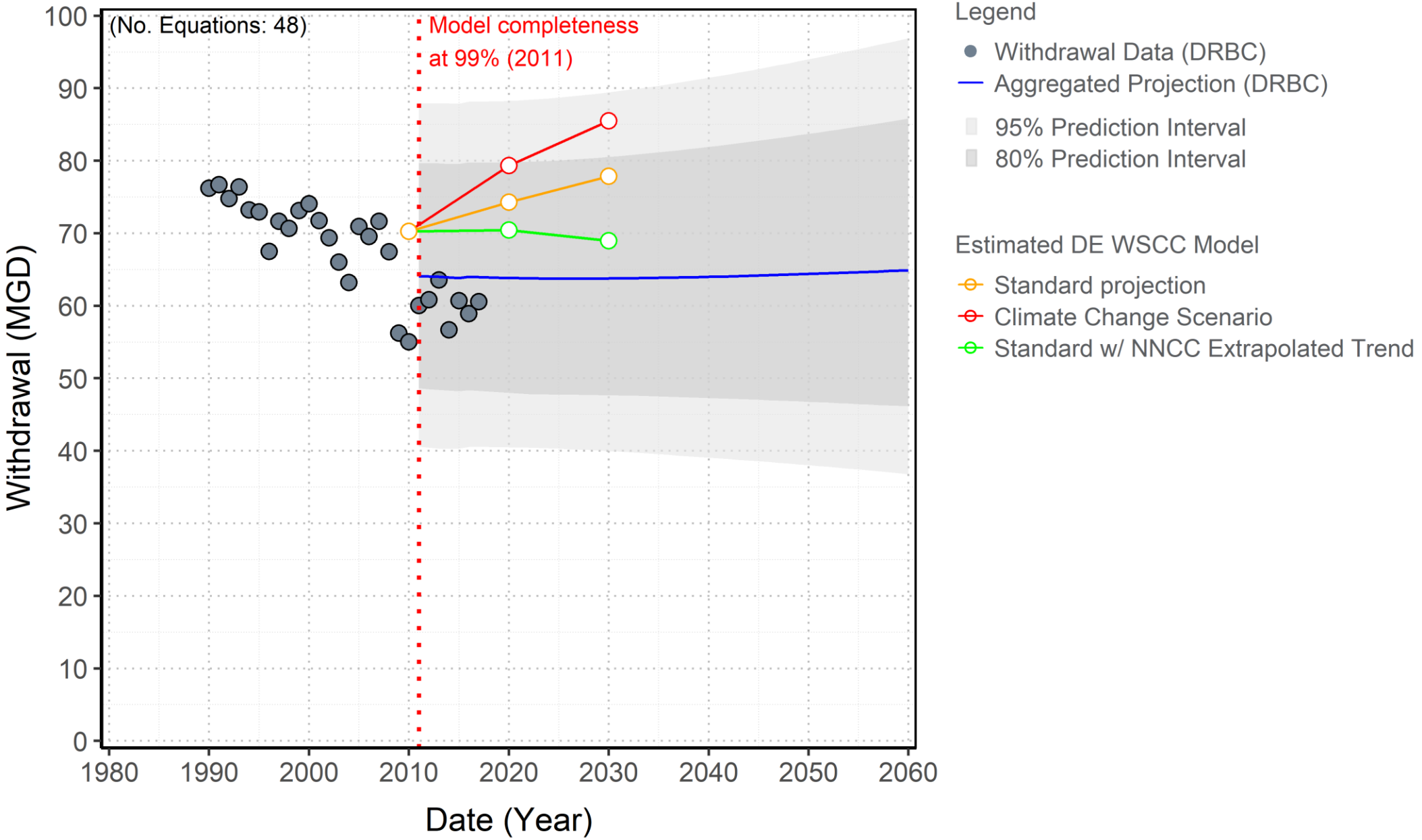
- SSD withdrawals calculated based on per-capita rates (1 number per state).
  For Delaware we used 80 gpcd
- All counties had the same growth trends.
- Increasing population & public water supply withdrawals are counter to Basin-wide trends.

Basin wide PWS & population trend:

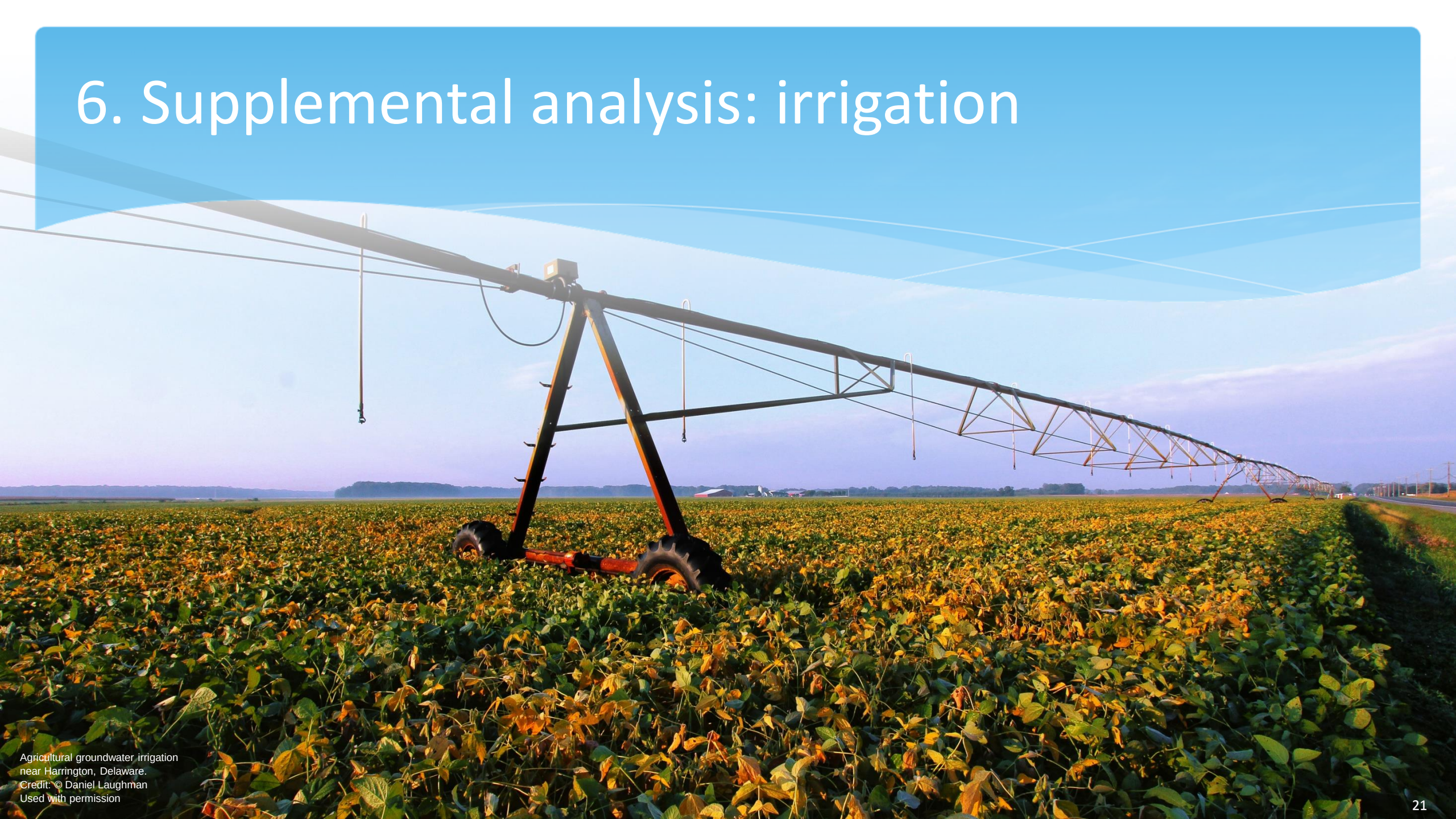
Year	Population iside service areas	Public water supply withdrawals (MGD)
2020	7,371,663	806.509
2060	7,803,099	776.505



Projected water withdrawals from the Delaware portion of the Delaware River Basin compared to DE WSCC studies



6. Supplemental analysis: irrigation



Agricultural groundwater irrigation near Harrington, Delaware.
Credit: © Daniel Laughman
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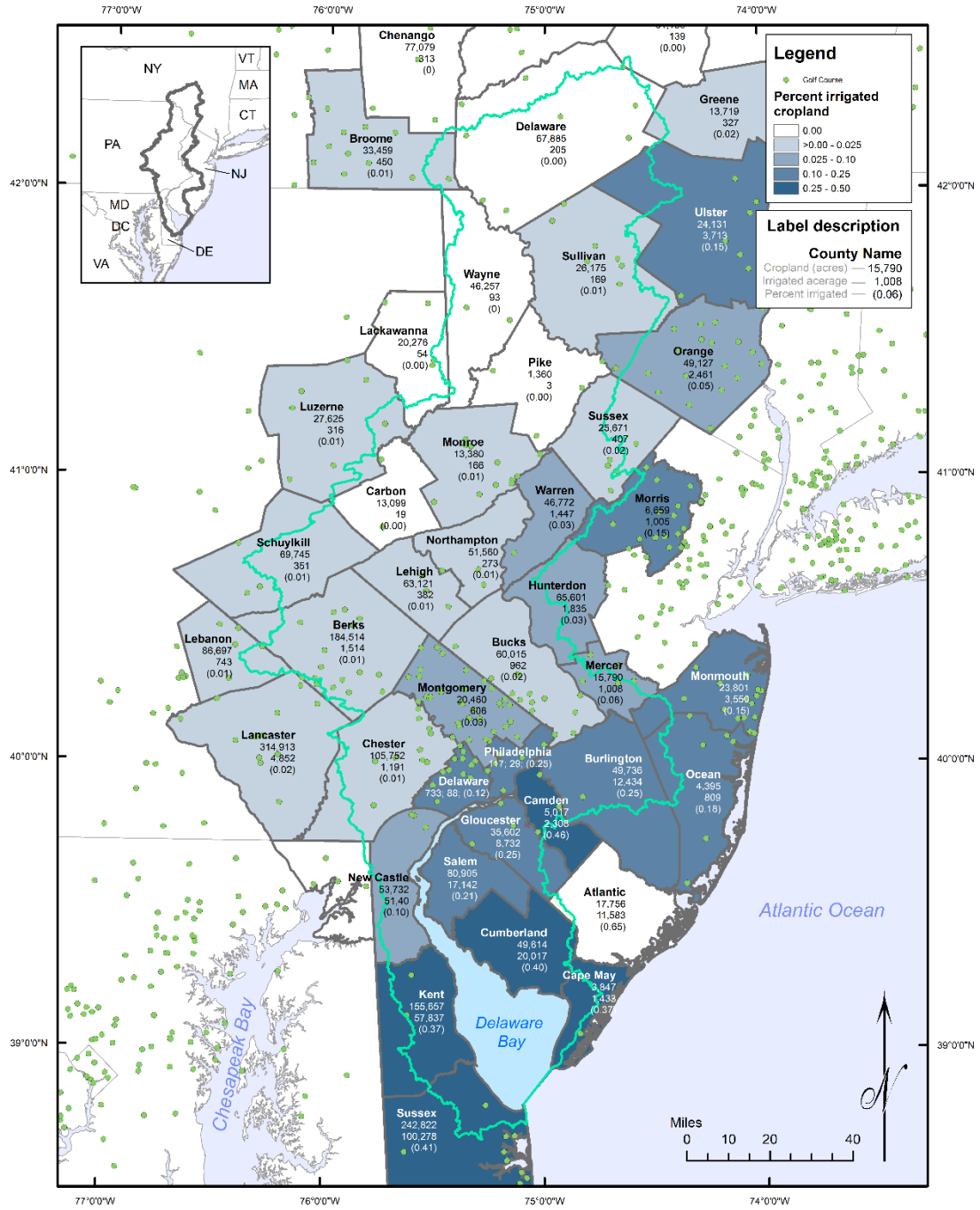
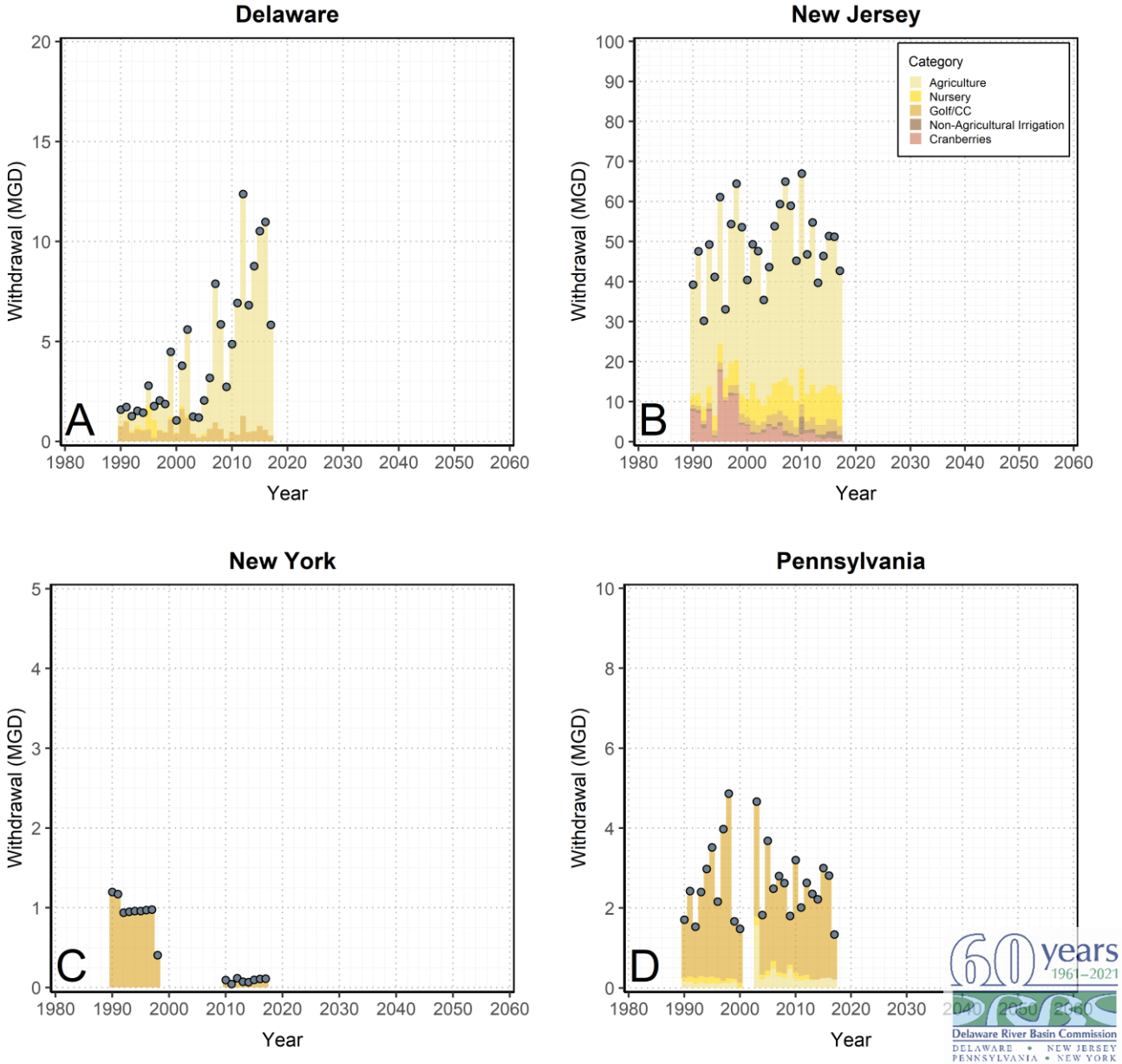


Irrigation water withdrawals from the Delaware River Basin states



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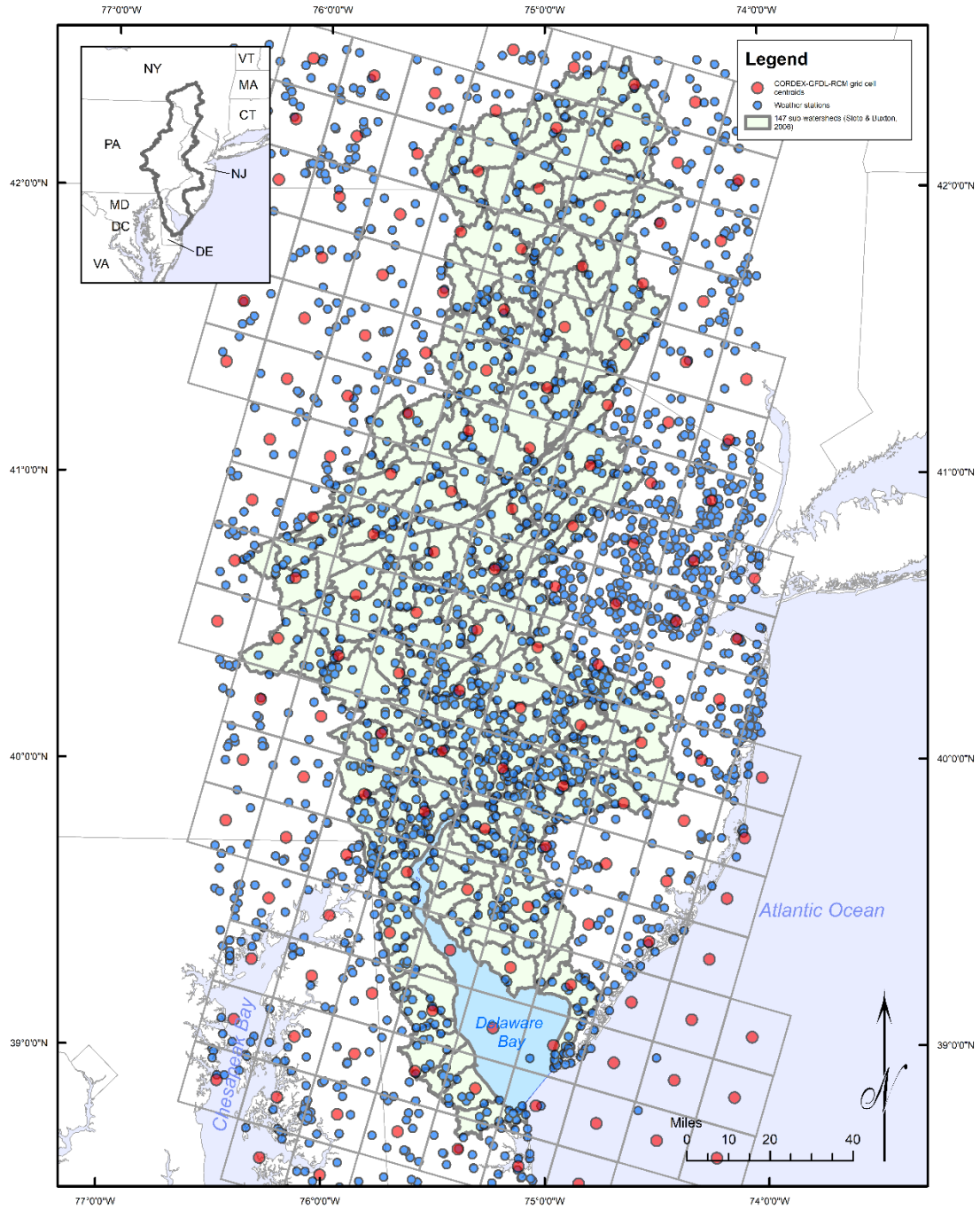

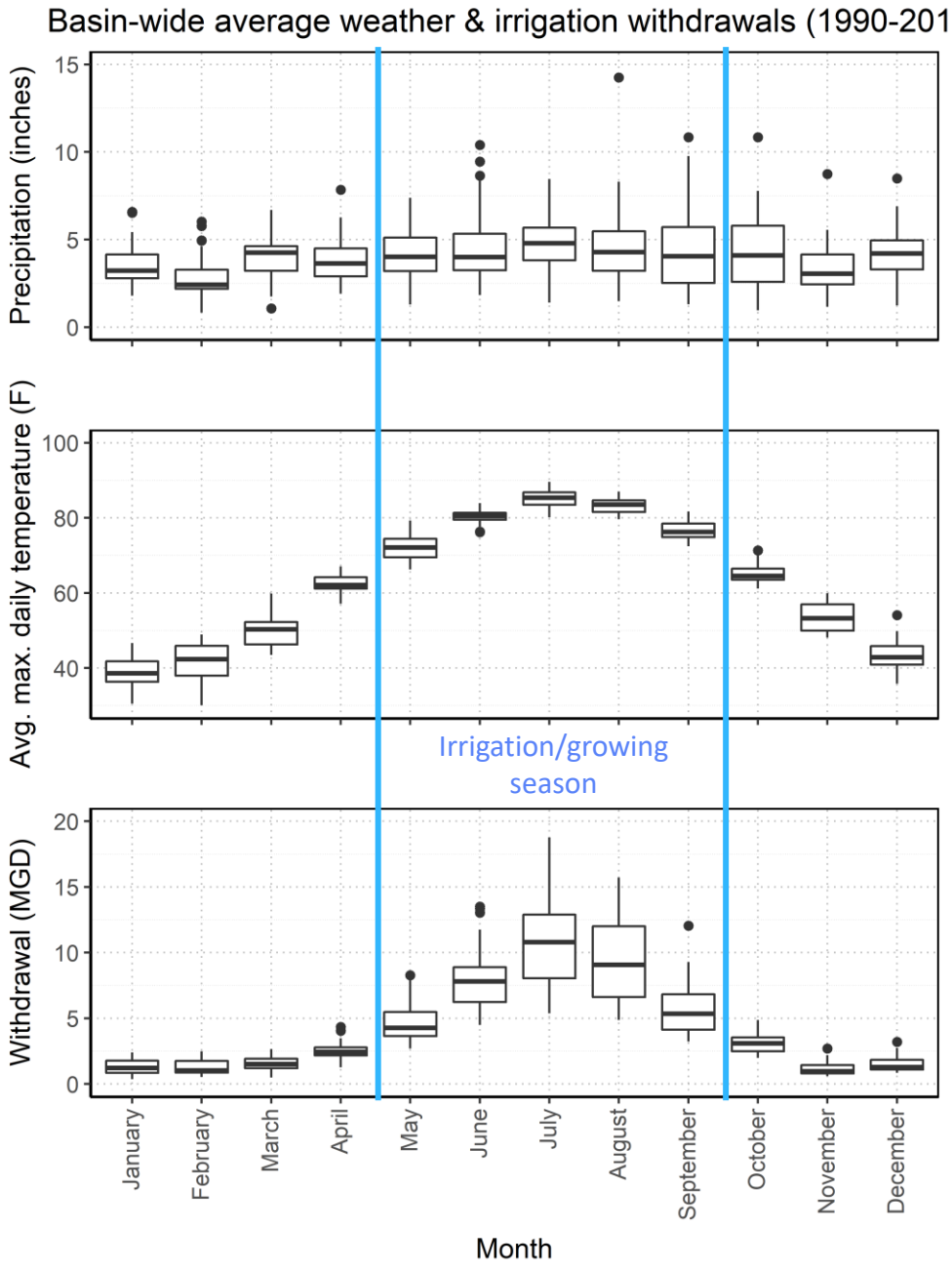

Month	Median MGD	Percent
January	1.235	2.52%
February	1.044	2.13%
March	1.531	3.13%
April	2.452	5.01%
May	4.285	8.75%
June	7.817	15.96%
July	10.804	22.06%
August	9.078	18.53%
September	5.357	10.94%
October	3.095	6.32%
November	0.978	2.00%
December	1.301	2.66%

56.6% 76.2% 87.6% 92.7%

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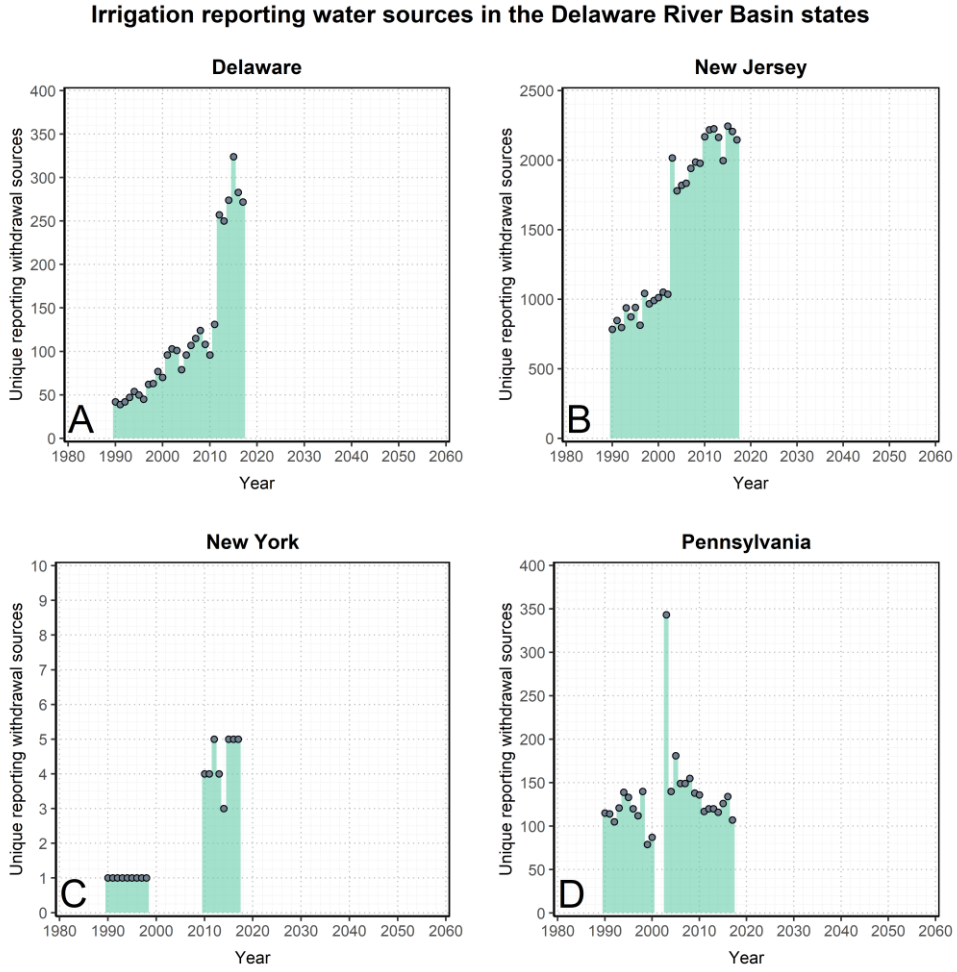

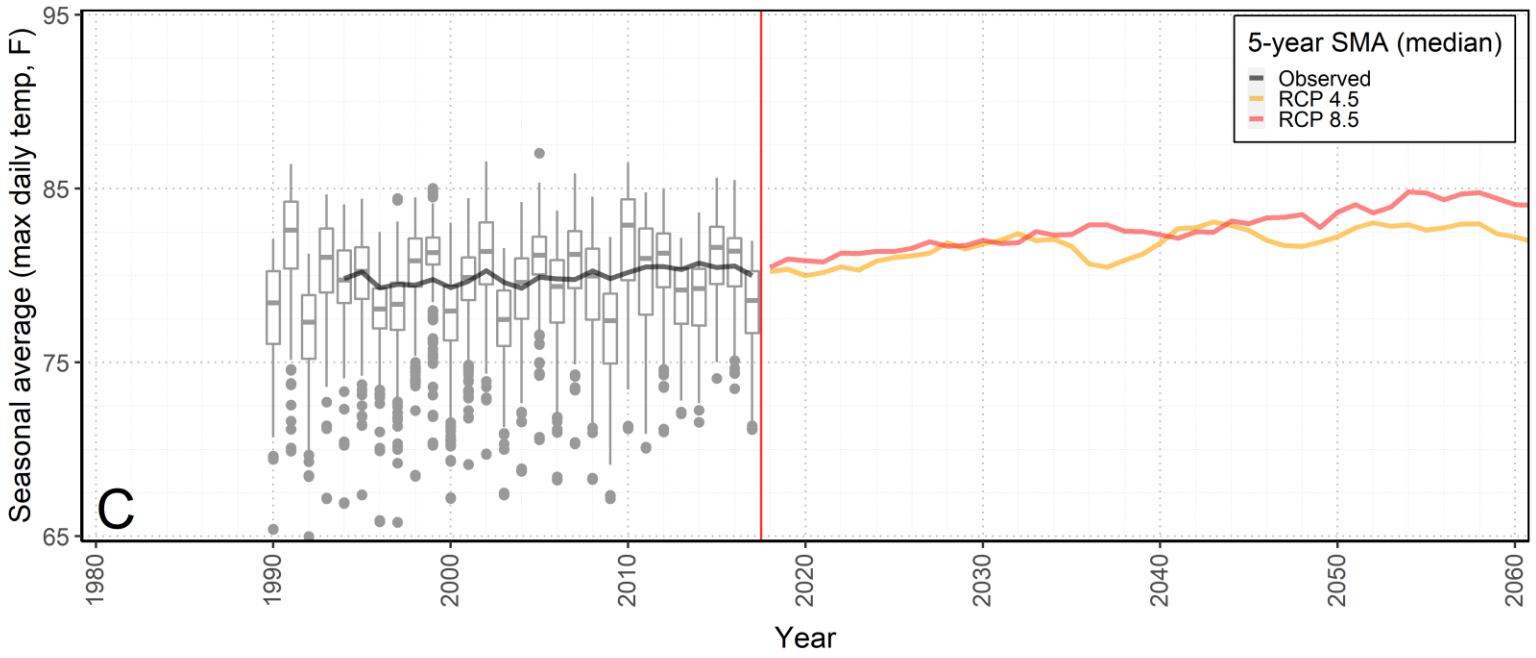

SIMPLIFY

CALIBRATE

Constant Temperature Precipitation No. Sources

$$W_{i,j,t} = \alpha_j + \beta_j T_{i,t} + \gamma_j P_{i,t} + \delta_j S_{i,j,t}$$

PROJECT

$$W_{i,j,t} = \alpha_j^* + \beta_j T_{i,t}$$

where,

$W_{i,j,t}$	=	The annual withdrawal from subbasin *i* at year *t*, where *j* is either GW or SW
$\alpha, \beta, \gamma, \delta$	=	Constants from a linear regression, where *j* is either GW or SW
$T_{i,t}$	=	Seasonal average daily max temperature (°F) for subbasin *i*, at year *t*
$P_{i,t}$	=	Seasonal total precipitation (inches) for subbasin *i*, at year *t*
$S_{i,j,t}$	=	The number of sources resulting in the annual withdrawal for $W_{i,j,t}$

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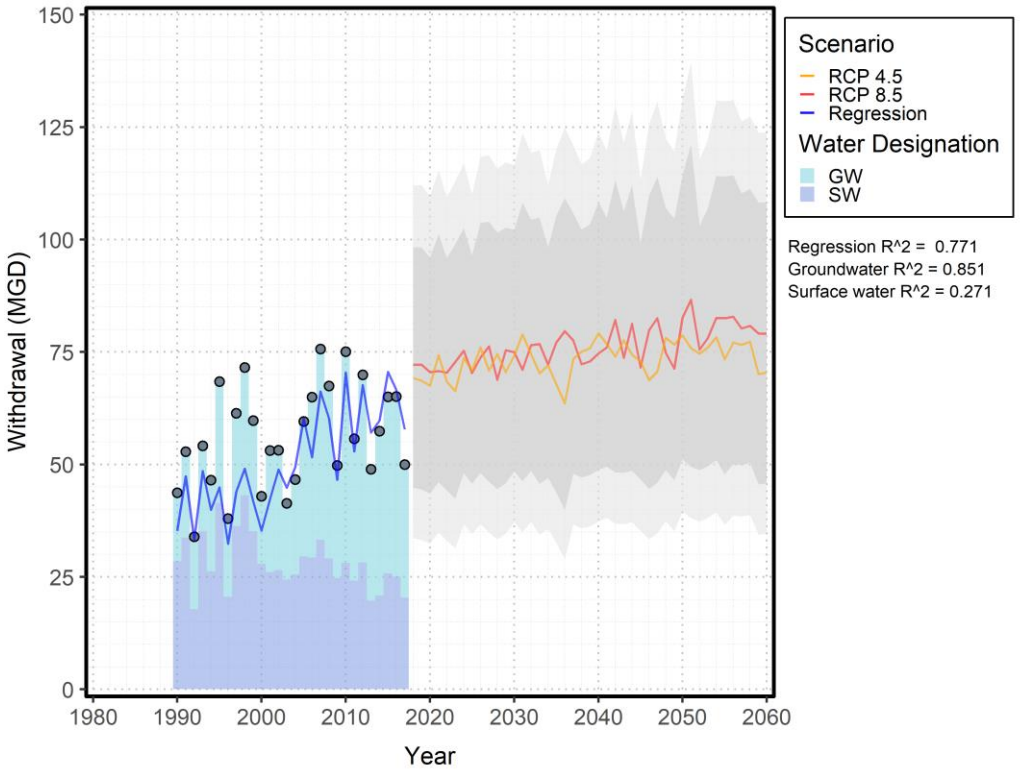
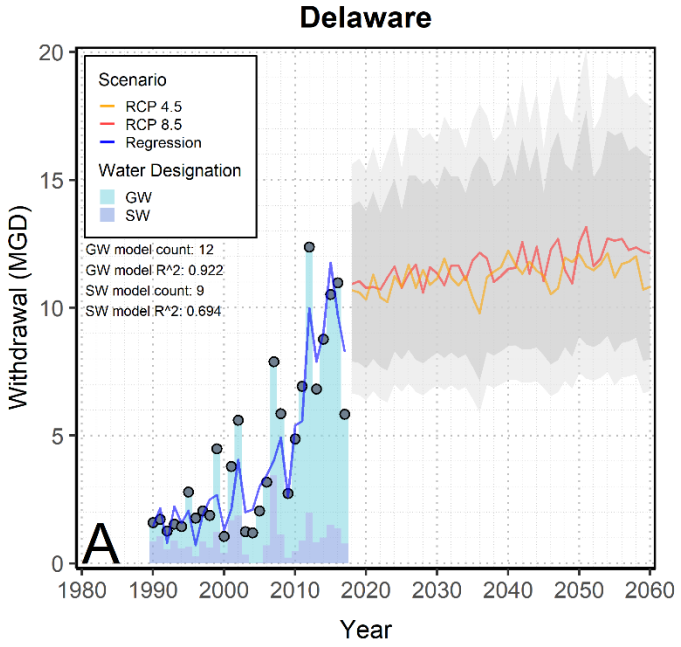
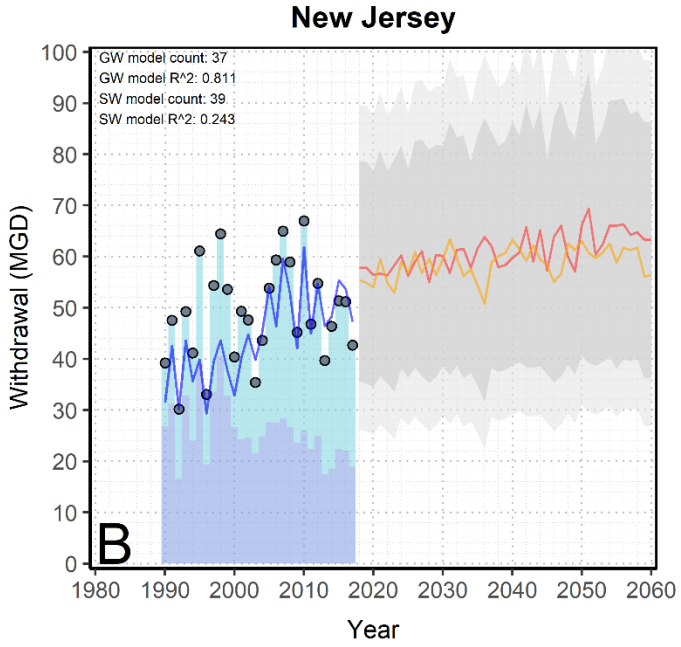
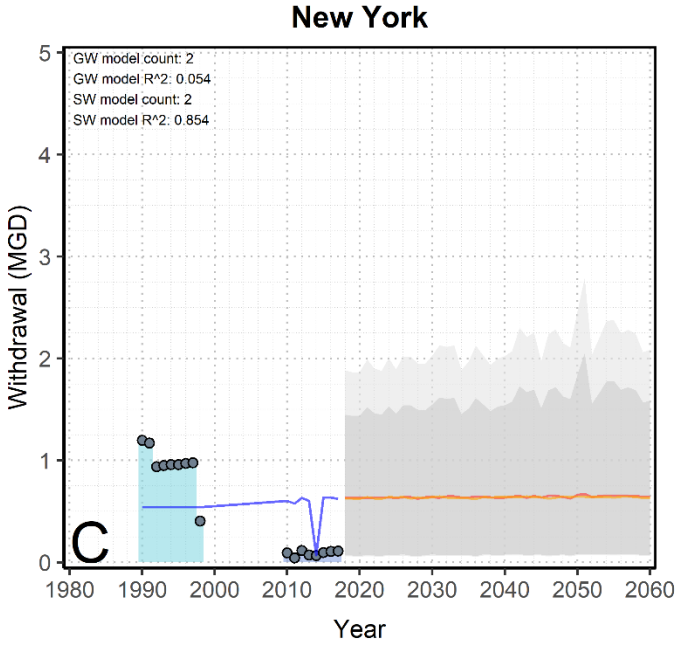
Projected irrigation water withdrawals from the Delaware River Basin

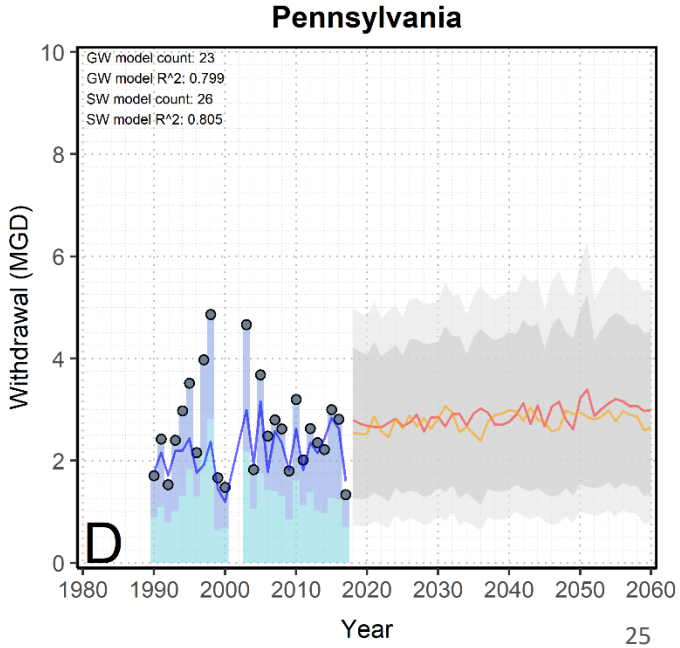


Projected irrigation water withdrawals from the Delaware River Basin states









60 years 1961–2021
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7. Next Steps

* Groundwater availability
  * 147 HUC scale
  * SEPA GWPA scale
* Surface Water availability
  * Consider effects of climate change
  * Consider reservoir operations
  * Consider the Drought of Record

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8. Questions

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