Projections of the Public Water Supply Sector in the Delaware River Basin

Water Management Advisory Committee

October 21, 2020

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Delaware River Basin Commission
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Outline

1. Water Supply Planning – Why, How, What?
2. Water Use Data *et al.*
3. Methodology
4. Results
5. Next Steps

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/.

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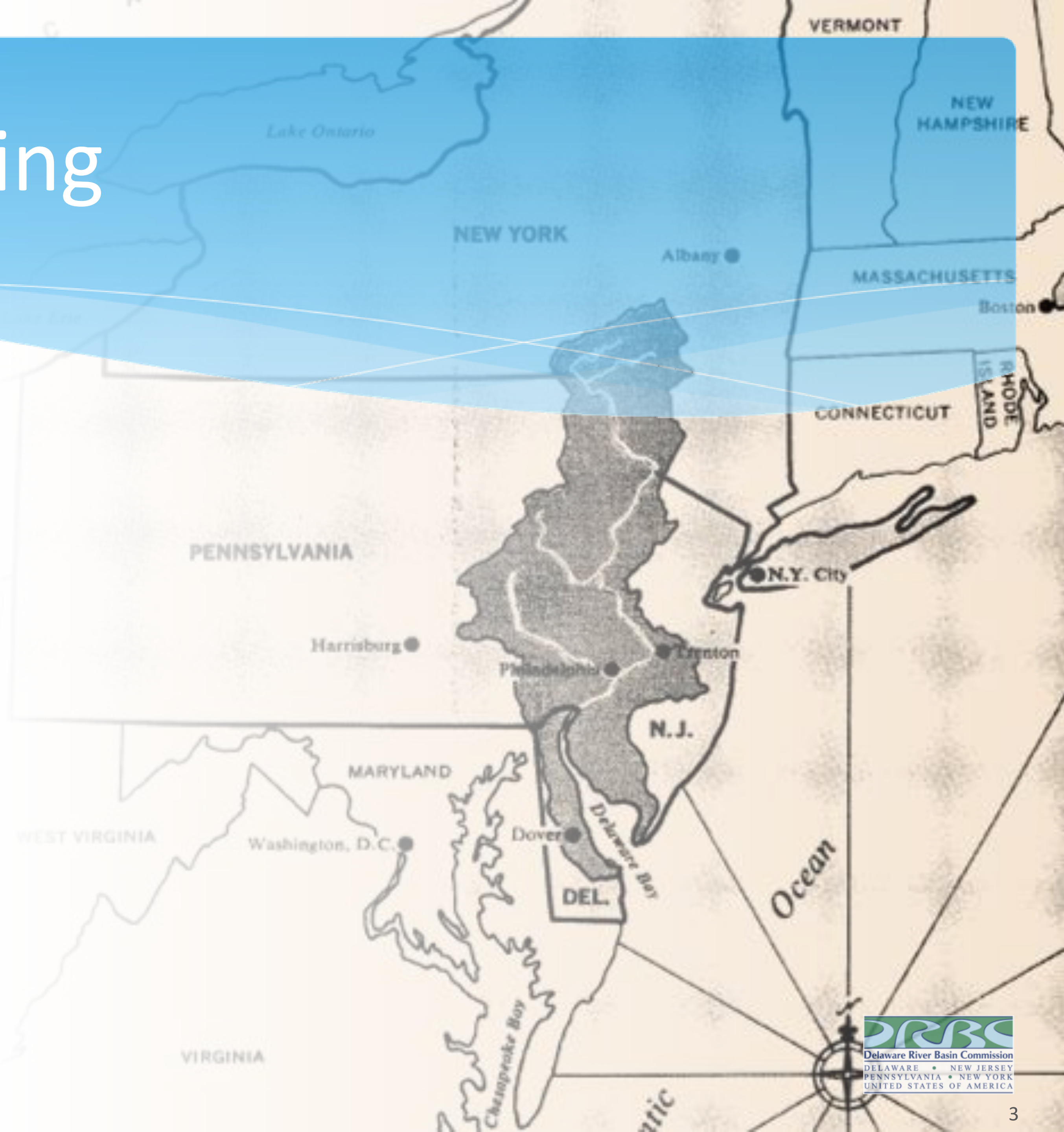
1. Water Supply Planning

"Dynamic equilibrium is the planning goal."

- DRBC Comprehensive Plan, 1973



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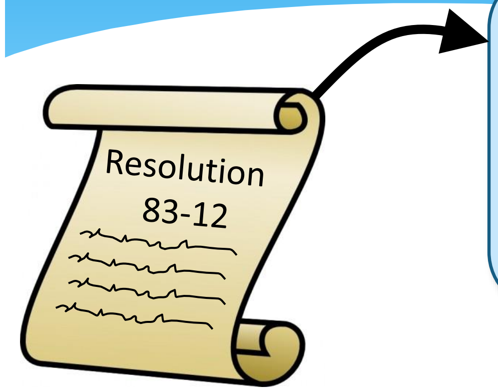
1. Water Supply Planning: Why are we projecting water use?



18 CFR 410 §2.400.1 - Water Supply
The drought of record, which occurred in the period 1961-1967, shall be the basis for determination and planning of dependable Basin water supply.

Is there enough water to meet future demand during a repeat of the Drought of Record (DoR) where water has been allocated?

1. Water Supply Planning: What authority is there to do so?

DELAWARE RIVER BASIN COMPACT (1961)

3.6 General Powers. The commission may:

…

"(c) Conduct and sponsor research on water resources, their planning, use, conservation, management, development, control and protection, and the capacity, adaptability and best utility of each facility thereof, and collect, compile, correlate, analyze, report and interpret data on water resources and uses in the basin, including without limitation thereto the relation of water to other resources, industrial water technology, ground water movement, relation between water price and water demand, and general hydrological conditions;"

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1. Water Supply Planning: What's been done?

The Delaware River near Trenton (Calhoun Street Bridge) in November, 1963.

1962 – Comprehensive Plan #1*

1973 – Comprehensive Plan #2 (Draft)**

1975 – Water Mgmt. of the DRB (staff report)

“Indefinite delay” of Tocks Island

1978 – Res. # 78-20. DRBC calls upon Decree Parties for “Good Faith” Discussions

1981 – “Level B Study”

1983 – Good Faith Agreement (GFA)

→ Resolutions Updating the Comprehensive Plan (Water Code) with GFA recommendations; defines DoR as planning benchmark
--
FMTAC Interim Report – With repeat of DoR; Montague & Trenton flow targets and NYC & NJ diversions cannot be met. 14 BG deficit

1985 – Depletive Water Use Budget

2000 – Consumptive Use Analysis

2001 – Comprehensive Plan #3

2004 – “Basin Plan”

2005/06 – Supply Demand Study

DRBC/USGS: Est. GW Availability Study

2007/08 – DRBC/USACE: Multi-jurisdictional Study

2010-13 – Key Sector Trend Analysis

Present – 2060 Water Supply Availability

Drought of Record 1961-1967

Reservoir Building: Cannonsville, Beltzville, Blue Marsh

GFA & Revisions

FFMP

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1. Water Supply Planning: Past presentations to WMAC

Not limited to:

10/18/2011 – Presented withdrawal history for 40 industrial facilities, 38 thermoelectric power generating facilities and 40 public water supply facilities

10/22/2013 – Introduction of the vision document for DRBC's "Sustainable Water Resources 2060"

10/16/2014 – Outlined water supply planning initiatives for the DRBC, included but not limited to:

- *Basin-wide model* to *Identify/develop adequate evaluation tool (spatial and temporal capabilities)*
- *Use and Availability Analysis* to *Update water supply and demand forecasts*.
- *Consumptive Use Analysis* to *Update consumptive use basin-wide*

02/19/2015 – "Sustainable Water Future 2060" presentations (DRBC and USACE)

This presentation provides preliminary water use projections which may likely be involved in future planning tasks put before WMAC.

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. Water Use Data

“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

2. Water Use Data: Thank you state partners and regulated community

pennsylvania
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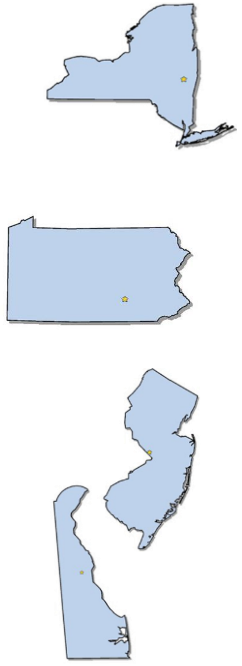
DEPARTMENT OF ENVIRONMENTAL PROTECTION NEW JERSEY

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

DEPARTMENT OF ENVIRONMENTAL CONSERVATION • NEW YORK STATE •

2. Water Use Data: What does it look like?

Source; Supplier; Time; Volume

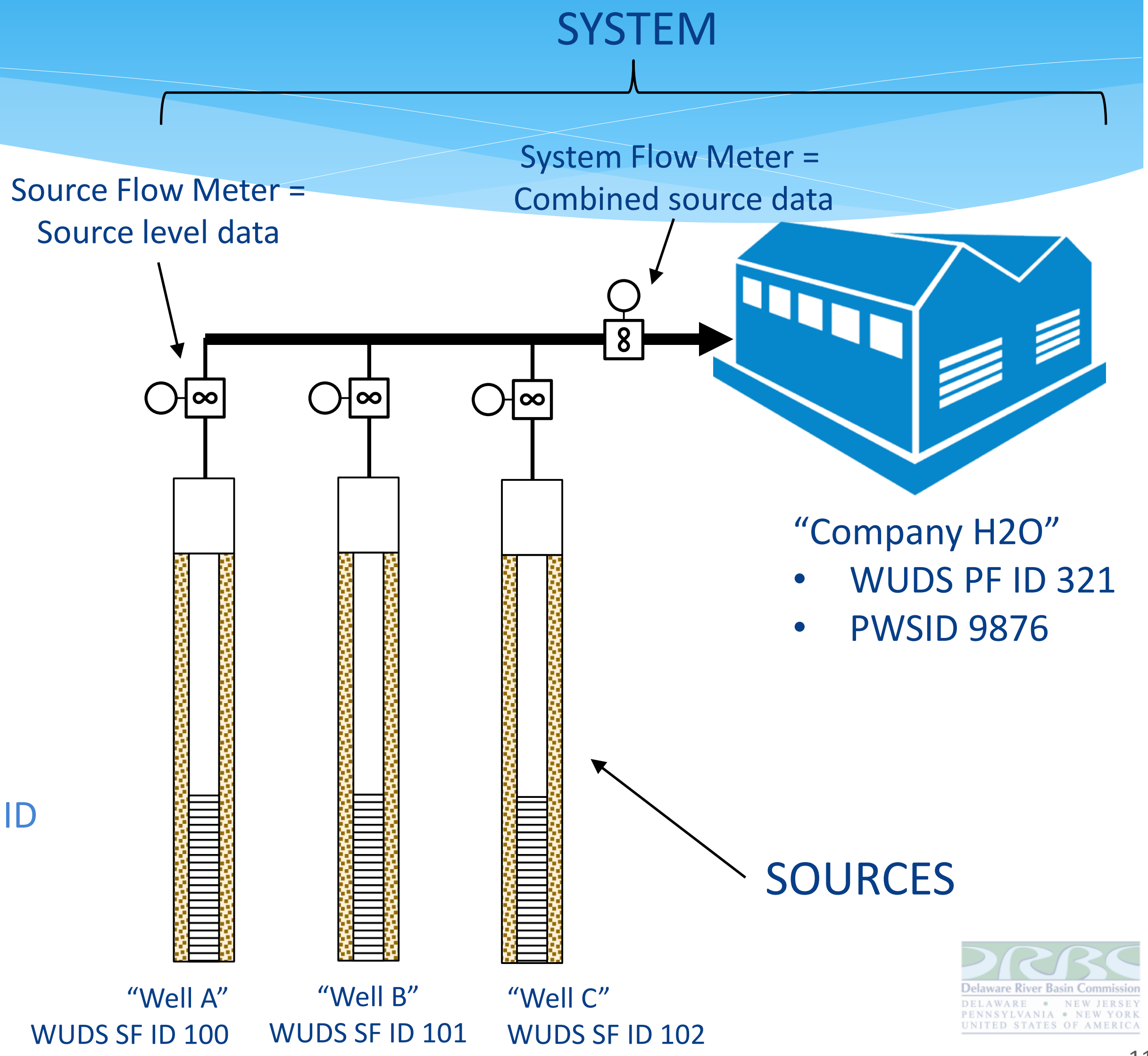


New York:
(System Level) NYSDEC ID

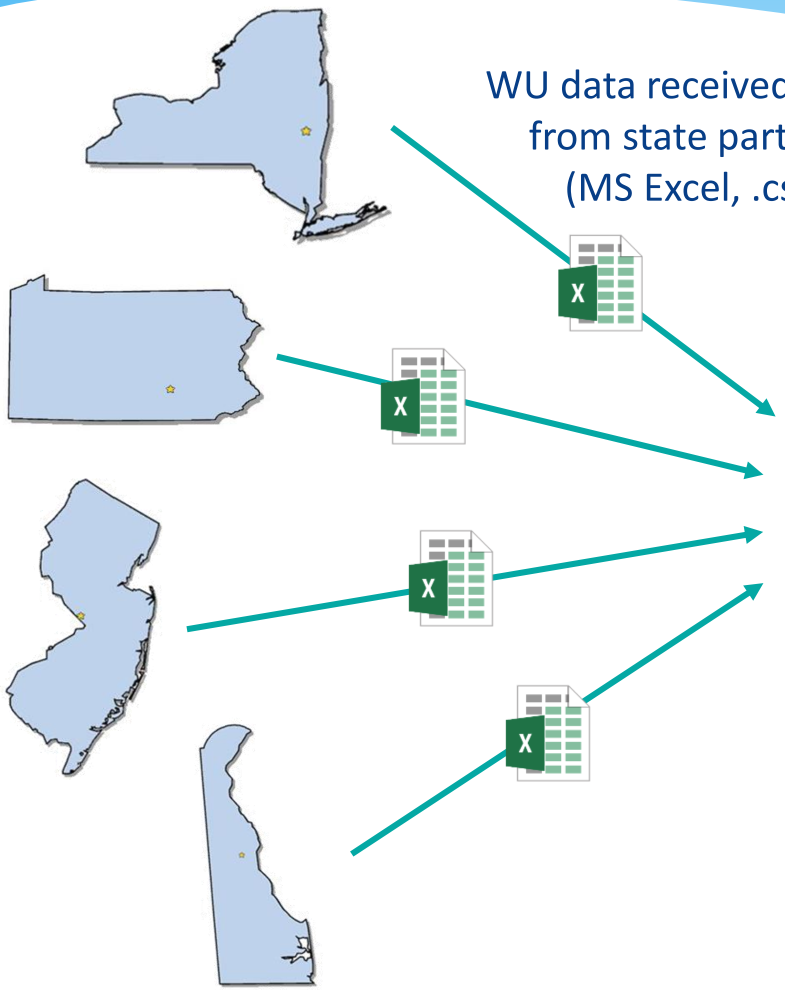
Pennsylvania:
WUDS = Water Use Data System
(System Level) WUDS PF ID – "Primary Facility ID"
(Source Level) WUDS SF ID – "Sub Facility ID"

New Jersey:
(System Level) NJPIID – New Jersey Program Interest ID
(Source Level) NJSIID – New Jersey Subject Item ID

Delaware:
(Source Level) DNREC-ID

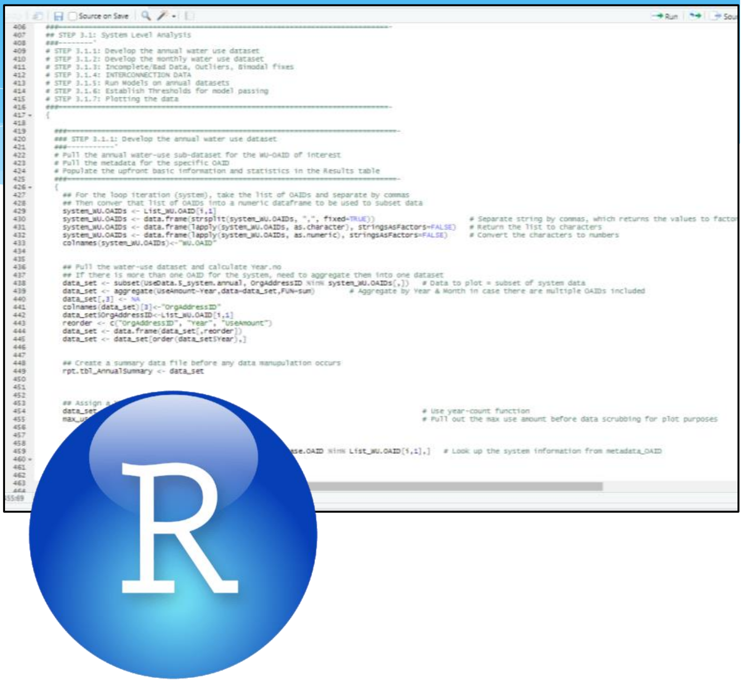


2. Water Use Data: Where does it come from?



WU data received yearly
from state partners
(MS Excel, .csv)

Query the data for specific systems



DRBC staff:

- Review data (QAQC)
- Assign our own IDs
  (System Level) OAID = OrgAddressID
  (Source Level) WSID = WaterSourceID
- Upload to a large MS Access Database

Analyze data outputs using computational programs such as R-Studio, able to handle millions of rows of data

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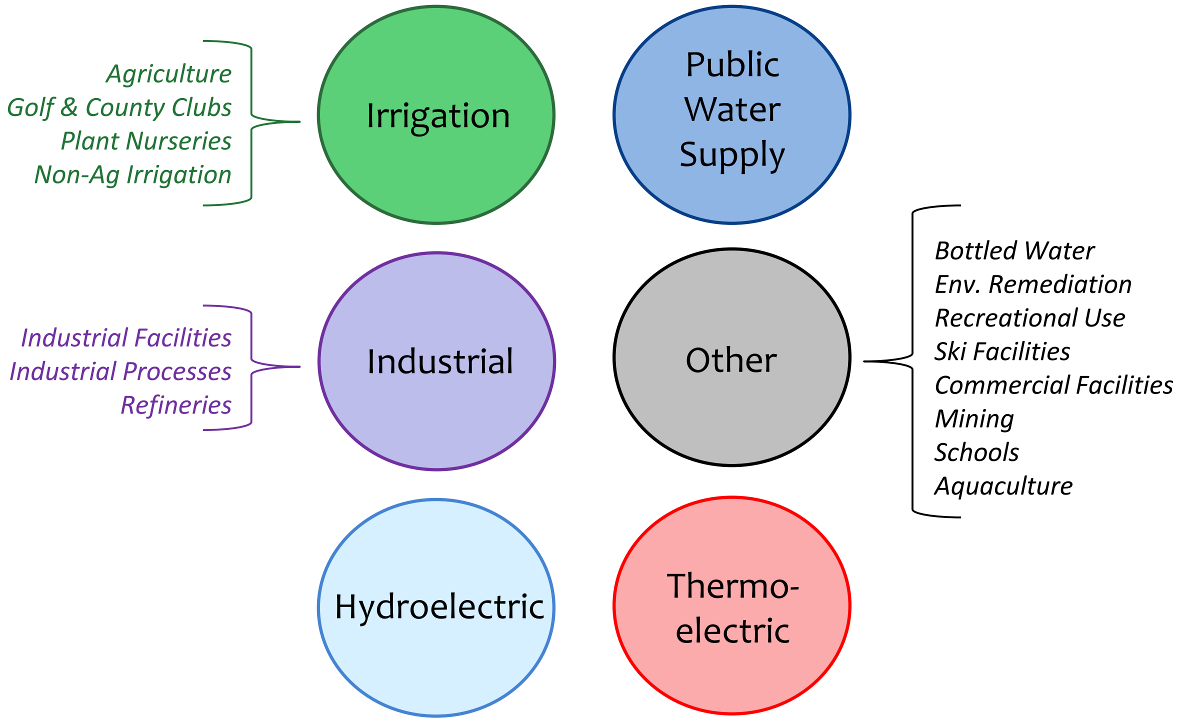
2. Water Use Data: Metadata

Geospatial information
(i.e. where is the source of withdrawal)

AWWA Water Audit data
(e.g. non-revenue water)

Interconnection data
(i.e. water transferred between systems)

Water use category & sector
(i.e. how to describe the water use)



2. Water Use Data: What is “Public Water Supply” water use?

Technically

The Safe Drinking Water Act of 1974 defined the term public water supply system as “*a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals*”

Further defined by individual states’ regulations…

Pragmatically…

Water withdrawals from sources in the DRB, tagged as “Public Water Supply”

- Generally sources are initially categorized by state agencies
- QAQC during DRBC uploads

2. Water Use Data

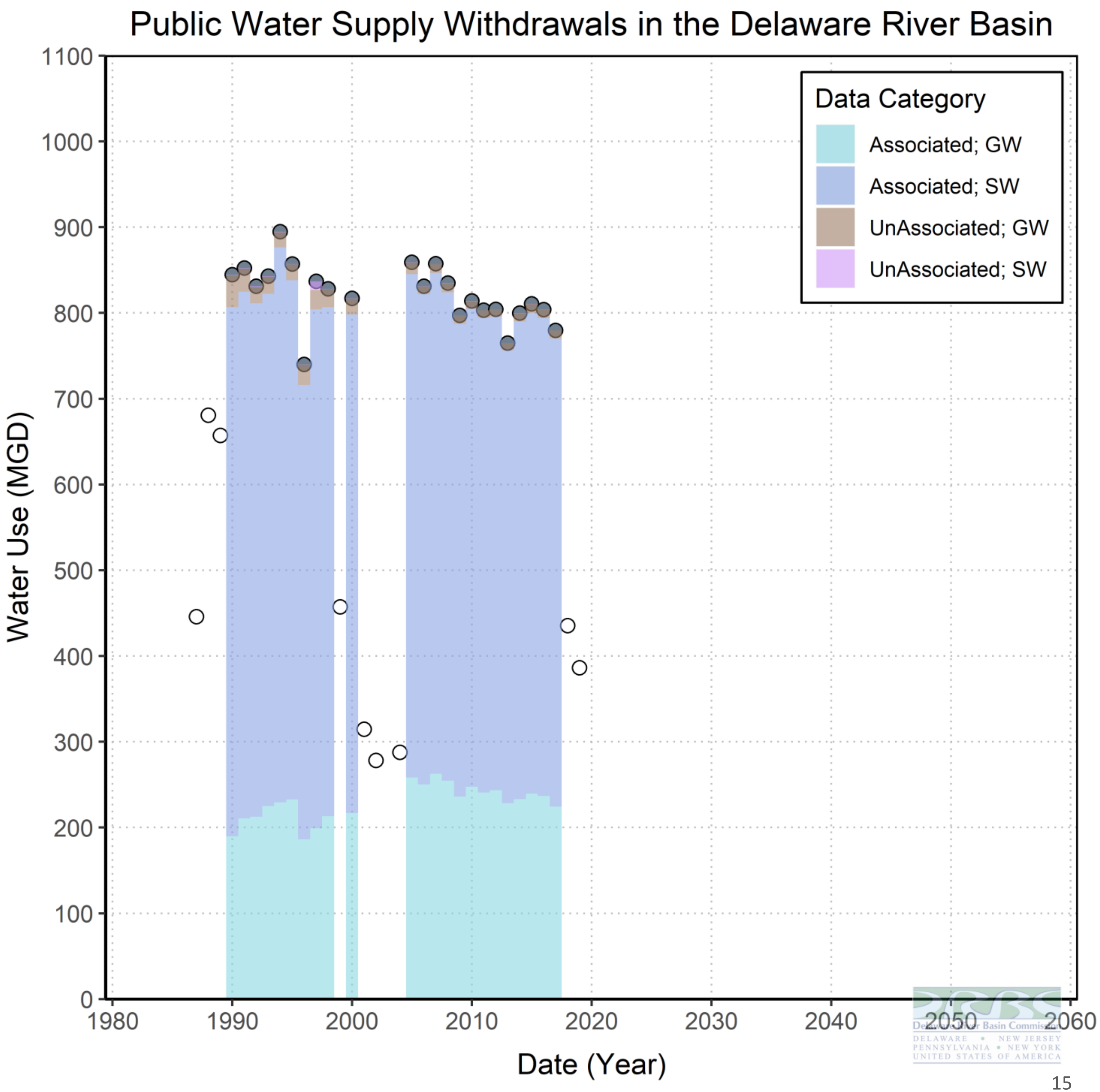
Focus on…

1. Systems subject to DRBC water audit reporting requirements, and
2. Systems with DRBC approval, but operate below water audit thresholds

QAQC against reported data

Data Category	Systems (OAIDs)	Water Type	Sources (WSIDs)	Avg. WD (MGD)	Percent Total WD
Associated	346*	GW	2,085	235.190	28.8%
		SW	131	573.339	70.1%
Unassocaited	586	GW	1,237	8.631	1.1%
		SW	30	0.238	0.0%
Totals:	932	--	3,483	817.397	100.0%

* Accounts for 332 public water supply systems.

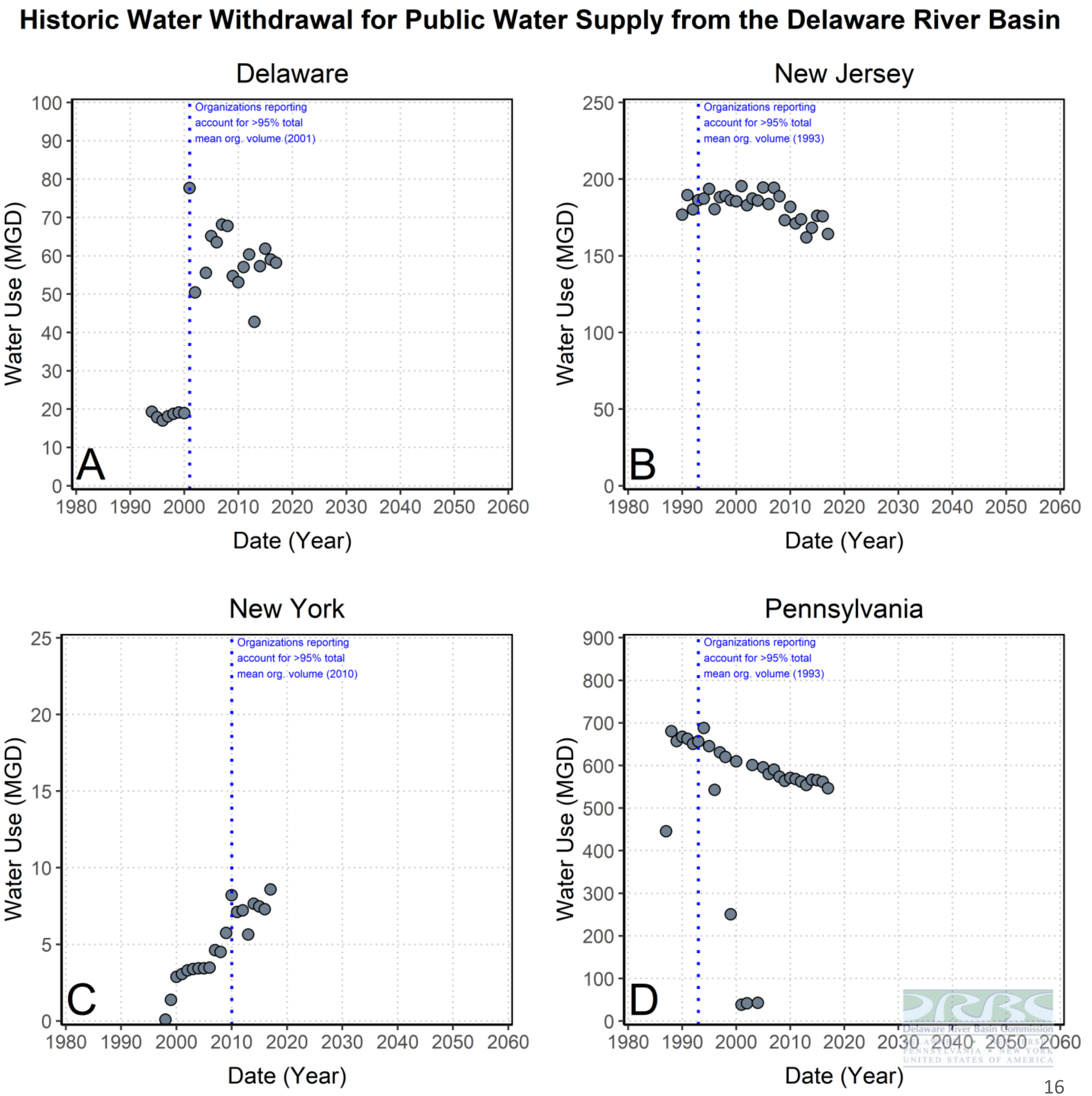


2. Water Use Data

Aggregation of data can disguise reporting inconsistencies as trends in water withdrawal

Major exclusions from study:

- NYC reservoir diversions
- NJ Raritan Canal diversion
- Intra-basin transfers
- Self-supplied domestic



3. Methodology

"Though conceptually appealing, it is impossible to fully account in practice for all the individual decisions and behaviors that constitute the nation's water use."

- National Research Council, 2002

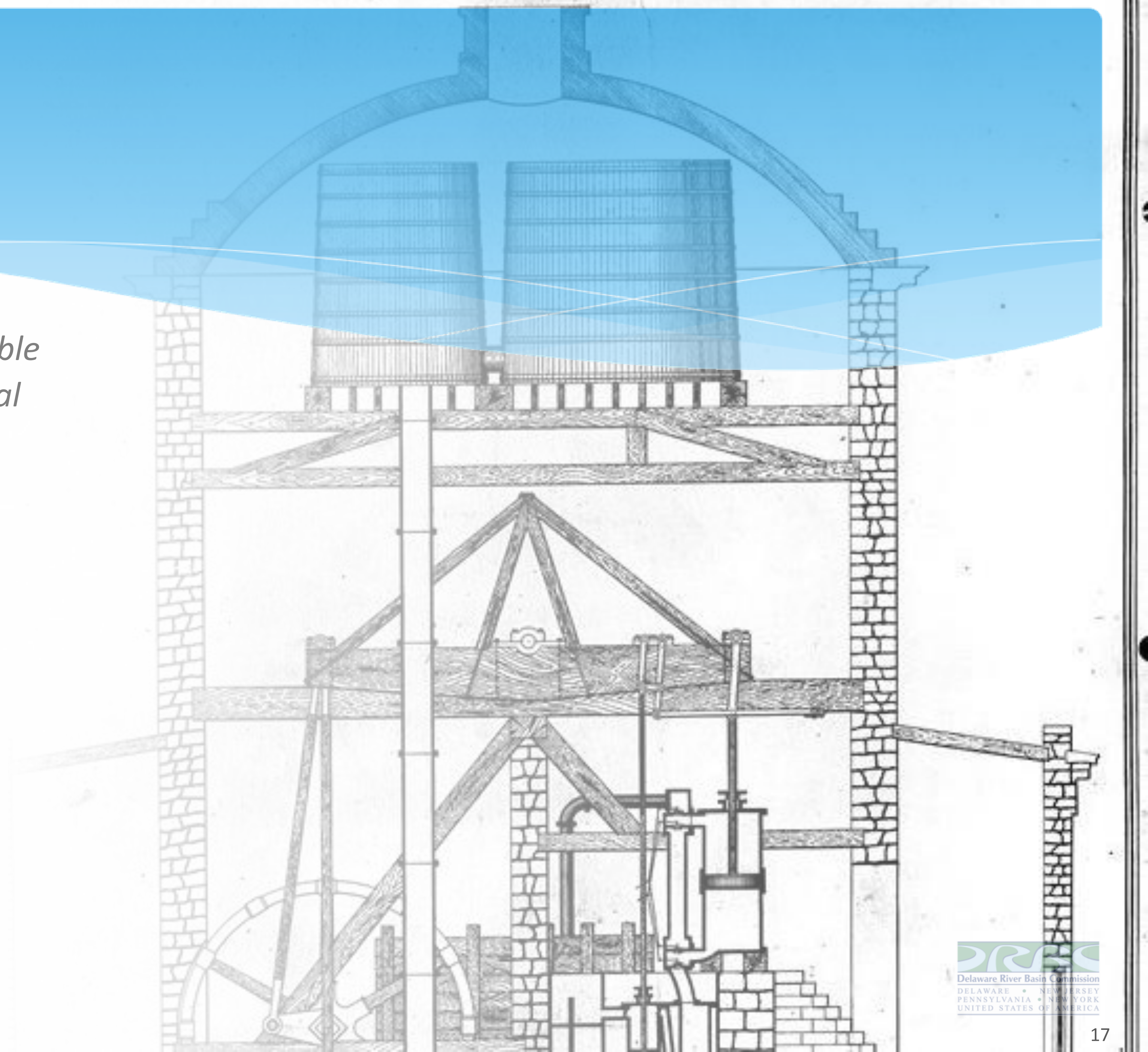


Image adopted from: http://www.waterworkshistory.us/PA/Philadelphia/

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3. Methodology: What have other studies done?

[1] Does not necessarily correspond to the entire basin size.
[2] Does not include basin scale, as all studies provided this result.

Study	Study Region	Study Scale[1] (mi^2)	Major States	Projected data used for estimating PWS	Projected data scale	Reported Results Scale[2]	Future: Water Use	Future: Consumptive Use	PWS Projection Method: Extrapolation of historic withdrawal data	PWS Projection Method: Population growth rate applied to current water	PWS Projection Method: Per-capita rates applied to population	PWS Projection Method: Considered multiple projection scenarios	PWS Projection Method: Temporally variable per capita rates	PWS Projection Method: Considers climate change
(Hutson et al, 2004)	Tennessee River Watershed	40,910	AL, GA, KY, MI, NC, TN, VA	No. households	County	RCA, WUTA	X	X			X			
(ICPRB, 2012)	Potomic River Basin	14,670	DC, MD, PA, VA, WV	Population	County	County	X	X			X	X	X	X
(USDOI, 2012)	Colorado River Basin	246,000	AZ, CA, CO, NM, NV,UT, WY	Population	*NA*	State	X				X	X	X	
(USDOI, 2016)	Klamath River Basin	15,700	CA, OR	Population	County	County		X			X	X		X
(SRBC, 2016)	Susquehanna River Basin	27,502	MD, NY, PA	Population	County	HUC-10		X		X				
(Robinson, 2019)	Cumberland River Watershed	17,900	KY, TN	Population	County	RCA	X	X			X			
(Sabzi et al, 2019)	Red River Basin	65,595	AK, LA, NM, OK, TX	Water use	County	County		X	X					X

Van Abs et al., 2018 / NJDEP

- Performed at PWS system level
- Dasymetric analysis for population distribution with MPO projections
- Utility surveys and refined per-capita rates
- Multiple sets of projection scenarios, accounting for water loss and conservation
- Recommended model Δ * NJWaTr avgs.

Delaware WSCC Studies

- Three studies: SNCC (2006), KSC (2014), NNCC (2018)
- Largely based population projections applied to an est. benchmark of use
- Studies were performed at utility level
- NNCC also provided extrapolation/trend
- KSC also provided climate change scenarios

PA SWP – Appendix I

- Pilot study of the projection methodology for Lehigh River Basin
- Split 2003 water use by service area into residential and non-residential
- Develop per-capita and per-employee
- Apply rates to pop. & emp. projections

3. Methodology: What is this study doing?

Two main categories:

- **DIRECT**
- **INDIRECT**

Estimating Water Use

DIRECT
- complete inventory approach
- stratified random sampling approach

INDIRECT
- coefficient-based methods
  (e.g. per-capita estimations)
- multi-variate regressions
  (e.g. factors affecting water-use)
- econometric methods
  (similar to multi-variate)

Projecting Water Use

DIRECT
- Trend extrapolation (OLS regression)
- Exponential smoothing
- ARIMA

INDIRECT
- Coefficients & indirect forecasts
  (e.g. per-capita applied to population projections)
- Disaggregated factor forecast
  (per unit use is fixed)
- Functional unit approach
  (multivariate model)

Some references:

NRC (2002). Estimating Water Use in the United States: A New Paradigm for the National Water-Use Information Program. Advance online publication. https://doi.org/10.17226/10484

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

PADEP. (2009). Pennsylvania State Water Plan – Appendix I. Harrisburg, Pennsylvania. Pennsylvania Department of Environmental Protection. http://files.dep.state.pa.us/Water/Division%20of%20Planning%20and%20Conservation/StateWaterPlan/StateWaterPlanPrinciples/3010-BK-DEP4222.pdf

USACE & DRBC. (2008). *Enhancing Multi-jurisdictional Use and Management of Water Resources for the Delaware River Basin, NY, NJ, PA, and DE*. Ewing, New Jersey. USACE Philadelphia District and the Delaware River Basin Commission. https://www.nj.gov/drbc/about/public/multi-juris-study.html

3. Methodology: What scale to analyze?

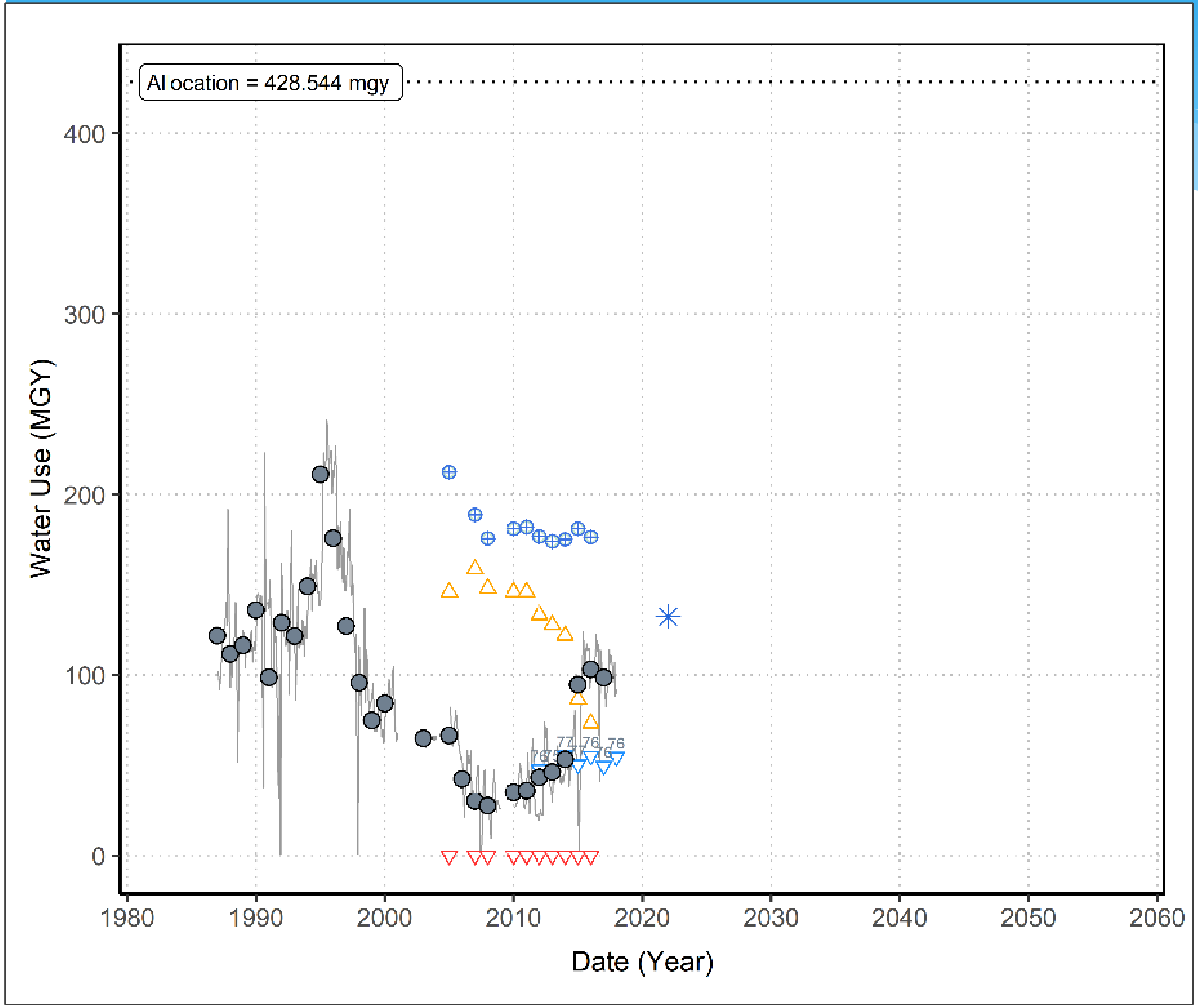
Recall planning objectives…

Analysis at the system level

Projections at a scale finer than the system level…

- Pertinent metadata is often at the system level
- Reporting inconsistencies disguised as trends
- System sources show cause-and-effect relationships

3. Methodology: Rationale for system level analysis



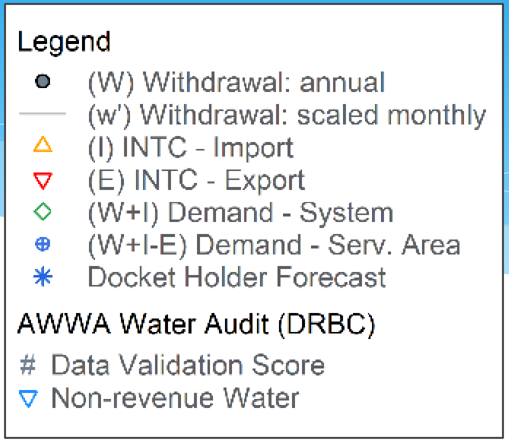


Figure #: An example public water supply system's annual withdrawal data. Interconnection data can be used to calculate other information, such as total service area demand. As may otherwise not be discernable, an operational shift is apparent around the year 2010 where bulk purchases begin to be replaced by source withdrawals. This suggests that an attempt to extrapolate the entire data set or ignoring the calculated total system demand would not be appropriate in reflecting the current operational trend. Note that interconnection data likely extends back beyond the dataset availability.

Pertinent metadata is often at the system level

3. Methodology: Rationale for system level analysis

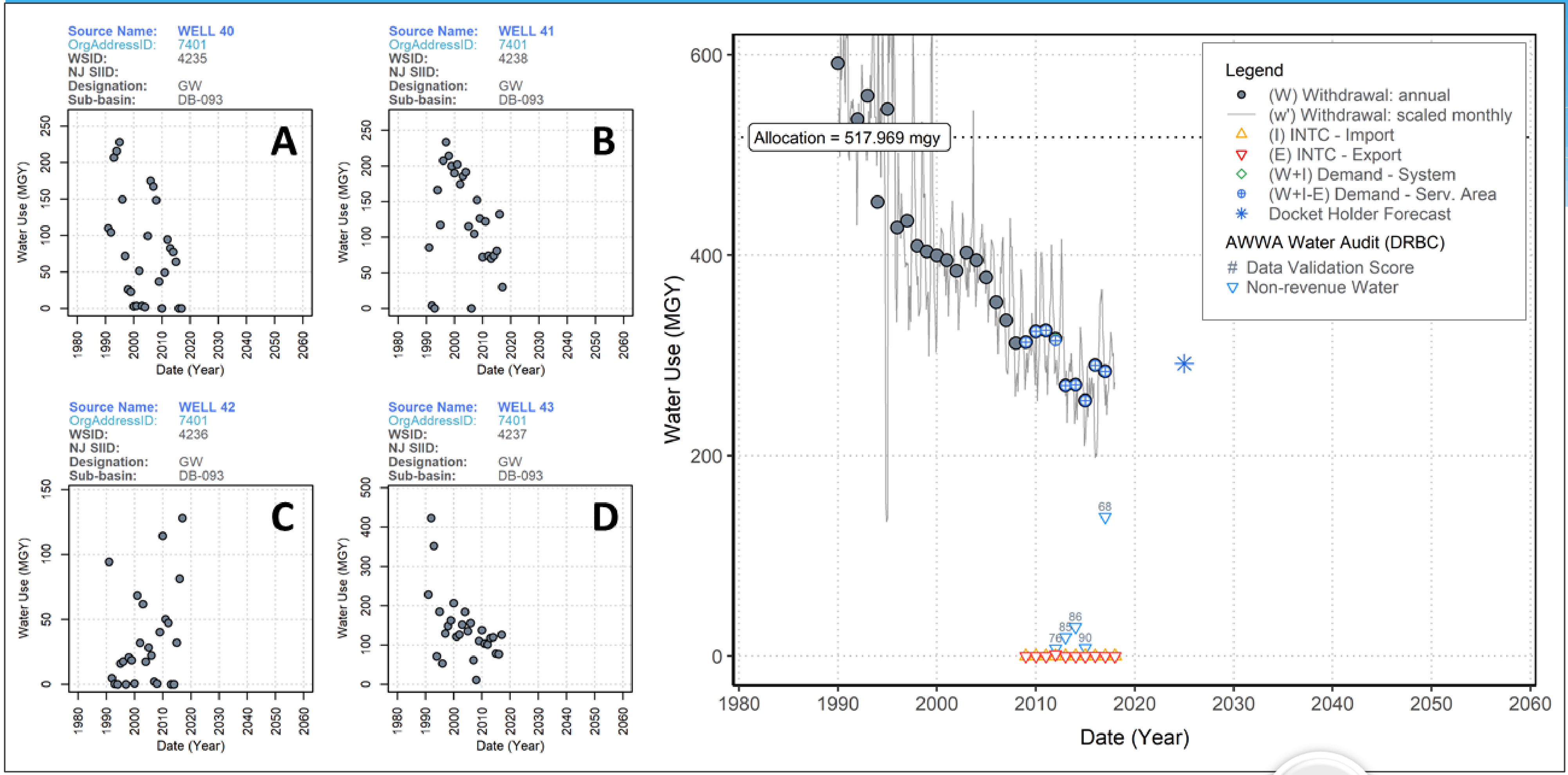


Figure #: An example of water withdrawal data associated with a public water supply system, comprised of four groundwater sources. These figures are representative of graphical outputs from the developed projection methodology. (A-D) The data associated with the four groundwater sources which comprise the system, all visibly having poor relationships between time and withdrawal volume. (E) The same data aggregated together to represent water withdrawal at the system level, demonstrating a strong relationship between time and withdrawal volume.

System sources show cause-and-effect relationship

3. Methodology: A plan for projecting data?

Where do we start?

Time-series hierarchy

Aggregate to results here

Level 1
(Sector level)

Level 2
(Regulatory level)

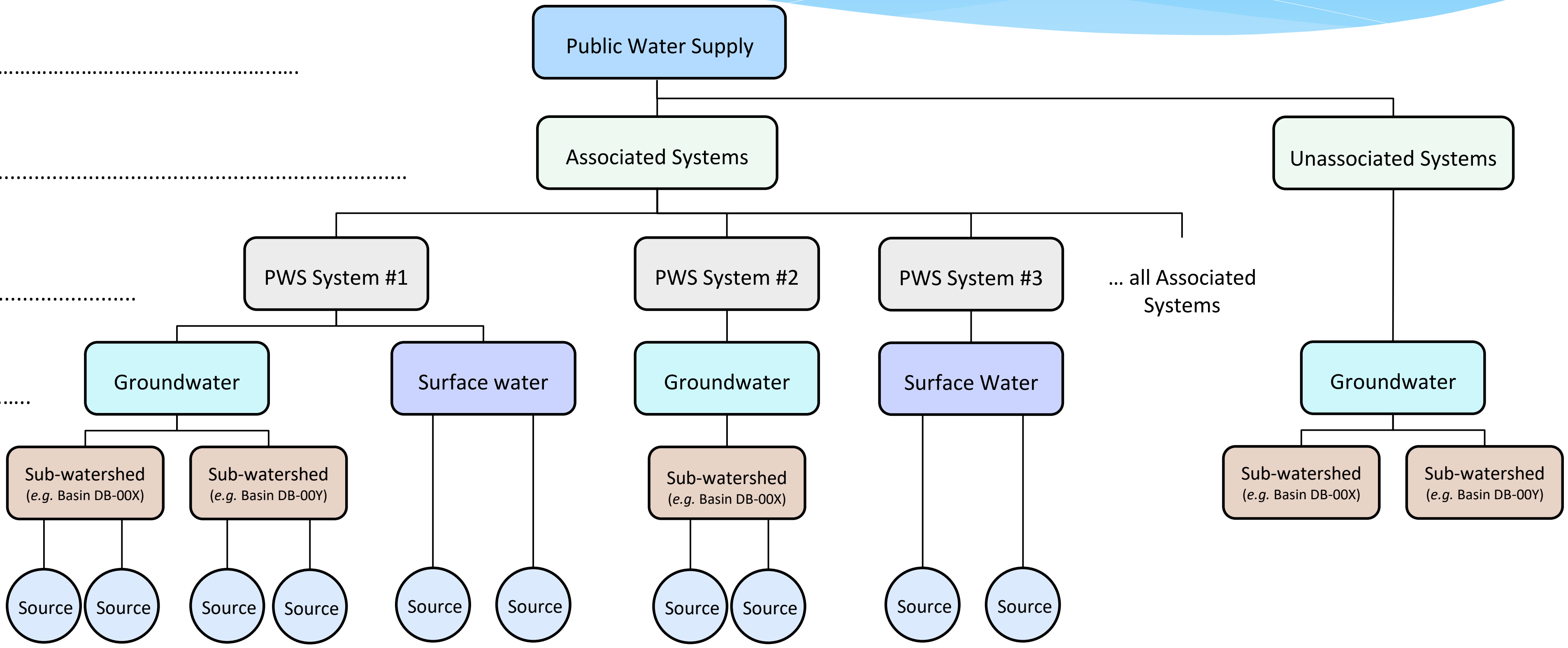
Level 3
(System level)

Level 4
(Source-type level)

Perform projections here

Level 5
(Sub-watershed level)

Level 6
(Source level)



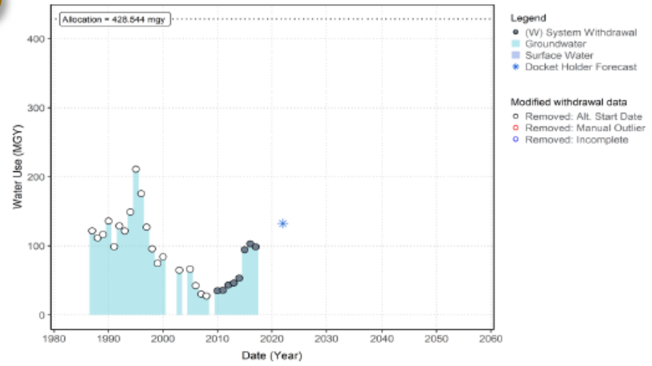
Hyndman, R., & Athanasopoulos, G. (2018). *Forecasting: principles and practice* (2nd ed.). Melbourne, Australia: OTexts. https://otexts.com/fpp2/

3. Methodology: A plan for projecting data?

Develop a report!

- Standardized
- 1 report per system
- Allows QAQC
- All analysis levels
- Staff review
- Result selection
- Store results

Org Name:
System Name:
WaterUse OAID:
State:
Docket No.:
Analysis: 1: System Level Analysis



Docket holder forecast (if available):

Description	Value	Units
Year of analysis:	2012	--
Predicted Year:	2022	--
Predicted Avg. Use:	0.363	MGD
Predicted Avg. Use:	132.495	MGY

All OrgAddressIDs for WSIDs included in analysis:

OAID	System Name
6694	

Annual data summary in analysis:

Year	UseAmount	With_GW	With_SW	INTC_IMP	INTC_EXP	Qualifier
1987	121.690	121.690	NA	NA	NA	Removed - bimodal
1988	111.490	111.490	NA	NA	NA	Removed - bimodal
1989	116.410	116.410	NA	NA	NA	Removed - bimodal
1990	135.980	135.980	NA	NA	NA	Removed - bimodal
1991	98.630	98.630	NA	NA	NA	Removed - bimodal
1992	128.920	128.920	NA	NA	NA	Removed - bimodal
1993	121.510	121.510	NA	NA	NA	Removed - bimodal
1994	149.000	149.000	NA	NA	NA	Removed - bimodal
1995	211.200	211.200	NA	NA	NA	Removed - bimodal
1996	175.600	175.600	NA	NA	NA	Removed - bimodal
1997	127.170	127.170	NA	NA	NA	Removed - bimodal
1998	95.641	95.641	NA	NA	NA	Removed - bimodal
1999	74.751	74.751	NA	NA	NA	Removed - bimodal
2000	84.252	84.252	NA	NA	NA	Removed - bimodal
2003	64.929	64.929	NA	NA	NA	Removed - bimodal
2005	66.490	66.490	NA	146.006	0.000	Removed - bimodal
2006	42.339	42.339	NA	NA	NA	Removed - bimodal
2007	30.174	30.174	NA	158.624	0.000	Removed - bimodal
2008	27.482	27.482	NA	148.090	0.000	Removed - bimodal
2010	34.870	34.870	NA	146.148	0.000	
2011	35.852	35.852	NA	146.105	0.000	
2012	43.275	43.275	NA	133.426	0.000	
2013	46.187	46.187	NA	127.784	0.000	
2014	53.236	53.236	NA	121.840	0.000	
2015	94.594	94.594	NA	86.500	0.000	
2016	103.064	103.064	NA	73.418	0.000	
2017	98.393	98.393	NA	NA	NA	

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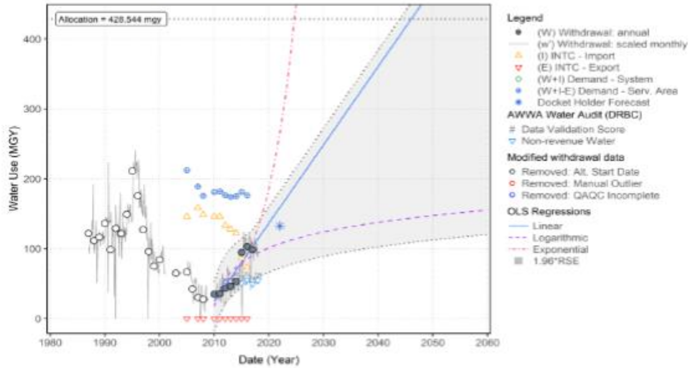
Org Name:
System Name:
WaterUse OAID:
State:
Docket No.:
Analysis: 1: System Level Analysis



Modeled data summary:

Param.	Value	Units
Mean:	63.684	mgy
Mean(5yr)	79.095	mgy
Median:	49.712	mgy
Sigma:	29.635	mgy
CV:	0.465	---
x-start:	2010	(i.e. x=1)
NumPts:	8	---

System model thresholds:

Description	Threshold
Adj. R2 min:	0.2
p-value max:	0.05
2060_bottom:	0
2060_runaway:	10
2060_horiz:	0.75-1.25

Withdrawal QAQC thresholds:

QAQC Param.	Threshold
No. months (>=):	3
Low-limit (mgm,<=):	0.01
Bimodal Year:	2009
Outlier Year(s):	NA

System model results summary:

Model	Adj. R2	p-value	2060(mgy)	b-coef	c-coef	1.96_SE	P/F	
LIN	0.835	0.001	584.997	13.234	11.211	23.585	Pass	Equation: y = c*X + b
LOG	0.641	0.010	155.044	17.217	35.054	34.804	Pass	Equation: y = (c*Ln[X]) + b
EXP	0.890	0.000	##########	25.916	0.179	22.267	Fail	Equation: y = b * e^(c*X)

WSID's included in the analysis:

WSID	No. OAID(s)	Desig.	WU-CatID	HUC-147	NoRecords <>(NA,0)	Start	End	Source Name
1723	1	GW	21	DB-123	318	1987	2017	
16401	1	GW	21	DB-123	38	2014	2017	

WSIDs not included in this analysis:

WSID	No. OAID(s)	Desig.	WU-CatID	In DRB?	Reason Excluded	Source Name
7310	1	SW	21	FALSE	No coordinates available	

INTC's included in the analysis:

PWSID	Primary_WUDS	OAID	Imp_Exp	ToFrom_PWSID	ToFrom_WUDS	ToFrom_OAID	UseAmount	ToFrom_Name
--		6694	Import	--		419	981.2	
--		6694	Import	--		6694	306.7	
--		6694	Export	--		419	0.0	
--		6694	Export	--		6694	0.0	

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3. Methodology: How do you aggregate projections?

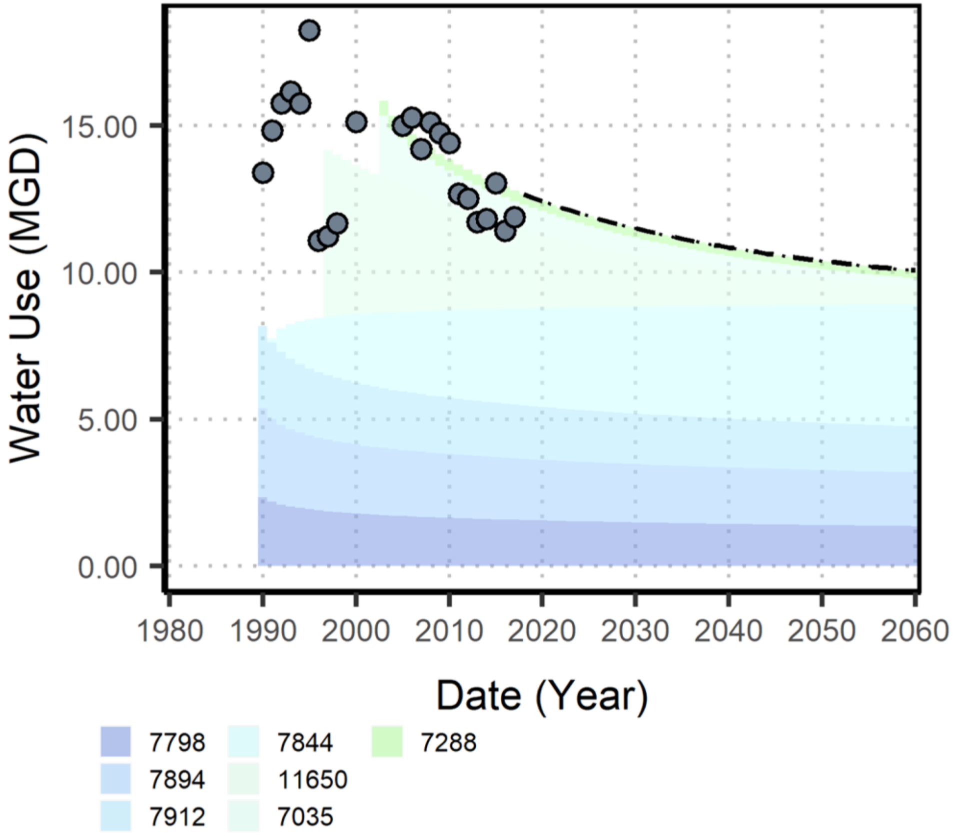
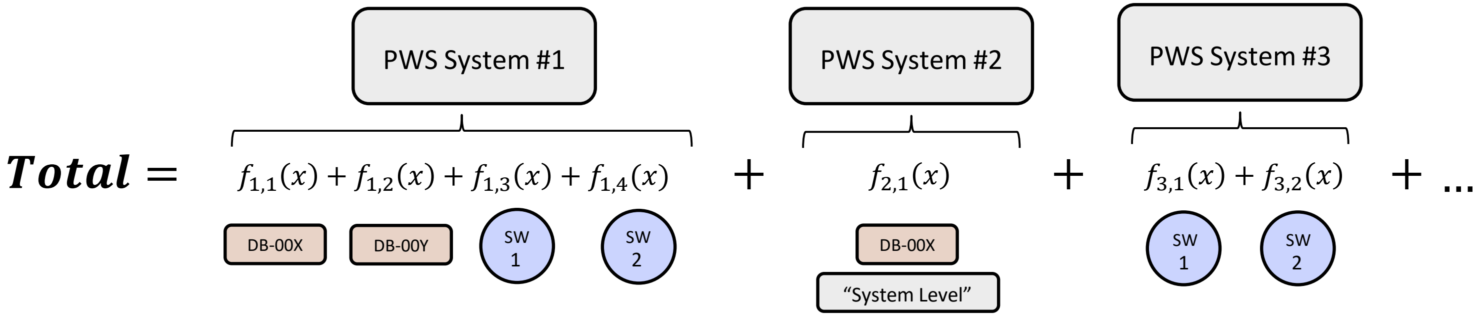


Figure #: An example of a single sub-watershed, with multiple projections for public water supply systems using groundwater, aggregated against respective data.

"Bottom-up approach"



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3. Methodology: Major assumptions

"the rate of change in water use over the recent past is assumed to continue into the future are the same rate of change."

"(a) there is no correlation between time and factors that affect water use, or that (b) time and factors that affect water use are perfectly correlated".

- Prediction intervals
- Best professional judgement
- Metadata / reports

PADEP. (2009). Pennsylvania State Water Plan – Appendix I. Harrisburg, Pennsylvania. Pennsylvania Department of Environmental Protection. http://files.dep.state.pa.us/Water/Division%20of%20Planning%20and%20Conservation/StateWaterPlan/StateWaterPlanPrinciples/3010-BK-DEP4222.pdf

3. Methodology: Projection equations

Model Class	Model Group	Number of Equations	Avg. Modelled MGD (2013-2017)	Percent MGD
Associated	OLS	331	624.907	77.5%
	Mean Value	125	143.383	17.8%
	Other	43	37.743	4.7%
Un-associated	OLS	NA	NA	NA
	Mean Value	NA	NA	NA
	Other	NA	NA	NA
	Totals:	499	806.033	100.0%

Ordinary Least Squares (OLS)

Name	Linear Form: $Y = c * X + b$		Simplified form
	Y	X	
Linear	$\hat{y}$	x	$\hat{y} = c * x + b$
Logarithmic	$\hat{y}$	$ln(x)$	$\hat{y} = c * ln(x) + b$
Exponential	$ln(\hat{y})$	x	$\hat{y} = b' * e^{c*x}$

Treated as zero slope linear

Top-down equations

- Average historical proportions
- Difference based projections

Structural break offset equations

- Heaviside step function

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3. Methodology: Prediction intervals

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

$\hat{y}$	= the projected withdrawal volume (mgy)
x	= (Year – Start Year + 1) i.e. *x*=1,2,3…*n*
$\bar{x}$	= mean of the observed *x* values
$t_{\alpha,v}$	= Student t-statistic
$\hat{\sigma}_e$	= residual standard error
n	= total number of observations
s_x^2	= standard deviation of observed *x* values

The model follows the general form $\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x$

The residual errors are normally distributed

The residual errors are independent of each other, i.e. "uncorrelated".

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

3. Methodology: Data quality

Data quality assurance and quality control (QAQC) procedures may have resulted in data being excluded from a particular projection:

Source Verification

- Verification against approval
- Duplicate but reported
  (e.g. some combined data sources)
- Not located in the Basin

Annual data completeness

Projection Level	Number of months not reported, zero or below threshold	Low-limit threshold (MGM)
System	3	0.010
Sub-watershed	6	0.001
Source	6	0.001

Best Professional Judgement

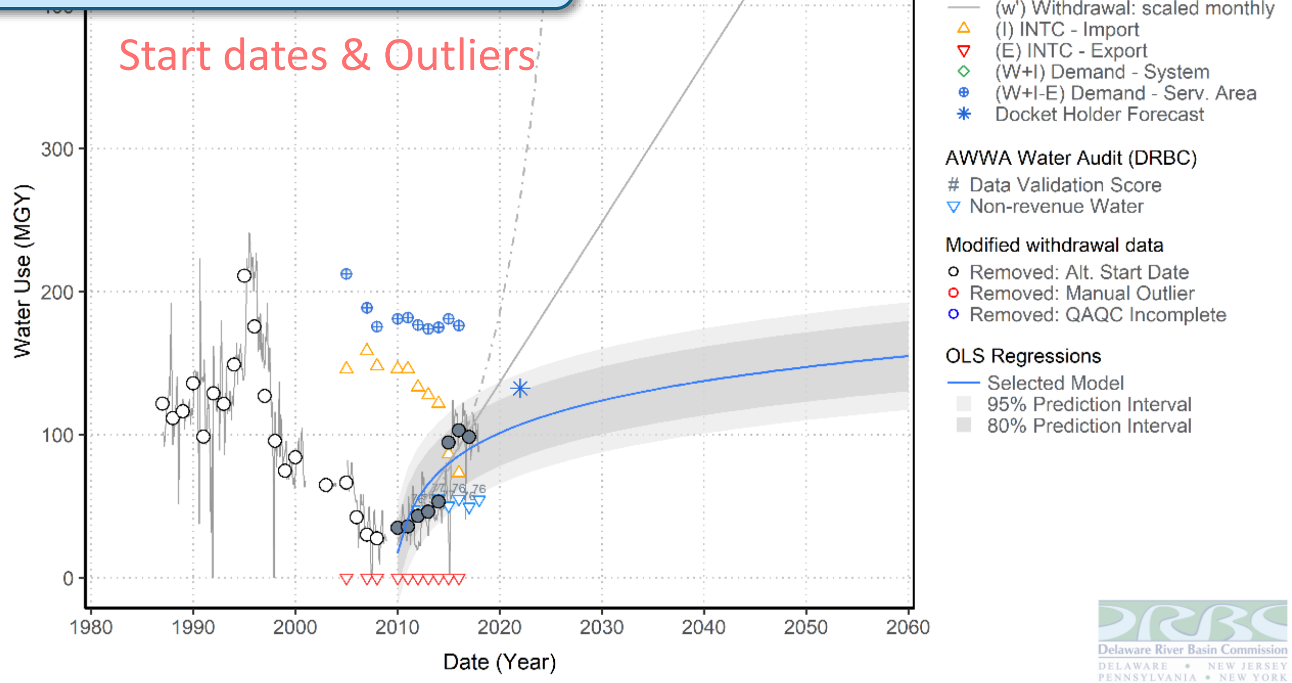


Figure #: An example projected data for the same system shown in Figure X.

3. Methodology: Limitations

Training set vs. Test set

Test set might typically be 20% of full dataset...

however… system dataset sizes are limited.

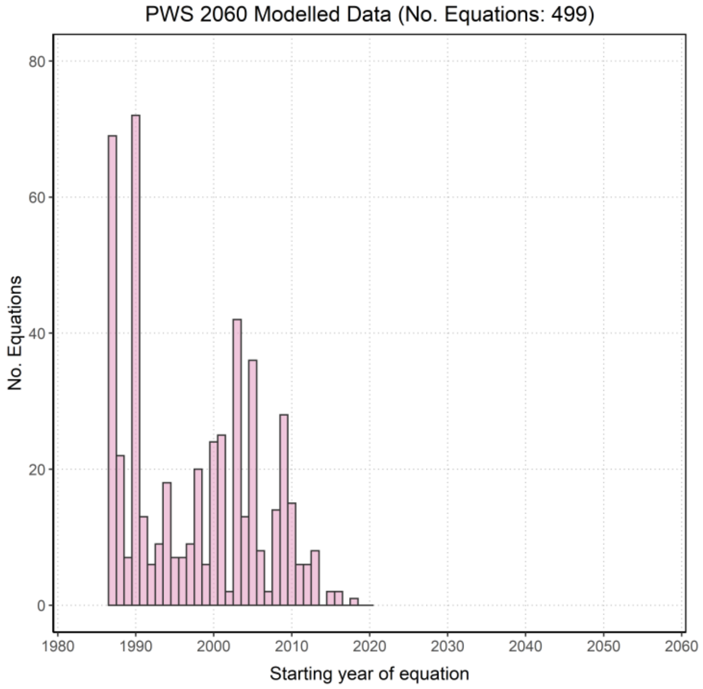
A potential solution by determining when aggregated models are “substantially complete”

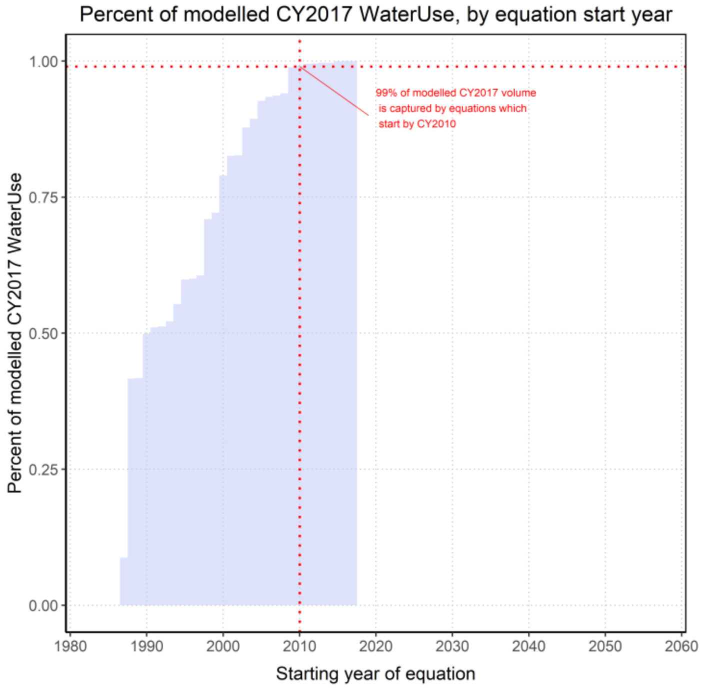
Projection horizon

Might typically be the length of the test set…

…*however*… doesn’t meet planning objectives

A potential compromise is to place indicators on projection graphics.





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4. Results

“Knowledge of quantity and distribution of withdrawals is an essential part of any water-resources study.”

- Kenneth MacKichan, 1950

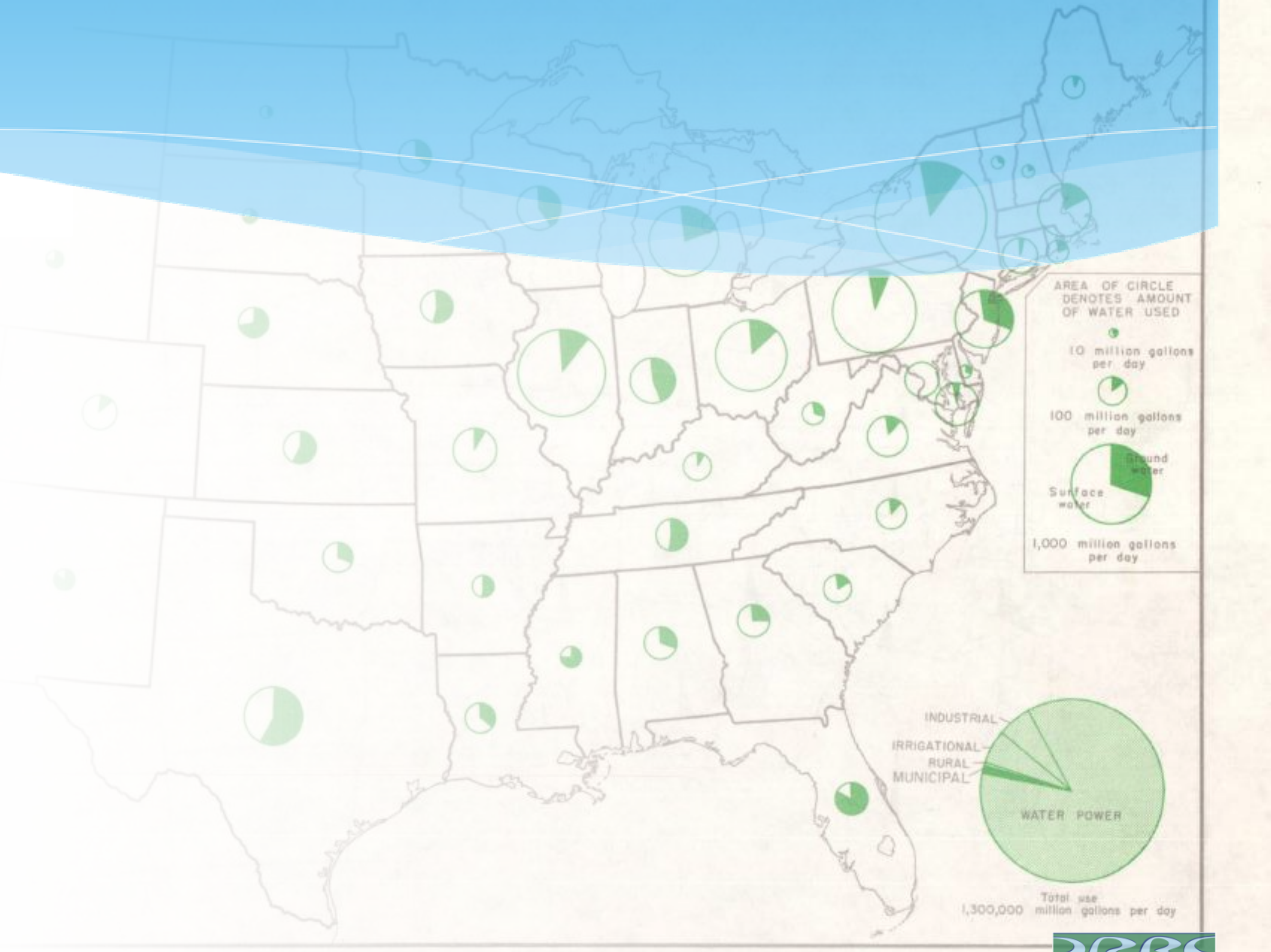

Figure 3.—Water used for municipal supply, 1950.

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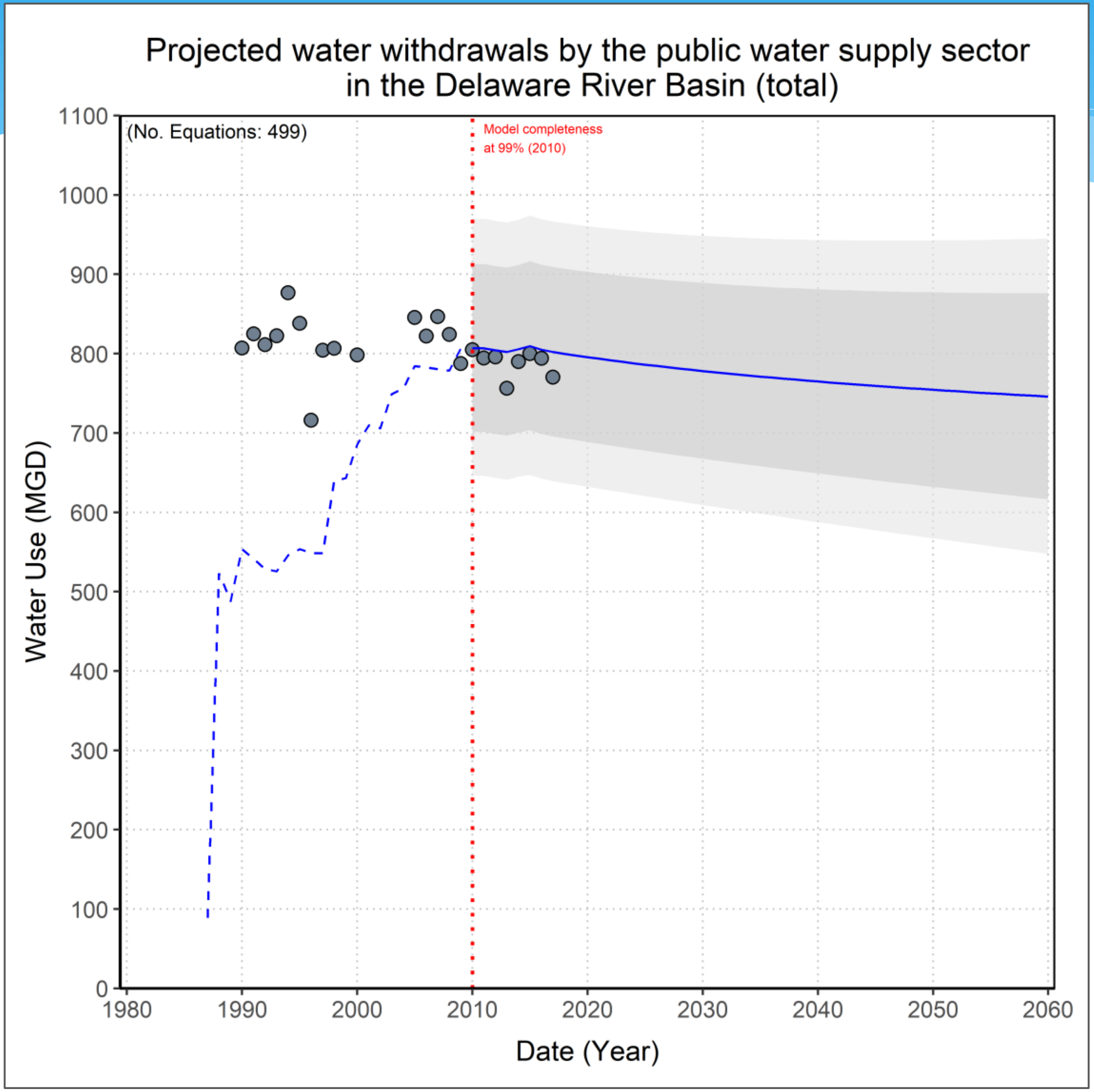
MacKichan, K.A., 1951, Estimated use of water in the United States, 1950: U.S. Geological Survey Circular 115, 13 p.

4. Results: Basin-wide aggregation

<u>Recall</u>: Withdrawals by the public water supply sector, not representing residential consumption.



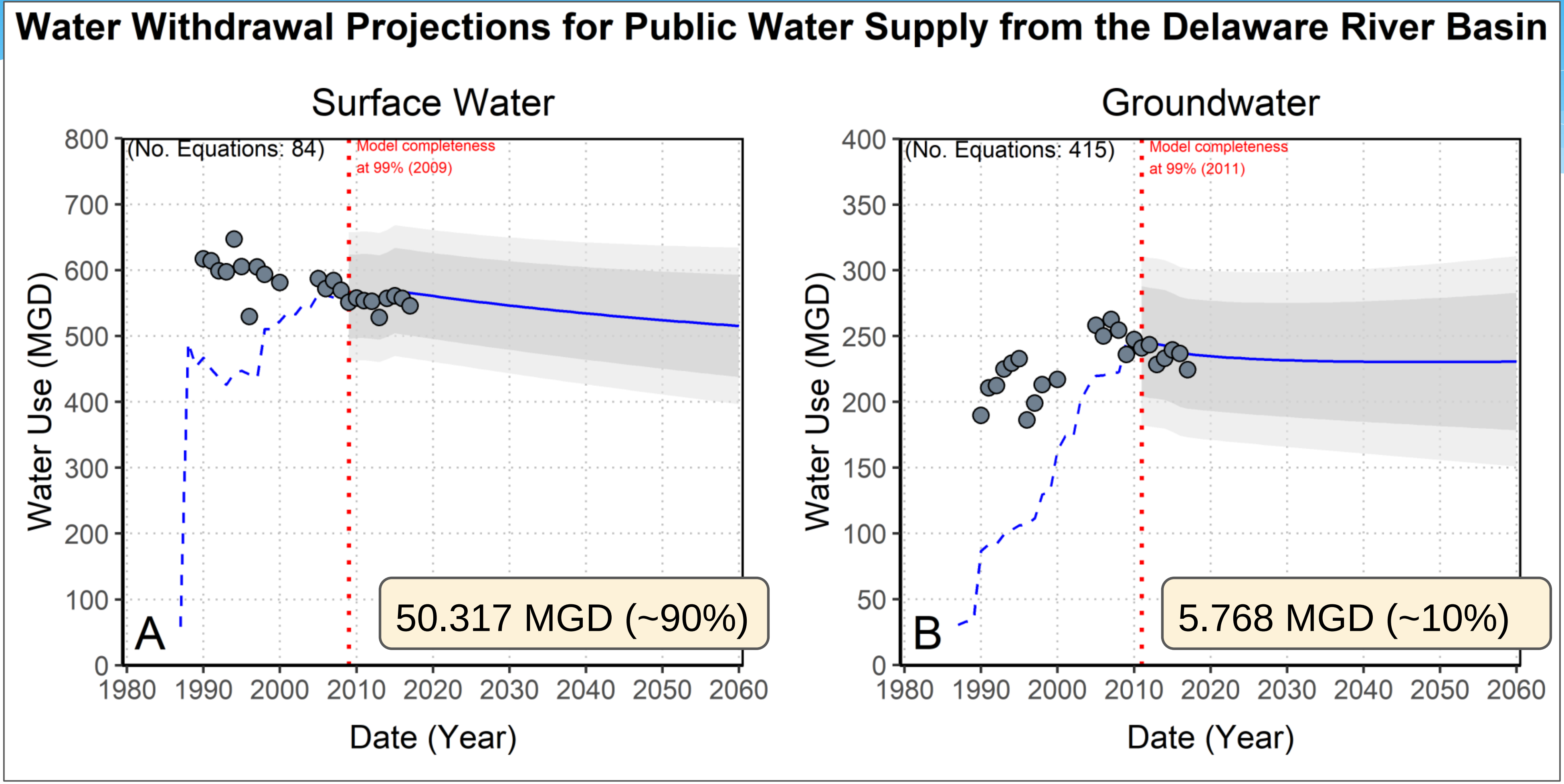
Preliminary Conclusions

- Basin-wide modelled withdrawal decrease of 56.085 MGD (7.0%) from 2017 through 2060
- 95% PI ranges from ±20.5% (2020) to ±26.6% (2060)
- 80% PI ranges from ±13.3% (2020) to ±17.4% (2060)
- Average error against data ≈ 2.2%
- Peak use by PWS has already occurred at the Basin scale

Year	Historic Withdrawal (MGD)	Modelled Withdrawal (MDG)	Percent Error (%)	Modelled withdrawal prediction intervals			
				upr80	upr95	lwr80	lwr95
2010	804.85	806.767	0.24	912.831	969.801	701.846	646.459
2011	794.359	806.682	1.55	912.982	970.044	701.469	645.91
2012	795.814	804.229	1.06	910.462	967.461	699.032	643.466
2013	756.286	802.134	6.06	908.367	965.34	696.893	641.29
2014	789.942	805.669	1.99	911.819	968.724	700.469	644.876
2015	800.134	809.527	1.17	916.564	973.92	703.402	647.306
2016	794.053	805.032	1.38	912.162	969.548	698.779	642.606
2017	770.132	802.026	4.14	909.187	966.571	695.712	639.497
2020	*NA*	795.569	*NA*	903.116	960.662	688.789	632.302
2030	*NA*	778.135	*NA*	889.13	948.416	667.74	609.282
2040	*NA*	764.928	*NA*	881.262	943.336	649.107	587.74
2050	*NA*	754.47	*NA*	877.234	942.698	632.171	567.346
2060	*NA*	745.941	*NA*	875.84	945.08	616.478	547.839

<u>Does not include ‘unassociated’ projections or data.</u>

4. Results: Basin-wide aggregation by source designation



GW decreases appear to diminish by 2030 and plateau towards the end of the projection horizon.

Does not include 'unassociated' projections or data.

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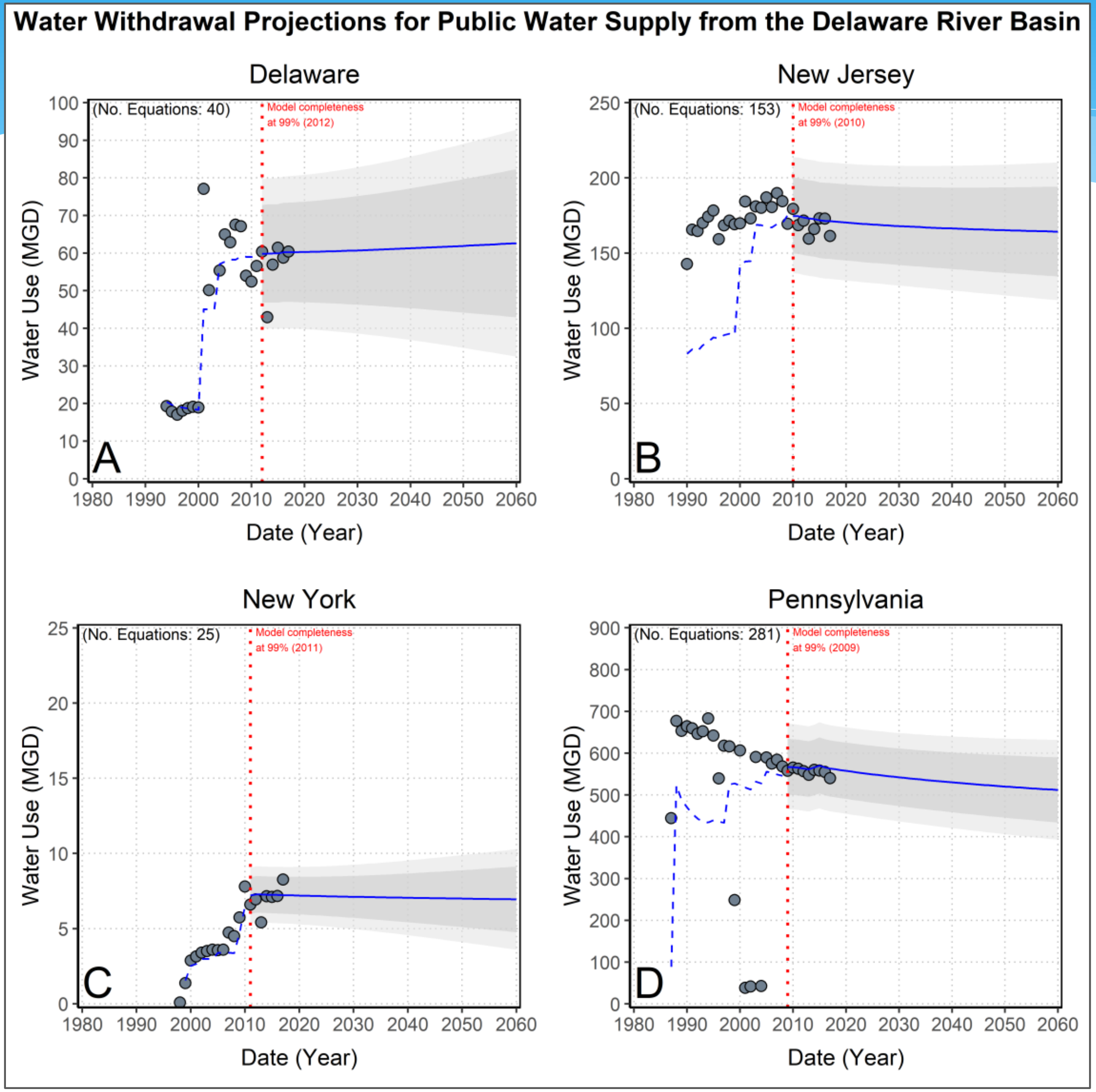
4. Results: Basin-wide aggregation by state



State	2017			2060		ΔMGD (2017 - 2060)
	Actual Withdrawal	Modelled Withdrawal	Modelled 95% PI	Modelled Withdrawal	Modelled 95% PI	
DE	60.379	60.225	±20.200	62.625	±30.152	2.400
PA	540.185	563.332	±103.442	512.101	±119.731	-51.231
NJ	161.308	171.241	±39.031	164.268	±45.917	-6.973
NY	8.259	7.228	±1.871	6.947	±3.340	-0.281
ALL	770.131	802.026	164.544	745.941	199.140	-56.085

Does not include 'unassociated' projections or data.

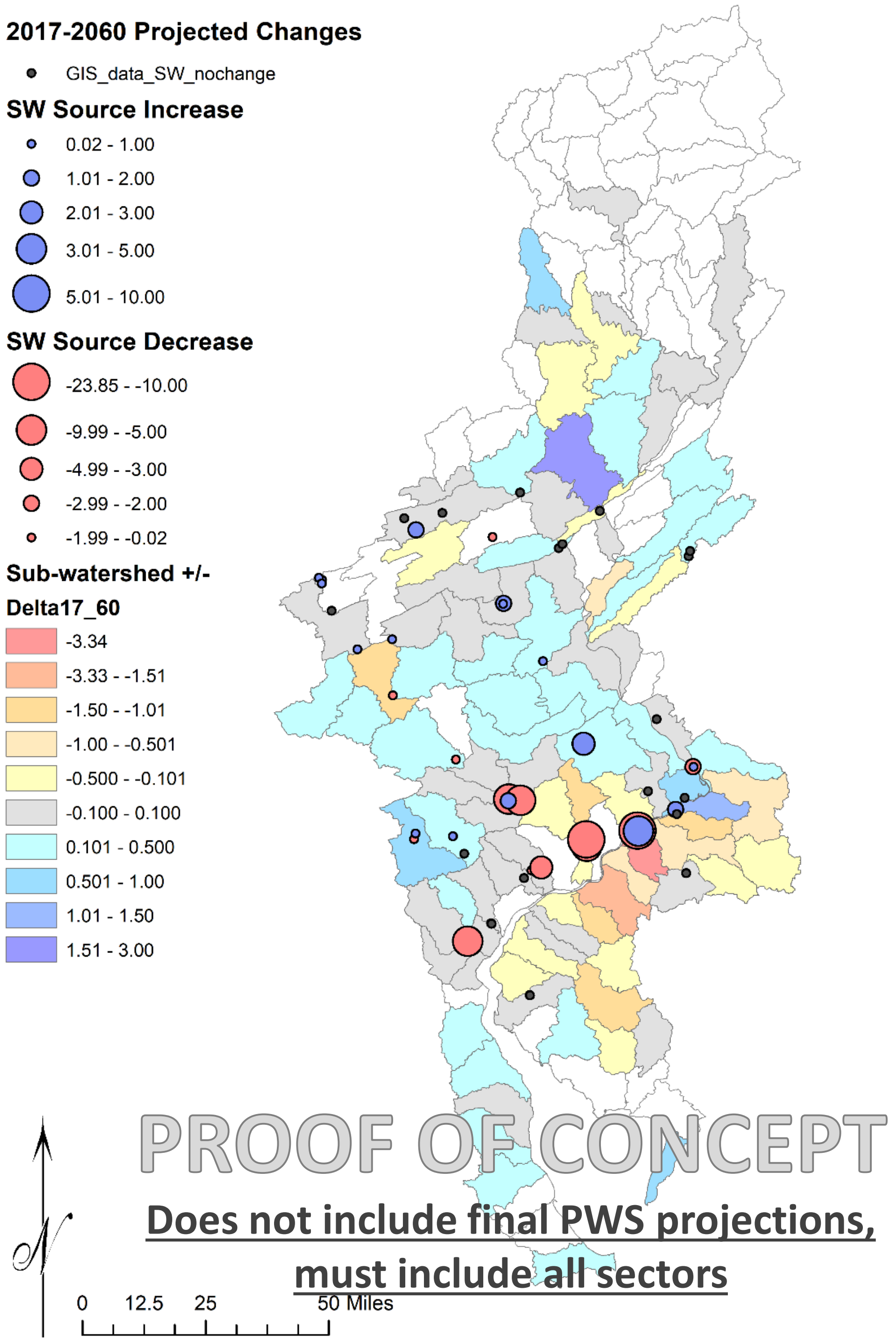
4. Results: Projections vs. Availability

Groundwater

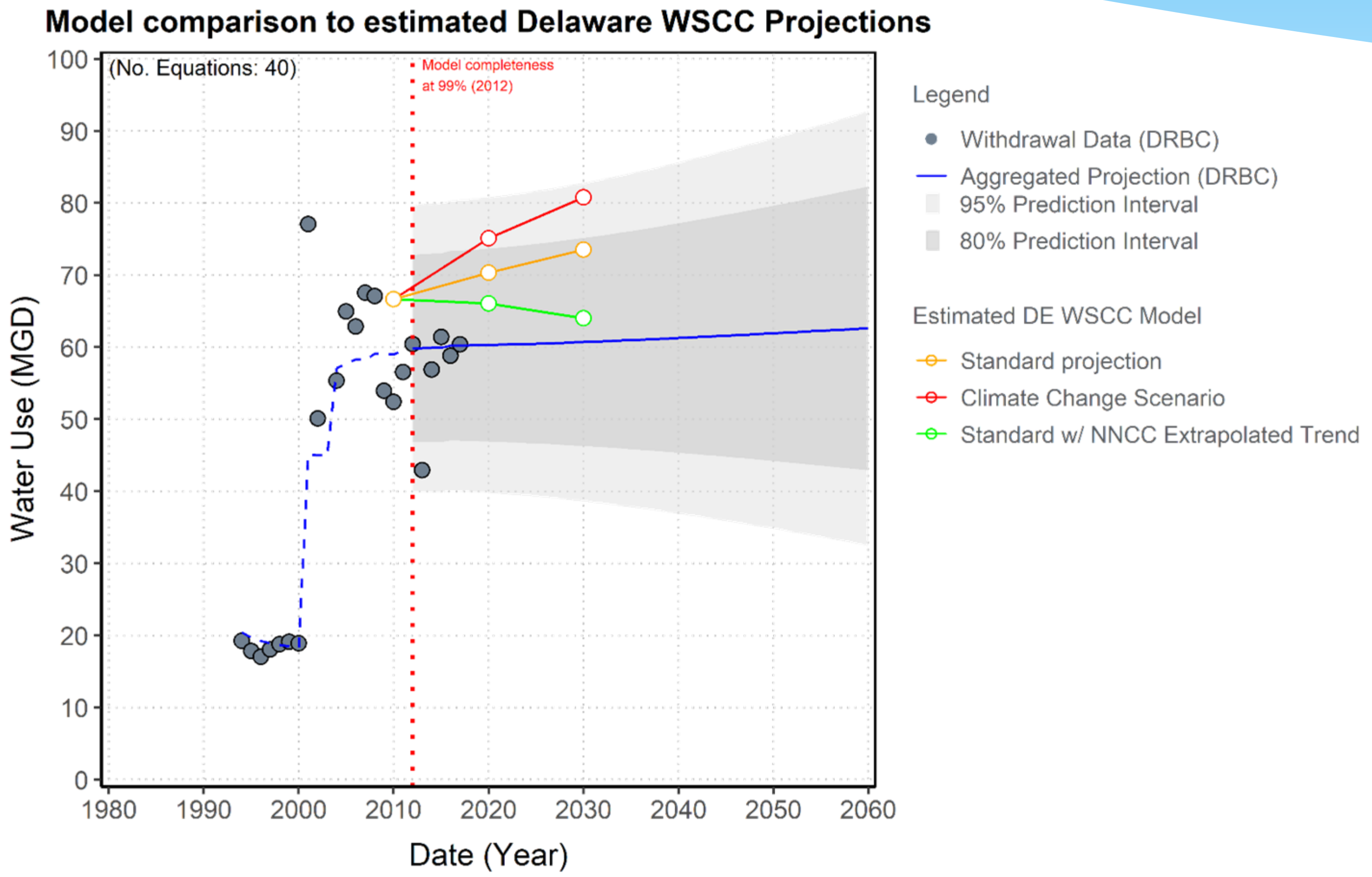
- Percent change by sub-watershed
- Current and projected withdrawals vs. resource availability:
  - Baseflow 25-year recurrence interval / 147 watershed
  - SEPA-GWPA

Surface water

- Point comparison against groundwater trends
- Availability assessments (e.g. pass-by flow requirements)
- Surface Water Estimation & Evaluation Tool (SWEET)



4. Results: Comparison against DE WSCC studies



Delaware WSCC Studies

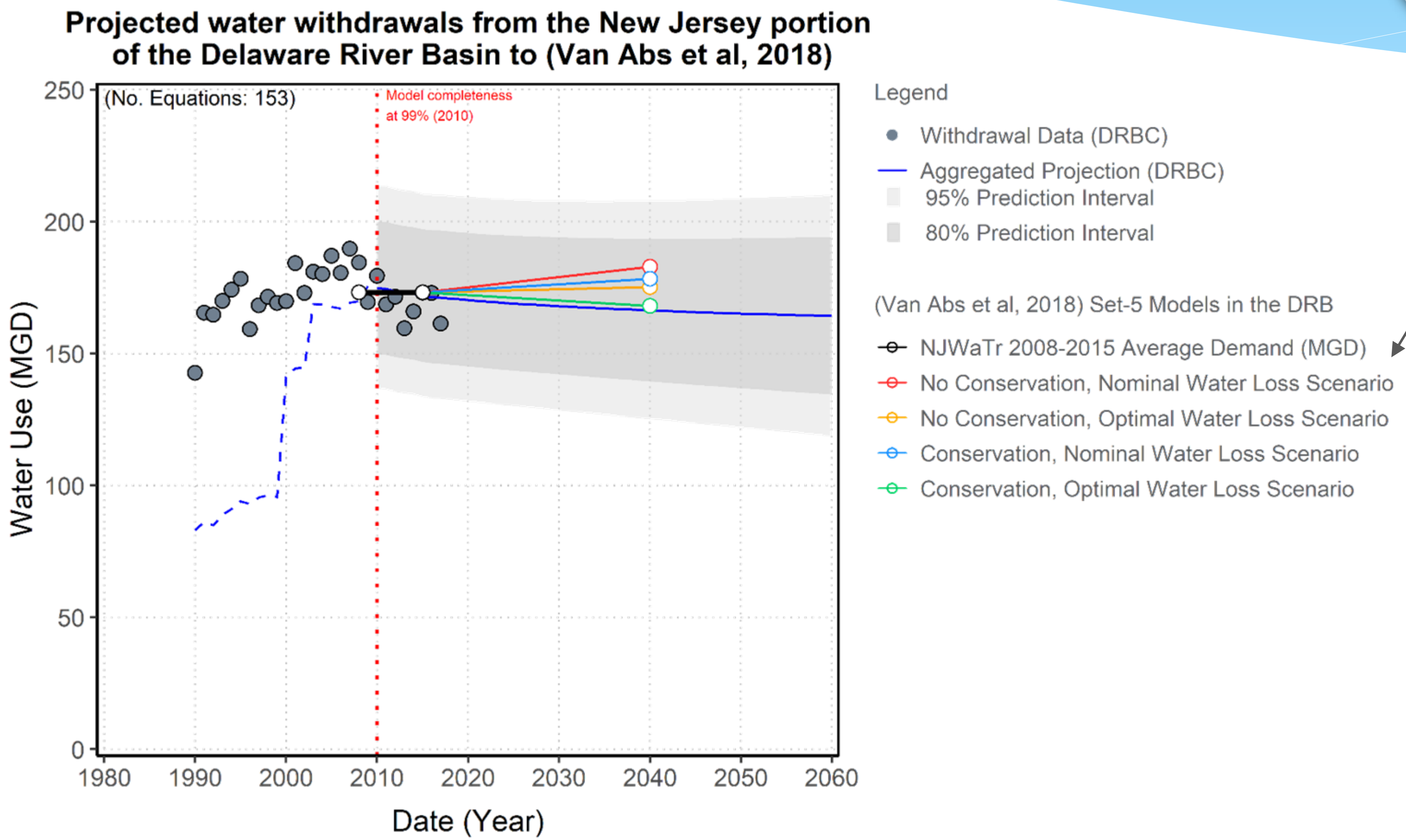
- Three studies: SNCC (2006), KSC (2014), NNCC (2018)
- Largely based population projections applied to an est. benchmark of use
- Studies were performed at utility level
- NNCC also provided extrapolation/trend
- KSC also provided climate change scenarios

Comparison

- Assess utilities against DRBC approvals and flag as in or out of Basin
- SNCC and KSC, convert units based on provided peaking factors
- NNCC convert units based on calculated monthly peaking factors from DRBC data
- Apply climate change methods from SNCC
- Apply extrapolation method from NNCC

<u>Does not include 'unassociated' projections or data.</u>

4. Results: Comparison against (Van Abs et al., 2018)



Van Abs et al., 2018 / NJDEP

- Performed at PWS system level
- Dasymetric analysis for population distribution with MPO projections
- Utility surveys and refined per-capita rates
- Multiple sets of projection scenarios, accounting for water loss and conservation
- Recommended model Δ * NJWaTr avgs.

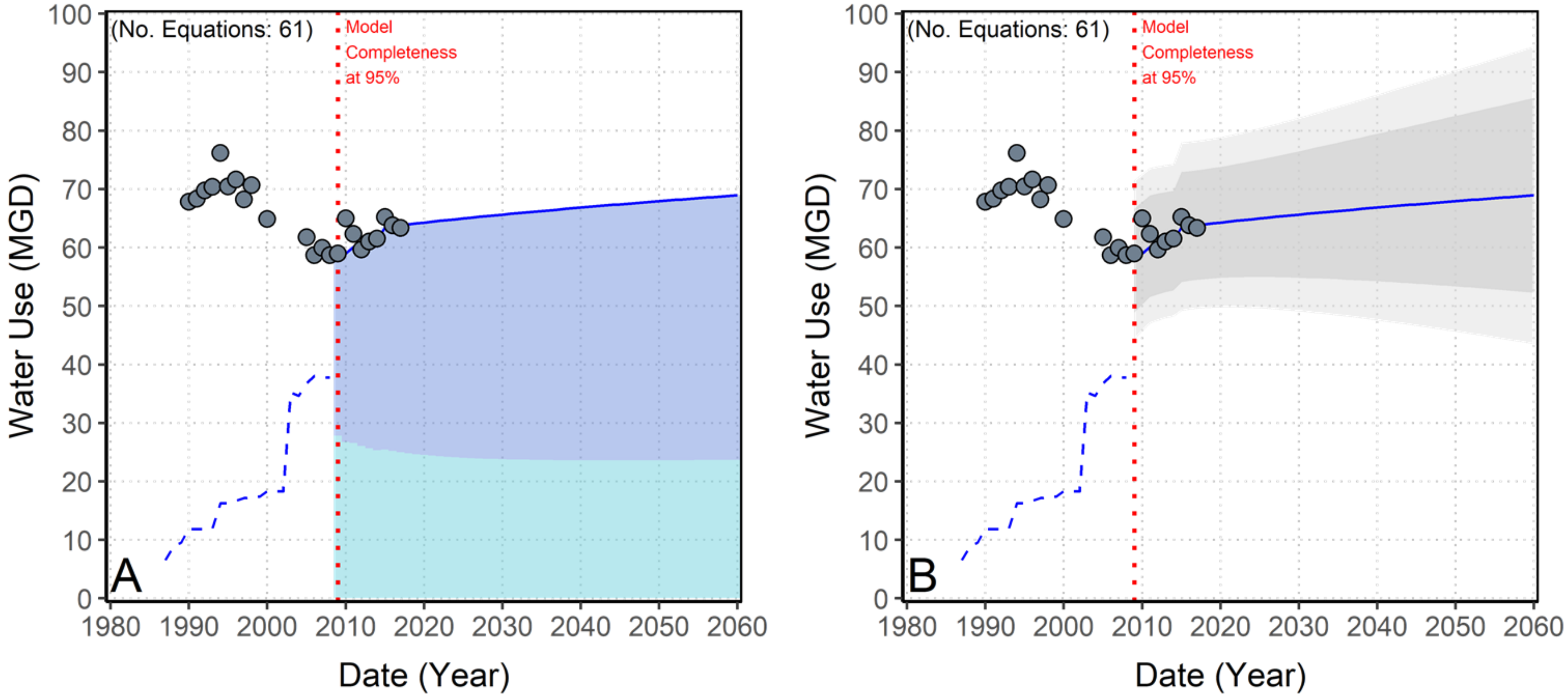
Comparison

- Van Abs et al., 2018 results filtered to PWS suppliers in DRB by NJPIID & PWSID
- 99 unique NJPIIDs in comparison
- Used this study data to calculate demand averages 2008-2015, compared and found systems on Basin boundary = main error
- Imp (12.031 MGD) and exp (16.900 MGD) show water moves, but not much leaves
- Compare demand and withdrawal projections, if at the Basin scale

Does not include 'unassociated' projections or data.

4. Results: Other analyses

Water Withdrawal Projections for Public Water Supply from the Lehigh River Basin



PA SWP – Appendix I

- Pilot study of the projection methodology for Lehigh River Basin
- Split 2003 water use by service area into residential and non-residential
- Develop per-capita and per-employee
- Apply rates to pop. & emp. projections

Comparison

- Not directly comparable, pilot study applies rates to entire LRB population ∴ cons. demand
- Withdrawals restricted to LRB represent the demand on natural resources in the LRB
- i.e. some people in LRB likely get water withdrawn from outside LRB or are self-supplied
- However, can perform HUC-8

<u>Does not include ‘unassociated’ projections or data.</u>

5. Next Steps

TASK	STATUS
• Power generation sector analysis	Substantially complete
• Industrial & Refinery sector analysis	In progress
• Consumptive use incorporation	In progress
• Discussion with utilities	Not started
• Agricultural sector method	Not started
• Other sectors analysis	Not started
• Unassociated data projections	Not started
• Final report	In progress

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Questions

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