



Appendix A

Mann-Kendall Trend Tests

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1 Mann-Kendall Trend Tests

Seasonal and annual trends in streamflow and groundwater levels were assessed using the Mann-Kendall test (Mann, 1945). A recent 30-year period was used to evaluate trends for active U.S. Geological Survey (USGS) gages, and the most recent available data were used for pertinent inactive gages. Trends were assessed based on a 5% significance level. Results including the trend (increasing streamflow or rising groundwater level, decreasing streamflow or falling groundwater level, or no trend), as well as the Sen Slope indicating the strength of the trend, are provided for groundwater levels in **Table A-1**, with additional data about the monitoring wells provided in **Table A-2**. **Table A-3** and **Table A-4** present results for streamflow.

Table A-1. Annual and seasonal trend statistics for groundwater elevations at USGS monitoring sites in the St. Joseph watershed of the Northeast Basin.

USGS ID	Well Name	Years	Annual		Winter		Spring		Summer		Fall	
			T	S	T	S	T	S	T	S	T	S
413121085481301	ELKHART 4	1995-2024	-	-0.01	o	--	o	--	-	-0.02	-	-0.02
411922085221801	NOBLE 8	1995-2024	-	-0.02	-	-0.03	-	-0.01	-	-0.02	-	-0.03
414318085200601	LAGRANGE 2	1995-2024	-	-0.004	+	0.01	+	0.01	-	-0.02	-	-0.02

T = Mann-Kendall trend, significance level of 5%: o = no trend; + = increasing trend; - = decreasing trend.

S = Sen Slope, magnitude indicates the strength of the trend.

Table A-2. Data on USGS groundwater monitoring wells.

USGS ID	Well Name	Well Depth (feet)	Aquifer	Confined
413121085481301	ELKHART 4	62	Sand and Gravel	No
411922085221801	NOBLE 8	149	Sand and Gravel	No
414318085200601	LAGRANGE 2	86	Sand and Gravel	No

Table A-3. Annual and seasonal trend statistics for stream discharge at USGS stream gages in the St. Joseph Watershed of the Northeast Basin.

Gage	Name	Years	Annual		Winter		Spring		Summer		Fall	
			T	S	T	S	T	S	T	S	T	S
04098500	Fawn River near White Pigeon, MI	1957-1974	+	2.3	+	4.6	+	3.9	+	1.4	+	0.7
04099000	St. Joseph River at Mottville, MI	1995-2024	+	9.5	+	7.9	+	16	+	11	+	8.1
04099510	Pigeon River near Angola, IN	1995-2024	-	-0.3	o	--	o	--	-	-0.5	-	-0.4
04099750	Pigeon River near Scott, IN	1995-2024	-	-0.4	o	--	+	2.7	-	-0.6	-	-1.4
04100222	Elkhart River near Cosperville, IN	1995-2024	+	0.4	+	0.4	+	1.2	+	0.4	o	--
04100500	Elkhart River near Goshen, IN	1995-2024	o	--	o	--	+	2.0	+	1.3	-	-1.3
04101000	St. Joseph River at Elkhart, IN	1995-2024	+	9.7	+	8.6	+	23	+	11	+	5.2
04101225	St. Joseph River at South Bend	2019-2024	-	-274	-	-225	-	-225	-	-148	-	-205
04101500	St. Joseph River at Niles, MI	1995-2024	+	8.2	+	7.8	+	21	+	8.3	+	4.7

T = Mann-Kendall trend, significance level of 5%: o = no trend; + = increasing trend; - = decreasing trend.

S = Sen Slope, magnitude indicates the strength of the trend.

Table A-4. Annual and seasonal trend statistics in the Maumee watershed of the Northeast Basin.

Gage	Name	Years	Annual		Winter		Spring		Summer		Fall	
			T	S	T	S	T	S	T	S	T	S
04178000	St. Joseph River near Newville, IN	1995-2024	-	-0.7	o	--	o	--	o	--	-	-0.7
04180000	Cedar Creek near Cedarville, IN	1995-2024	-	-0.3	o	--	+	1.6	o	--	-	-0.3
04180500	St. Joseph River near Fort Wayne, IN	1995-2024	-	-1.6	o	--	o	--	-	-2.0	-	-0.9
04180988	St. Marys River at Rockford, OH	2005-2024	-	-1.1	-	-3.8	o	--	o	--	-	-0.3
04181500	St. Marys River at Decatur, IN	1995-2024	-	-0.3	o	--	+	3.2	-	-0.9	-	-0.3
04182000	St. Marys River near Fort Wayne, IN	1995-2024	-	-0.5	o	--	+	3.8	-	-1.2	-	-0.4
04183000	Maumee River at New Haven, IN	1995-2024	-	-3.2	o	--	o	--	-	-5.2	-	-1.9
04183500	Maumee River at Antwerp, OH	2014-2024	-	-36	-	-34	o	--	-	-38	-	-16

T = Mann-Kendall trend, significance level of 5%: o = no trend; + = increasing trend; - = decreasing trend.

S = Sen Slope, magnitude indicates the strength of the trend.

2 References

Mann, H.B. 1945. "Non-parametric tests against trend," *Econometrica* 13 (3): 245-259.



Appendix B

Demand Model and Projections

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1 Regression Models: Public Water Supply, Irrigation, and Industrial Water Sectors

Water demand for the public water supply, irrigation, and industrial water-use sectors was projected for future years using regression models. The following sections provide the technical details of the regression modeling process, including a discussion of the demand drivers and climate parameters used for each model.

Demand differs from one county to the next for reasons the drivers do not fully capture: local industry, soils, the mix of customers a utility serves, and historical patterns of use. A model fitting the whole region with a single relationship would either ignore these differences or be distorted by the largest counties. Fitting each county its own independent model fails for the opposite reason: many counties have short or sparse records and only a handful of large users, so county-by-county responses to climate and population would be unstable and prone to chasing noise in the local record. The forecasts therefore use a linear mixed-effects model, which fits one shared relationship for the region while allowing each county its own adjustment around it. The shared part, the fixed effects, captures how demand responds to population, climate, and the other drivers, and is what allows the model to project into the future. The county-specific part, the random effects, absorbs the persistent local differences in level and sensitivity so that each county's forecast starts from its own observed baseline rather than a regional average. Pooling in this way lets data-rich counties inform data-poor ones without forcing every county to look identical.

The model is fit with R's lme4 package: each county has its own random intercept and random slopes on the time trend, detrended income, and the deficit. The random effects are specified as uncorrelated (lme4's || form), which drops the intercept–slope covariances; with only nine counties, this is the more stable choice and avoids over-parameterizing the random structure. This partial-pooling structure is used in place of fitting each county its own regression, and the fitted county random effects are retained in all diagnostics, forecasts, and sensitivity analyses.

The response is monthly Significant Water Withdrawal Facility (SWWF) withdrawal by facility, aggregated to county × month and held internally in million gallons per year (MGY); reported quantities are converted to million gallons per day (MGD). Withdrawals and the climate drivers are de-seasonalized before fitting using a multiplicative seasonal form (an STL decomposition for public supply, a multiplicative monthly climatology for the others), chosen because the seasonal swing scales with the overall level of demand rather than adding a fixed monthly offset. The growing-season moisture deficit ($\text{Deficit} = \text{PET} - \text{AET}$, potential minus actual evapotranspiration) is scaled by its standard deviation and shifted to stay non-negative, population is expressed in millions, time is measured in years from a 1984 origin rather than rescaled, and income is detrended into a residual series (logpci_resid) against a single pooled income trend fitted across all counties removing its collinearity with the time trend, so the income and time effects are not confounded. Each demand-model category is fit independently through the same pipeline, with the transform parameters stored and frozen with the fit; the deliverable forecasts are re-seasonalized back to the monthly scale. The seasonal multipliers are held constant at their historical values, but because they are multipliers, the seasonal swing scales with the baseline: as projected demand rises, the summer peak rises with it. Within-year shifts beyond that come only through the climate terms, where a projected month that is hotter or drier than its historical norm raises that month's demand.

2 Projecting the Future Drivers

The two socioeconomic drivers, population and per-capita income, are projected to 2070 from official county data extended with Shared Socioeconomic Pathway (SSP) scenarios.

Population is taken from the Indiana Business Research Center (IBRC) county projection through 2050. Beyond 2050, each county is extended on a single SSP scenario chosen county by county: the Socioeconomic Data and Applications Center (SEDAC) county-level scenario (SSP1–SSP5) with the smallest error against that county’s IBRC trajectory over 2020–2050 is selected, rescaled to the county’s IBRC value at 2050, and carried forward. Because the match is made per county, the selected SSP can differ between counties (**Figure B-1**); regional population stays roughly flat over the horizon. The IBRC base and the SSP used to extend it are the population lever in the uncertainty discussion.

Population also enters the analysis spatially, separately from the county time series on which the models are fit. Where a quantity has to be resolved below the county scale, U.S. Census Bureau block-group population is apportioned by area to the target geometry. This area-apportionment (1) splits each county into its in-project and out-of-project portions, so that only the part inside the basin is counted; (2) distributes county-level results to the model sub-basins; (3) separates the public-supply served population from the unserved with private-well population behind self-supplied residential; and (4) subdivides self-supplied residential demand into its sub-county parts. The block-group counts supply this spatial snapshot, while the IBRC and SSP series above supply the change over time.

Per-capita income is taken from the Bureau of Economic Analysis (BEA) county series and compounded forward at a single regional growth rate applied to every county, unlike population, which is matched county by county. SSP2-4.5 is adopted for the climate forcing because its warming matches current central estimates, but the SSP2 income figure (about 0.7 percent per year) implies a marked slowdown from the region’s long-run pace with no basis for expecting it; the central case therefore uses the observed historical mean, about 1.2 percent per year over 1985–2023 (the same per-county income trend the model de-trends against), so projected income continues its historical trajectory rather than shifting to the lower SSP2 growth rate. **Figure B-2** shows the historical series against the SSP1–SSP5 growth pathways for reference. Alternative income-growth rates are the income lever in the uncertainty discussion.

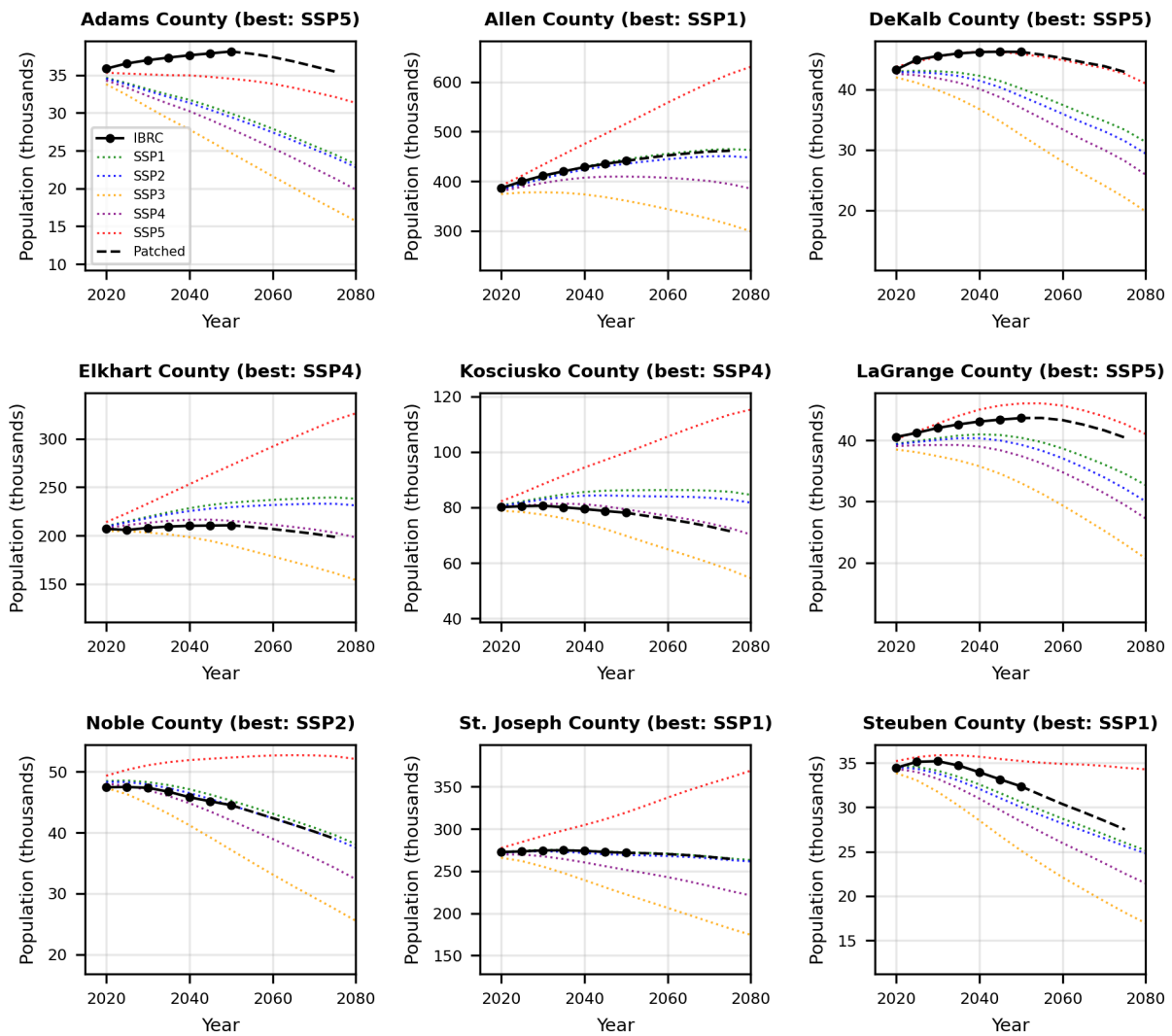


Figure B-1. Population projection by county: the IBRC projection (solid, through 2050), the five SSP scenarios (dotted), and the selected SSP rescaled to the IBRC 2050 value and carried forward (dashed). The best-matching SSP, noted in each panel, can differ by county.

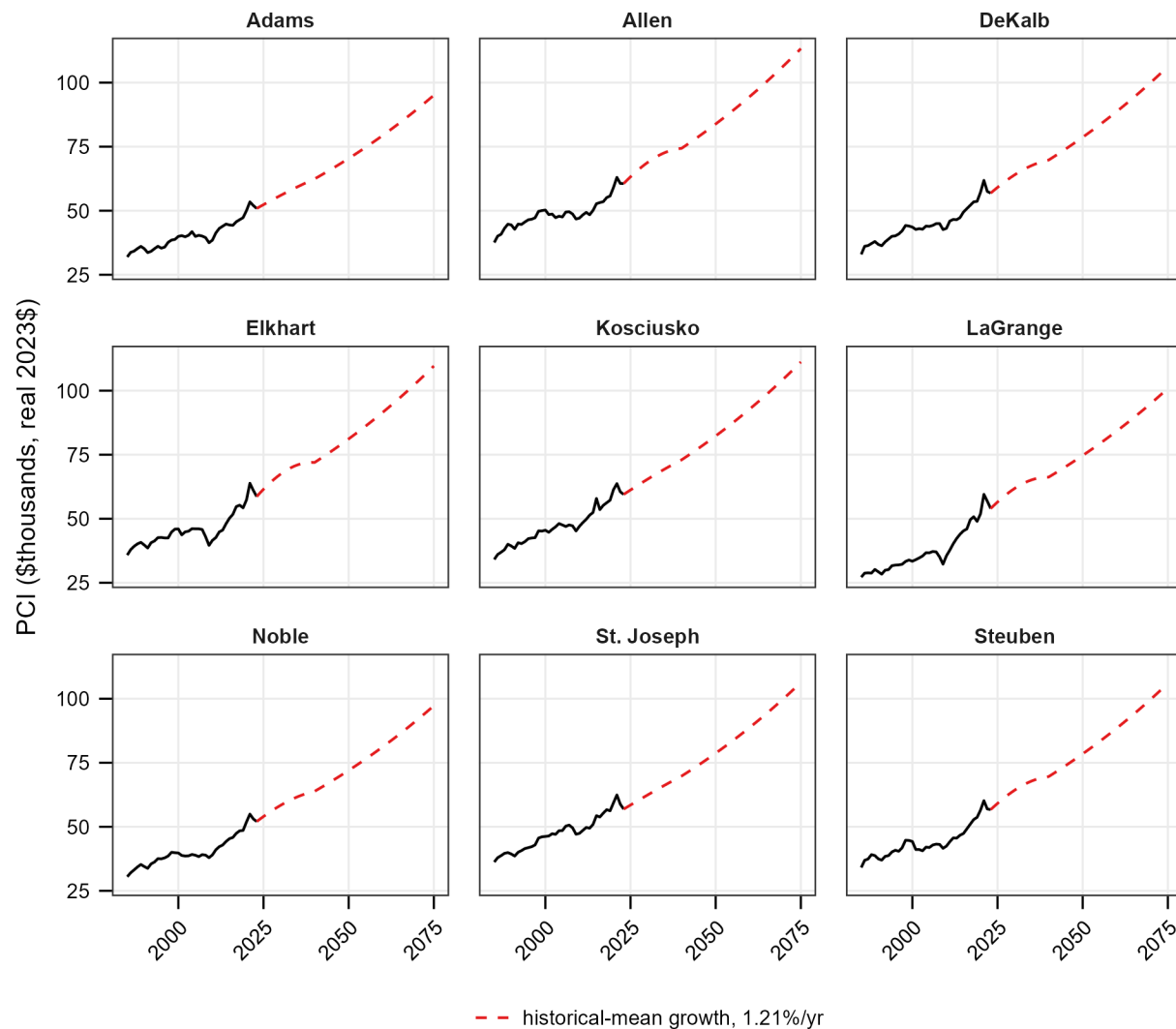


Figure B-2. Per-capita income by county: the Bureau of Economic Analysis (BEA) historical series with the SSP growth-rate extrapolations (SSP1–SSP5).

Temperature and precipitation drive the weather-sensitive sectors, principally irrigation and, to a lesser degree, public supply. The models use derived climate predictors such as the growing-season moisture deficit along with raw temperature and rainfall, because the deficit more directly represents the water that crops and landscapes need beyond what precipitation supplies. Historical climate comes from the observed PRISM record, and future climate comes from the downscaled (LOCA2) projections from NCCV, with the central forecast driven by a single centrally positioned model, CNRM-CM6-1 under SSP2-4.5. A climate model projects the general trajectory and statistical behavior of future climate (its long-run trend and its typical year-to-year variability), not the weather of any particular calendar year. The forecasts therefore reproduce realistic year-to-year swings, but those swings represent the expected spread of conditions rather than a prediction that a given year will be wet or dry; the trend and the range are informative, while the value attached to any single year is not.

Some sectors rely on data that applies only to that sector. Public supply forecasts draw on utility-level information, including water-audit records of served population and use, to separate demand from withdrawal and to characterize per-customer use. Irrigation forecasts depend on the area of irrigated land, which is developed separately and projected forward. These sector-specific inputs are described in more detail where they are used below.

3 Model Selection

Demand forecasts come from statistical models fitted to the historical record of monthly withdrawals and extended forward to 2070. Each model relates demand to explanatory drivers (population, income, and climate, together with sector-specific factors), so the forecast responds to expected future changes in those drivers rather than continuing a past trend.

One safeguard is fixed in the model setup, before any candidate is fitted. A fitted time trend need not correspond to any physical process, so the time variable itself is capped: it advances normally to a chosen year (2030 in the deliverable) and is held flat thereafter, while the response to population, income, and climate continues unchanged. Demand still changes after 2030 through those drivers, but no category is projected to 2070 on the strength of a bare statistical trend. Because the cap is part of how the time variable is defined, every model discussed below is fitted and projected on that basis.

No single equation is imposed. For each use sector, a large family of candidate specifications is built by a stepwise search driven by the Bayesian Information Criterion (BIC), which rewards fit while penalizing the number of parameters. The search varies the demand transform, the response form, the fixed- and random-effects structure, and the interactions, so the candidates that emerge already sit on a fit-versus-parsimony frontier rather than being assembled by hand. Carrying a family forward instead of one preferred specification is what makes the eventual choice defensible and what exposes how sensitive the forecast is to modeling decisions.

The candidates are then screened on three criteria:

- **Quality of fit.** How well the model reproduces the historical record on standard goodness-of-fit measures, judged across the region rather than on any single county or year.
- **Stability under extrapolation.** Whether the model remains well behaved when pushed beyond the range of the historical data. Even with the time term capped, a specification can track the past closely and still produce implausible growth or collapse fifty years forward through its other terms; those are removed whatever their historical fit.
- **Physical sensitivity.** Whether demand responds to a realistic change in conditions in the physically correct direction, for example rising with a hotter, drier growing season. The test applies to the model's net response rather than to individual coefficient signs, because one physical variable can enter through several terms. Precipitation appears both as its own predictor and inside the moisture-deficit term, so its standalone coefficient can take an unexpected sign while the response summed across every term it feeds remains correct.

What remains is a set of models that all fit history acceptably, extrapolate safely, and respond sensibly to their drivers. One is chosen for the reported forecast, and it is not necessarily the best-fitting candidate. The aim is a model at the central tendency of that set, so the reported forecast sits within the body of credible projections rather than at an optimistic or pessimistic extreme, with the spread of the

remaining models retained as the expression of forecast uncertainty. This is an objective rather than a guarantee: where no well-fitting candidate also projects near the middle, the choice is a compromise.

Public supply is a case where both conditions hold. The deliverable is the highest-skill candidate, and its 2025–2070 average of about 83 MGD sits near the 82 MGD median of the retained pool, so the headline forecast is both a strong fit and a central estimate. For irrigation, the selected model has the lowest peak-demand root mean square error (7.03 MGD) and the highest skill (0.853) among the candidates projecting near the ensemble median. Selecting on projection level alone would have meant adopting the plainest-fitting irrigation specifications, which project only about 60 to 72 MGD because they treat irrigated area additively rather than as a scaler on demand.

Two categories are not forecast with the demand model above. Energy production is dominated (about 97 percent) by a single combined heat-and-power facility serving the University of Notre Dame in St. Joseph County. Its withdrawal record steps once, in 2022: annual-mean withdrawal sat between about 21 and 28 MGD across 2010–2021 and rose to about 40 MGD in 2022–2023. The step coincides with the facility's registration moving from one intake pump to a larger one.

The step reflects how the plant is configured, not how much water the campus uses. Notre Dame ceased burning coal in September 2019 (University of Notre Dame, 2019) and replaced its coal boilers with natural-gas combined-cycle turbines and new electric chillers (University of Notre Dame, 2018; Contractor Magazine, 2019). That configuration routes more heat through a non-contact cooling loop drawn from and returned to St. Joseph Lake, a campus lake, so the metered withdrawal rises even though campus energy use did not. The larger intake registered in 2022 is what carries the increased flow, which is why the meter steps in that year rather than when the generating equipment came online.

The category is therefore modeled as a per-county regime level shift, anchored to the observed 2022–2023 mean of about 40 MGD and held flat forward. The record before 2022 characterizes the earlier configuration and does not enter the projection. A flat projection is the institution-appropriate central case: a typical campus would contract with the national decline in the college-age population (Grawe, 2018), but Notre Dame is highly selective and demand-saturated, filling its class regardless of the shrinking applicant pool (University of Notre Dame, 2024), so its cooling load is expected to hold steady. County population, a bare time trend, and campus floor area were each considered as forward drivers and rejected: the county population projection declines and tracks the county rather than the campus, the time trend is unstable across estimation windows and extrapolates implausibly, and campus floor area roughly doubled between 1988 and 2023 while withdrawal fell or stepped, so efficiency offsets growth.

Self-supplied residential is the other category produced outside the regression model, as population multiplied by a per-capita rate. Rural use is fit with the demand model, using a category-specific, climate-light specification on the 1985–2023 rural withdrawal record, but its futures store, along with that of energy production, is excluded from the parameter-uncertainty analysis in **Section 5**.

3.1 Chosen-Model Specifications

The fitted forecast models are the lme4 linear mixed-effects regressions on the deseasonalized monthly series described in B.1: each carries a county random intercept and uncorrelated random slopes (the || form, one parenthesis per model below), and the random unit is the county (the nine reported counties,

or the subset that reports a category). Both the fixed terms and the random slopes are selected by the BIC stepwise procedure, so each model keeps only the subset of its category's candidate predictors that improved the fit; a term offered to a category (a season, temperature, or precipitation term, for instance) is absent from the equation below when it did not lower the BIC. The predictor symbols are: t , time in years since 1984 ($\text{year} + (\text{month} - 0.5)/12 - 1984$), and $\log(t)$ its natural log; $\logpci_resid$, detrended log per-capita income (log per-capita income minus its pooled linear time trend); $deficit$, the growing-season moisture deficit ($PET - AET$, deseasonalized, scaled by its standard deviation and shifted non-negative), and $deficit_lag1$ its one-month lag; $w = deficit \times season^2$, the moisture deficit weighted by a bounded growing-season shape (a half-sine over March–November, 0 to 1, peaking in July, squared to concentrate it on the summer peak), and w_lag1 its one-month lag; pop , population in millions (utility-served population for public supply, in-Region county population for rural use); and ir_area , county irrigated area in acres. Demand is in MGD, so $demand/pop$ is gallons per capita per day and $demand/ir_area$ is MGD per acre. Each equation also fits an intercept. **Tables B- 1 to B- 5** give the region-wide base coefficients (the fixed effects) and each county's total coefficient (base plus its random adjustment); a term without a random slope has the same value in every county.

Public supply. Log per-capita withdrawal, fit from the full climate-stress candidate set (season, t , $\logpci_resid$, w , w_lag1 , mean temperature, precipitation); the BIC search keeps the time trend, detrended income, and the climate-stress term with its lag, with a county random intercept and random slopes on t , $\logpci_resid$, and w :

$$\log(demand/pop) \sim t + \logpci_resid + w + w_lag1 + (1 + t + \logpci_resid + w \mid \mid \text{county})$$

Table B- 1. Public-supply coefficients (response: log of gallons per capita per day).

County	Intercept	t	$\logpci_resid$	w	w_lag1
Base (region-wide)	4.999	-0.00874	0.275	0.0817	0.0377
Adams	5.130	-0.01480	-1.059	0.0509	0.0377
Allen	4.906	-0.00374	0.639	0.0892	0.0377
DeKalb	5.126	-0.00580	0.382	0.0453	0.0377
Elkhart	5.332	-0.01103	0.308	0.1300	0.0377
Kosciusko	4.688	-0.01213	0.740	0.0922	0.0377
LaGrange	4.703	0.00588	0.106	0.0608	0.0377
Noble	5.161	-0.01249	0.219	0.0135	0.0377
St. Joseph	5.258	-0.01560	0.582	0.1732	0.0377
Steuben	4.687	-0.00896	0.555	0.0803	0.0377

Industry. Withdrawal, untransformed, fit from the full candidate set (season, t , $\log(t)$, $\logpci_resid$); the fit keeps a combined linear-and-log time trend and detrended income, with a county random intercept and random slopes on t , $\log(t)$, and $\logpci_resid$:

$$\text{demand} \sim t + \log(t) + \logpci_resid + (1 + t + \log(t) + \logpci_resid \parallel \text{county})$$

Table B- 2. Industry coefficients (response: MGD).

County	Intercept	t	$\log(t)$	$\logpci_resid$
Base (region-wide)	2.777	-0.0531	0.165	3.549
Adams	1.092	0.0054	-0.114	-1.014
Allen	5.837	-0.0333	-0.000	17.851
DeKalb	1.308	0.0897	-0.109	-2.282
Elkhart	7.968	-0.4376	1.987	15.896
Kosciusko	1.211	-0.0506	0.638	6.301
LaGrange	-0.266	-0.0142	0.338	-0.093
Noble	0.401	-0.0530	0.642	1.338
St. Joseph	7.257	0.0190	-1.969	-6.524
Steuben	0.187	-0.0035	0.075	0.468

Irrigation. Withdrawal per irrigated acre (which treats irrigated area as a demand scaler rather than an additive predictor), fit from the precipitation-free candidate set (season, maximum temperature, deficit, deficit_lag1); the fit keeps the moisture deficit and its one-month lag, with a county random intercept and a random slope on deficit. Adams is excluded (trace withdrawals):

```
demand/ir_area ~ deficit + deficit_lag1 +
(1 + deficit || county)
```

Table B- 3. Irrigation coefficients (response: MGD per acre)

County	Intercept	deficit	deficit_lag1
Base (region-wide)	934	411	180
Allen	2,325	789	180
DeKalb	556	356	180
Elkhart	1,003	459	180
Kosciusko	515	268	180
LaGrange	1,009	466	180
Noble	801	405	180
St. Joseph	157	71	180
Steuben	1,107	479	180

Miscellaneous. Withdrawal, untransformed, constant specification: no time, climate, or income driver is admitted to the candidate set, and the BIC search added no county random slopes, so the model reduces to a per-county mean of the deseasonalized series, reseasonalized back to the monthly scale for the forecast:

$$\text{demand} \sim (1 \mid \text{county})$$

Table B- 4. Miscellaneous coefficients (response: MGD).

County	Intercept
Base (region-wide)	0.620
Allen	0.480
DeKalb	0.058
Elkhart	0.707
Kosciusko	0.020
LaGrange	0.031
Noble	0.359
St. Joseph	3.241
Steuben	0.064

Rural use. Withdrawal, untransformed, fit from the irrigated-area-free candidate set (t , $\logpci_resid$, pop); the fit keeps all three, with a county random intercept and random slopes on $\logpci_resid$ and pop . This model is fit on the four counties with a usable rural record; Adams, Allen, and Noble are carried forward separately as a constant equal to the mean of their last five observed years, and the two parts are summed into the reported rural category:

$$\text{demand} \sim t + \logpci_resid + pop + (1 + \logpci_resid + pop \parallel \text{county})$$

Table B- 5. Rural-use coefficients (response: MGD; pop in millions).

County	Intercept	t	$\logpci_resid$	pop
Base (region-wide)	3.080	0.0324	-0.956	-37.8
Elkhart	2.006	0.0324	-0.486	-13.5
LaGrange	3.017	0.0324	-1.712	-66.8
St. Joseph	6.066	0.0324	-0.993	-23.8
Steuben	1.230	0.0324	-0.632	-47.1

Energy production and self-supplied residential are produced outside this regression pipeline, as a facility-level regime level shift and as population times a per-capita rate, and are described above and in **Section 1**.

Table B- 6. Public supply model equation coefficients

County	Intercept	Years Since 1984: (t)	Log Of Per-Capita Income: (logpci_resid)	Deficit-By-Season Interaction: (w)	Deficit By Season One-Month Lag: (w_lag1)
<i>Base (region-wide)</i>	<i>4.9991</i>	<i>-0.0087</i>	<i>0.2748</i>	<i>0.0817</i>	<i>0.0377</i>
Adams	5.1303	-0.0148	-1.0589	0.0509	0.0377
Allen	4.9063	-0.0037	0.6393	0.0892	0.0377
DeKalb	5.1258	-0.0058	0.3824	0.0453	0.0377
Elkhart	5.3321	-0.0110	0.3084	0.1300	0.0377
Kosciusko	4.6882	-0.0121	0.7397	0.0922	0.0377
LaGrange	4.7028	0.0059	0.1060	0.0608	0.0377
Noble	5.1613	-0.0125	0.2192	0.0135	0.0377
Steuben	4.6875	-0.0090	0.5550	0.0803	0.0377
St Joseph	5.2579	-0.0156	0.5822	0.1732	0.0377

Table B- 7. Industry model equation coefficients

County	Intercept	Years Since 1984: (t)	Log of Years: log(t)	Log Of Per-Capita Income: (logpci_resid)
<i>Base (region-wide)</i>	<i>2.7771</i>	<i>-0.0531</i>	<i>0.1653</i>	<i>3.5491</i>
Adams	1.0923	0.0054	-0.1142	-1.0136
Allen	5.8368	-0.0333	-0.0002	17.8509
DeKalb	1.3075	0.0897	-0.1094	-2.2819
Elkhart	7.9677	-0.4376	1.9867	15.8956
Kosciusko	1.2110	-0.0506	0.6379	6.3011
LaGrange	-0.2660	-0.0142	0.3379	-0.0928
Noble	0.4008	-0.0530	0.6423	1.3380
Steuben	0.1868	-0.0035	0.0755	0.4678
St Joseph	7.2571	0.0190	-1.9687	-6.5235

Table B- 8. Irrigation model equation coefficients

County	Intercept	Growing-Season Moisture Deficit	Growing-Season Moisture Deficit: (Deficit_Lag1)
<i>Base (region-wide)</i>	<i>0.0009</i>	<i>0.0004</i>	<i>0.0002</i>
Allen	0.0023	0.0008	0.0002
DeKalb	0.0006	0.0004	0.0002
Elkhart	0.0010	0.0005	0.0002
Kosciusko	0.0005	0.0003	0.0002
LaGrange	0.0010	0.0005	0.0002
Noble	0.0008	0.0004	0.0002
Steuben	0.0011	0.0005	0.0002
St Joseph	0.0002	0.0001	0.0002

Table B- 9. Miscellaneous model equation coefficients

County	Intercept
<i>Base (region-wide)</i>	<i>0.6200</i>
Allen	0.4801
DeKalb	0.0579
Elkhart	0.7069
Kosciusko	0.0200
LaGrange	0.0308
Noble	0.3594
Steuben	0.0636
St Joseph	3.2410

Table B- 10. Rural model equation coefficients

County	Intercept	Years Since 1984: (t)	Log Of Per-Capita Income: (logpci_resid)	Served Population: (pop)
<i>Base (region-wide)</i>	<i>3.0797</i>	<i>0.0324</i>	<i>-0.9557</i>	<i>-37.8178</i>
Elkhart	2.0056	0.0324	-0.4863	-13.4934
LaGrange	3.0172	0.0324	-1.7118	-66.8487
Steuben	1.2302	0.0324	-0.6321	-47.1187
St Joseph	6.0658	0.0324	-0.9928	-23.8103

4 Validation

Because the monthly series are strongly autocorrelated ($\phi \approx 0.70$) and the model's task is to extrapolate decades forward, a random k-fold cross-validation would be misleading. Random folds place adjacent months in both the training and test sets, so a held-out point is largely recoverable from its neighbors, and the exercise tests interpolation within the observed period rather than forward extrapolation. Validation therefore uses a temporal split. The checks below are additional validation carried out for public supply, the largest category and the one whose model choice most warrants scrutiny.

A decade-scale back-test (train on 1985–2005, predict 2006–2023; transforms refit on the training window and frozen) confirms that fit is an informative screen: the Spearman correlation between in-sample training RMSE and held-out test RMSE is about 0.74. It also shows the same pattern directly: training RMSE varies only 2.5–2.8 MGD across the kept public-supply pool, yet the eighteen-year-ahead regional-total ratio (projected/observed) spans 1.11–1.38. Every kept model over-predicts the late window by at least 11 percent, because the post-2005 per-capita decline ran faster than the training window implied; this is a structural trend break, not a coefficient error. Capping the time trend narrows the pool's ratio spread from 0.27 to 0.09 at the cost of higher bias: the cap trades variance for bias. The structural features that reduce extrapolation divergence are a per-capita response, random-effect slopes, and interactions: the family to which the chosen public-supply model belongs.

Three further checks support the selection and its reported error metrics:

Autocorrelation (AR(1)) refit. Refitting the chosen public-supply model with an AR(1) residual structure gives $\phi = 0.70$ (an effective sample of roughly 750 versus 4,212 observations, so BIC's $\log(n)$ over-counts information and BIC rankings should be treated as soft). Despite this, no term dies, and standard errors do not widen; the climate terms in fact strengthen. Model selection is robust to autocorrelation.

Skill-gate content. Seasonal climatology alone removes about 55 percent of the county-mean baseline error, so a skill measured against the county mean is dominated by free seasonality: 27 of 72 models clear the 0.8 threshold against the county-mean baseline, but 0 of 72 clear it against a seasonal-naïve baseline (the chosen model's 0.85 becomes 0.67). The reported skill should be described as a county-mean, seasonality-inclusive measure.

Decision-scale ranking. The chosen public-supply model is robust across the scales that matter for the deliverable: pooled county-month rank #1, regional-total annual rank #3, and sub-basin rank #1 of 22.

5 Forecast Uncertainty

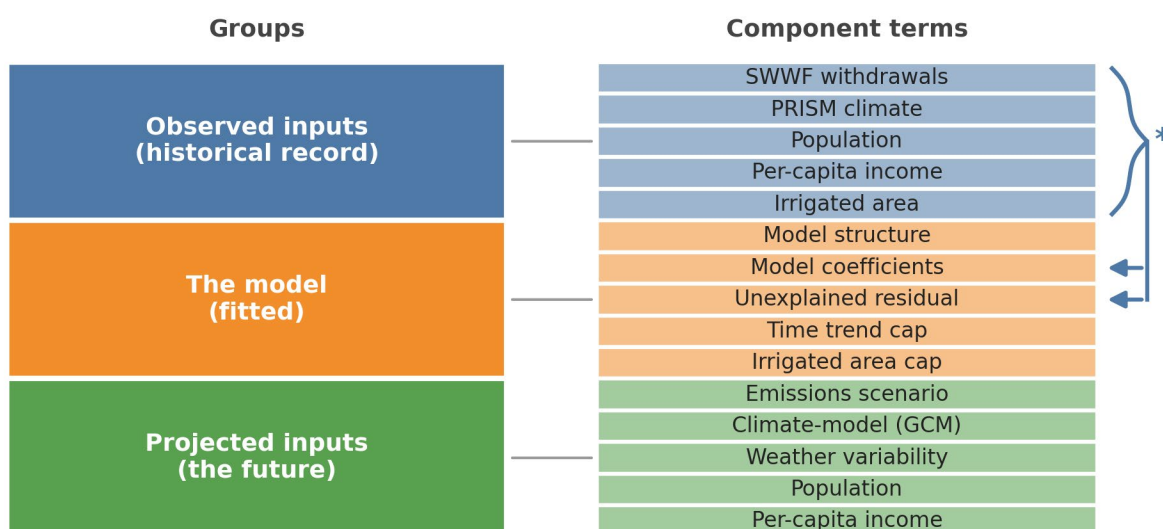
The forecast chooses a single climate model and a single demand model and produces one deterministic set of predictions, but that single trajectory carries substantial uncertainty. The sources are enumerated in **Figure B-3** and fall into three groups: the observed record the model is fit to, the fitted model itself, and the projected inputs that drive the forecast forward.

The observed inputs are the historical record: the SWWF withdrawals, PRISM climate, population, per-capita income, and irrigated area. Their measurement and estimation error is not carried as a separate term; the fit absorbs it into the model coefficients and the unexplained residual.

The model contributes the choice of specification (model structure), the fitted coefficients, and the unexplained residual, together with the extrapolation caps that bound how far fitted trends are carried forward (the time-trend cap and the irrigated-area cap).

The projected inputs are projected rather than measured and add the future-climate uncertainty together with the driver levers: the emissions scenario, the climate-model (GCM) spread, year-to-year weather variability, and the projected population and per-capita income. Two of these, the population and per-capita-income projections, are **not quantified** in the band.

How much each source matters is not uniform across categories. Each sector behaves differently, so the magnitudes are shown per category rather than as a single regional figure.



* observed-input error absorbed in the fit

Figure B-3. Conceptual sources of forecast uncertainty, grouped as observed inputs, the model, and projected inputs. Observed-input error is fully absorbed into the fit, where it surfaces as model-coefficient and residual uncertainty.

5.1 Uncertainty Terms

The table below lists each term, the parts of error it contains, and how (or whether) it is quantified, grouped as in **Figure B-3**.

5.1.1 Observed Inputs (Historical Record)

These errors are not separable on their own: the fit absorbs them into the model coefficients and the unexplained residual (the brace marked * in **Figure B-3**). They are listed as sources, not as separately quantified bands (**Table B-11**).

Table B-11. Historical record error sources

Term	Error sources (parts)	How it enters / is quantified
SWWF withdrawals	Metering and recording error; reporting errors and omissions; withdrawals below the SWWF reporting threshold or from unregistered or excluded facilities	Not quantified on its own; propagates into model coefficients and the unexplained residual via the fit (*)
PRISM climate	Weather-station measurement error; spatial interpolation between stations; elevation and orographic adjustment; precipitation gauge under-catch	Absorbed in the fit (*)
Population (historical)	Census and intercensal estimate error; areal apportionment to service area and county; served-population assignment	Absorbed in the fit (*)
Per-capita income (historical)	Survey and estimate error (ACS, BEA); inflation deflation; county allocation	Absorbed in the fit (*)
Irrigated area (historical)	Land-cover classification and mapping error; reporting gaps; allocation to county	Absorbed in the fit (*)

5.1.2 The Model (Fitted)

The fitted model contributes three terms that are quantified as bands and two that are reported as levers. Structure and coefficients describe how far the forecast moves under equally defensible modeling choices, and the residual carries the scatter no driver explains. The two caps are decisions rather than estimated quantities, so they are shown as sensitivities across the plausible settings instead of as probability bands (**Table B-12**).

Table B-12. Fitted model error sources

Term	Error sources (parts)	How we quantify it
Model structure	Many specifications fit the record comparably yet project differently (functional form, which terms are included); equifinality	Spread across the kept set of gate-surviving models: p05–p95 of their central trajectories (the model-structure band)
Model coefficients	Finite-sample parameter-estimation error in the chosen model	Per-county-sigma plus AR(1) parametric bootstrap: refit on AR(1)-correlated (ϕ about 0.70), per-county-scaled simulated responses, so serial correlation is carried in the noise; p05–p95 of the refit trajectories
Unexplained residual	Scatter the drivers cannot explain (prediction-layer noise)	3.29 times the in-sample RMSE (observed versus chosen central); assumed stationary
Time-trend cap	Judgment on how far the time and per-capita trend is carried before it is held flat	Sensitivity across cap years (2030 / 2035 / uncapped); shown as a lever, not a probabilistic band
Irrigated-area cap	Judgment on how far the irrigated-area trend is carried	Sensitivity across cap assumptions (for example historical-max versus regression-line anchor); lever

5.1.3 Projected Inputs (the Future)

The forecast is driven forward by inputs that are themselves projections, so each is quantified where the projection comes as an ensemble and flagged where it does not. Climate contributes three separable terms: the emissions scenario, the spread across climate models, and year-to-year weather variability. The population and per-capita-income projections enter the forecast without a quantified band (**Table B-13**).

Table B-13. Future projection error sources

Term	Error sources (parts)	How we quantify it
Emissions scenario	Which SSP emissions pathway actually occurs	Max minus min across scenario means (SSP2-4.5 / 3-7.0 / 5-8.5)
Climate model (GCM)	Across-model disagreement in the long-term response (the quantifiable part); plus error not in the spread: downscaling method, processes common to all models, PRISM-driven bias-correction error	p05–p95 across loess-smoothed GCM trajectories within SSP2-4.5 (24 GCMs); across-model spread only
Weather variability	Irreducible year-to-year internal (interannual) climate variability	3.29 times the pooled SD of loess residuals (within-GCM, detrended); constant in time
Population (future)	Demographic forecast error; choice of projection source	Not currently quantified
Per-capita income (future)	Income-growth forecast error	Not currently quantified

* Observed-input error absorbed in the fit (Figure B-3 footnote).

5.1.4 How the Band is Built

The uncertainty band is built by Monte Carlo simulations. Each simulated trajectory draws one combination of demand model (from the gate-surviving pool), GCM, and emissions scenario, then adds a coefficient draw and a residual draw; the spread of many such trajectories gives the p05–p95 band, and the components above are recombined in quadrature to attribute it. The climate variance is split into GCM, scenario, and weather components following Hawkins and Sutton (2009).

The coefficient layer is a per-county-sigma plus AR(1) parametric bootstrap: AR(1)-correlated residual noise (ϕ about 0.70), scaled by each county's own residual standard deviation, is baked into the simulated responses before each model is refit, so the monthly serial correlation propagates organically. Two simpler estimators were rejected: a marginal draw of the fixed effects overstates the uncertainty, because it re-draws level information the county data already pin down, and a plain conditional bootstrap understates it, because it ignores the residual autocorrelation. An out-of-sample check confirms the coefficient band alone is internally calibrated on the training window but does not cover held-out years, which fall systematically below it; at decadal horizons, structural and assumption uncertainty dominate coefficient uncertainty, so the coefficient band is never presented on its own.

The convention in the figures that follow is bands for the quantified probabilistic components and lines or hatched bars for the modeling choices (the cap year, the income-growth scenario, the population source).

5.1.5 Public Supply (Example)

Public supply's uncertainty is set mainly by the demand-side terms, the unexplained residual and the spread across model structures, with the climate terms secondary. **Figure B-4** shows the total band around the central public-supply forecast, and **Figure B-5** decomposes that band into the contributing terms.

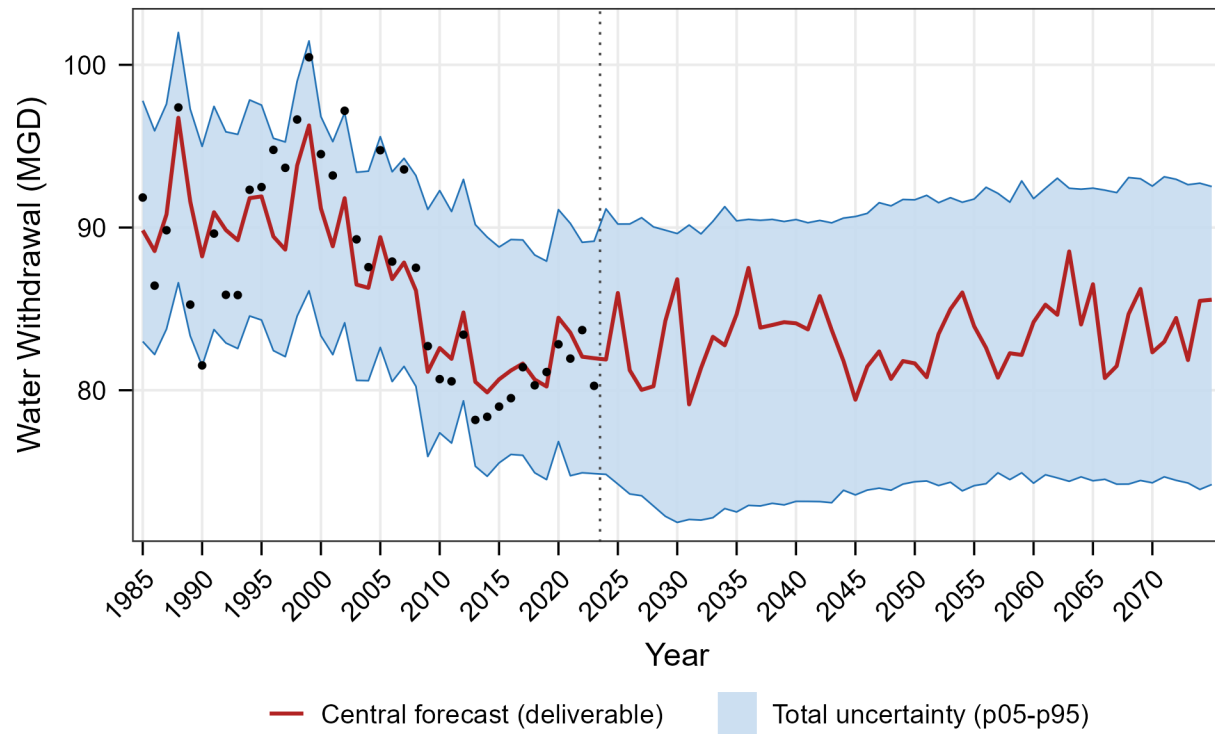
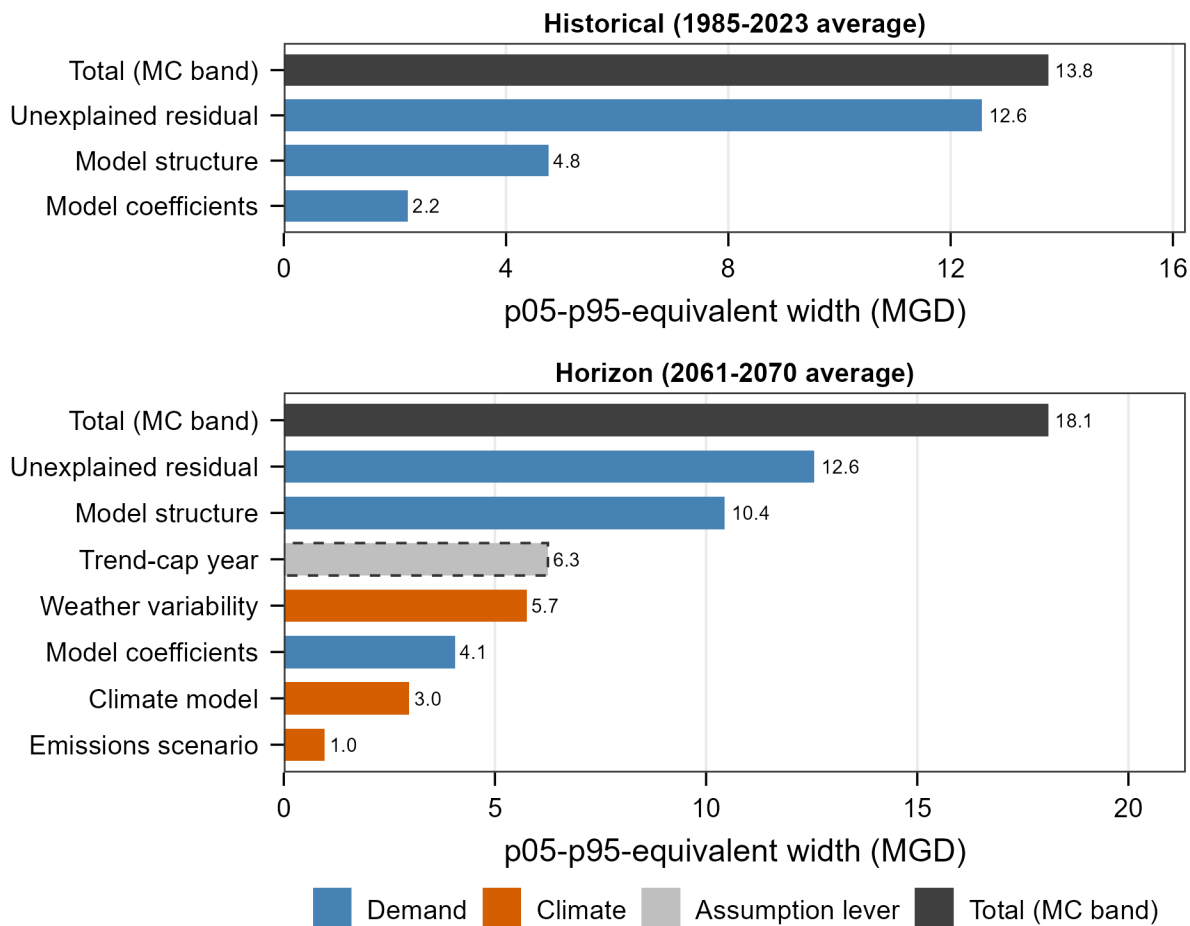


Figure B-4. Public-supply forecast with its total uncertainty band (p05–p95), all sources combined.

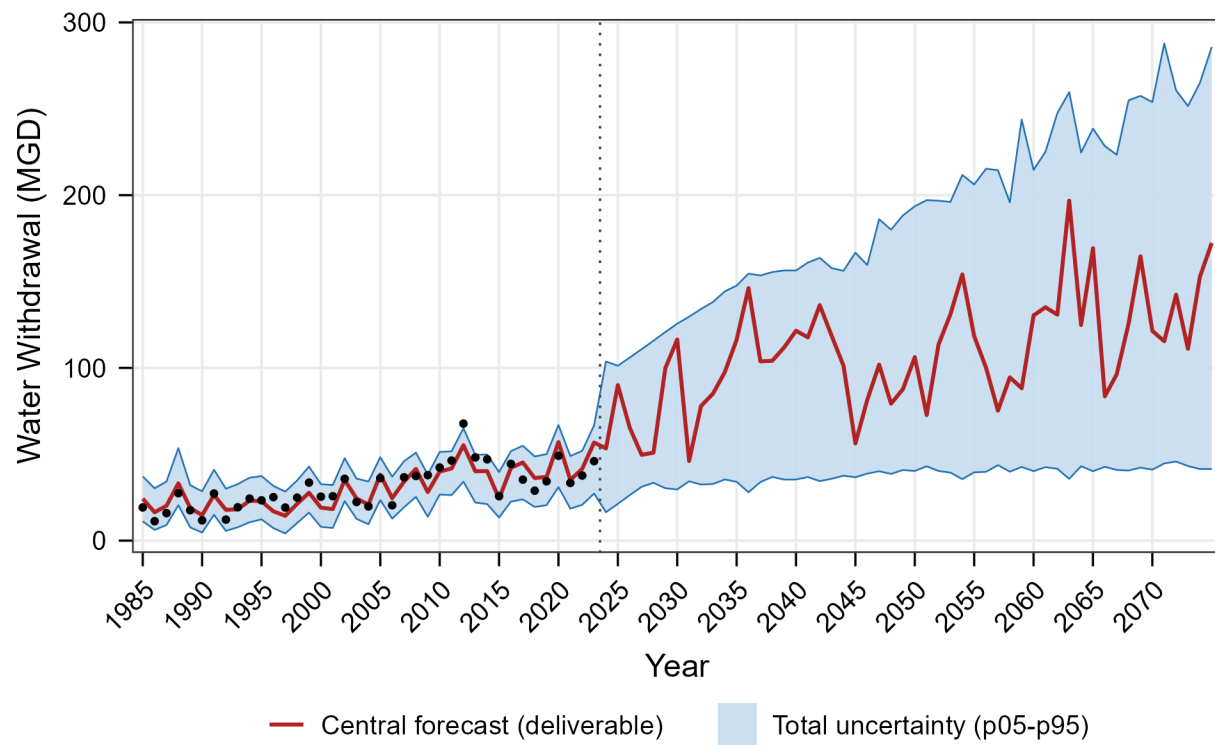


Climate components are zero historically: PRISM climate is observed before 2024.
Bars combine in quadrature, not by addition: the root sum of their squares recovers the Total bar. The trend-cap lever (dashed) is excluded from that total.

Figure B-5. Public-supply uncertainty decomposition (tornado): the contribution of each source to the band width, with the time-trend cap shown as a lever rather than folded into the band.

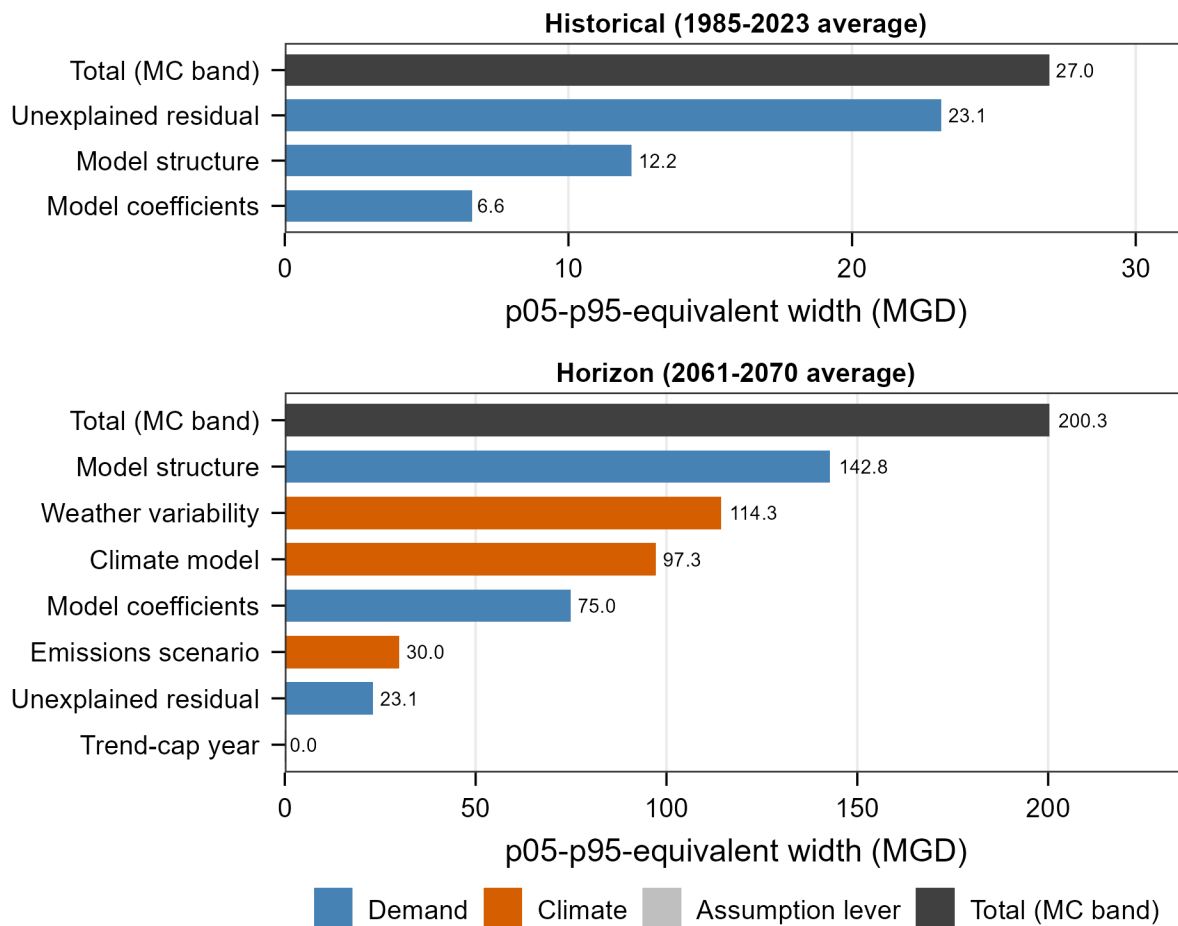
5.1.6 Irrigation (Example)

Irrigation behaves differently. It is the most climate-sensitive category, so the climate terms (the growing-season moisture deficit through the GCM spread and year-to-year weather) carry a much larger share of its band, and the band is correspondingly wider than public supply's. **Figure B-6** shows the total band, and **Figure B-7** shows the decomposition.



Points are observed annual totals; the dotted line is the 2023/2024 observed-to-projected boundary.

Figure B-6. Irrigation forecast with its total uncertainty band (p05–p95), all sources combined.



Climate components are zero historically: PRISM climate is observed before 2024.
Bars combine in quadrature, not by addition: the root sum of their squares recovers the Total bar. The trend-cap lever (dashed) is excluded from that total.

Figure B-7. Irrigation uncertainty decomposition (tornado): the contribution of each source to the band width.

6 Climate Forcing

Historical demand is driven by observed PRISM climate (PRISM Climate Group, Oregon State University), which provides the most accurate climate forcing for the historical period; the forecast is driven by the downscaled (LOCA2) climate ensemble (Pierce et al., 2023), with the central forecast on CNRM-CM6-1 under SSP2-4.5.

CNRM-CM6-1 is a central, not extreme, choice. It ranks 13th of 24 SSP2-4.5 models on growing-season deficit change, the demand-relevant driver, and sits near the ensemble center across all three pairwise views of the projected growing-season climate (**Figure B-8** through **B-10**): moisture deficit against temperature, precipitation against temperature, and precipitation against deficit.

In the figures below the four points in the legend labeled "Means" in each figure are ensemble reference points rather than individual models. MMM is the unweighted average across the 24 models; WMMM is

the average weighted by the NCA5 Bayesian model-averaging weights; and MMM_likelyECS and MMM_verylikelyECS average only those models whose equilibrium climate sensitivity falls in the IPCC likely and very likely ranges. Together they mark where the ensemble center sits under different weighting choices, so a model close to all four is central regardless of which weighting is preferred. They are not candidate futures: the deterministic forecast uses one model's own internally consistent series and never a blended average.

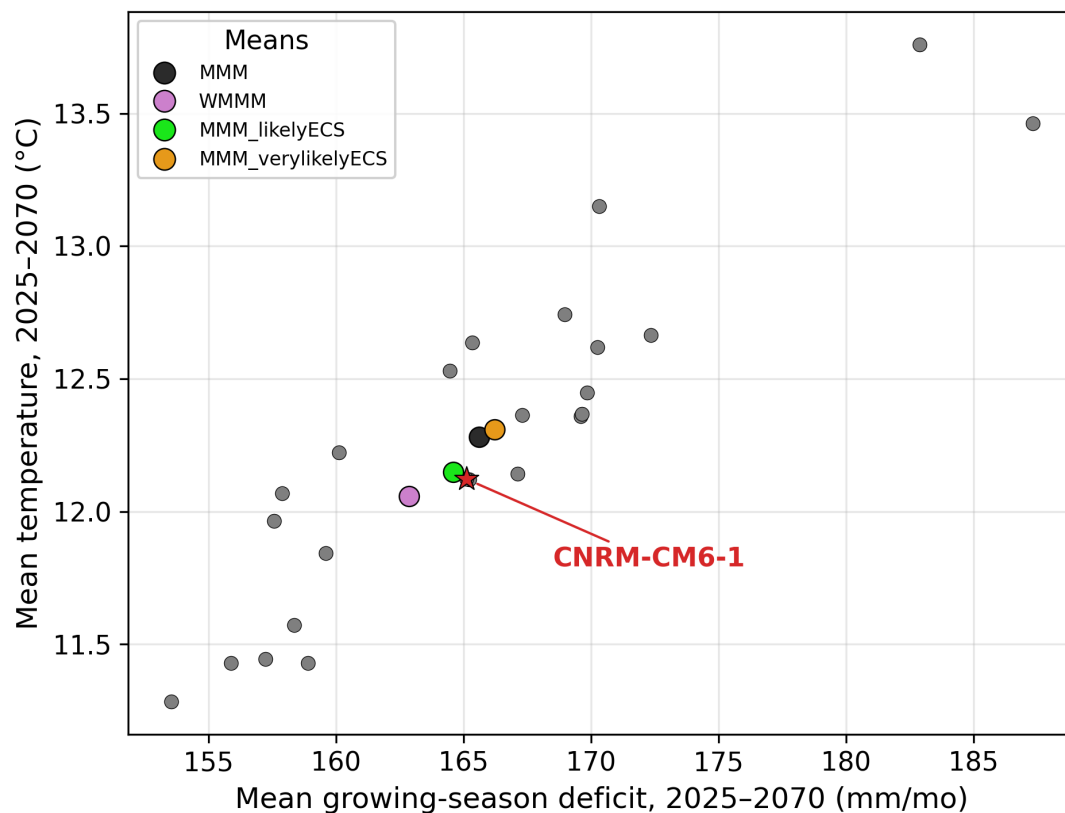


Figure B-8. Growing-season mean moisture deficit versus mean temperature (2025–2070) across the 24-model SSP2-4.5 GCM ensemble, with ensemble-mean stars; the chosen model CNRM-CM6-1 (red star) sits near the center, confirming it is a central choice on the demand-relevant deficit.

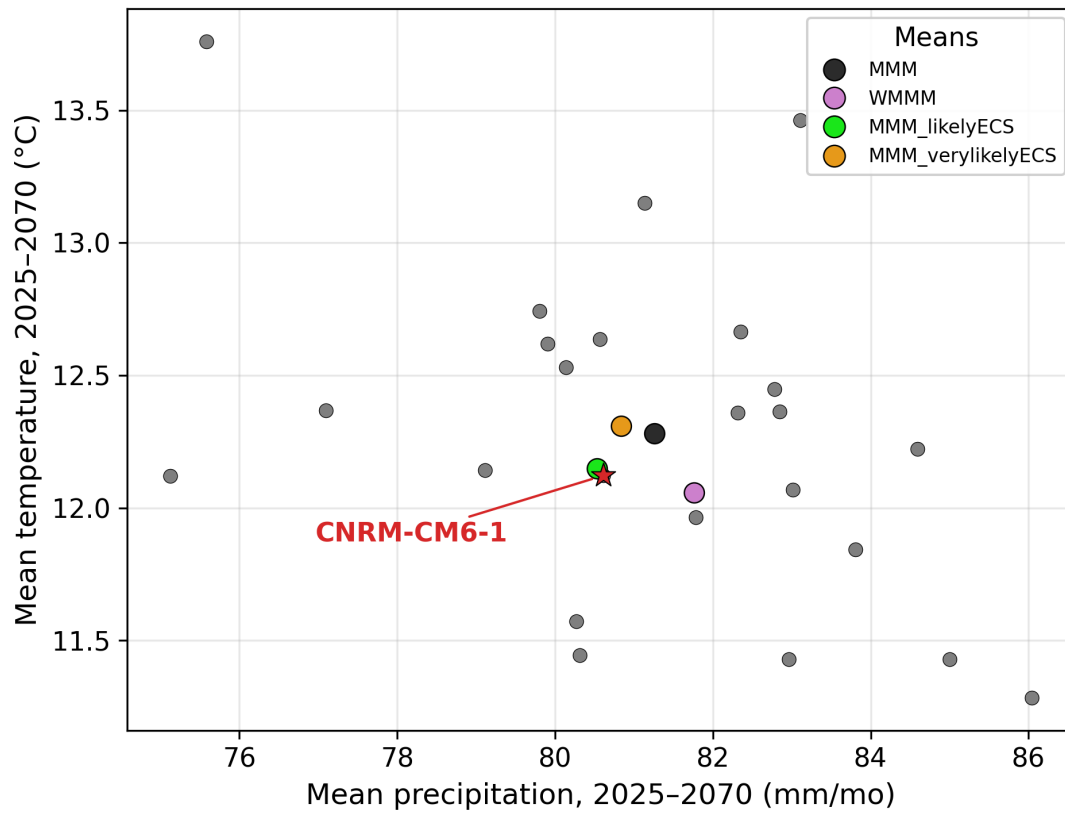


Figure B-9. Growing-season mean precipitation versus mean temperature (2025-2075) across the SSP2-4.5 GCM ensemble; CNRM-CM6-1 (red star) is near the center on both axes.

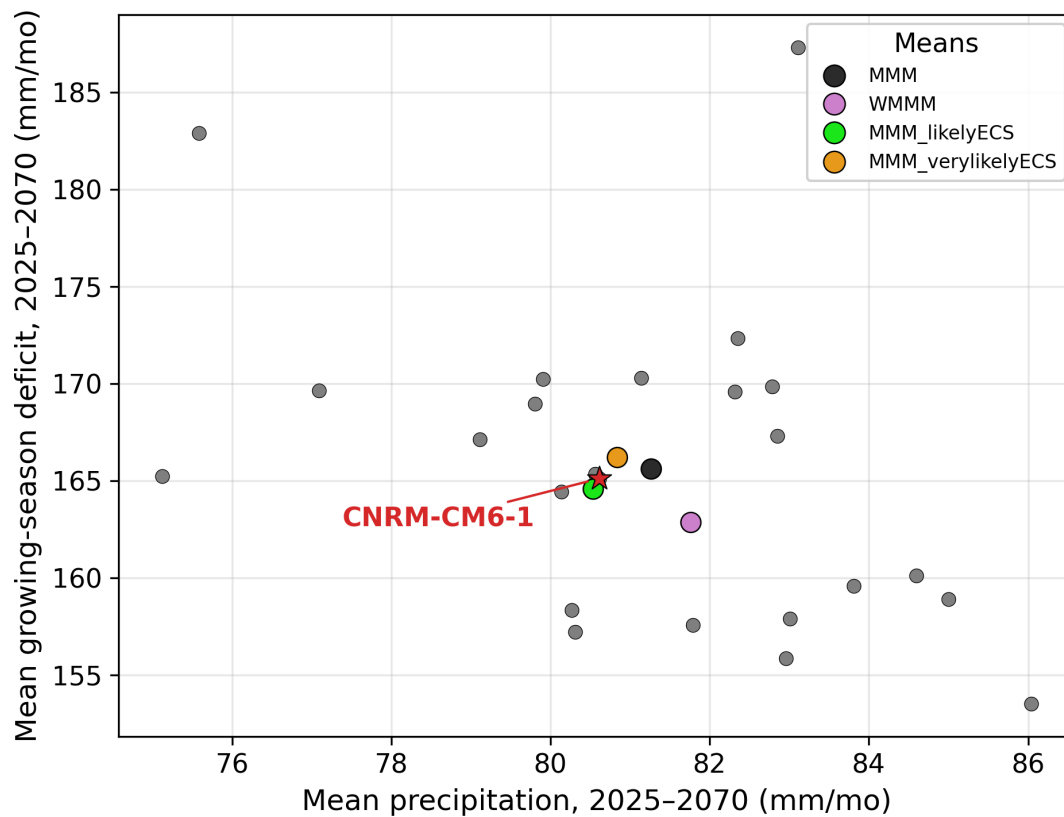


Figure B-10. Growing-season mean precipitation versus mean moisture deficit (2025–2075) across the SSP2-4.5 GCM ensemble; CNRM-CM6-1 (red star) is central on the deficit axis.

6.1 The Observed-to-Projected Splice

The historical period is forced with PRISM and the forecast with the GCM, so the join between them must not introduce a spurious jump. For the population-driven categories, it does not: replacing direct GCM forcing with a delta-change forcing (observed climatology plus the GCM anomaly) changes public-supply demand by less than 1 percent, so the splice is sound there.

For irrigation, the splice matters. Holding the demand model fixed and swapping only the climate input, projected-climate irrigation demand sits about 17 percent above observed-climate demand over the same 1985–2023 years. This is a genuine **trend** mismatch, not a bias-correction failure: over the bias-correction training window (1950–2014), the GCM ensemble matches PRISM on every driver to within about 1 percent, and the gap opens monotonically toward the present (**Table B-14**):

Table B-14. Growing-season (May–Sep) offset, projected (GCM) versus observed (PRISM), by driver and window.

Driver	1950–2014 (BC training)	1985–2014	2015–2023
Precipitation	–0.4%	–3.8%	–12.4%
PET (Hargreaves)	0.0%	+2.8%	+7.7%
Deficit (PET – AET)	+0.8%	+6.2%	+21.1%

Two documented phenomena combine to produce this. First, the region’s observed summers have been wetting and not warming due to the U.S. Midwest “warming hole,” attributed to twentieth-century cropland intensification (Mueller et al., 2016; Nikiel and Eltahir, 2019), which global models largely fail to reproduce. Second, quantile-mapping bias correction anchors each model’s distribution to observations over the training window but preserves the model’s own trend (Cannon et al., 2015), so the models’ steeper growing-season warming and drying is carried forward. The convex, deficit-driven irrigation response amplifies the roughly 9 percent growing-season deficit gap over 1985–2023 as a whole, spanning the +6.2 and +21.1 percent sub-window values in Table B-4, into the roughly 17 percent demand gap.. The observed recent deficit slope (–1.2 millimeters [mm]/decade) sits at the low edge of the GCM spread (–3.2 to +6.3 mm/decade); a minority of models (including the chosen CNRM-CM6-1, whose recent-decade direction matches the observed decline even though its level runs high) reproduce the observed slope, but the ensemble central tendency rises. The robust, near-universal feature is the level offset, not a unanimous slope. This is why projected irrigation growth carries the explicit caveat in the irrigation and agricultural water supply forecast, and constraining it to moderate-sensitivity models does not materially narrow it (Hausfather et al., 2022).

7 Monthly Demand Forecasts by Category

The headline forecasts in the main report are annual averages. The monthly resolution that underlies them is shown here for each category, as the regional total and by county (history on observed PRISM climate, forecast on the chosen GCM, 1985–2070) (**Figure B-11** through **B-23**). The within-year seasonal cycle and its year-to-year variability are most pronounced in the weather-sensitive categories. Counties with no withdrawals in a sector are omitted from that sector's figure, so panel counts differ.

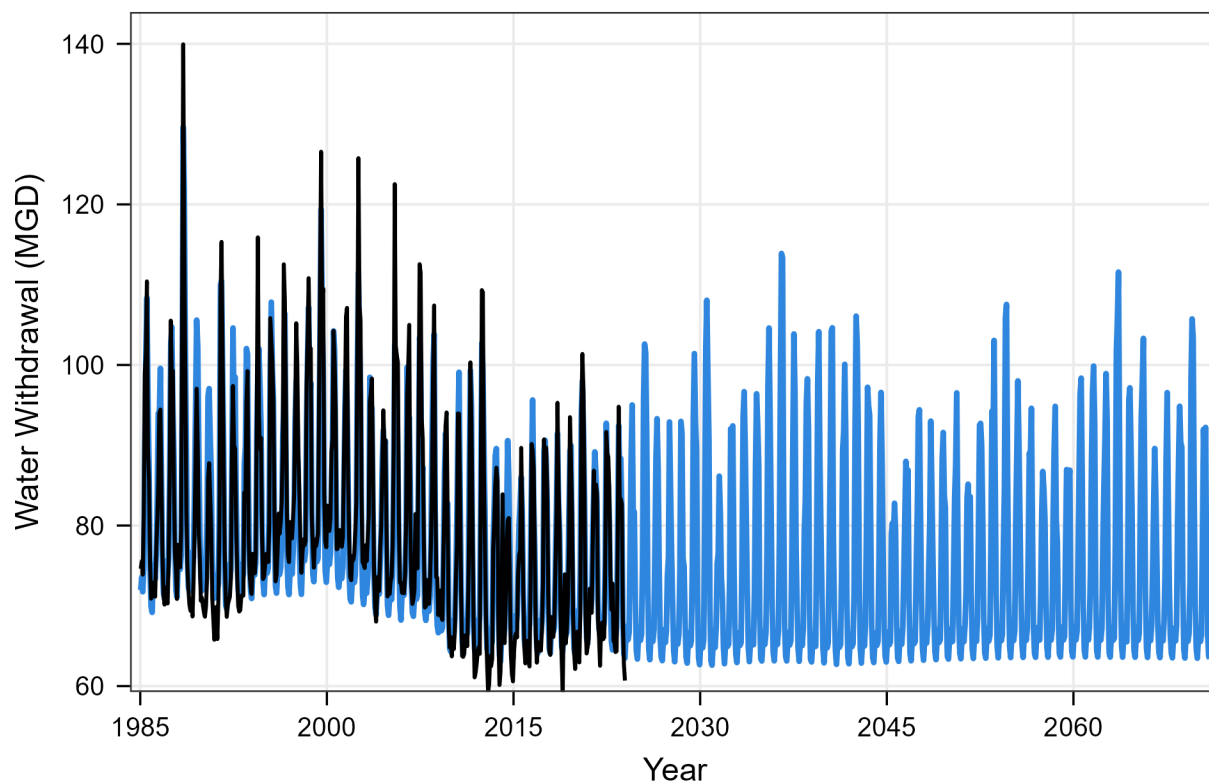


Figure B-11. Monthly public-supply demand (MGD), regional total, 1985-2070.

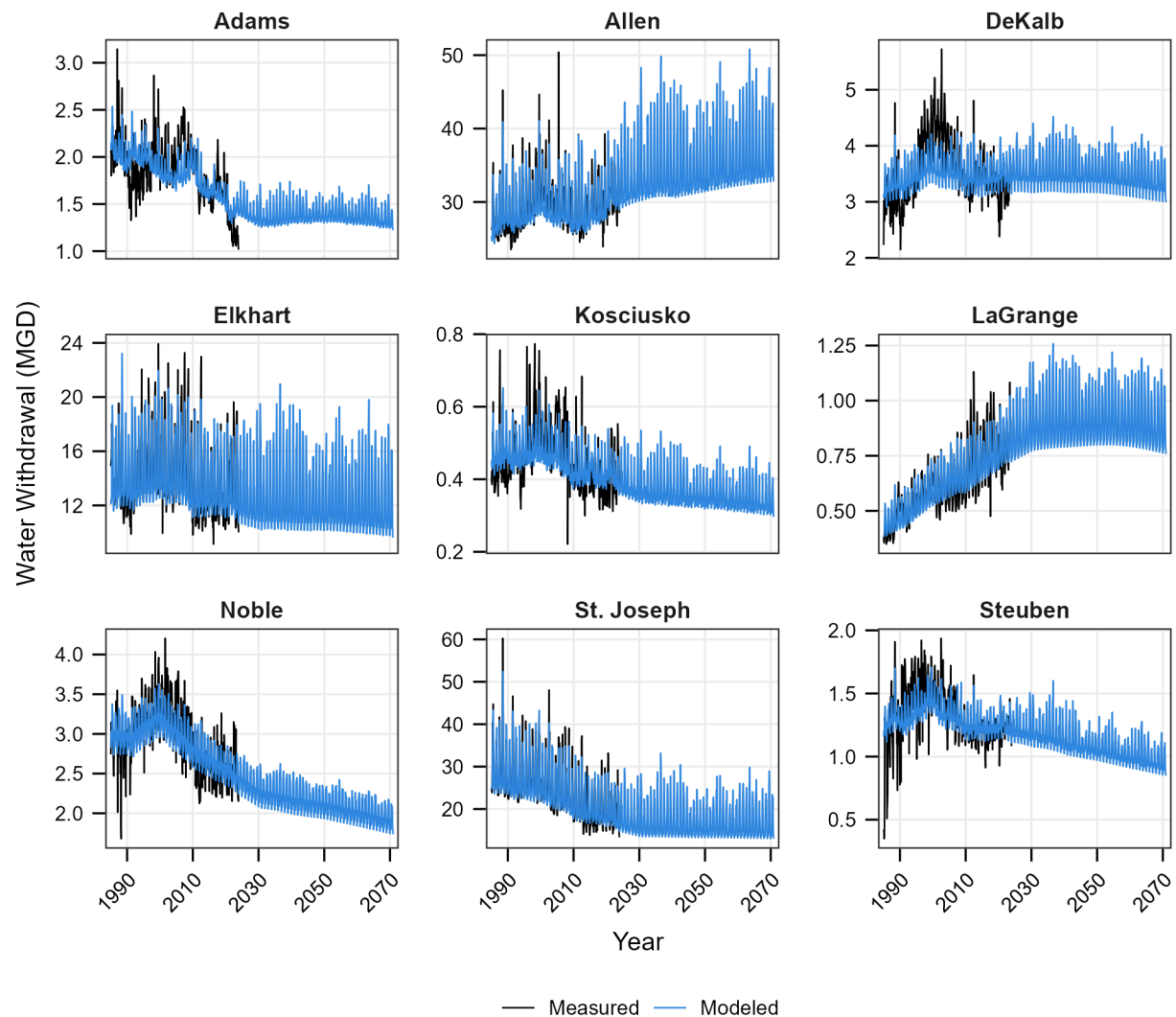


Figure B-12. Monthly public-supply demand (MGD) by county, 1985-2070.

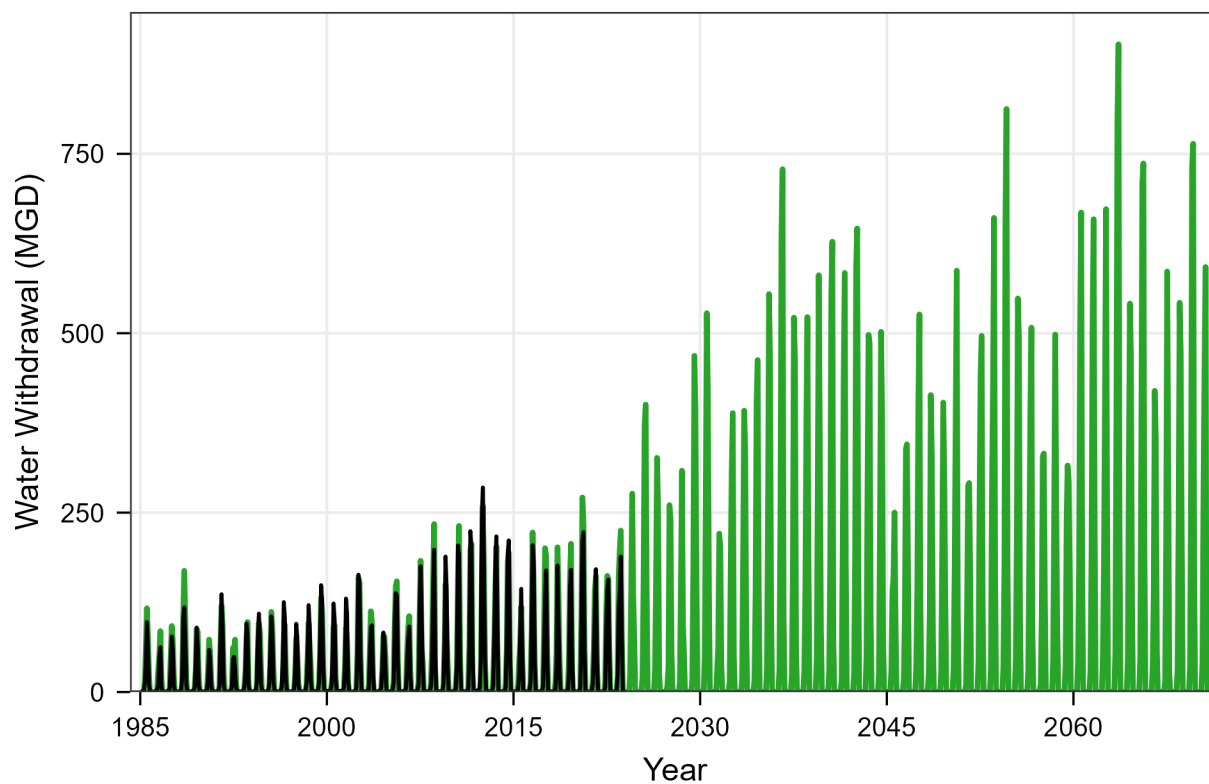


Figure B-13. Monthly irrigation demand (MGD), regional total, 1985-2070.

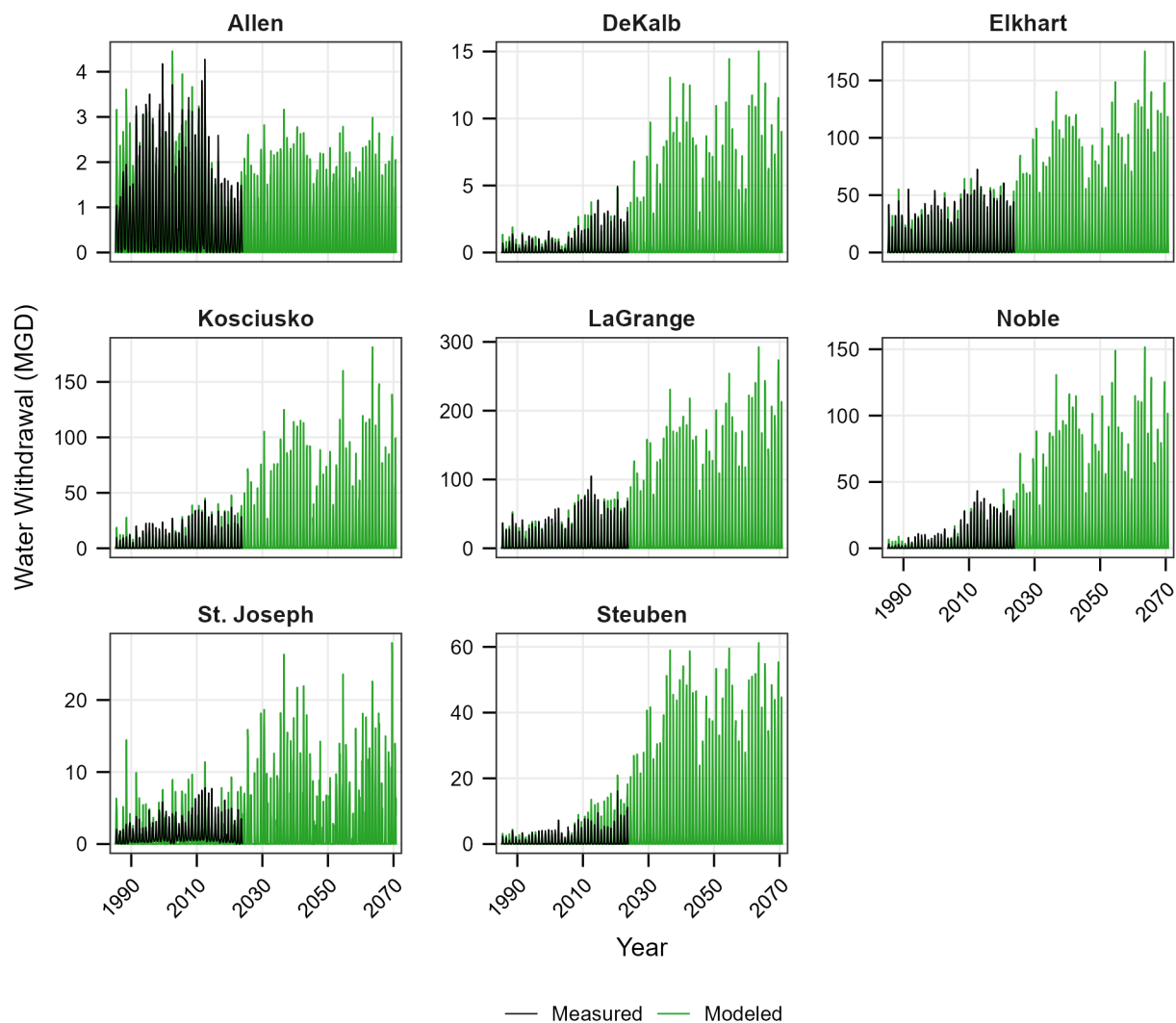


Figure B-14. Monthly irrigation demand (MGD) by county, 1985-2070.

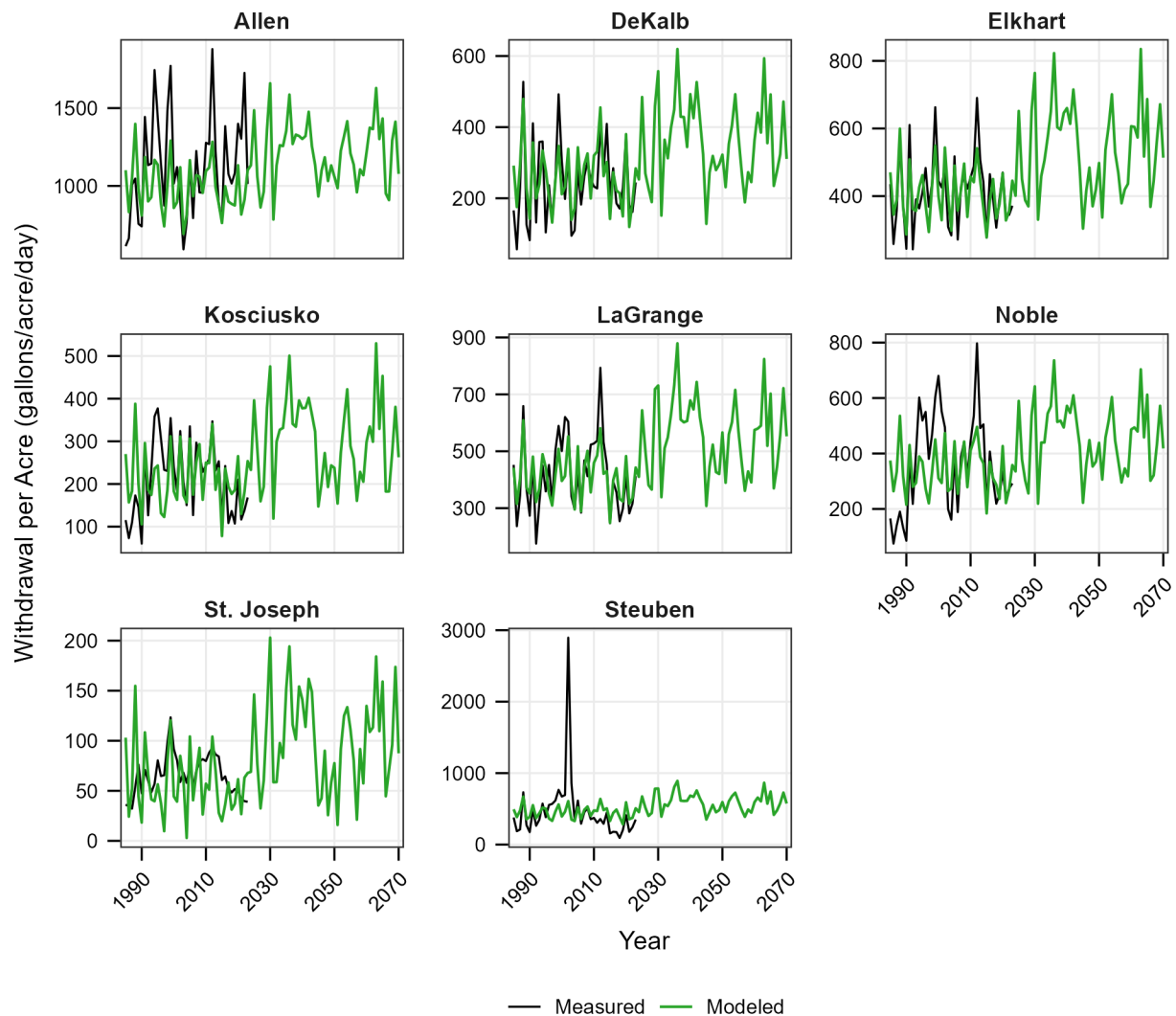


Figure B-15. Irrigation demand per irrigated acre by county (the per-acre basis the model scales by irrigated area).

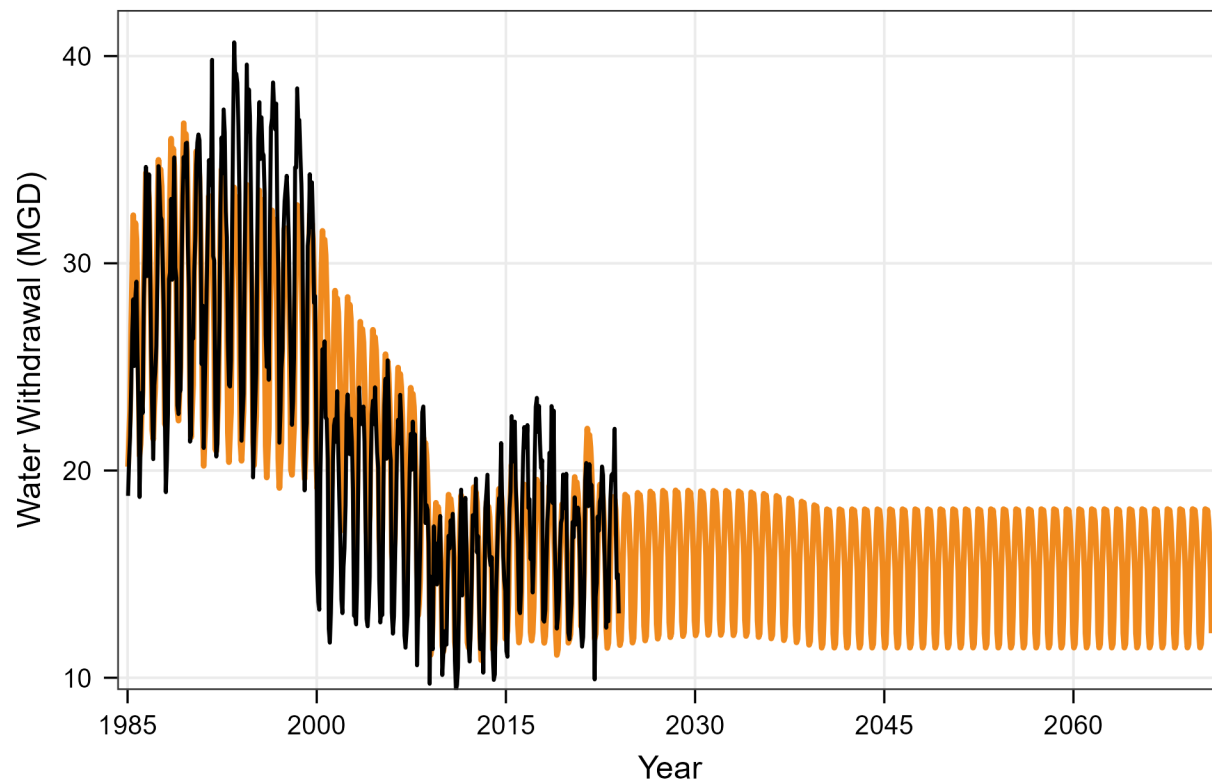


Figure B-16. Monthly industry demand (MGD), regional total, 1985–2070.

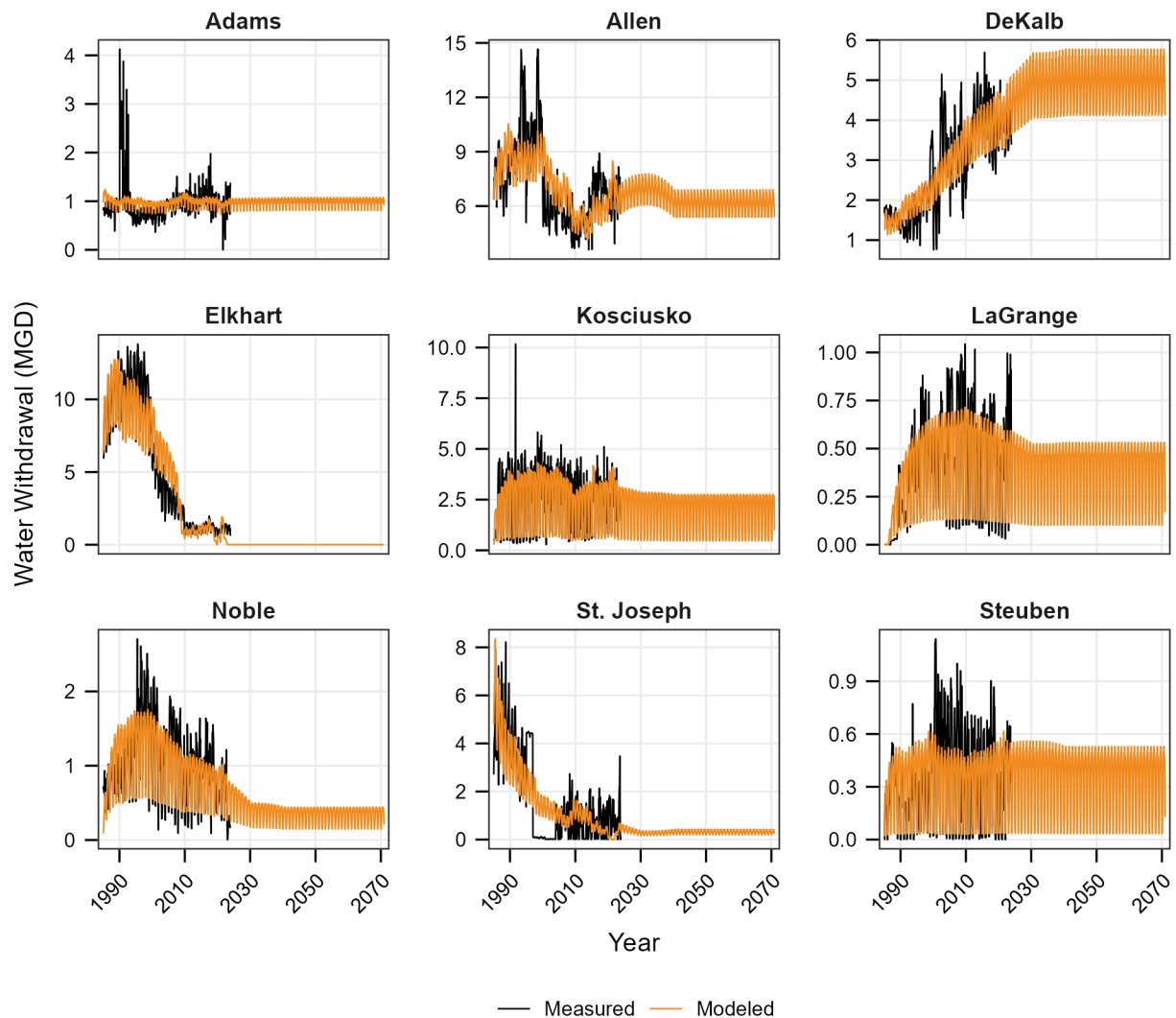


Figure B-17. Monthly industry demand (MGD) by county, 1985-2070.

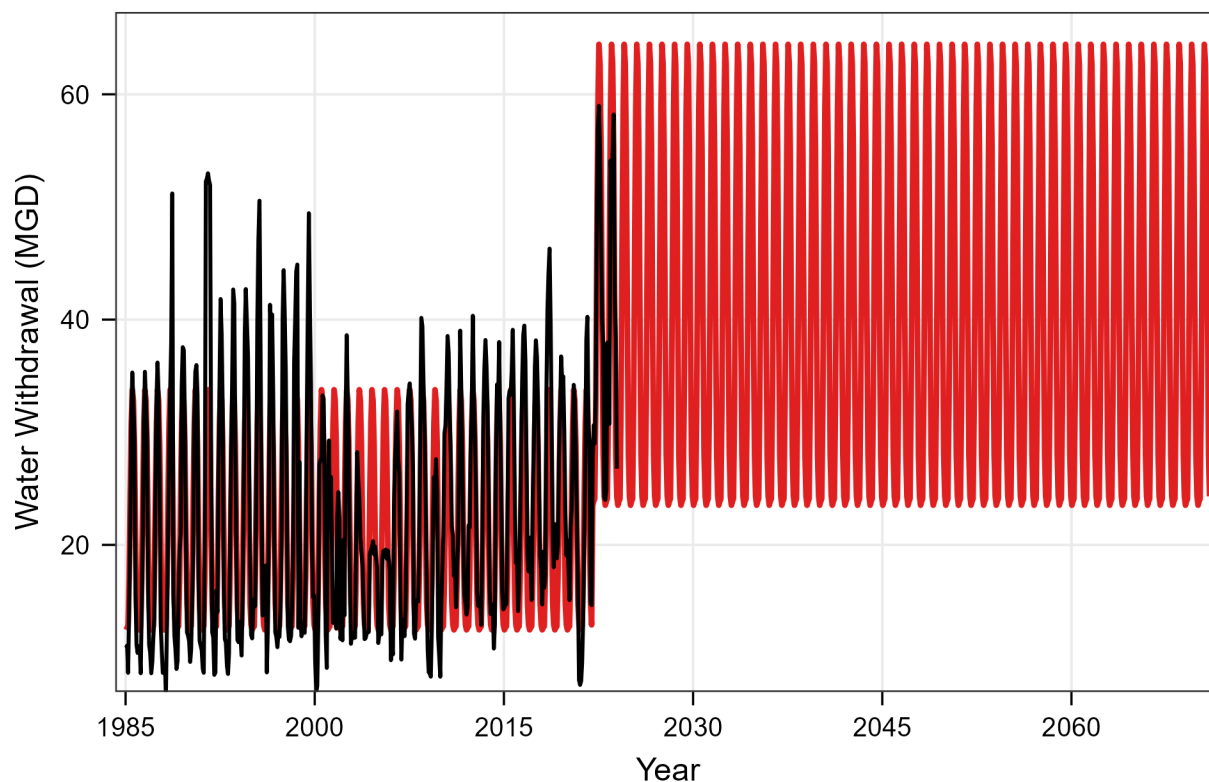


Figure B-18. Monthly power-generation demand (MGD), regional total, 1985-2070.

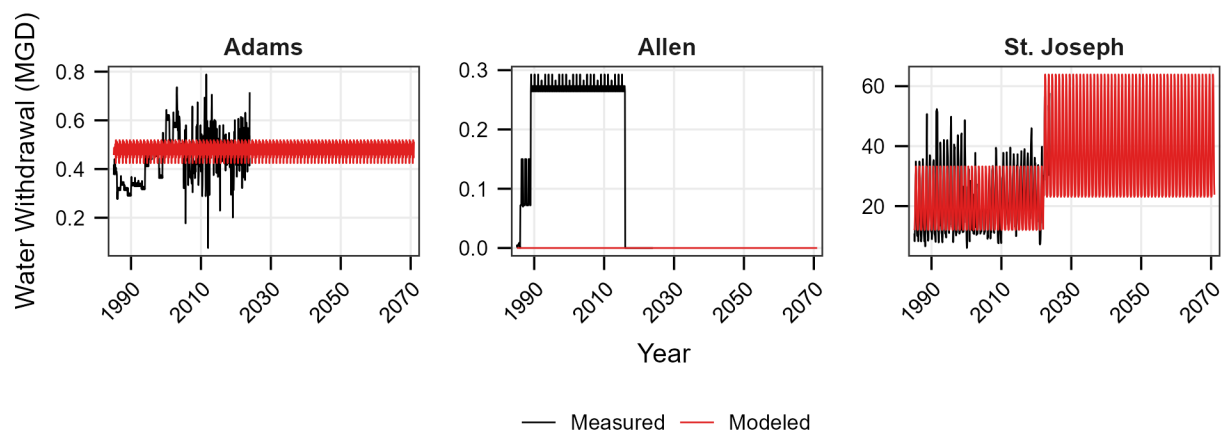


Figure B-19. Monthly power-generation demand (MGD) by county, 1985-2070.

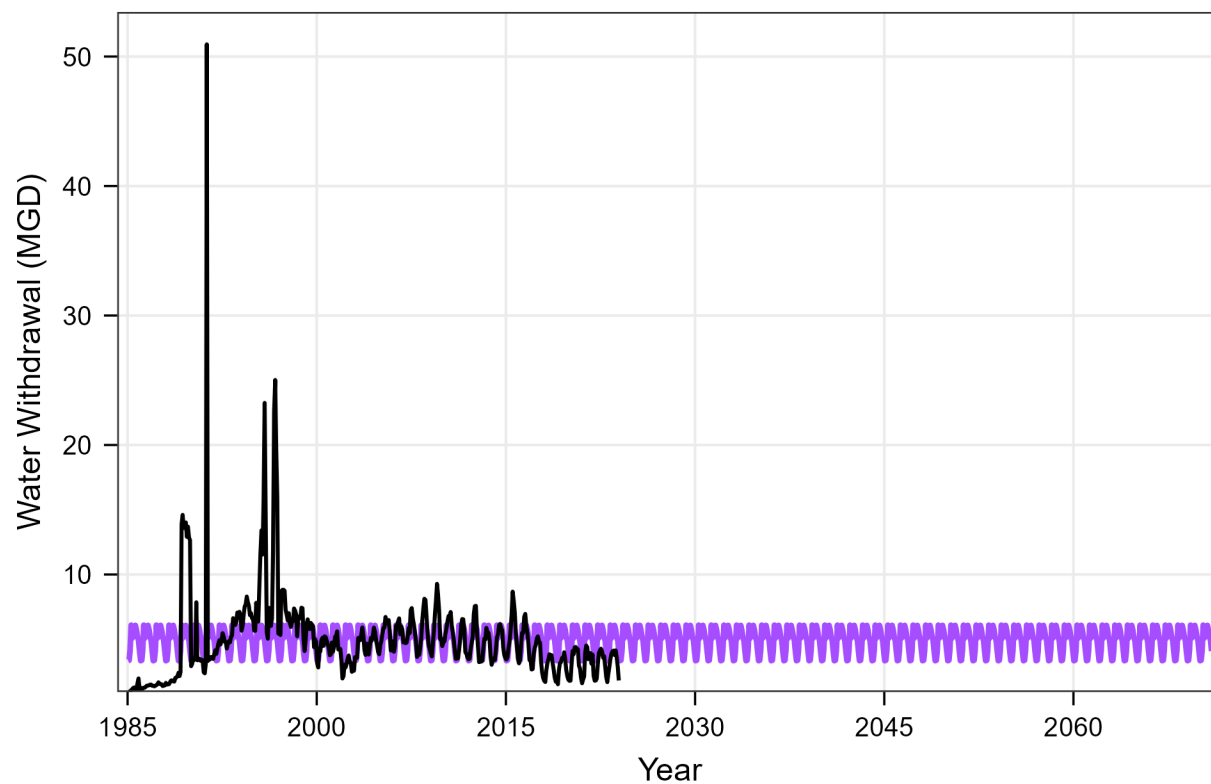


Figure B-20. Monthly miscellaneous demand (MGD), regional total, 1985–2070.

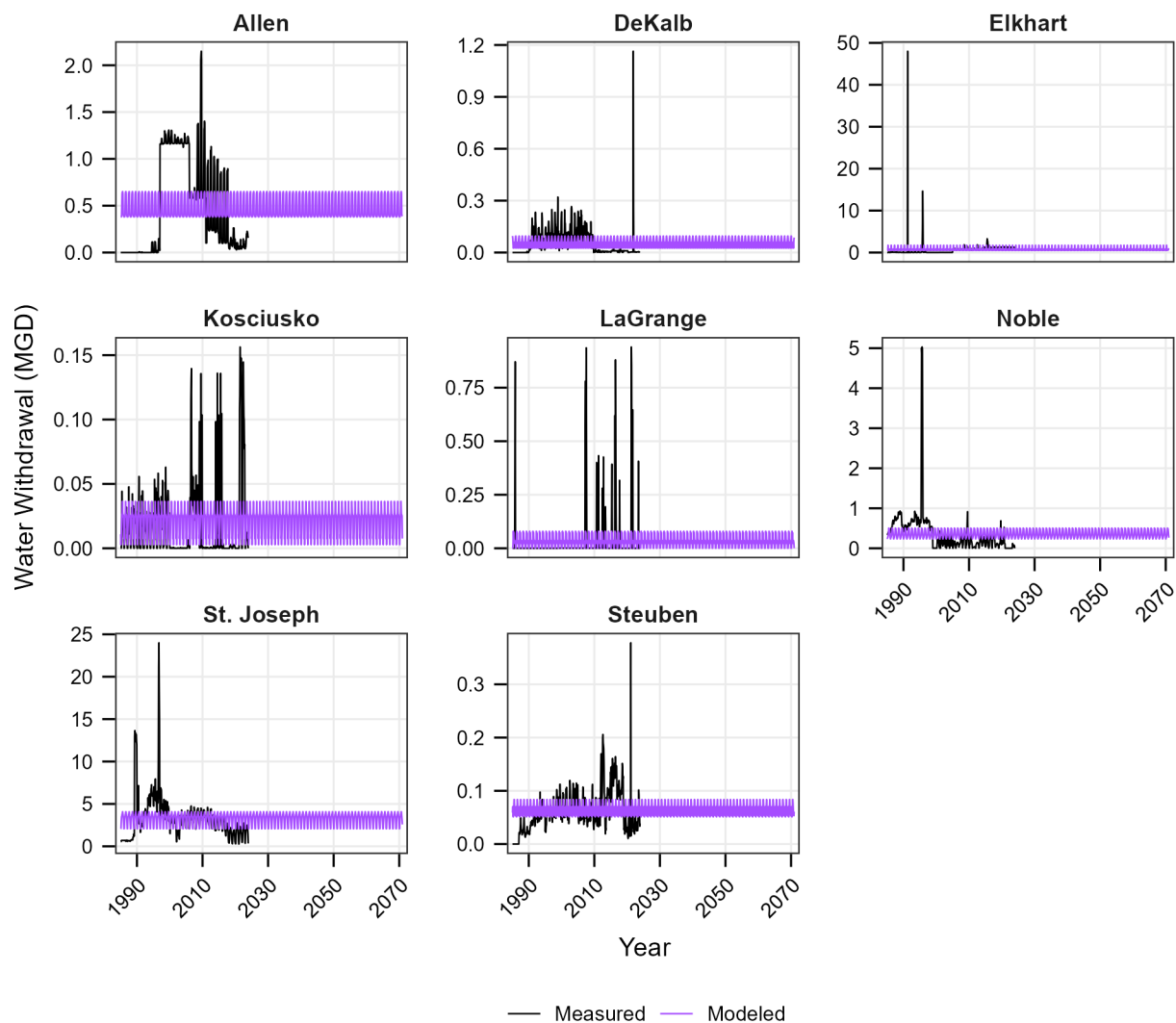


Figure B-21. Monthly miscellaneous demand (MGD) by county, 1985-2070.

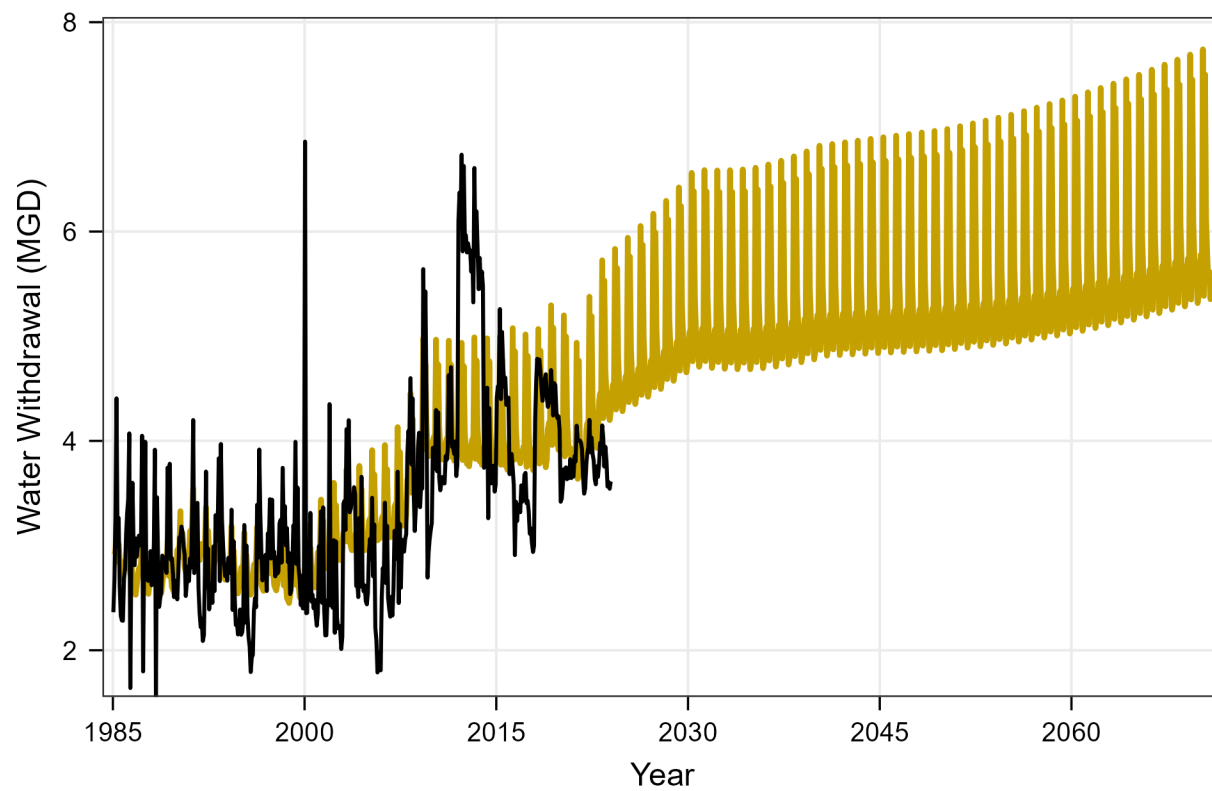


Figure B-22. Monthly rural-use demand (MGD), regional total, 1985-2070.

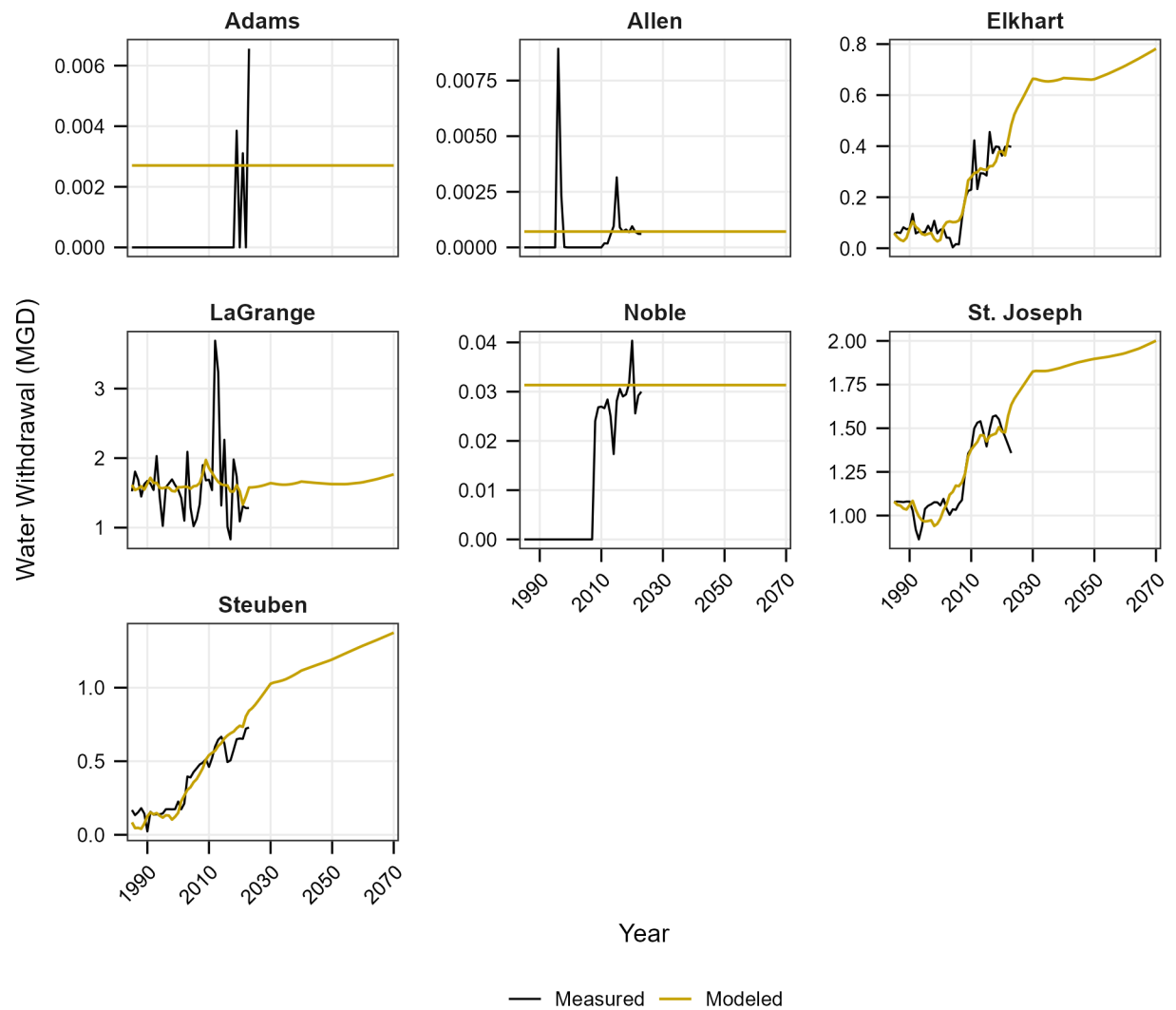


Figure B-23. Monthly rural-use demand (MGD) by county, 1985–2070.

8 Non-Regression Demand Models: Self-Supplied Residential, Energy Production, and CFO and CAFO Water Sectors

Three categories bypass this regression pipeline. **Self-supplied residential** demand is computed directly rather than fit. Statewide public-water-utility service-area polygons (a 2014 base with a 2023 partial update) are dissolved into a single “served” geometry, and 2020 American Community Survey block-group population (U.S. Census Bureau, 2020) is apportioned by area to each whole county and to the part of each county inside the served geometry; the difference is the unserved (private-well) population. Self-supplied demand is then the unserved population times the per-capita rate of Table 13 in the main report text, a population-weighted blend of 80 gallons per capita per day (GPCD) (general population; a conventional self-supplied domestic rate, after Dieter et al., 2018) and 40 GPCD (Amish population; a reduced central estimate, set below the roughly 50 GPCD on-site wastewater design flow for a conventional single-family household [U.S. Environmental Protection Agency, 2002] to reflect more limited in-home plumbing) using each county’s 2010 religious-census Amish share (Association of Statisticians of American Religious Bodies, 2010), converted to MGD. The served share and the per-capita rate are held constant over time, and the unserved population is carried forward with the county population projection, so the forecast scales with population alone and is spread evenly across the months. Three assumptions are worth flagging as caveats: the self-supplied population is the county population remaining after the utilities’ own reported service populations are subtracted, apportioned among counties by where each service area falls, so it inherits whatever error those reported figures carry and relies on substitute values for the utilities that report none; the per-capita rate is assumed, not calibrated; and service-area expansion over the fifty-year horizon is not modeled. **Energy production** is likewise handled outside the regression model, as a facility-level regime level shift (B.3).

8.1 CFO and CAFO Demand Modeling

Water use associated with Confined Feeding Operations (CFOs) and Concentrated Animal Feeding Operations (CAFOs) was estimated using livestock census data from two sources: the USDA Agricultural Census and the Indiana Department of Environmental Management (IDEM), Office of Land Quality. The U.S. Department of Agriculture (USDA) dataset provides historical livestock end-of-year inventories at five-year intervals from 1997 through 2022, while the IDEM dataset identifies operations meeting CFO or CAFO livestock thresholds in 2021. Although the IDEM data more accurately represent regulated feeding operations, the USDA dataset was used to establish historical trends because it provides the only multi-year record.

Livestock records were grouped by county and consolidated into broad animal categories, including cattle, pigs, poultry, horses, goats, and sheep. Animal populations were multiplied by category-specific daily water-use rates to estimate total livestock water demand for each county and census year. These estimates were then evaluated as time series to develop county-specific equations for projecting future water use.

Because the USDA data include smaller farms that do not qualify as CFOs or CAFOs, its estimated water-use totals were higher than those derived from the 2021 IDEM dataset. Therefore, county-specific adjustment factors were calculated using the ratio of 2021 IDEM-estimated water use to 2022 USDA-estimated water use. These factors were applied to the USDA-based projections to produce estimates more representative of actual CFO and CAFO operations.

Additional water-use was scaled from the county area to the portions of the county that are within the subbasin. County-level projections were first scaled to represent only the portions of each county located within the study area. Subbasin estimates were then developed by calculating the contribution from each county intersecting a subbasin and applying the appropriate county-specific projection and adjustment factors. Finally, annual projections were converted to monthly values for incorporation into the water model. Seasonal multipliers were applied to reflect higher livestock water demand during the summer, with demand increasing in June and September and reaching its highest level in July and August.

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Appendix C

Historical Water Availability

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1 Streamflow Infilling and Synthetic Records

The daily streamflow records for the U.S. Geological Survey (USGS) gages presented in **Table C-1** required either infilling missing periods of data or extending the record through correlation with nearby gages. An example of flow correlation for the Fawn River and the Prairie River is shown in **Figure C-1**.

Table C-1. Daily flow records that required infilling or record extension.

USGS Station	Description	Period of Record	Action
04098500	Fawn River near White Pigeon, MI	1957-1974	Correlation with 04097540
04101225	St Joseph River at South Bend, IN	2019-2025	Correlation with 04101500
04191378	Flatrock Creek near Payne, OH	2015-2016	Correlation with 04186500
04183500	Maumee River at Antwerp, OH	miss. 2007-2014	Correlation with 04183000

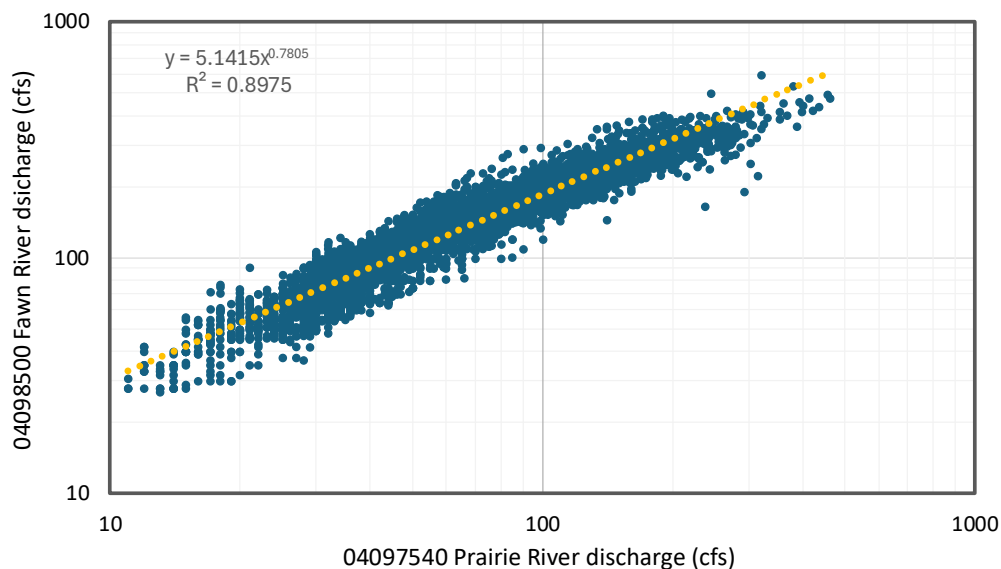


Figure C-1. Example of streamflow correlation.

2 Maumee Basin: Net Returns, Natural Streamflow and Natural Baseflow

Essential quantities for the evaluation of historical water availability are summarized graphically in the following pages. First is a summary of withdrawals and return flows by sub-basin (**Figures C-2 through C-4**), followed by a summary of monthly average natural streamflow and natural baseflow by sub-basin (**Figures C-5 through C-7**) in the Maumee River watershed.

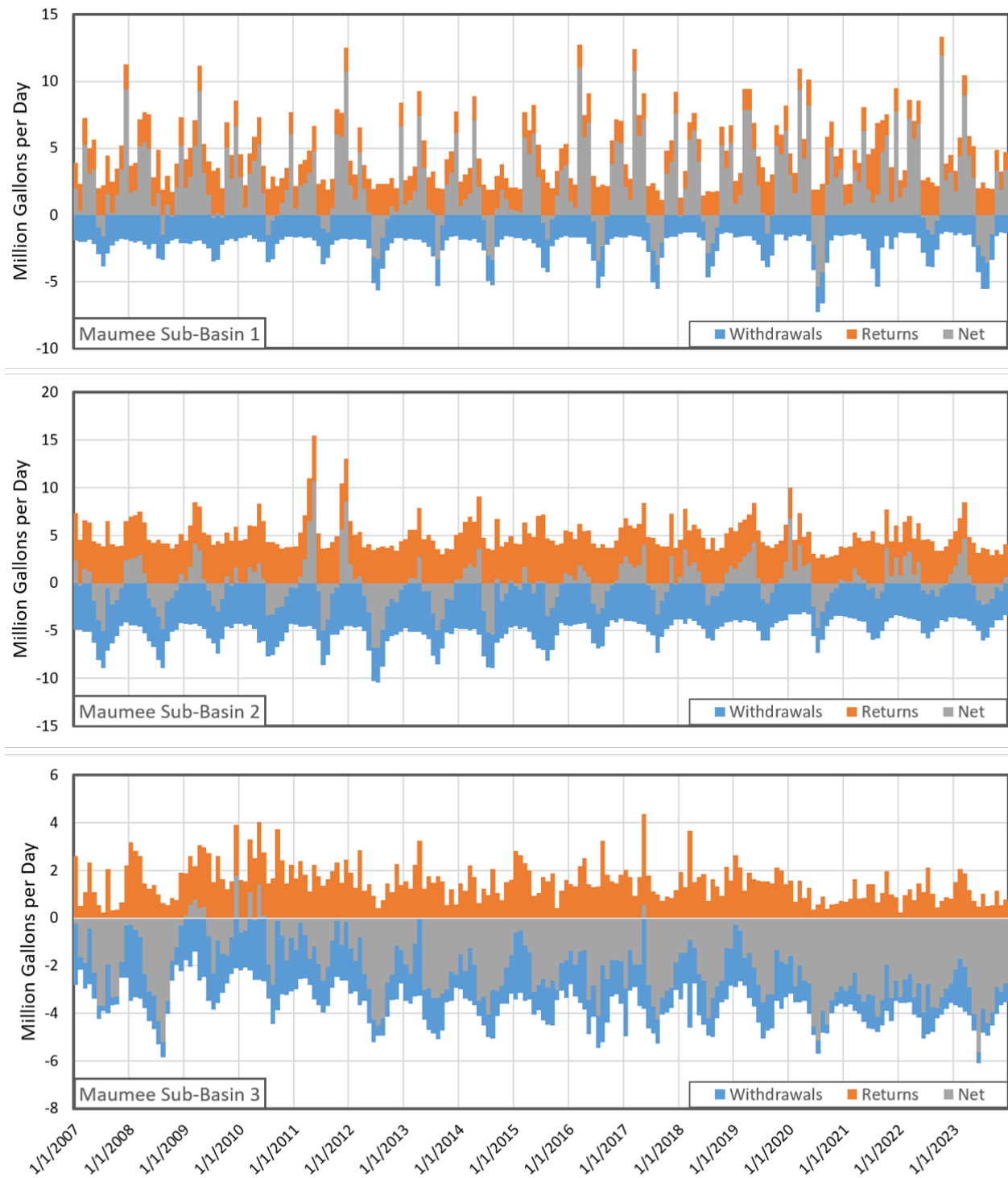


Figure C-2. Withdrawals and returns in Sub-Basins 1-3.

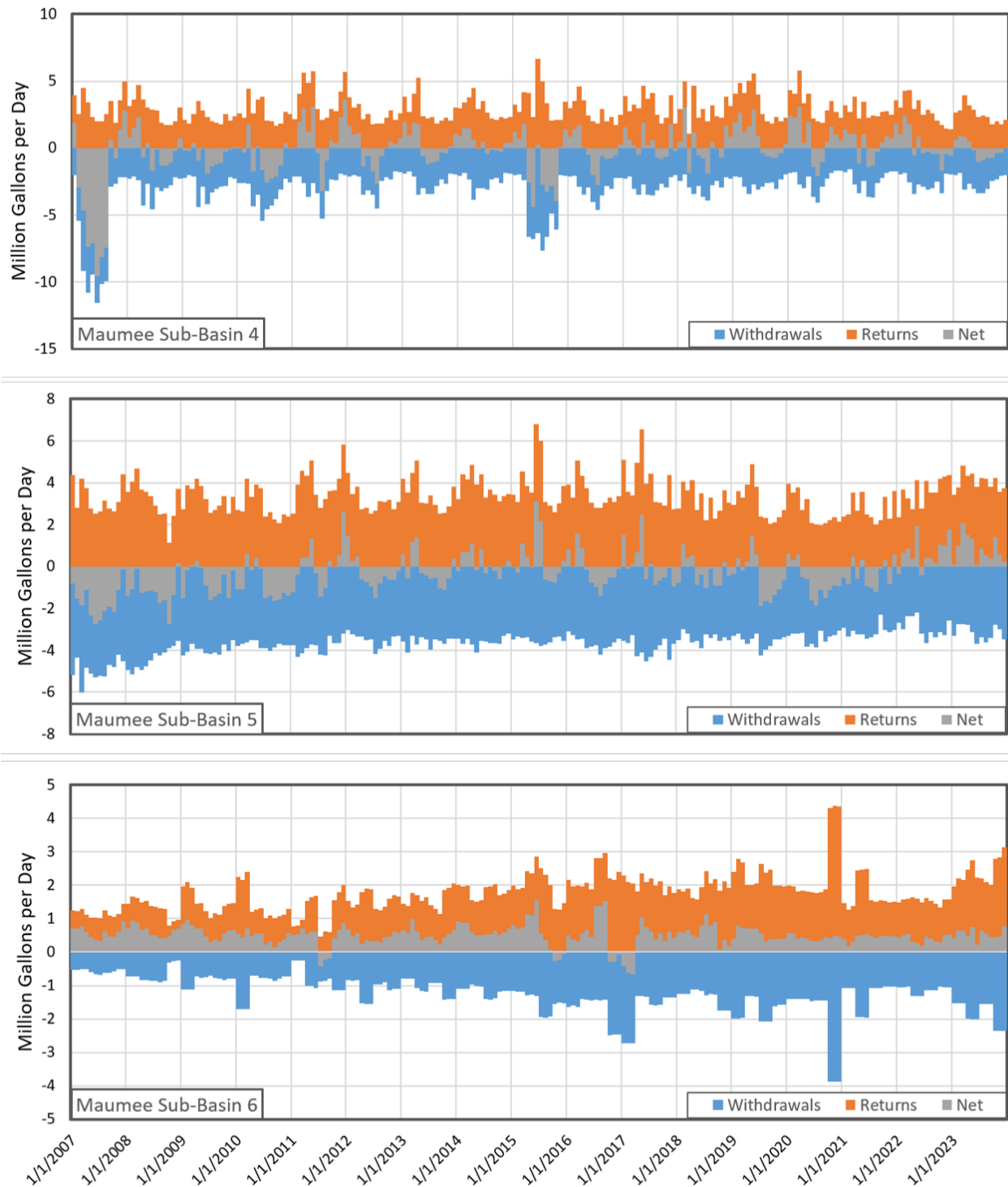


Figure C-3. Withdrawals and returns in Sub-Basins 4-6.

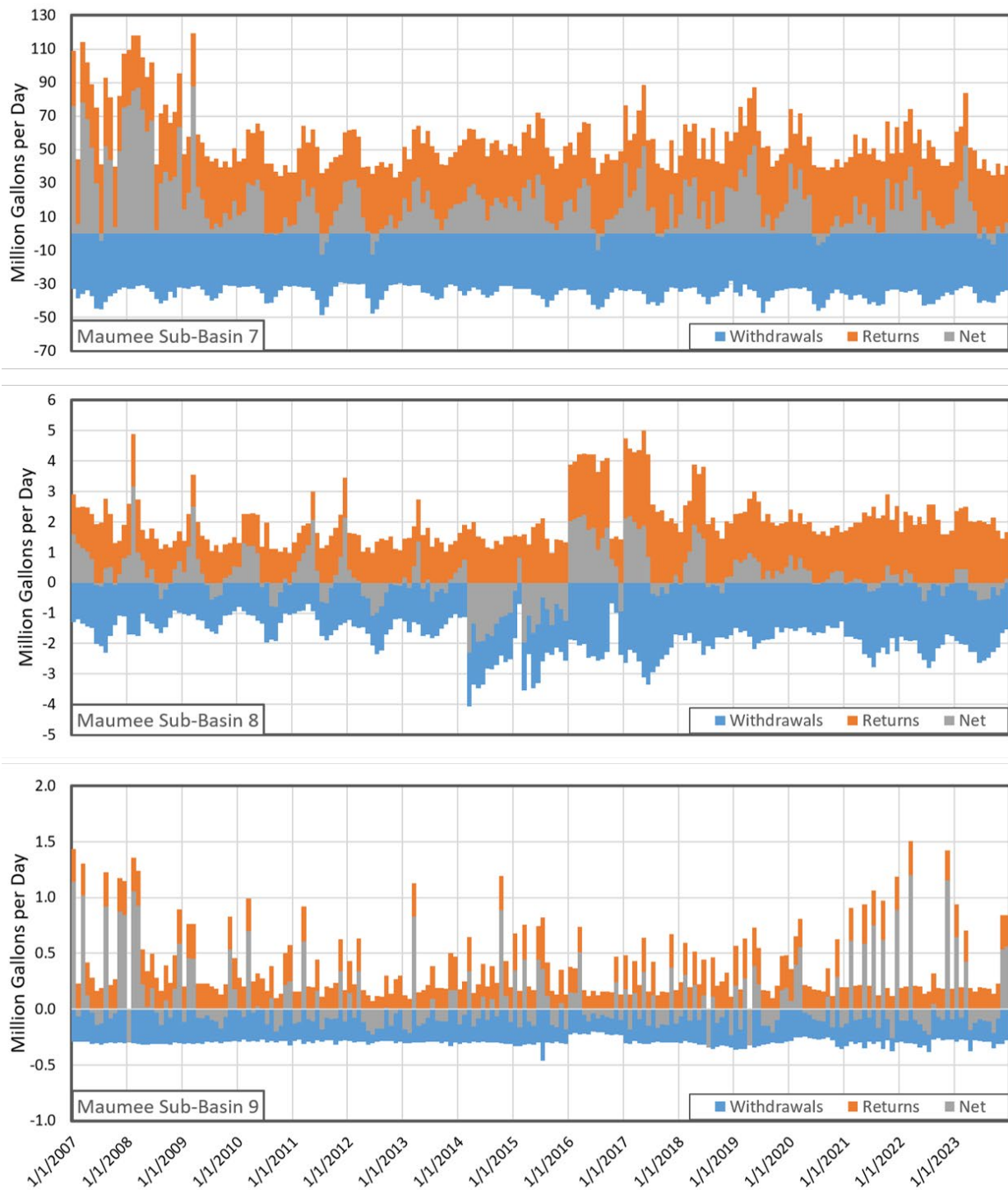


Figure C-4. Withdrawals and returns in Sub-Basins 7-9.

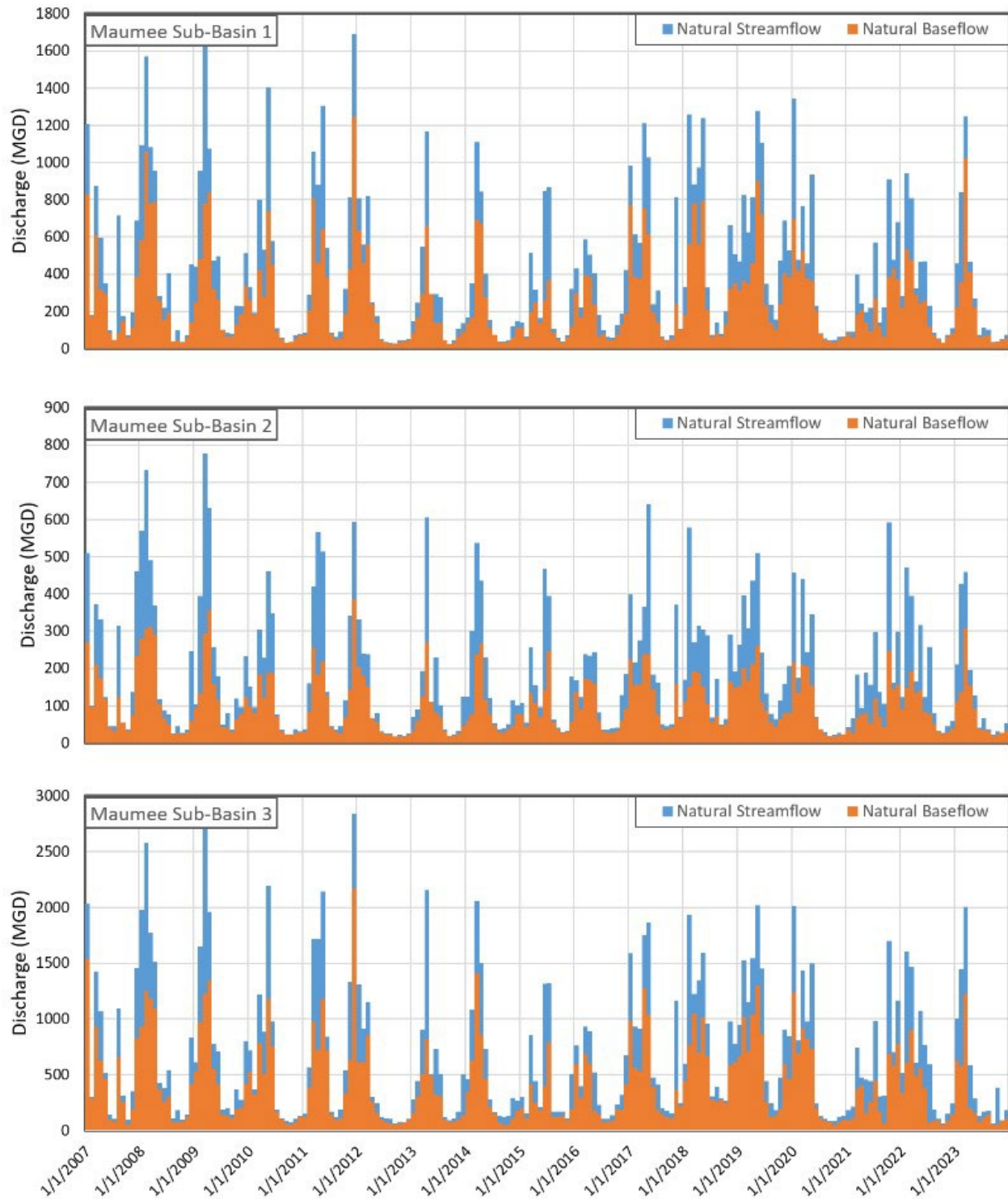


Figure C-5. Monthly average natural streamflow and natural baseflow at the outlet of Sub-Basins 1-3.

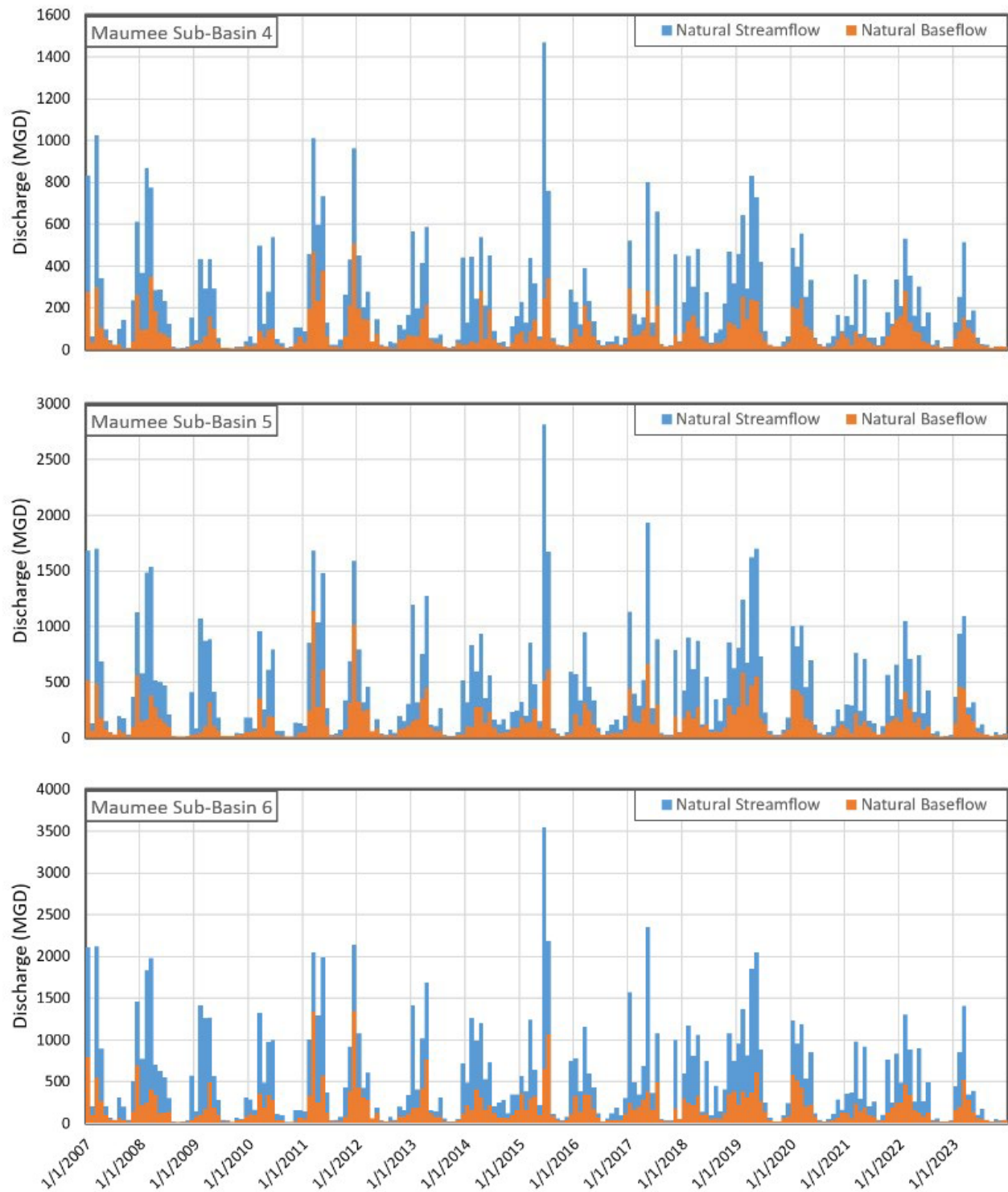


Figure C-6. Monthly average natural streamflow and natural baseflow at the outlet of Sub-Basins 4-6.

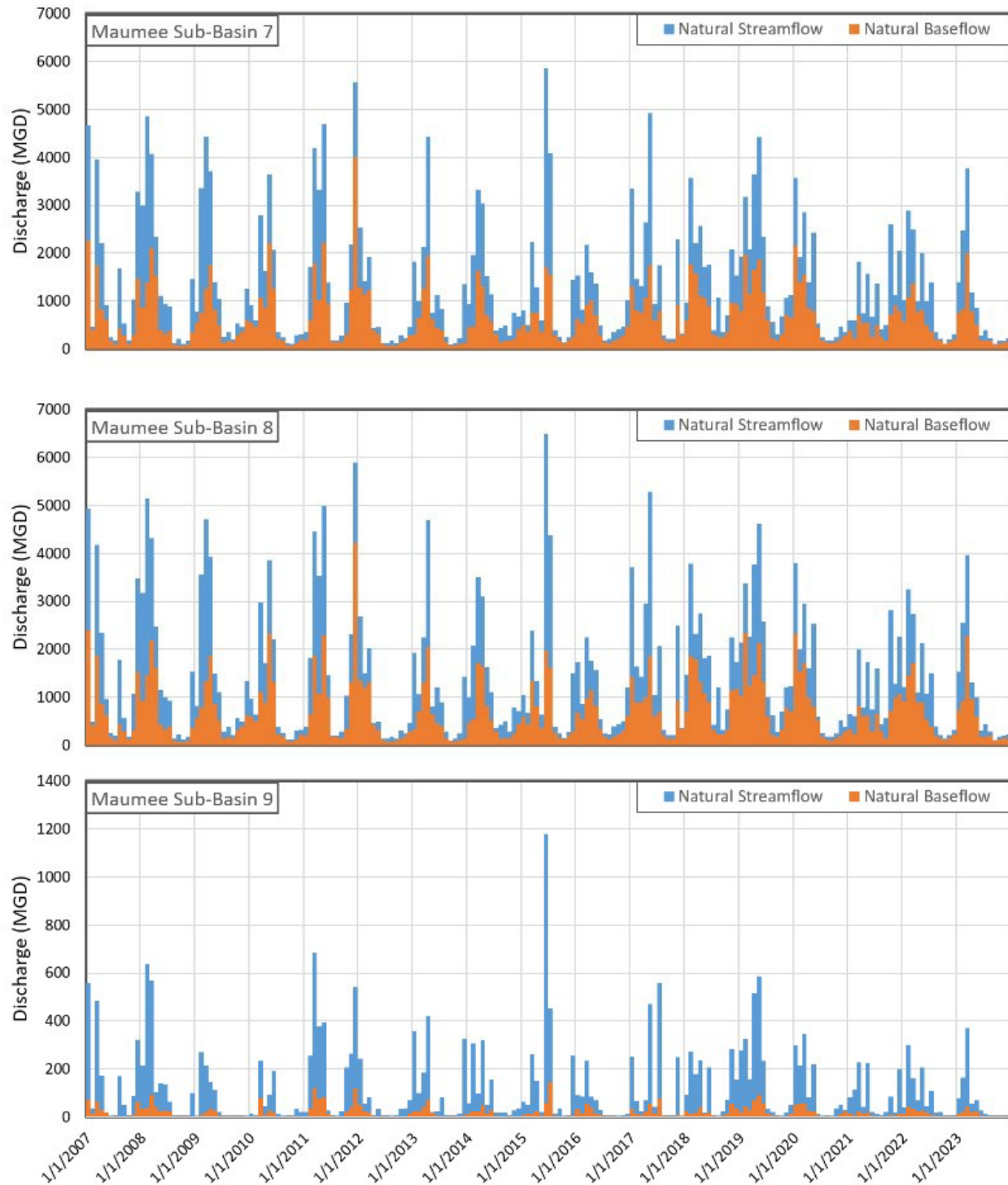


Figure C-7. Monthly average natural streamflow and natural baseflow at the outlet of Sub-Basins 7-9.

3 St. Joseph Basin: Net Returns, Natural Streamflow and Natural Baseflow

Essential quantities for the evaluation of historical water availability are summarized graphically in the following pages. First is a summary of withdrawals and return flows by sub-basin (**Figures C-8 through C-10**), followed by a summary of monthly average natural streamflow and natural baseflow by sub-basin (**Figures C-11 through C-13**) in the St. Joseph River watershed.

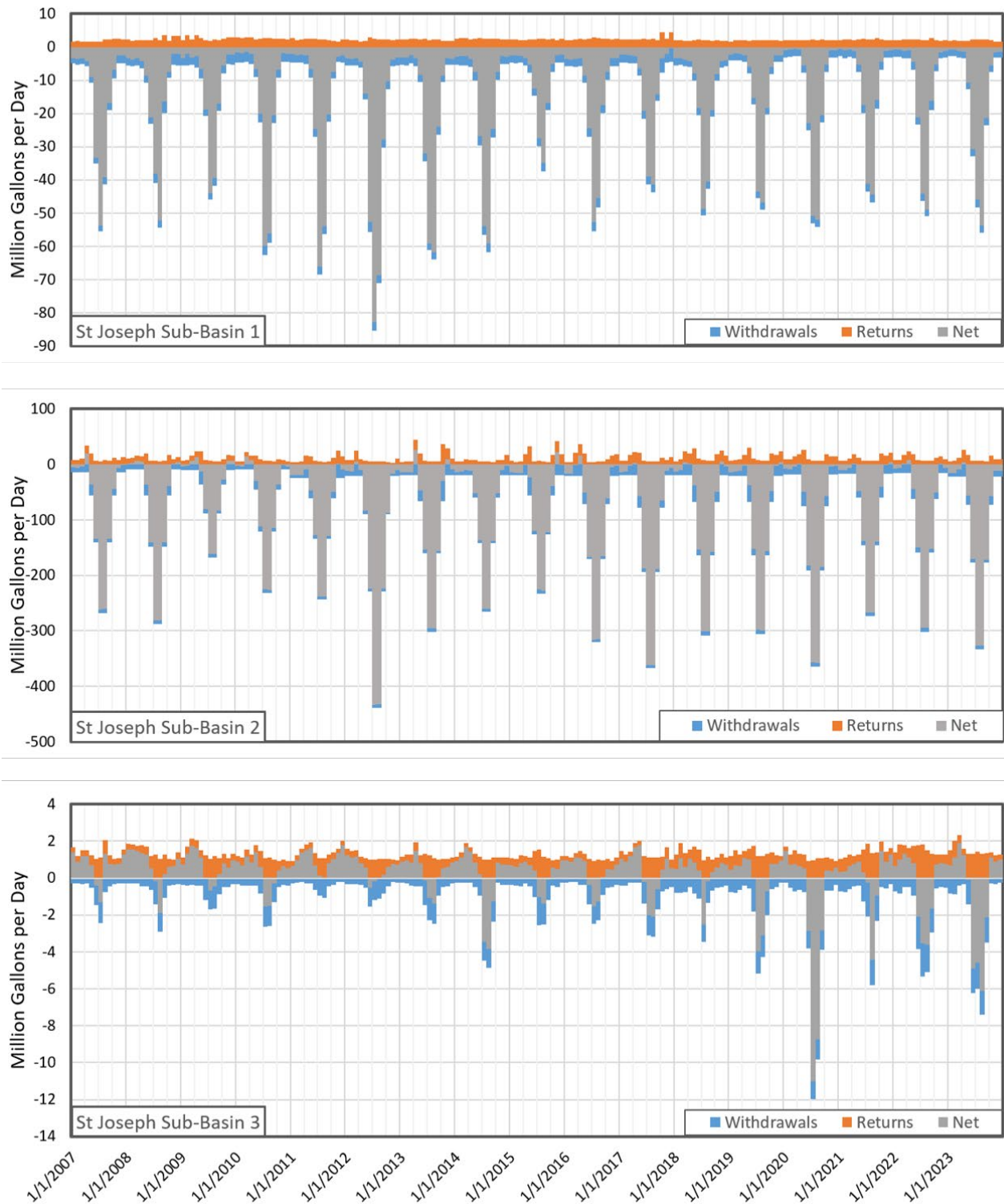


Figure C-8. Withdrawals and returns in Sub-Basins 1-3.

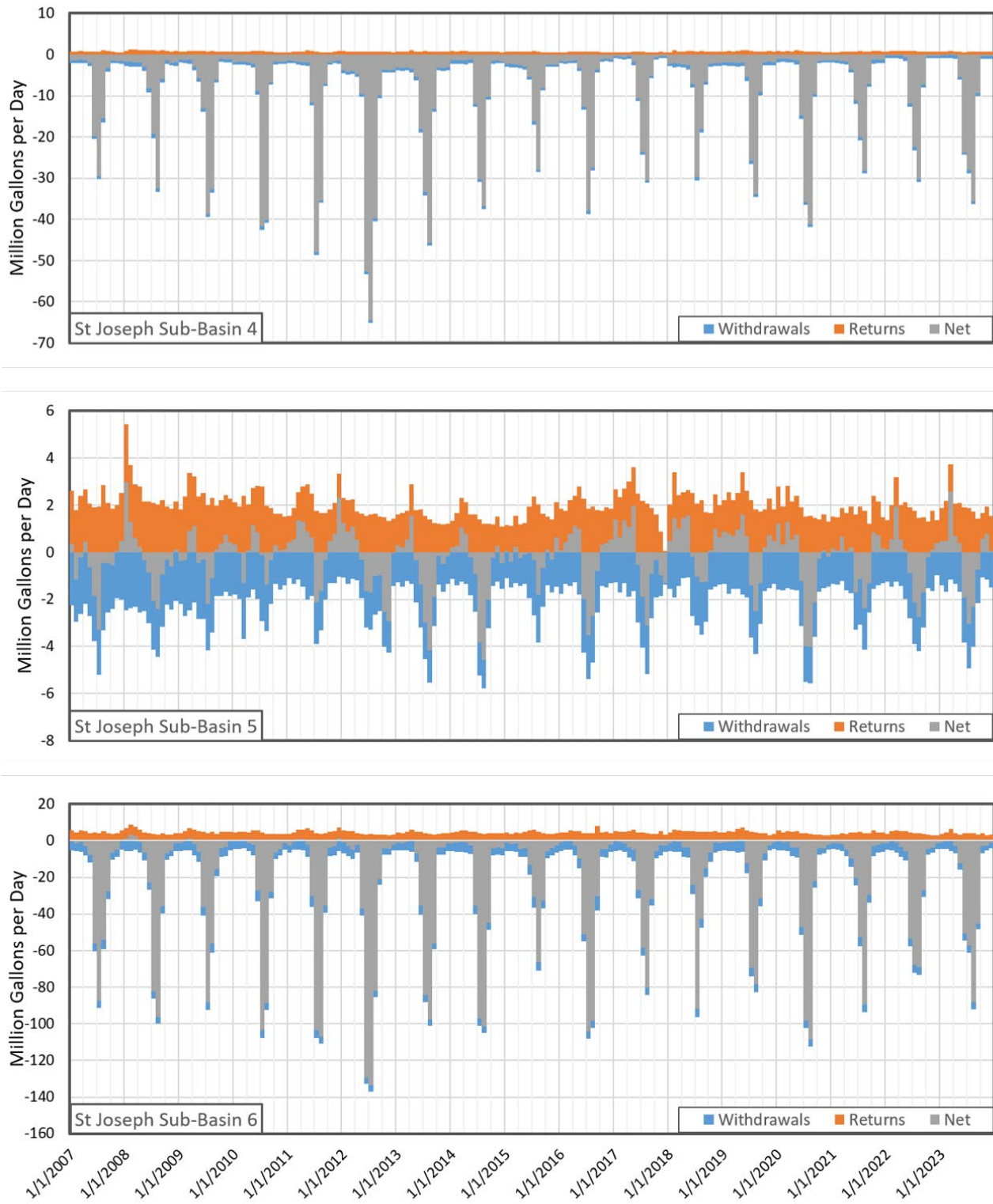


Figure C-9. Withdrawals and returns in Sub-Basins 4-6.

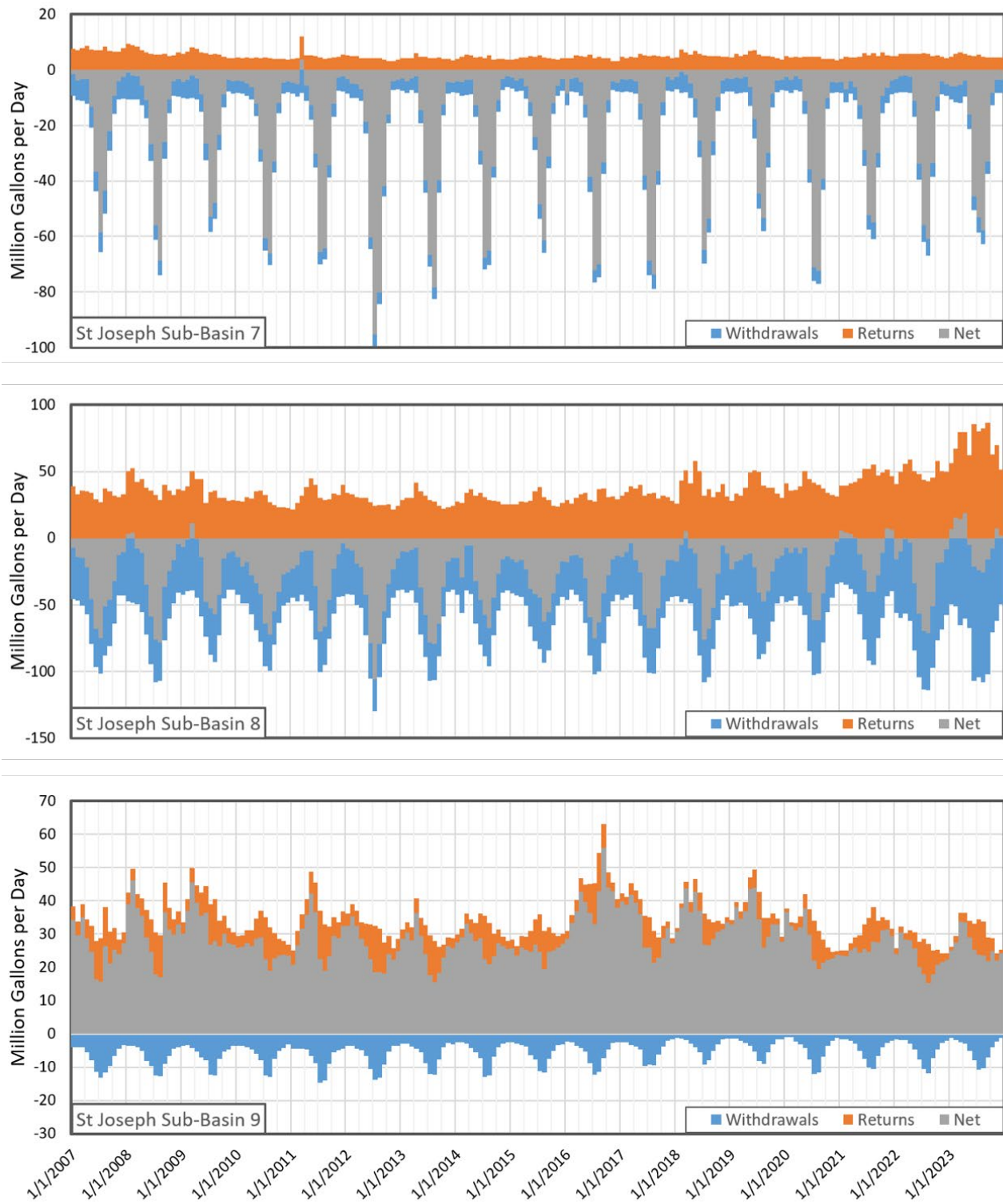


Figure C-10. Withdrawals and returns in Sub-Basins 7-9.



Figure C-11. Natural streamflow and natural baseflow at the outlet of Sub-Basins 1-3.

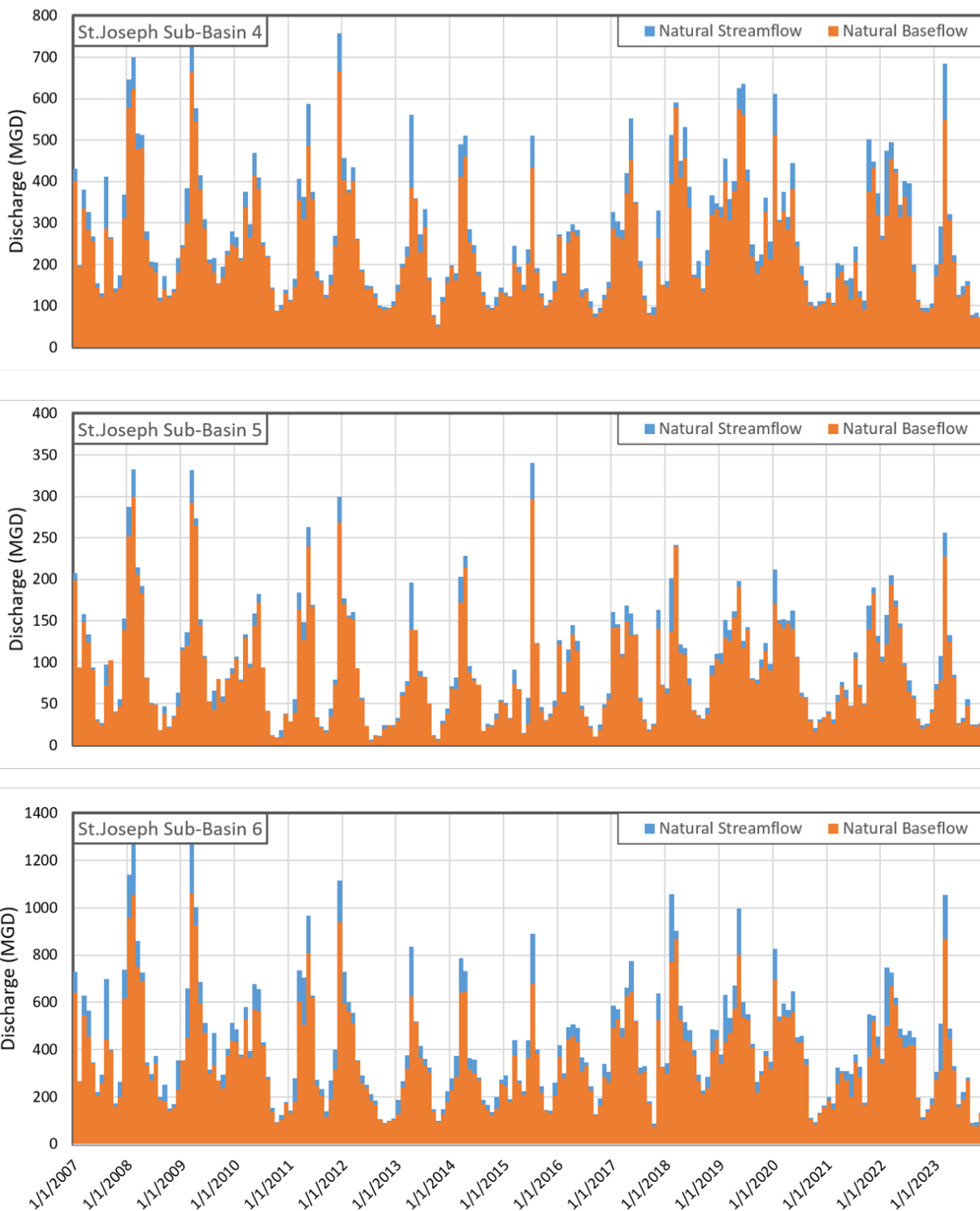


Figure C-12. Natural streamflow and natural baseflow at the outlet of Sub-Basins 4-6.

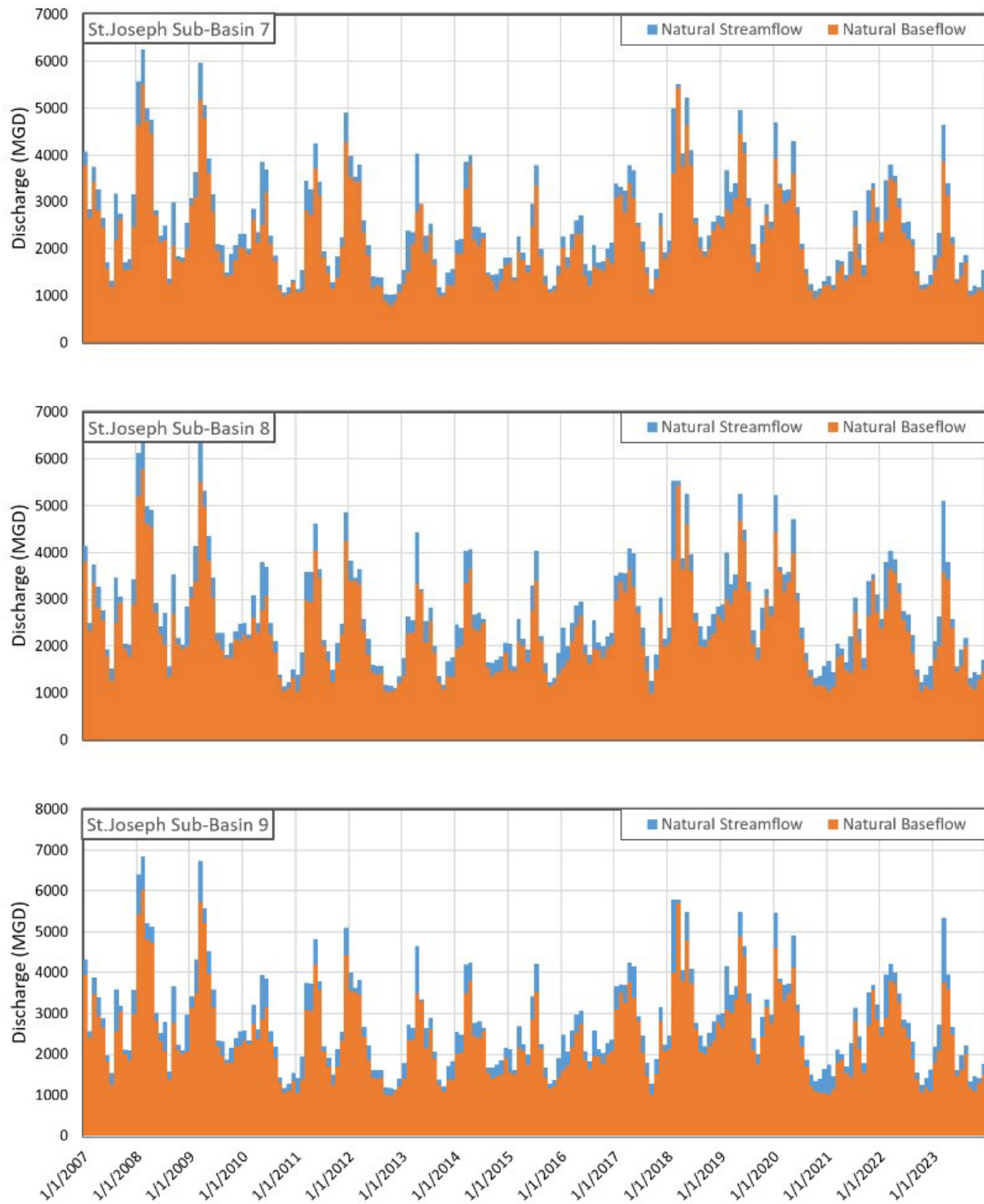


Figure C-13. Natural streamflow and natural baseflow at the outlet of Sub-Basins 7-9.



Appendix D

Water Availability Projections

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1 Climate Change Model and Natural Streamflow Projections

Estimates of future natural streamflow (NSF) are based on the Water-Balance Model (WBM) (Wolock and McCabe, 1999; McCabe and Wolock, 2011). The WBM is incorporated into the National Climate Change Viewer (NCCV, Alder and Hostetler, 2014; Hostetler and Alder, 2016) and produces estimates of NSF from inputs of temperature, precipitation, and potential solar radiation. The inputs are provided by the suite of Global Climate Models included in the NCCV. Output from a single global climate model was used to drive the streamflow model: CNRM-CM6-1, Scenario SSP2-4.5. More details on the choice of this global climate model are provided in Appendix B. Output from the hydrologic model includes a monthly timeseries of NSF, provided in inches per month on a HUC-8 spatial scale; the results were then scaled to each sub-basin or watershed within the HUC-8.

2 Quantile Bias Correction and Downscaling

The resulting natural streamflows generated for each sub-basin were then compared with the historical natural streamflows (2007 to 2023). Flow duration curves were created for the observed data and data from the same period for the hydrologic model. In the Maumee Basin, the flow duration curves were comparable, and the model results were accepted. In the St. Joseph Basin, the comparisons were poor at the low-flow end of the flow duration curves; this is likely due to very high base flow that occurs in the St. Joseph Basin. The historical data (2007 to 2023) for the outlet of Sub-Basin 9 is compared to the model results for the same period in **Figure D-1**; the high flows are similar, but the model low flows are much lower than the historical data indicate. The corresponding flow duration curves for the historic data and the model are shown in **Figure D-2** (top).

Linear quantile bias correction (Hagemann, et al. 2024) was applied to the model flow: model low flows were adjusted to correspond to the historical flow duration data, as illustrated in **Figure D-2** (bottom). Quantile Delta mapping is commonly applied to bias corrections to allow for the flow duration curve to change in the future. In this case, the model predicts no significant variation in the flow duration curve throughout the 50-year projection period. This is illustrated in **Figure D-3**, which plots model flow duration curves over various time spans. Quantile delta mapping is not necessary here. This same procedure was followed for all sub-basins in the St. Joseph River watershed, which is comparable to spatial downscaling of a global climate model.

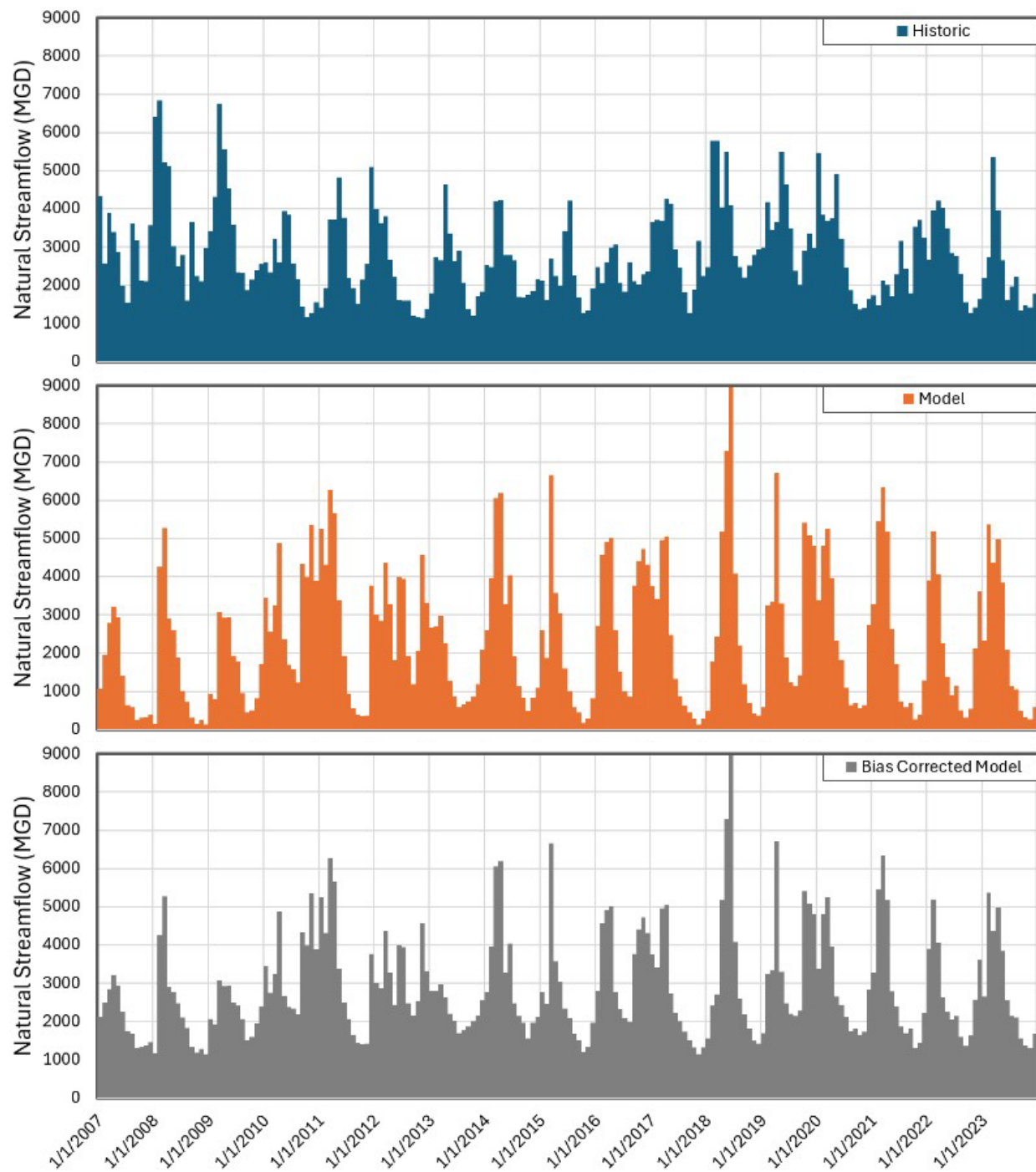


Figure D-1. Historical natural streamflow (top) and model (WBM) streamflow (middle) at the outlet of St. Joseph Sub-Basin 9 for 2007-2023. The bottom panel shows the model streamflow after quantile bias correction.

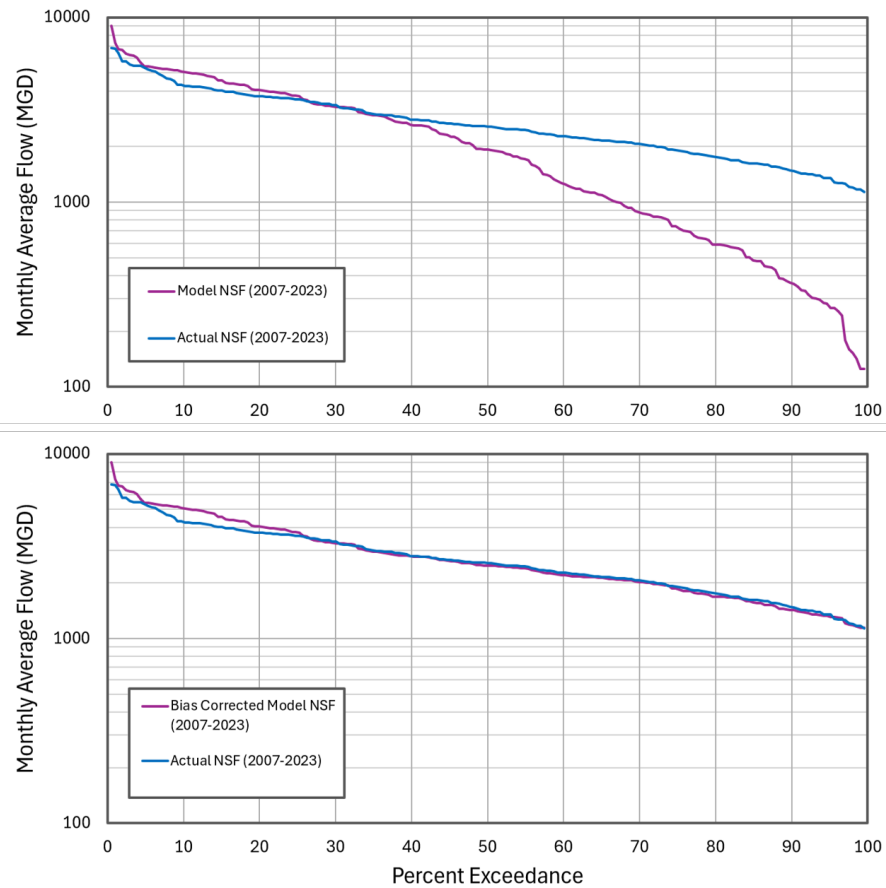


Figure D-2. Model (WBM) and actual flow duration curves before bias correction (top) and after bias correction (bottom). Results shown for St. Joseph Sub-Basin 9.

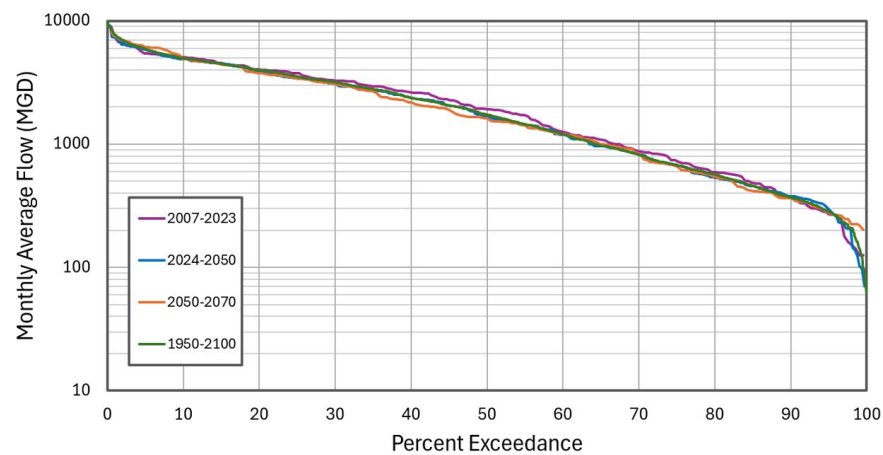


Figure D-3. Projected variation in Model (WBM) flow duration curves through time. Results shown are for St. Joseph Sub-Basin 9 and have not been bias-corrected.

3 Seasonal Baseflow Index Analysis of Historical Data

As the projected NSF from the WBM is at a monthly timescale, standard baseflow separation techniques that rely on daily data cannot be used to estimate the natural baseflow. Instead, an analysis of the seasonal baseflow index was conducted using the historical record (2007-2023).

In the St. Joseph Basin, there was no apparent seasonal variation in the baseflow index (BFI); a single annual average BFI was used for each sub-basin to separate future natural baseflow from future NSF (**Table D-2**). In the Maumee Basin, seasonal relationships for each watershed were developed relating natural streamflow and natural baseflow and applied to the projected natural streamflows.

An example of this analysis is presented in the following figures. **Figure D-4** shows the relationship between seasonal NSF and the seasonal BFI for the three gages in the St. Joseph River HUC-8 of the Maumee Basin. For values of NSF less than 2 inches per month, there is a sharp increase in the BFI.

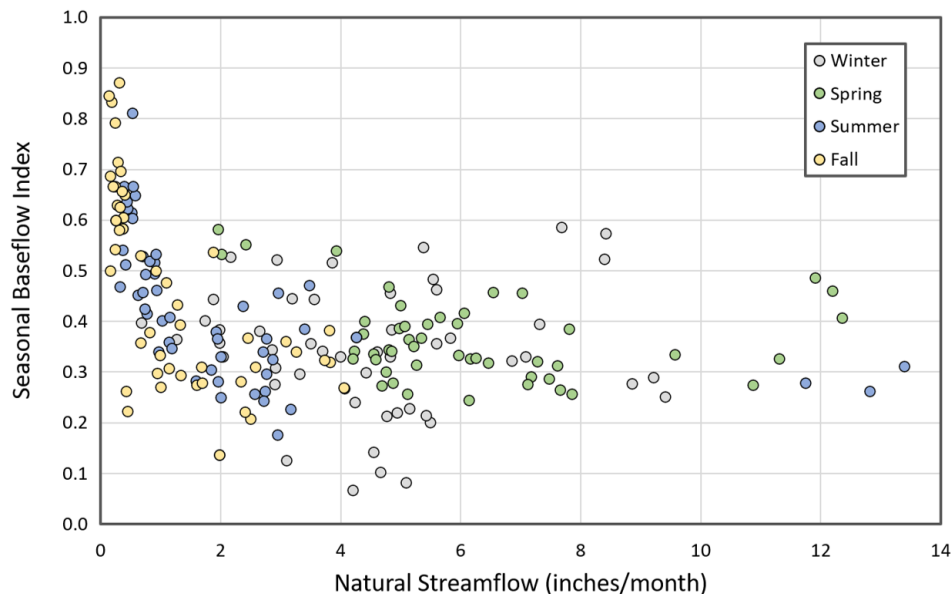


Figure D-4. Example: relationship between seasonal baseflow index and natural streamflow, Maumee Sub-basin 6.

The behavior is more easily identified by separating the Winter and Spring data (**Figure D-5**) from the Summer and Fall data (**Figure D-6**). In the Winter and Spring, there is no correlation between NSF and BFI, and a median value of 0.34 is fixed. In the Summer and Fall, when the NSF is lower, a linear relationship appears when plotted on a semi-log scale. The two red lines intersect at a natural streamflow of 2 inches/month. A separate relationship is developed for each of the HUC-8 regions of the Maumee basin; the expressions relating BFI to NSF are summarized in **Table D-1**. The annual average BFI developed for each stream gage in the St. Joseph Basin are presented in **Table D-2**.

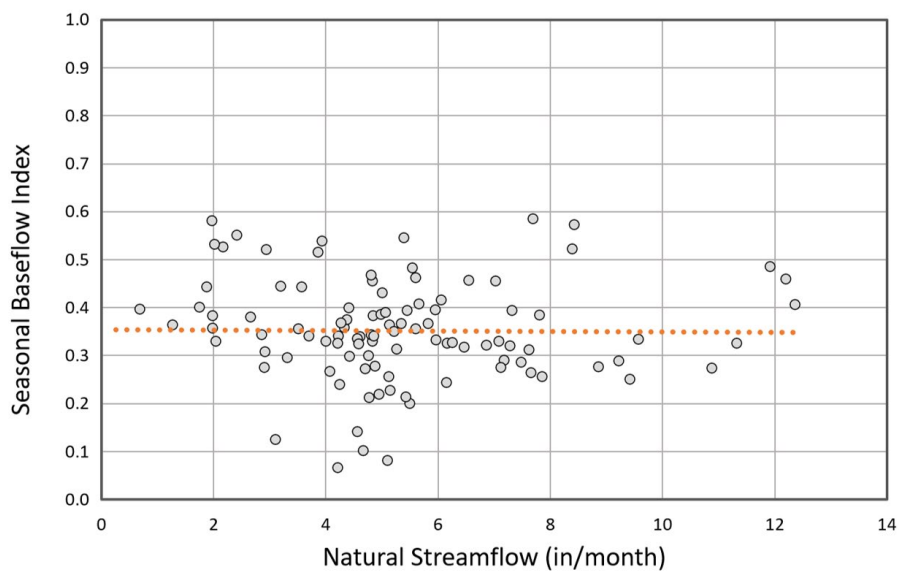


Figure D-5. Relationship between BFI and NSF in the winter and spring, Maumee Sub-basin 6.

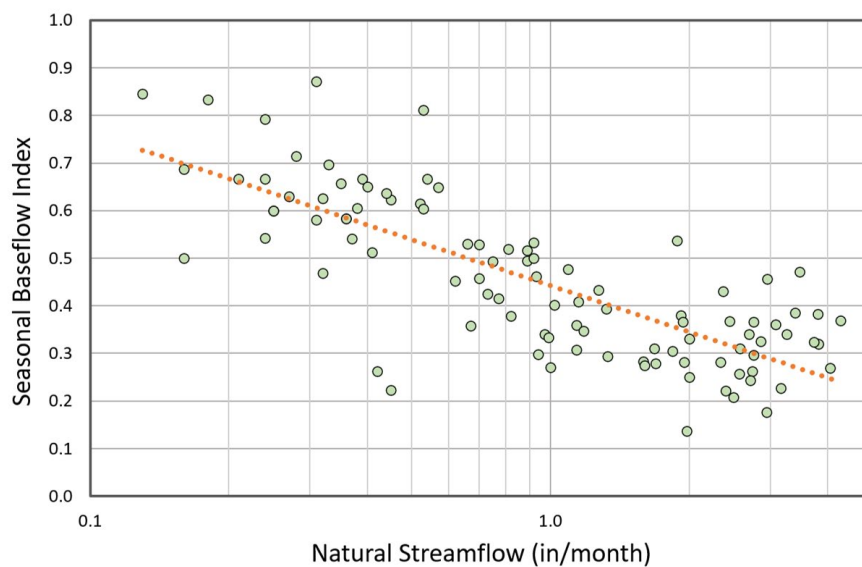


Figure D-6. Relationship between BFI and NSF in the summer and fall, Maumee Sub-basin 6.

Table D-1. Mathematical relationship between Baseflow Index and Natural Streamflow in the Maumee Basin.

HUC-8	Sub-basins	NSF (in/month)	BFI
St. Joseph	1,2,3	≤ 2.0	$-0.135 \ln (\text{NSF}) + 0.6957$
		> 2.0	0.60
St. Mary's	4,5,6	≤ 2.0	$-0.14 \ln (\text{NSF}) + 0.4421$
		> 2.0	0.34
Upper Maumee	7,8	≤ 2.0	$-0.093 \ln (\text{NSF}) + 0.5488$
		> 2.0	0.48
Auglaize	9	≤ 1.1	0.28
		> 1.1	0.28

Table D-2. Baseflow Index for sub-basin outlets in the St. Joseph Basin.

USGS Station	Sub-basin	Annual BFI
04098500	1	0.95
04099000	2	0.87
04099510	3	0.89
04099750	4	0.90
04100222	5	0.92
04100500	6	0.87
04101000	7	0.88
04101225	8	0.87
04101500	9	0.87

4 Consumptive Use Projections

Sub-basin scale consumptive use factors were estimated during the analysis of historical water availability by relating water withdrawal sectors to return flows through the standard industrial classification (SIC) code present in the National Pollutant Discharge Elimination System (NPDES) records. In this way, consumptive use factors were obtained for each withdrawal sector by sub-basin. The resulting factors are presented in **Table D-3** and **Table D-4**.

A single annual average consumptive use coefficient was adequate for most sectors; no seasonal pattern was observed in withdrawals and returns. Public supply withdrawals and the corresponding returns at wastewater treatment plants often exhibit seasonal patterns. Combined Sewer Overflow systems are present throughout the Northeast Region and therefore returns historically have exceeded withdrawals. Within a sub-basin, if returns historically exceed withdrawals throughout the year, a consumptive use factor of zero was applied to future public supply withdrawals. When returns and withdrawals exhibited seasonality with withdrawals exceeding returns during summer and fall, seasonal consumptive use coefficients were developed for those sub-basins.

A constant consumptive use factor of 0.13 was applied to all self-supplied residential withdrawals. A factor of 0.9 was applied to all concentrated animal feeding operation (CAFO) withdrawals. A consumptive use factor of 1.0 was applied to all projected irrigation withdrawals.

Table D-3. Sub-basin scale consumptive use coefficients by water use sector for the Maumee Basin.

Sub-basin	Season	Public Supply	Industry	Irrigation	Miscellaneous	Energy Production	Rural Use	Self-Supply	CAFO
1	All	0.00	0.60	1.00	N/A	1.00	N/A	0.13	0.90
2	All	0.00	0.35	1.00	N/A	N/A	N/A	0.13	0.90
3	All	0.81	0.53	1.00	1.00	N/A	N/A	0.13	0.90
4	All	0.00	0.44	1.00	0.96	1.00	N/A	0.13	0.90
5	Winter	0.00	0.00	1.00	N/A	1.00	N/A	0.13	0.90
	Spring	0.00	0.00	1.00	N/A	1.00	N/A	0.13	0.90
	Summer	0.06	0.00	1.00	N/A	1.00	N/A	0.13	0.90
	Fall	0.11	0.00	1.00	N/A	1.00	N/A	0.13	0.90
6	All	0.00	0.00	1.00	N/A	N/A	N/A	0.13	0.90
7	All	0.00	0.00	1.00	1.00	1.00	N/A	0.13	0.90
8	All	0.00	0.00	1.00	1.00	1.00	N/A	0.13	0.90
9	All	0.00	1.00	1.00	N/A	N/A	1.00	0.13	0.90

Table D-4. Sub-basin scale consumptive use coefficients for the St. Joseph Basin.

Sub-basin	Season	Public Supply	Industry	Irrigation	Miscellaneous	Energy Production	Rural Use	Self-Supply	CAFO
1	All	0.00	0.45	1.00	1.00	N/A	N/A	0.13	0.90
2	All	0.00	1.00	1.00	1.00	1.00	N/A	0.13	0.90
3	All	0.00	1.00	1.00	N/A	N/A	N/A	0.13	0.90
4	All	0.00	1.00	1.00	N/A	N/A	1.00	0.13	0.90
5	All	0.00	1.00	1.00	1.00	N/A	N/A	0.13	0.90
6	Winter	0.00	1.00	1.00	1.00	1.00	1.00	0.13	0.90
	Spring	0.00	1.00	1.00	1.00	1.00	1.00	0.13	0.90
	Summer	0.20	1.00	1.00	1.00	1.00	1.00	0.13	0.90
	Fall	0.15	1.00	1.00	1.00	1.00	1.00	0.13	0.90
7	Winter	0.32	0.83	1.00	1.00	1.00	1.00	0.13	0.90
	Spring	0.32	0.83	1.00	1.00	1.00	1.00	0.13	0.90
	Summer	0.54	0.83	1.00	1.00	1.00	1.00	0.13	0.90
	Fall	0.44	0.83	1.00	1.00	1.00	1.00	0.13	0.90
8	Winter	0.00	0.00	1.00	0.00	0.05	1.00	0.13	0.90
	Spring	0.00	0.00	1.00	0.00	0.05	1.00	0.13	0.90
	Summer	0.29	0.00	1.00	0.00	0.05	1.00	0.13	0.90
	Fall	0.17	0.00	1.00	0.00	0.05	1.00	0.13	0.90
9	All	0.00	0.04	1.00	1.00	1.00	N/A	0.13	0.90

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Appendix E

Annual and Seasonal Summaries

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1 Natural Baseflow

Natural baseflow is an estimate of the natural groundwater discharge to the stream that would occur in the watershed in the absence of groundwater withdrawals and return flows. Natural baseflow is the primary source of water availability. Seasonal and annual natural baseflows are presented in 5-year intervals, from 2010 to 2070 (**Tables E-1** through **E-10**). The values represent the baseflow derived from the entire watershed upstream of the sub-basin outlet. Units are in millions of gallons per day (MGD).

Table E-1. Annual average natural baseflow (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	244.0	141.3	267.9	161.7	148.8	184.7	306.7	270.7	289.5	138.8	181.2	268.9	235.5
Maumee 2	95.9	87.0	98.5	70.6	65.0	80.7	134.0	118.3	126.5	60.6	79.2	117.5	102.9
Maumee 3	410.9	249.5	454.9	277.3	255.2	316.7	526.1	464.4	496.6	238.1	310.8	461.3	404.0
Maumee 4	40.4	96.7	86.7	41.2	52.3	57.6	92.3	83.3	91.0	41.6	65.3	78.4	69.1
Maumee 5	90.1	179.4	157.2	75.5	95.9	105.6	169.1	152.6	166.7	76.3	119.6	143.6	126.6
Maumee 6	110.9	224.4	102.5	92.6	117.6	129.5	207.4	187.2	204.4	93.5	146.7	176.1	155.2
Maumee 7	636.7	590.7	717.6	393.3	400.1	477.5	793.5	695.0	753.4	351.8	490.5	680.0	598.4
Maumee 8	670.6	685.1	774.4	413.5	423.6	504.4	845.0	732.4	798.5	369.2	519.0	716.7	632.2
Maumee 9	11.7	23.5	20.9	13.3	16.0	15.4	32.7	23.7	28.1	11.5	19.9	25.3	19.8

Table E-2. Winter average natural baseflow (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	260.1	93.1	501.6	239.2	162.0	354.7	402.5	288.1	461.7	212.4	308.6	614.1	165.6
Maumee 2	101.1	66.2	143.9	104.5	70.8	155.0	175.9	125.9	201.7	92.8	134.8	268.3	72.3
Maumee 3	423.7	163.7	799.6	410.3	277.9	608.4	690.5	494.1	791.9	364.4	529.3	1053.4	284.0
Maumee 4	17.7	66.3	142.8	24.0	60.8	77.3	93.2	96.4	128.5	69.4	74.0	159.9	71.1
Maumee 5	55.3	137.1	308.2	43.9	111.4	141.6	170.7	176.6	235.4	127.2	135.6	293.0	130.3
Maumee 6	11.9	21.4	41.6	53.8	136.7	173.7	209.3	216.5	288.7	156.0	166.3	359.3	159.7
Maumee 7	543.1	425.4	1404.9	489.2	451.6	838.4	969.8	757.9	1163.7	553.1	747.7	1512.7	483.6
Maumee 8	573.1	484.3	1516.7	510.7	483.5	886.9	1030.1	798.6	1235.2	581.3	792.6	1598.8	518.0
Maumee 9	0.6	8.1	38.5	11.0	23.9	26.3	36.9	24.8	45.8	22.4	26.4	61.6	21.8

Table E-3. Spring average natural baseflow (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	482.1	191.5	422.6	273.3	288.2	256.3	553.8	407.2	479.8	201.5	256.5	316.7	335.8
Maumee 2	164.2	104.0	189.7	119.4	125.9	112.0	242.0	177.9	209.6	88.0	112.1	138.4	146.7
Maumee 3	825.0	282.3	825.0	468.7	494.3	439.6	949.9	698.5	822.9	345.6	440.0	543.2	575.9
Maumee 4	82.2	92.5	150.9	91.7	94.5	98.0	185.2	134.1	146.4	49.1	107.0	98.8	131.3
Maumee 5	215.4	162.4	236.5	168.0	173.1	179.5	339.4	245.7	268.2	89.9	196.0	181.1	240.6
Maumee 6	297.3	239.6	287.2	206.1	212.3	220.1	416.2	301.3	328.9	110.3	240.4	222.1	295.1
Maumee 7	1378.5	620.5	1062.7	721.1	756.4	705.2	1488.2	1072.0	1237.7	482.3	732.2	812.6	934.8
Maumee 8	1448.9	833.0	1168.6	761.0	799.3	744.2	1593.2	1134.1	1311.6	505.1	776.8	853.3	989.7
Maumee 9	38.4	13.3	36.4	31.0	28.9	25.8	68.8	48.9	47.4	14.9	35.8	29.4	39.5

Table E-4. Summer average natural baseflow (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	195.0	235.8	108.6	99.7	84.8	72.6	127.9	246.0	151.2	88.4	93.0	95.5	104.7
Maumee 2	95.4	147.4	41.3	43.5	37.1	31.7	55.9	107.5	66.1	38.6	40.6	41.7	45.7
Maumee 3	332.4	436.5	130.2	171.0	145.5	124.6	219.4	421.9	259.4	151.6	159.4	163.7	179.6
Maumee 4	46.2	210.7	27.6	36.4	28.7	32.8	53.3	62.9	61.2	26.4	45.4	36.7	43.7
Maumee 5	77.7	396.6	42.4	66.7	52.7	60.1	97.6	115.2	112.2	48.4	83.2	67.3	80.1
Maumee 6	118.3	603.3	40.4	81.8	64.6	73.7	119.7	141.3	137.6	59.3	102.0	82.5	98.3
Maumee 7	535.1	1174.1	248.9	270.0	223.1	212.3	366.0	602.5	426.2	223.6	279.4	261.9	297.3
Maumee 8	564.6	1271.3	264.5	284.9	234.3	224.4	389.2	636.4	451.3	234.5	294.9	275.3	314.1
Maumee 9	7.6	69.6	3.5	9.1	5.7	5.6	13.1	15.4	13.8	5.4	10.4	7.2	8.8

Table E-5. Fall average natural baseflow (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	38.9	44.8	38.9	34.6	60.2	55.0	142.6	141.6	65.4	52.9	66.7	49.5	336.1
Maumee 2	22.7	30.4	19.1	15.1	26.3	24.0	62.3	61.9	28.6	23.1	29.1	21.6	146.8
Maumee 3	62.8	115.4	64.8	59.3	103.3	94.4	244.7	242.9	112.2	90.7	114.4	84.9	576.4
Maumee 4	15.6	17.5	25.3	12.7	25.3	22.5	37.4	39.9	27.8	21.6	34.7	18.0	30.2
Maumee 5	11.9	21.4	41.6	23.2	46.3	41.3	68.6	73.1	51.0	39.6	63.6	33.0	55.3
Maumee 6	16.0	33.6	40.9	28.5	56.8	50.6	84.1	89.7	62.5	48.5	78.0	40.4	67.8
Maumee 7	90.2	142.7	154.0	93.0	169.4	154.2	349.7	347.6	186.0	148.2	202.8	132.9	677.9
Maumee 8	95.8	151.7	147.7	97.5	177.4	162.1	367.7	360.4	195.8	156.0	211.8	139.4	706.8
Maumee 9	0.3	3.0	5.0	2.3	5.4	3.8	11.9	5.9	5.4	3.3	7.1	2.9	9.2

Table E-6. Annual average natural baseflow (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	126.8	108.2	140.7	109.5	113.7	113.7	135.7	142.9	139.0	115.4	114.0	129.9	141.1
St. Joseph 2	1087.4	926.0	1475.4	967.7	1052.2	1051.0	1339.0	1382.9	1361.2	1047.8	1030.4	1269.1	1384.9
St. Joseph 3	51.5	34.0	60.0	39.6	43.1	45.2	64.8	72.7	67.6	45.5	43.0	59.6	68.1
St. Joseph 4	240.1	170.6	240.7	179.3	194.2	195.0	256.8	273.0	261.0	196.6	191.8	239.5	265.6
St. Joseph 5	81.0	70.3	94.2	54.3	59.0	61.8	88.8	99.5	92.5	62.3	58.8	81.6	93.3
St. Joseph 6	357.1	287.2	390.8	260.1	290.2	293.5	393.9	421.3	407.3	294.9	285.7	373.3	414.2
St. Joseph 7	1950.5	1751.1	2381.3	1757.7	1907.8	1914.5	2447.8	2533.5	2495.8	1906.9	1870.7	2322.4	2535.0
St. Joseph 8	2065.8	1880.1	2638.1	1895.3	2063.5	2066.9	2617.0	2682.2	2662.4	2055.8	2017.5	2492.3	2708.1
St. Joseph 9	2132.8	1939.4	2698.3	1907.3	2077.1	2083.3	2640.9	2707.6	2689.6	2071.5	2032.1	2516.8	2732.0

Table E-7. Winter average natural baseflow (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	125.3	99.0	174.2	136.8	104.2	158.3	163.0	151.4	179.4	140.8	146.4	200.0	122.4
St. Joseph 2	1001.7	814.3	2006.3	1228.9	903.8	1645.2	1752.9	1441.2	1847.3	1304.4	1464.3	2235.1	1072.0
St. Joseph 3	51.8	22.3	103.4	64.8	34.0	93.3	100.4	84.7	108.6	70.3	77.8	131.3	49.9
St. Joseph 4	234.2	127.6	343.3	245.3	165.0	329.0	351.0	290.5	369.7	259.1	286.6	447.3	206.3
St. Joseph 5	89.7	45.0	135.6	88.7	46.6	127.8	137.4	116.0	148.7	96.2	106.6	179.9	68.4
St. Joseph 6	414.1	228.3	512.7	366.2	230.0	515.3	550.8	464.0	594.8	402.7	452.6	719.7	308.0
St. Joseph 7	1978.2	1568.3	3230.8	2248.0	1628.9	3029.4	3230.1	2662.4	3413.0	2391.7	2682.3	4129.4	1955.5
St. Joseph 8	2173.3	1607.3	3559.4	2379.1	1750.7	3188.7	3397.7	2794.8	3582.8	2527.2	2837.1	4334.8	2108.3
St. Joseph 9	2265.3	1663.5	3710.6	2397.0	1757.2	3223.7	3435.4	2831.1	3629.3	2553.5	2867.5	4391.1	2119.4

Table E-8. Spring average natural baseflow (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	150.5	120.0	173.7	139.4	158.1	135.2	190.2	161.7	190.2	146.6	131.1	144.2	168.1
St. Joseph 2	1367.6	948.2	1991.5	1305.5	1676.0	1233.7	1998.6	1714.3	2028.5	1434.8	1164.7	1388.5	1750.6
St. Joseph 3	87.7	40.6	89.1	68.4	93.8	62.6	114.0	97.2	119.1	78.1	57.0	74.9	98.2
St. Joseph 4	339.6	173.2	331.4	259.5	334.1	241.1	399.6	342.7	407.9	286.9	230.4	275.2	349.1
St. Joseph 5	122.6	51.2	143.0	93.7	128.4	85.7	156.1	133.2	163.1	107.0	78.1	102.5	134.5
St. Joseph 6	489.2	281.6	546.4	390.5	524.2	368.8	629.3	537.7	652.6	439.7	342.5	429.7	548.3
St. Joseph 7	2425.4	1737.9	3202.0	2387.2	3082.6	2250.3	3682.0	3156.5	3746.0	2631.6	2119.0	2546.1	3220.7
St. Joseph 8	2556.8	1921.0	3507.0	2527.5	3248.2	2388.1	3874.1	3322.6	3932.6	2778.6	2254.0	2690.3	3393.0
St. Joseph 9	2659.2	1987.5	3642.6	2547.7	3284.0	2406.6	3918.1	3359.4	3981.8	2802.0	2270.8	2718.9	3430.7

Table E-9. Summer average natural baseflow (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	156.0	138.2	133.8	92.9	95.3	84.7	94.0	141.4	105.7	97.1	87.9	94.4	98.4
St. Joseph 2	1395.8	1339.4	1233.7	777.8	805.1	699.0	794.7	1358.8	905.9	822.8	727.8	787.9	829.9
St. Joseph 3	53.1	57.9	33.4	19.1	20.8	14.5	21.2	71.1	30.2	23.2	16.2	19.7	22.2
St. Joseph 4	280.3	272.8	188.9	128.1	133.8	112.3	135.4	269.8	161.1	142.1	118.1	130.1	138.6
St. Joseph 5	101.7	149.9	73.5	26.2	28.5	19.8	29.1	97.3	41.3	31.8	22.2	27.0	30.4
St. Joseph 6	415.2	475.8	398.3	191.1	201.8	163.5	195.0	407.6	236.4	208.8	169.7	197.8	210.1
St. Joseph 7	2336.3	2552.7	2056.2	1398.3	1439.9	1256.5	1423.5	2484.4	1633.8	1476.2	1309.8	1420.8	1489.8
St. Joseph 8	2392.7	2741.3	2256.0	1564.0	1612.4	1427.9	1584.6	2630.8	1787.1	1647.0	1467.2	1593.5	1660.6
St. Joseph 9	2451.5	2832.3	2313.0	1570.6	1619.6	1435.1	1591.4	2652.5	1794.1	1654.6	1472.5	1600.5	1665.9

Table E-10. Fall average natural baseflow (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	75.5	75.5	81.0	68.9	97.2	76.5	95.5	116.9	80.7	76.9	90.5	80.9	175.7
St. Joseph 2	584.4	602.2	670.0	558.7	823.9	626.0	809.7	1017.5	663.2	629.4	764.9	664.8	1887.2
St. Joseph 3	13.6	15.0	14.2	6.3	23.9	10.2	23.8	37.8	12.4	10.4	20.8	12.5	102.1
St. Joseph 4	106.2	108.9	99.3	84.3	143.7	97.7	141.4	189.2	105.2	98.4	132.1	105.5	368.6
St. Joseph 5	10.0	35.3	24.7	8.6	32.7	14.0	32.6	51.7	17.0	14.2	28.5	17.1	139.9
St. Joseph 6	110.0	163.4	105.5	92.5	205.1	126.6	200.3	276.1	145.4	128.3	178.1	146.0	590.4
St. Joseph 7	1061.9	1145.6	1036.2	997.5	1479.8	1121.8	1455.5	1830.6	1190.5	1128.1	1371.8	1193.4	3474.0
St. Joseph 8	1140.4	1251.0	1230.2	1110.6	1642.5	1262.9	1611.7	1980.5	1347.0	1270.6	1511.6	1350.5	3670.7
St. Joseph 9	1155.2	1274.2	1127.2	1113.8	1647.4	1268.0	1618.8	1987.4	1353.2	1275.8	1517.5	1356.8	3712.1

2 Water Availability

Water Availability is the portion of natural baseflow generated within a sub-basin and remaining in the stream at the sub-basin outlet after instream flow requirements in the sub-basin are accounted for. Instream flows are minimum streamflows required to support the ecological health of the stream, recreational use, and water quality. Water availability within a sub-basin may be supplemented by flows released from reservoir storage. While the net baseflow generated in a sub-basin may be negative, the water availability in a sub-basin cannot be less than zero. Seasonal and annual water availability are presented by sub-basin in 5-year intervals, from 2010 to 2070 (**Tables E-11 through E-20**). Units are in millions of gallons per day (MGD).

Table E-11. Annual average water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	213.0	110.3	236.9	130.7	119.7	153.7	275.7	239.7	258.5	107.8	150.2	237.9	204.5
Maumee 2	77.9	69.0	80.5	52.8	48.3	62.7	116.1	100.3	108.5	42.7	61.2	99.5	84.9
Maumee 3	68.0	32.2	87.6	36.5	34.3	42.9	76.9	66.8	72.1	30.1	41.9	66.3	57.5
Maumee 4	33.6	89.9	79.9	34.6	46.0	50.8	85.5	76.5	84.2	34.8	58.5	71.6	62.3
Maumee 5	45.3	76.5	63.8	27.5	37.0	41.1	69.9	62.4	68.8	27.7	47.4	58.3	50.6
Maumee 6	53.1	91.0	40.0	14.5	19.2	21.3	35.6	31.9	35.1	14.6	24.4	29.8	26.0
Maumee 7	92.2	86.8	83.7	9.0	13.5	16.0	40.7	23.7	34.5	5.8	16.8	27.4	18.9
Maumee 8	18.0	82.5	46.8	6.2	9.9	11.3	36.3	21.4	29.1	4.1	12.7	20.9	18.5
Maumee 9	11.7	23.5	20.8	13.3	15.9	15.3	32.6	23.7	28.0	11.5	19.9	25.2	19.8

Table E-12. Winter average water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	219.1	52.1	460.6	198.2	128.5	313.7	361.5	247.1	420.7	171.4	267.6	573.1	124.6
Maumee 2	78.1	43.2	120.9	81.5	52.8	132.0	152.9	102.9	178.7	69.8	111.8	245.3	49.3
Maumee 3	63.3	0.0	140.7	45.6	29.5	77.7	91.0	59.2	107.5	38.1	64.9	149.9	26.8
Maumee 4	6.7	55.3	131.8	13.8	51.8	66.3	82.2	85.4	117.5	58.4	63.0	148.9	60.1
Maumee 5	29.6	62.8	157.3	12.3	43.9	56.3	69.5	72.2	98.9	49.8	53.6	125.1	51.2
Maumee 6	43.9	86.0	78.9	6.1	21.8	28.1	34.6	36.0	49.3	24.8	26.7	62.3	25.5
Maumee 7	35.8	43.1	195.3	8.5	23.2	37.4	51.0	28.3	64.1	14.4	33.2	81.1	20.9
Maumee 8	3.4	32.4	84.8	2.0	12.9	21.5	35.8	13.7	44.5	5.4	19.0	59.1	10.3
Maumee 9	0.5	8.0	38.4	10.9	23.8	26.2	36.8	24.7	45.7	22.3	26.3	61.5	21.7

Table E-13. Spring average water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	441.1	150.5	381.6	232.3	247.2	215.3	512.8	366.2	438.8	160.5	215.5	275.7	294.8
Maumee 2	141.2	81.0	166.7	96.4	102.9	89.0	219.0	154.9	186.6	65.0	89.1	115.4	123.7
Maumee 3	157.6	22.3	191.6	55.1	59.2	50.3	133.1	92.3	112.5	35.1	50.4	67.1	72.4
Maumee 4	71.2	81.5	139.9	80.7	83.5	87.0	174.2	123.1	135.4	38.1	96.0	87.8	120.3
Maumee 5	125.2	61.9	77.6	68.3	70.6	73.5	146.2	103.6	113.8	32.9	81.1	74.3	101.3
Maumee 6	125.2	61.9	77.6	34.0	35.2	36.6	72.8	51.6	56.7	16.4	40.4	37.0	50.5
Maumee 7	266.8	79.6	62.8	27.3	30.9	26.4	103.1	53.2	66.9	8.8	32.8	28.3	44.8
Maumee 8	43.4	187.4	79.4	12.9	17.4	13.7	78.0	35.1	46.9	2.0	17.6	14.6	27.9
Maumee 9	38.3	13.2	36.3	30.9	28.8	25.7	68.7	48.8	47.3	14.8	35.7	29.3	39.4

Table E-14. Summer average water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	174.0	214.8	87.6	78.7	63.8	51.6	106.9	225.0	130.2	67.4	72.0	74.5	83.7
Maumee 2	82.4	134.4	28.3	30.5	24.1	18.7	42.9	94.5	53.1	25.6	27.6	28.7	32.7
Maumee 3	46.1	62.3	7.4	31.7	27.6	24.2	39.6	72.5	46.1	28.6	29.9	30.6	33.1
Maumee 4	43.6	208.1	25.0	33.8	26.1	30.2	50.7	60.3	58.6	23.8	42.8	34.1	41.1
Maumee 5	26.5	180.1	9.0	24.5	18.1	21.5	38.5	46.5	45.2	16.2	32.0	24.8	30.6
Maumee 6	39.4	205.4	0.8	13.8	10.6	12.3	20.8	24.8	24.1	9.6	17.5	13.9	16.8
Maumee 7	66.2	223.9	52.1	0.0	0.0	0.0	6.0	13.1	7.1	0.0	1.1	0.0	0.0
Maumee 8	24.5	99.8	23.0	9.8	6.2	7.1	18.2	28.8	20.1	5.9	10.4	8.4	11.8
Maumee 9	7.6	69.6	3.5	9.1	5.7	5.6	13.1	15.4	13.8	5.4	10.4	7.2	8.8

Table E-15. Fall average water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	17.9	23.8	17.9	13.6	39.2	34.0	121.6	120.6	44.4	31.9	45.7	28.5	315.1
Maumee 2	9.7	17.4	6.1	2.9	13.3	11.0	49.8	48.9	15.6	10.2	16.1	8.6	133.8
Maumee 3	5.1	44.1	10.8	13.6	20.8	19.3	43.7	43.4	22.2	18.7	22.6	17.8	97.5
Maumee 4	13.0	14.9	22.7	10.1	22.7	19.9	34.8	37.3	25.2	19.0	32.1	15.4	27.6
Maumee 5	0.0	1.2	11.2	4.8	15.2	12.9	25.4	27.4	17.4	12.2	23.1	9.2	19.3
Maumee 6	3.9	10.8	2.6	4.0	9.2	8.0	14.2	15.3	10.2	7.7	13.1	6.2	11.2
Maumee 7	0.0	0.4	24.8	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	9.8
Maumee 8	0.7	10.3	0.0	0.1	3.0	2.9	13.2	7.8	4.8	3.3	4.0	1.6	24.0
Maumee 9	0.3	3.0	5.0	2.3	5.4	3.8	11.9	5.9	5.4	3.3	7.1	2.9	9.2

Table E-16. Annual average water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	91.8	73.2	105.7	74.5	78.7	78.7	100.7	107.9	104.0	80.4	79.0	94.9	106.1
St. Joseph 2	602.6	459.9	976.7	500.2	582.1	579.3	845.3	882.1	864.2	574.5	558.4	781.2	885.8
St. Joseph 3	41.0	23.4	49.5	29.4	33.6	34.6	54.4	62.1	57.0	35.1	32.4	49.0	57.6
St. Joseph 4	128.1	76.2	120.2	79.2	91.0	89.4	131.5	139.9	133.0	90.7	88.4	119.5	137.1
St. Joseph 5	70.7	60.4	83.9	44.0	50.0	51.5	78.5	89.2	82.2	52.0	48.5	71.3	83.0
St. Joseph 6	213.4	154.2	233.9	143.1	171.0	169.0	242.4	259.1	252.1	169.9	164.2	229.0	258.2
St. Joseph 7	68.5	119.7	61.4	103.1	125.3	127.4	210.6	208.7	218.8	120.1	115.3	193.1	222.7
St. Joseph 8	45.6	63.8	143.3	54.7	68.8	63.1	69.8	59.2	69.9	63.3	59.3	72.0	79.2
St. Joseph 9	63.6	49.5	87.7	24.5	25.6	28.4	35.4	33.3	38.9	27.4	26.8	36.2	27.2

Table E-17. Winter average water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	82.3	56.0	131.2	93.8	61.2	115.3	120.0	108.4	136.4	97.8	103.4	157.0	79.4
St. Joseph 2	421.4	260.3	1377.1	637.1	351.2	1031.9	1135.0	834.8	1213.0	708.6	862.9	1580.1	494.7
St. Joseph 3	37.8	8.3	89.4	50.8	23.9	79.3	86.4	70.7	94.6	56.3	63.8	117.3	35.9
St. Joseph 4	108.4	31.3	165.9	106.5	58.6	161.7	176.6	131.9	187.2	114.8	134.7	242.0	82.4
St. Joseph 5	71.7	27.0	117.6	70.7	33.6	109.8	119.4	98.0	130.7	78.2	88.6	161.9	50.4
St. Joseph 6	237.4	96.3	290.2	190.5	106.3	300.5	326.4	261.0	359.2	219.5	259.0	452.8	152.6
St. Joseph 7	56.3	126.1	113.6	135.6	64.5	267.8	303.4	194.6	329.1	153.5	206.8	455.3	97.2
St. Joseph 8	42.0	1.9	131.6	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	18.0	1.3
St. Joseph 9	121.9	86.3	181.2	47.9	36.5	64.9	67.7	66.3	76.5	56.3	60.4	86.3	41.1

Table E-18. Spring average water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	107.5	77.0	130.7	96.4	115.1	92.2	147.2	118.7	147.2	103.6	88.1	101.2	125.1
St. Joseph 2	762.1	373.1	1362.8	711.0	1062.9	643.5	1353.4	1097.6	1383.3	833.2	578.6	789.3	1127.5
St. Joseph 3	73.7	26.6	75.1	54.4	79.8	48.6	100.0	83.2	105.1	64.1	43.0	60.9	84.2
St. Joseph 4	177.9	58.6	168.3	117.1	166.4	104.5	211.6	171.4	214.8	134.7	99.4	126.3	176.9
St. Joseph 5	104.6	34.7	125.0	75.7	110.4	67.7	138.1	115.2	145.1	89.0	60.1	84.5	116.5
St. Joseph 6	279.6	143.4	316.5	209.8	308.8	196.1	386.2	317.5	402.5	245.8	177.4	240.2	326.8
St. Joseph 7	125.8	62.9	60.6	159.7	276.3	134.8	382.5	289.9	385.0	198.3	109.3	180.8	300.6
St. Joseph 8	16.7	19.1	108.0	0.0	0.0	0.0	22.0	0.5	17.0	0.0	0.0	0.0	8.1
St. Joseph 9	132.5	96.5	165.6	50.1	65.8	48.5	74.0	66.8	79.2	53.4	46.8	58.6	67.7

Table E-19. Summer average water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	129.0	111.2	106.8	65.9	68.3	57.7	67.0	114.4	78.7	70.1	60.9	67.4	71.4
St. Joseph 2	978.9	940.3	838.9	423.9	448.8	353.3	439.6	956.3	539.1	464.6	378.8	432.5	470.5
St. Joseph 3	46.0	50.8	26.3	12.0	13.7	7.4	14.1	64.0	23.1	16.1	9.1	12.6	15.1
St. Joseph 4	180.3	168.0	108.6	62.1	66.1	51.0	67.2	151.8	84.0	71.9	55.0	63.5	69.5
St. Joseph 5	99.1	147.3	70.9	23.6	25.9	17.2	26.5	94.7	38.7	29.2	19.6	24.4	27.8
St. Joseph 6	275.1	287.4	286.4	126.5	134.9	105.2	127.5	271.8	156.7	138.7	109.1	132.4	141.3
St. Joseph 7	53.6	241.8	71.2	78.3	76.3	58.7	75.4	225.4	107.5	79.6	71.2	82.0	88.3
St. Joseph 8	75.3	158.6	169.8	135.7	142.5	141.4	131.1	116.4	123.3	140.7	127.4	142.7	140.8
St. Joseph 9	0.0	15.3	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table E-20. Fall average water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	48.5	48.5	54.0	41.9	70.2	49.5	68.5	89.9	53.7	49.9	63.5	53.9	148.7
St. Joseph 2	247.9	265.7	327.9	228.8	465.7	288.5	453.2	639.5	321.5	291.5	413.4	322.9	1450.5
St. Joseph 3	6.5	7.9	7.1	0.5	17.2	3.1	17.2	30.7	5.3	3.7	13.7	5.4	95.0
St. Joseph 4	45.7	47.0	38.2	31.1	72.9	40.6	70.7	104.6	45.9	41.1	64.4	46.1	219.6
St. Joseph 5	7.4	32.7	22.1	6.0	30.1	11.4	30.0	49.1	14.4	11.6	25.9	14.5	137.3
St. Joseph 6	61.6	89.7	42.4	45.6	134.0	74.2	129.3	186.0	90.0	75.6	111.2	90.5	412.1
St. Joseph 7	38.3	48.1	0.0	38.9	84.2	48.4	81.1	124.8	53.7	48.9	73.7	54.1	404.8
St. Joseph 8	48.5	75.4	164.1	83.2	132.6	111.1	126.2	119.9	126.5	112.5	109.8	127.2	166.7
St. Joseph 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3 Excess Water Availability

Excess Water Availability is the portion of water availability within a sub-basin that could be used to support additional surface water or groundwater withdrawals without impacting instream flows or existing water uses. Excess Water Availability is calculated as the water available in the sub-basin under natural baseflow conditions reduced by existing water use (i.e., existing withdrawals minus returns). A positive value indicates that there is unused water in the sub-basin, while a negative value indicates that more water is being used than is generated naturally within the sub-basin. Seasonal and annual excess water availability are presented by sub-basin in 5-year intervals, from 2010 to 2070 (**Tables E-21** through **E-30**). Units are in millions of gallons per day (MGD).

Table E-21. Annual average excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	215.1	112.1	239.5	130.6	119.5	153.5	275.4	239.9	258.4	107.6	149.9	237.5	204.4
Maumee 2	77.4	68.4	80.9	51.3	46.4	60.9	114.1	99.2	106.7	40.7	59.2	97.2	83.2
Maumee 3	67.7	30.2	84.4	33.4	30.9	39.6	73.5	63.7	68.8	26.8	38.5	62.9	54.1
Maumee 4	32.8	88.7	80.6	34.6	46.0	50.8	85.4	76.5	84.1	34.8	58.4	71.5	62.2
Maumee 5	44.6	76.9	63.1	26.4	35.8	39.9	68.7	61.2	67.6	26.5	46.1	57.0	49.2
Maumee 6	41.7	94.5	32.7	14.0	18.7	20.7	35.0	31.2	34.3	13.8	23.6	28.9	25.0
Maumee 7	106.1	105.2	97.6	8.0	12.5	15.0	39.8	22.8	33.7	4.9	15.9	26.4	18.0
Maumee 8	18.0	82.0	47.0	5.8	9.4	10.9	35.9	21.0	28.7	3.7	12.3	20.5	18.1
Maumee 9	11.7	23.5	20.9	13.2	15.8	15.2	32.5	23.5	27.9	11.3	19.7	25.1	19.6

Table E-22. Winter average excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	222.6	52.4	464.3	199.1	129.4	314.6	362.4	248.0	421.6	172.3	268.5	574.0	125.4
Maumee 2	78.8	43.0	124.3	81.0	52.2	131.4	152.3	102.3	178.1	69.2	111.2	244.7	48.7
Maumee 3	63.6	-0.9	138.6	43.2	27.0	75.2	88.5	56.6	104.9	35.5	62.3	147.3	24.2
Maumee 4	6.6	56.1	133.5	14.4	52.4	66.9	82.8	85.9	118.1	59.0	63.6	149.5	60.7
Maumee 5	28.8	62.8	157.4	11.3	42.8	55.3	68.5	71.1	97.8	48.6	52.4	123.8	49.9
Maumee 6	44.5	86.8	79.4	5.7	21.4	27.5	34.1	35.3	48.6	24.1	25.9	61.5	24.6
Maumee 7	50.1	61.4	223.8	8.1	22.7	36.9	50.6	27.9	63.7	13.9	32.7	80.6	20.4
Maumee 8	4.2	32.2	85.4	1.8	12.7	21.3	35.5	13.5	44.3	5.1	18.7	58.8	10.0
Maumee 9	0.5	8.0	38.6	10.8	23.7	26.1	36.7	24.6	45.6	22.2	26.2	61.4	21.5

Table E-23. Spring average excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	445.3	155.9	388.9	236.1	251.0	219.1	516.6	370.0	442.6	164.2	219.3	279.4	298.5
Maumee 2	142.9	81.3	169.3	95.7	102.1	88.2	218.2	154.2	185.9	64.2	88.3	114.5	122.9
Maumee 3	158.4	20.4	189.2	52.3	56.2	47.4	130.2	89.3	109.5	32.0	47.4	64.1	69.4
Maumee 4	71.3	79.8	141.7	81.2	83.9	87.4	174.7	123.5	135.8	38.5	96.4	88.3	120.8
Maumee 5	125.4	62.4	77.4	67.3	69.6	72.5	145.1	102.5	112.6	31.6	79.8	73.0	100.0
Maumee 6	78.5	74.2	47.1	33.6	34.7	36.1	72.2	51.0	56.0	15.6	39.6	36.2	49.6
Maumee 7	297.0	106.1	90.1	26.7	30.2	25.8	102.5	52.6	66.3	8.2	32.2	27.7	44.2
Maumee 8	43.4	187.4	79.4	12.6	17.1	13.4	77.7	34.8	46.6	1.6	17.3	14.3	27.5
Maumee 9	38.5	13.3	36.5	30.8	28.6	25.5	68.5	48.6	47.1	14.6	35.5	29.1	39.3

Table E-24. Summer average excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	173.8	214.9	83.6	73.7	58.3	46.2	100.9	220.9	124.8	61.7	66.4	68.2	78.3
Maumee 2	80.3	133.4	24.9	26.8	19.1	14.0	37.0	92.6	48.5	20.4	22.7	22.3	28.1
Maumee 3	44.5	59.5	2.8	27.6	23.0	19.7	34.8	68.7	41.7	24.0	25.3	25.6	28.7
Maumee 4	41.5	206.1	23.5	33.0	25.3	29.4	49.8	59.4	57.8	23.0	42.0	33.3	40.3
Maumee 5	25.5	181.7	7.5	23.4	16.9	20.2	37.3	45.2	43.8	14.8	30.6	23.3	29.1
Maumee 6	39.7	206.2	1.2	13.3	10.0	11.6	20.1	24.0	23.2	8.7	16.5	12.9	15.7
Maumee 7	74.6	247.5	47.5	-1.8	-2.0	-1.8	4.1	11.7	5.5	-1.7	-0.5	-1.8	-1.6
Maumee 8	24.2	98.9	23.0	9.0	5.3	6.3	17.3	28.3	19.4	5.1	9.7	7.6	11.1
Maumee 9	7.6	69.9	3.4	9.0	5.5	5.4	13.0	15.3	13.6	5.3	10.2	7.0	8.6

Table E-25. Fall average excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	18.8	25.3	21.4	13.6	39.3	34.1	121.8	120.8	44.5	32.0	45.6	28.4	315.2
Maumee 2	7.5	16.1	4.9	1.8	12.2	10.0	48.8	47.9	14.4	9.1	14.8	7.2	132.9
Maumee 3	4.2	41.6	7.1	10.6	17.5	16.1	40.5	40.2	19.0	15.5	19.2	14.4	94.3
Maumee 4	12.0	12.7	23.8	9.7	22.3	19.5	34.4	36.9	24.8	18.6	31.7	15.0	27.2
Maumee 5	-1.5	0.6	10.0	3.6	14.0	11.7	24.1	26.1	16.0	10.8	21.7	7.8	17.9
Maumee 6	4.2	10.7	3.1	3.5	8.7	7.5	13.6	14.6	9.5	6.9	12.3	5.3	10.3
Maumee 7	2.8	5.8	29.0	-0.9	-0.9	-0.8	1.9	-0.8	-0.7	-0.8	-0.8	-0.9	9.1
Maumee 8	0.4	9.3	0.3	-0.3	2.6	2.5	12.9	7.5	4.4	2.9	3.6	1.2	23.6
Maumee 9	0.2	2.9	5.0	2.1	5.3	3.7	11.8	5.7	5.2	3.2	7.0	2.7	9.0

Table E-26. Annual average excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	76.7	63.3	92.0	55.5	56.3	54.5	76.3	91.8	80.2	55.4	53.0	63.7	79.8
St. Joseph 2	542.3	394.6	876.0	402.5	484.5	481.6	747.6	784.4	766.6	476.8	460.8	683.5	788.1
St. Joseph 3	41.3	23.7	47.9	25.3	28.0	27.8	47.8	58.4	50.8	28.7	26.2	41.3	51.5
St. Joseph 4	118.7	69.8	110.9	63.3	71.4	68.0	109.9	128.0	112.0	68.3	64.6	89.4	112.7
St. Joseph 5	70.7	60.1	83.3	41.4	47.0	48.5	75.2	87.4	79.1	48.8	45.1	67.2	79.8
St. Joseph 6	191.6	140.0	209.2	98.5	114.6	115.2	184.6	231.7	203.6	114.9	102.8	148.0	203.5
St. Joseph 7	48.4	102.0	39.7	79.4	98.5	101.3	183.6	189.6	193.7	93.6	86.6	160.7	195.0
St. Joseph 8	10.0	30.5	118.6	40.7	53.4	48.8	55.6	48.1	57.3	49.7	44.7	56.4	65.9
St. Joseph 9	88.7	74.3	115.6	37.7	38.2	41.4	48.5	47.4	52.6	40.7	39.8	48.9	40.7

Table E-27. Winter average excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	80.4	53.4	129.7	93.1	60.4	114.6	119.1	107.6	135.5	96.9	102.4	156.0	78.3
St. Joseph 2	421.8	250.2	1373.0	623.3	337.3	1018.0	1121.1	820.9	1199.1	694.7	849.0	1566.2	480.8
St. Joseph 3	38.6	9.0	90.5	50.7	23.8	79.2	86.3	70.6	94.5	56.2	63.7	117.2	35.8
St. Joseph 4	106.8	29.2	164.6	104.5	56.5	159.6	174.5	129.7	185.0	112.7	132.6	239.8	80.1
St. Joseph 5	71.9	26.7	118.3	70.2	33.1	109.3	119.0	97.5	130.2	77.7	88.1	161.3	49.8
St. Joseph 6	237.5	94.0	289.5	188.7	104.7	298.8	324.7	259.3	357.4	217.7	257.2	451.0	150.8
St. Joseph 7	52.2	123.1	110.4	132.5	61.4	264.7	300.3	191.5	326.0	150.3	203.7	452.1	94.1
St. Joseph 8	26.9	-13.9	121.0	-3.3	-3.5	-3.5	-3.5	-3.5	9.3	-3.6	-3.6	14.4	-2.3
St. Joseph 9	148.2	111.3	213.5	67.5	56.1	84.5	87.3	85.9	96.1	75.9	80.0	105.9	60.7

Table E-28. Spring average excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	104.1	73.3	128.4	93.4	111.1	88.6	143.6	114.7	143.3	99.1	84.2	96.5	120.6
St. Joseph 2	759.6	360.0	1345.4	690.5	1042.3	622.9	1332.8	1077.0	1362.7	812.6	558.0	768.7	1106.9
St. Joseph 3	74.8	27.4	75.8	53.8	78.7	47.7	99.2	82.3	104.2	63.0	42.3	59.7	83.1
St. Joseph 4	176.0	55.9	167.1	113.9	162.2	100.9	207.9	167.5	211.0	130.3	95.5	121.6	172.4
St. Joseph 5	104.6	34.7	125.8	74.8	109.5	66.9	137.3	114.3	144.3	88.1	59.3	83.6	115.6
St. Joseph 6	278.7	140.1	313.8	204.3	300.5	189.5	379.8	310.7	395.8	236.8	169.4	230.9	318.5
St. Joseph 7	118.0	55.9	55.1	153.9	269.5	128.6	376.3	283.5	378.7	191.3	102.7	173.7	293.8
St. Joseph 8	-9.9	-7.0	99.3	-5.4	-7.1	-6.7	16.4	-4.7	10.8	-6.3	-7.4	-6.7	2.2
St. Joseph 9	159.9	121.8	199.2	68.0	83.0	65.9	91.9	84.9	96.8	71.0	63.9	76.1	85.6

Table E-29. Summer average excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	83.3	86.1	64.7	4.0	-5.9	-24.3	-17.4	64.5	-1.3	-13.8	-25.9	-38.1	-19.1
St. Joseph 2	790.3	748.4	539.0	147.8	172.7	77.2	163.6	680.3	263.1	188.5	102.8	156.5	194.4
St. Joseph 3	45.1	50.1	18.8	-1.5	-5.6	-16.4	-10.0	52.2	1.5	-6.0	-12.3	-13.9	-6.5
St. Joseph 4	149.9	151.5	77.8	11.0	1.4	-21.9	-8.7	116.4	12.9	-4.2	-25.2	-39.4	-15.7
St. Joseph 5	98.8	146.6	67.8	16.4	17.0	7.9	15.9	90.1	29.2	19.3	9.1	11.3	17.7
St. Joseph 6	201.5	250.4	201.3	-19.8	-55.0	-80.1	-81.1	190.2	-9.0	-49.8	-94.8	-144.7	-48.2
St. Joseph 7	1.5	196.9	11.1	8.6	-3.5	-22.1	-9.9	173.0	31.0	-0.4	-15.9	-18.1	1.2
St. Joseph 8	15.5	108.6	115.1	101.2	104.6	105.7	95.1	91.8	94.4	107.2	92.7	104.8	108.9
St. Joseph 9	23.5	38.9	27.7	4.1	2.7	3.5	3.6	7.0	6.0	4.0	3.9	2.8	4.8

Table E-30. Fall average excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	38.8	40.4	45.1	31.4	59.4	39.1	60.0	80.3	43.2	39.6	51.4	40.4	139.5
St. Joseph 2	197.7	219.9	246.4	148.7	385.6	208.4	373.1	559.4	241.4	211.4	333.3	242.8	1370.4
St. Joseph 3	6.7	8.2	6.4	-1.7	14.8	0.8	15.8	28.5	2.8	1.6	10.9	2.0	93.6
St. Joseph 4	42.3	42.7	34.1	23.7	65.4	33.6	65.9	98.6	39.0	34.3	55.5	35.7	213.9
St. Joseph 5	7.4	32.4	21.3	4.3	28.5	9.8	28.8	47.7	12.9	10.2	24.0	12.4	136.0
St. Joseph 6	48.8	75.5	32.3	20.9	108.1	52.6	114.9	166.7	70.3	54.8	79.3	54.8	392.9
St. Joseph 7	21.8	31.9	-17.9	22.5	66.8	33.8	67.9	110.3	39.2	33.4	56.0	35.1	390.7
St. Joseph 8	7.5	34.1	139.0	70.4	119.6	99.8	114.1	108.8	114.8	101.3	97.2	113.2	154.9
St. Joseph 9	23.4	25.2	22.1	11.2	11.1	11.7	11.3	11.8	11.4	11.8	11.2	10.7	11.5

4 Cumulative Excess Water Availability

Cumulative Excess Water Availability (CXS WA) is the Excess Water Availability (XS WA) summed over all upstream sub-basins. Sub-basins with negative excess water availability are using the positive excess water availability from upstream sub-basins to supply demand. Most values of cumulative excess water availability are positive; a negative value means that the streamflow falls below the minimum instream flow targets. The streamflow itself is always positive. Seasonal and annual cumulative excess water availability are presented by sub-basin in 5-year intervals, from 2010 to 2070 (**Tables E-31 through E-40**). Units are in millions of gallons per day (MGD).

Table E-31. Annual average cumulative excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	215.1	112.1	239.5	130.6	119.5	153.5	275.4	239.9	258.4	107.6	149.9	237.5	204.4
Maumee 2	77.4	68.4	80.9	51.3	46.4	60.9	114.1	99.2	106.7	40.7	59.2	97.2	83.2
Maumee 3	360.2	210.7	404.8	215.4	196.8	254.0	463.0	402.8	433.9	175.1	247.7	397.5	341.7
Maumee 4	32.8	88.7	80.6	34.6	46.0	50.8	85.4	76.5	84.1	34.8	58.4	71.5	62.2
Maumee 5	77.4	165.5	143.7	60.9	81.8	90.7	154.2	137.7	151.7	61.2	104.5	128.5	111.4
Maumee 6	119.2	260.0	176.4	75.0	100.5	111.4	189.1	168.9	186.0	75.1	128.1	157.4	136.5
Maumee 7	585.4	575.9	678.8	298.4	309.8	380.4	691.9	594.6	653.6	255.0	391.7	581.3	496.2
Maumee 8	603.5	657.9	725.8	304.2	319.3	391.3	727.8	615.6	682.3	258.7	404.1	601.8	514.3
Maumee 9	11.7	23.5	20.9	13.2	15.8	15.2	32.5	23.5	27.9	11.3	19.7	25.1	19.6

Table E-32. Winter average cumulative excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	222.6	52.4	464.3	199.1	129.4	314.6	362.4	248.0	421.6	172.3	268.5	574.0	125.4
Maumee 2	78.8	43.0	124.3	81.0	52.2	131.4	152.3	102.3	178.1	69.2	111.2	244.7	48.7
Maumee 3	364.9	94.4	727.2	323.4	208.5	521.2	603.2	406.8	704.6	277.1	441.9	966.0	198.3
Maumee 4	6.6	56.1	133.5	14.4	52.4	66.9	82.8	85.9	118.1	59.0	63.6	149.5	60.7
Maumee 5	35.5	118.9	290.9	25.7	95.2	122.1	151.2	157.0	215.8	107.6	116.0	273.3	110.6
Maumee 6	80.0	205.7	370.3	31.4	116.5	149.7	185.3	192.4	264.4	131.7	141.9	334.8	135.2
Maumee 7	495.0	361.5	1321.3	362.8	347.8	707.8	839.1	627.0	1032.7	422.7	616.5	1381.4	354.0
Maumee 8	499.2	393.8	1406.7	364.6	360.5	729.0	874.6	640.5	1077.0	427.8	635.3	1440.2	364.0
Maumee 9	0.5	8.0	38.6	10.8	23.7	26.1	36.7	24.6	45.6	22.2	26.2	61.4	21.5

Table E-33. Spring average cumulative excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	445.3	155.9	388.9	236.1	251.0	219.1	516.6	370.0	442.6	164.2	219.3	279.4	298.5
Maumee 2	142.9	81.3	169.3	95.7	102.1	88.2	218.2	154.2	185.9	64.2	88.3	114.5	122.9
Maumee 3	746.6	257.6	747.4	384.1	409.4	354.7	865.0	613.5	738.0	260.4	354.9	458.0	490.8
Maumee 4	71.3	79.8	141.7	81.2	83.9	87.4	174.7	123.5	135.8	38.5	96.4	88.3	120.8
Maumee 5	196.7	142.2	219.2	148.5	153.5	159.9	319.7	226.0	248.5	70.2	176.3	161.3	220.8
Maumee 6	275.2	216.3	266.2	182.1	188.2	196.0	392.0	277.0	304.5	85.8	215.9	197.4	270.4
Maumee 7	1318.8	580.1	1103.8	593.0	627.7	576.5	1359.5	943.1	1108.8	354.4	603.0	683.1	805.4
Maumee 8	1362.2	767.5	1183.2	605.5	644.8	589.8	1437.1	977.9	1155.4	356.0	620.2	697.3	832.9
Maumee 9	38.5	13.3	36.5	30.8	28.6	25.5	68.5	48.6	47.1	14.6	35.5	29.1	39.3

Table E-34. Summer average cumulative excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	173.8	214.9	83.6	73.7	58.3	46.2	100.9	220.9	124.8	61.7	66.4	68.2	78.3
Maumee 2	80.3	133.4	24.9	26.8	19.1	14.0	37.0	92.6	48.5	20.4	22.7	22.3	28.1
Maumee 3	298.5	407.8	111.3	128.1	100.3	79.9	172.7	382.1	215.0	106.1	114.4	116.1	135.1
Maumee 4	41.5	206.1	23.5	33.0	25.3	29.4	49.8	59.4	57.8	23.0	42.0	33.3	40.3
Maumee 5	67.0	387.8	31.0	56.3	42.2	49.6	87.1	104.6	101.6	37.7	72.5	56.6	69.4
Maumee 6	106.7	594.0	32.1	69.6	52.2	61.2	107.1	128.6	124.8	46.4	89.0	69.5	85.1
Maumee 7	479.9	1249.2	190.9	195.9	150.6	139.3	284.0	522.4	345.4	150.9	202.9	183.7	218.6
Maumee 8	504.1	1348.2	213.9	204.9	155.9	145.6	301.3	550.7	364.8	156.0	212.6	191.3	229.7
Maumee 9	7.6	69.9	3.4	9.0	5.5	5.4	13.0	15.3	13.6	5.3	10.2	7.0	8.6

Table E-35. Fall average cumulative excess water availability (MGD) in the Maumee Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Maumee 1	18.8	25.3	21.4	13.6	39.3	34.1	121.8	120.8	44.5	32.0	45.6	28.4	315.2
Maumee 2	7.5	16.1	4.9	1.8	12.2	10.0	48.8	47.9	14.4	9.1	14.8	7.2	132.9
Maumee 3	30.6	83.0	33.4	26.0	69.0	60.3	211.2	208.8	77.9	56.6	79.7	49.9	542.4
Maumee 4	12.0	12.7	23.8	9.7	22.3	19.5	34.4	36.9	24.8	18.6	31.7	15.0	27.2
Maumee 5	10.5	13.3	33.8	13.2	36.3	31.2	58.5	63.0	40.8	29.4	53.4	22.7	45.0
Maumee 6	14.7	24.0	36.9	16.8	45.0	38.7	72.2	77.6	50.4	36.3	65.6	28.0	55.3
Maumee 7	48.0	112.8	99.3	41.9	113.2	98.2	285.2	285.7	127.5	92.2	144.5	77.1	606.8
Maumee 8	48.4	122.0	99.6	41.5	115.8	100.7	298.1	293.2	131.9	95.1	148.1	78.3	630.4
Maumee 9	0.2	2.9	5.0	2.1	5.3	3.7	11.8	5.7	5.2	3.2	7.0	2.7	9.0

Table E-36. Annual average cumulative excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	76.7	63.3	92.0	55.5	56.3	54.5	76.3	91.8	80.2	55.4	53.0	63.7	79.8
St. Joseph 2	619.0	457.9	968.0	458.0	540.8	536.1	824.0	876.2	846.8	532.3	513.8	747.2	867.9
St. Joseph 3	41.3	23.7	47.9	25.3	28.0	27.8	47.8	58.4	50.8	28.7	26.2	41.3	51.5
St. Joseph 4	160.1	93.5	158.8	88.6	99.3	95.9	157.7	186.5	162.8	97.0	90.8	130.7	164.2
St. Joseph 5	70.7	60.1	83.3	41.4	47.0	48.5	75.2	87.4	79.1	48.8	45.1	67.2	79.8
St. Joseph 6	262.3	200.1	292.5	139.9	161.6	163.7	259.8	319.1	282.7	163.7	147.9	215.2	283.3
St. Joseph 7	1089.8	853.4	1459.0	765.9	900.3	896.9	1425.1	1571.3	1486.0	886.6	839.1	1253.8	1510.4
St. Joseph 8	1099.8	883.9	1577.6	806.6	953.7	945.8	1480.7	1619.4	1543.3	936.2	883.9	1310.2	1576.3
St. Joseph 9	1188.5	958.2	1693.2	844.4	991.9	987.2	1529.2	1666.8	1595.9	976.9	923.6	1359.1	1617.0

Table E-37. Winter average cumulative excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	80.4	53.4	129.7	93.1	60.4	114.6	119.1	107.6	135.5	96.9	102.4	156.0	78.3
St. Joseph 2	502.2	303.6	1502.8	716.4	397.7	1132.6	1240.2	928.5	1334.5	791.6	951.4	1722.2	559.1
St. Joseph 3	38.6	9.0	90.5	50.7	23.8	79.2	86.3	70.6	94.5	56.2	63.7	117.2	35.8
St. Joseph 4	145.5	38.2	255.1	155.1	80.3	238.8	260.8	200.3	279.5	168.9	196.3	357.0	115.9
St. Joseph 5	71.9	26.7	118.3	70.2	33.1	109.3	119.0	97.5	130.2	77.7	88.1	161.3	49.8
St. Joseph 6	309.4	120.7	407.8	258.9	137.7	408.2	443.6	356.8	487.6	295.4	345.3	612.4	200.6
St. Joseph 7	1009.2	585.5	2276.1	1263.0	677.2	2044.2	2244.9	1677.1	2427.6	1406.2	1696.7	3143.7	969.7
St. Joseph 8	1036.1	571.7	2397.1	1259.6	673.7	2040.7	2241.4	1673.5	2436.9	1402.6	1693.1	3158.1	967.4
St. Joseph 9	1184.3	683.0	2610.6	1327.2	729.8	2125.2	2328.7	1759.4	2533.0	1478.6	1773.2	3264.0	1028.1

Table E-38. Spring average cumulative excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	104.1	73.3	128.4	93.4	111.1	88.6	143.6	114.7	143.3	99.1	84.2	96.5	120.6
St. Joseph 2	863.7	433.3	1473.8	783.9	1153.4	711.5	1476.4	1191.8	1506.0	911.7	642.2	865.2	1227.5
St. Joseph 3	74.8	27.4	75.8	53.8	78.7	47.7	99.2	82.3	104.2	63.0	42.3	59.7	83.1
St. Joseph 4	250.8	83.3	242.8	167.7	241.0	148.5	307.1	249.8	315.2	193.3	137.8	181.2	255.5
St. Joseph 5	104.6	34.7	125.8	74.8	109.5	66.9	137.3	114.3	144.3	88.1	59.3	83.6	115.6
St. Joseph 6	383.3	174.7	439.6	279.1	410.0	256.4	517.1	425.0	540.0	324.9	228.7	314.5	434.2
St. Joseph 7	1615.8	747.3	2211.3	1384.6	2073.9	1245.1	2676.9	2150.0	2740.0	1621.1	1111.4	1534.6	2211.1
St. Joseph 8	1605.8	740.3	2310.6	1379.2	2066.8	1238.4	2693.3	2145.3	2750.7	1614.8	1104.0	1527.9	2213.3
St. Joseph 9	1765.8	862.1	2509.8	1447.3	2149.8	1304.3	2785.2	2230.2	2847.6	1685.9	1167.9	1604.0	2298.9

Table E-39. Summer average cumulative excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	83.3	86.1	64.7	4.0	-5.9	-24.3	-17.4	64.5	-1.3	-13.8	-25.9	-38.1	-19.1
St. Joseph 2	873.6	834.5	603.7	151.8	166.8	52.9	146.2	744.8	261.8	174.7	76.9	118.3	175.3
St. Joseph 3	45.1	50.1	18.8	-1.5	-5.6	-16.4	-10.0	52.2	1.5	-6.0	-12.3	-13.9	-6.5
St. Joseph 4	195.0	201.6	96.6	9.5	-4.1	-38.3	-18.7	168.7	14.4	-10.2	-37.5	-53.2	-22.1
St. Joseph 5	98.8	146.6	67.8	16.4	17.0	7.9	15.9	90.1	29.2	19.3	9.1	11.3	17.7
St. Joseph 6	300.3	397.1	269.1	-3.4	-37.9	-72.2	-65.2	280.3	20.1	-30.5	-85.6	-133.3	-30.5
St. Joseph 7	1370.5	1630.0	980.6	166.5	121.3	-79.8	52.4	1366.8	327.4	133.7	-62.1	-86.3	123.9
St. Joseph 8	1386.0	1738.6	1095.7	267.6	225.8	26.0	147.5	1458.7	421.8	240.9	30.6	18.5	232.7
St. Joseph 9	1409.5	1777.5	1123.3	271.8	228.5	29.5	151.1	1465.7	427.8	244.9	34.5	21.3	237.6

Table E-40. Fall average cumulative excess water availability (MGD) in the St. Joseph Basin.

Sub-basin	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
St. Joseph 1	38.8	40.4	45.1	31.4	59.4	39.1	60.0	80.3	43.2	39.6	51.4	40.4	139.5
St. Joseph 2	236.5	260.3	291.6	180.1	445.1	247.5	433.1	639.7	284.7	251.0	384.7	283.2	1509.9
St. Joseph 3	6.7	8.2	6.4	-1.7	14.8	0.8	15.8	28.5	2.8	1.6	10.9	2.0	93.6
St. Joseph 4	49.0	50.9	40.5	22.0	80.2	34.4	81.7	127.1	41.9	36.0	66.4	37.7	307.6
St. Joseph 5	7.4	32.4	21.3	4.3	28.5	9.8	28.8	47.7	12.9	10.2	24.0	12.4	136.0
St. Joseph 6	56.3	107.9	53.6	25.1	136.6	62.4	143.7	214.4	83.2	65.0	103.3	67.2	528.9
St. Joseph 7	363.6	451.0	367.8	249.6	728.7	378.2	726.4	1091.5	448.9	385.4	610.4	423.1	2737.0
St. Joseph 8	371.1	485.1	506.8	320.0	848.3	478.0	840.5	1200.3	563.7	486.6	707.6	536.3	2891.9
St. Joseph 9	394.4	510.3	529.0	331.2	859.4	489.7	851.9	1212.1	575.1	498.4	718.8	547.0	2903.4



Appendix F

County Withdrawal Summaries

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1 Adams

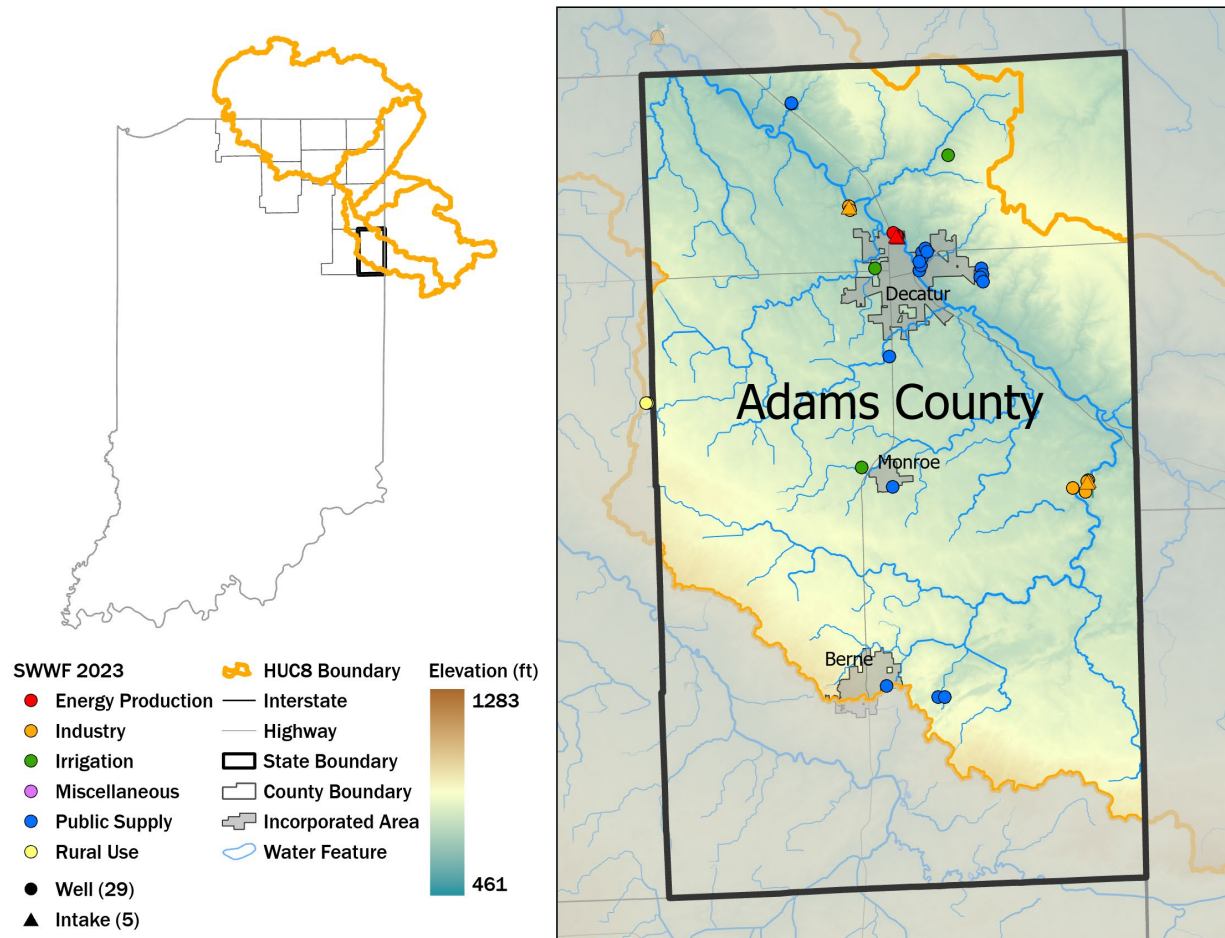


Figure F-1. Water withdrawal locations in Adams County, Northeast Indiana Region (1985-2023). Adams County lies partially within the Northeast Region.

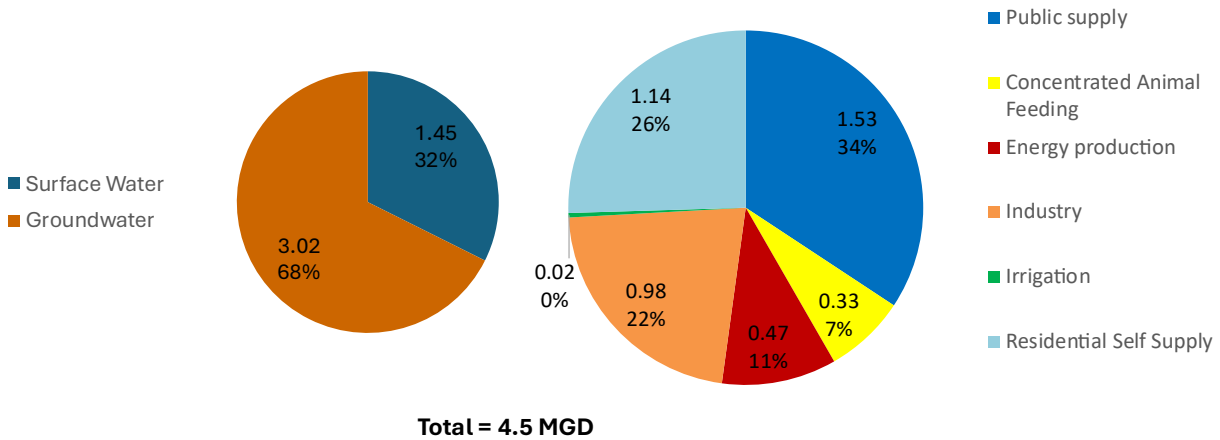


Figure F-2. 2020 water withdrawals in MGD in Adams County. Adams County lies partially within the Northeast Region. Only data from within the Region are presented.

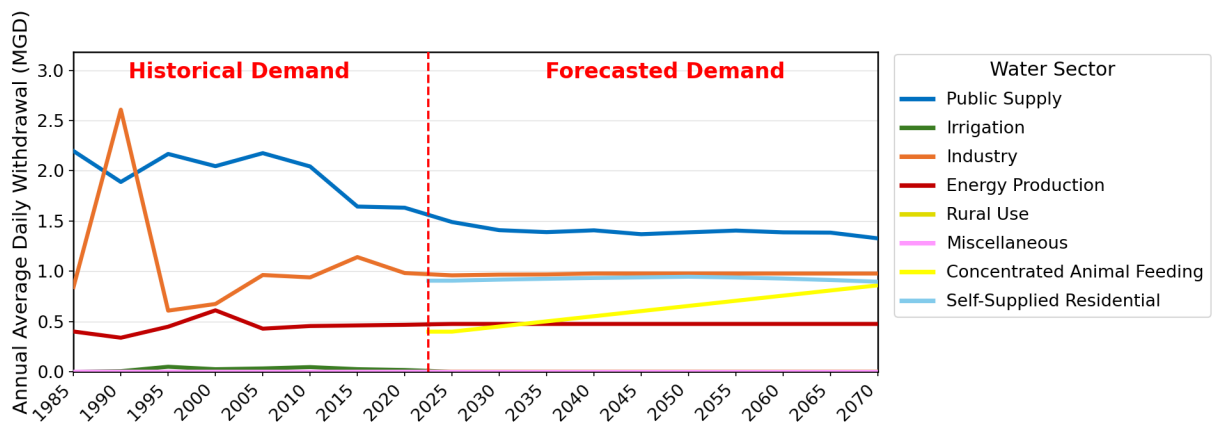


Figure F-3. Historical and forecasted water withdrawals in Adams County in MGD from 1985-2070. Adams County lies partially within the Northeast Region. Only data from within the Region are presented.

2 Allen

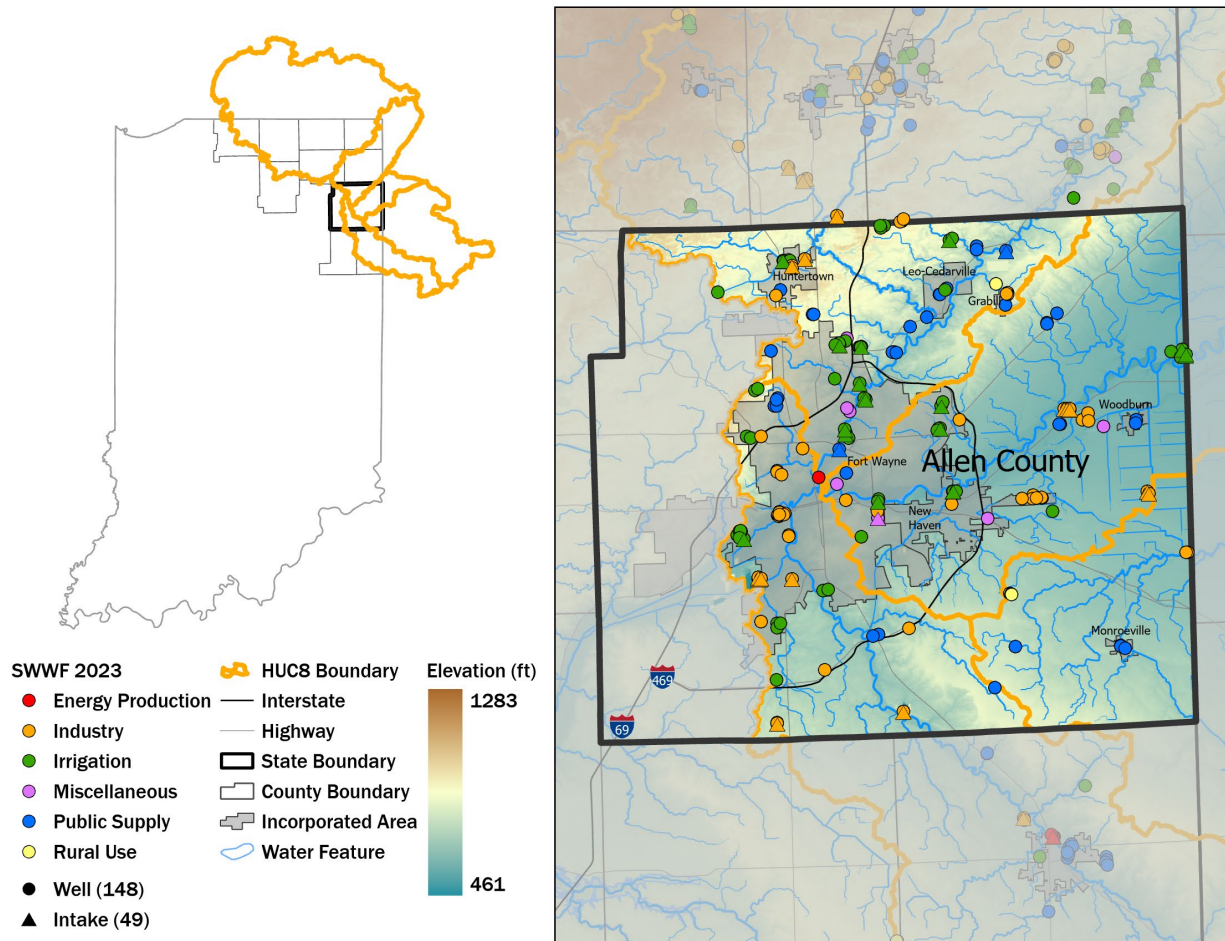


Figure F-4. Water withdrawal locations in Allen County, Northeast Indiana Region (1985-2023). Allen County lies partially within the Northeast Region.

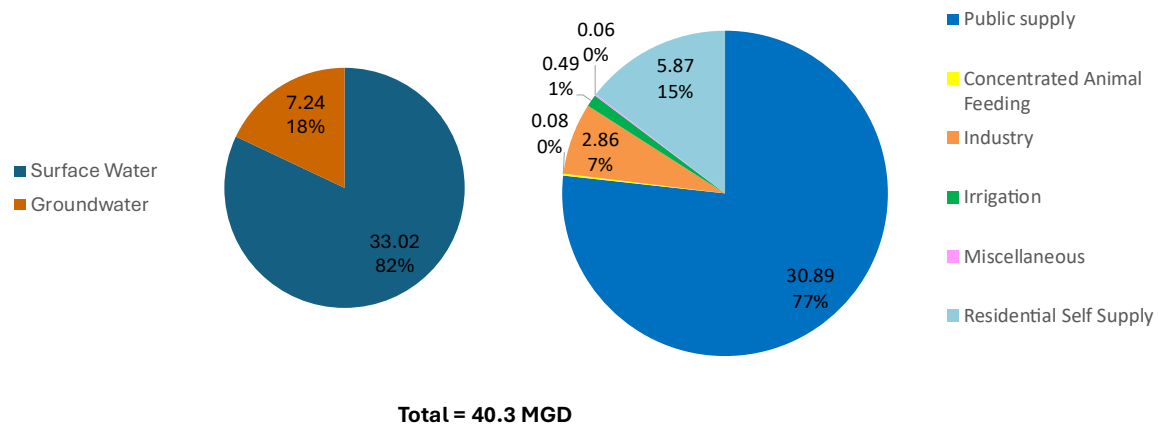


Figure F-5. 2020 water withdrawals in MGD in Allen County. Allen County lies partially within the Northeast Region. Only data from within the Region are presented.

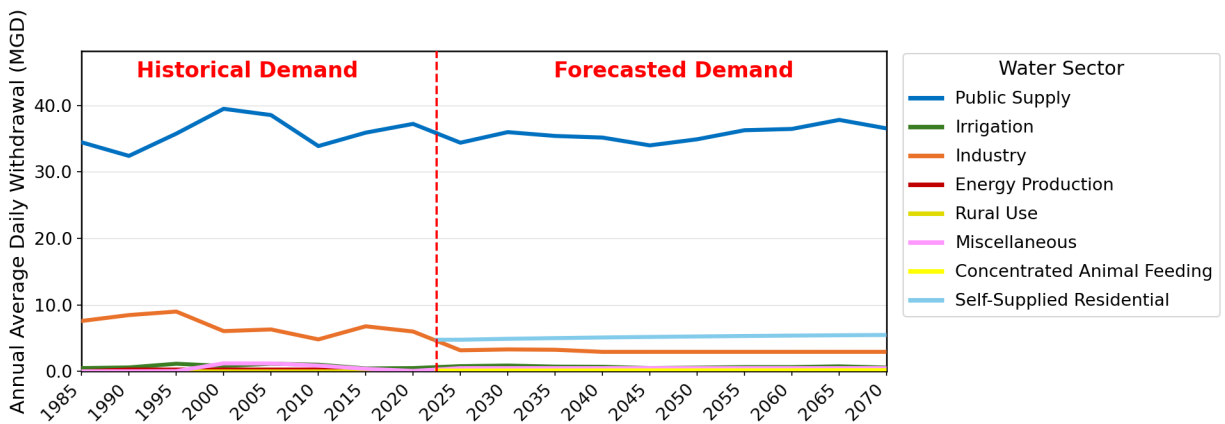


Figure F-6. Historical and forecasted water withdrawals in Allen County in MGD from 1985-2070. Allen County lies partially within the Northeast Region. Only data from within the Region are presented.

3 DeKalb

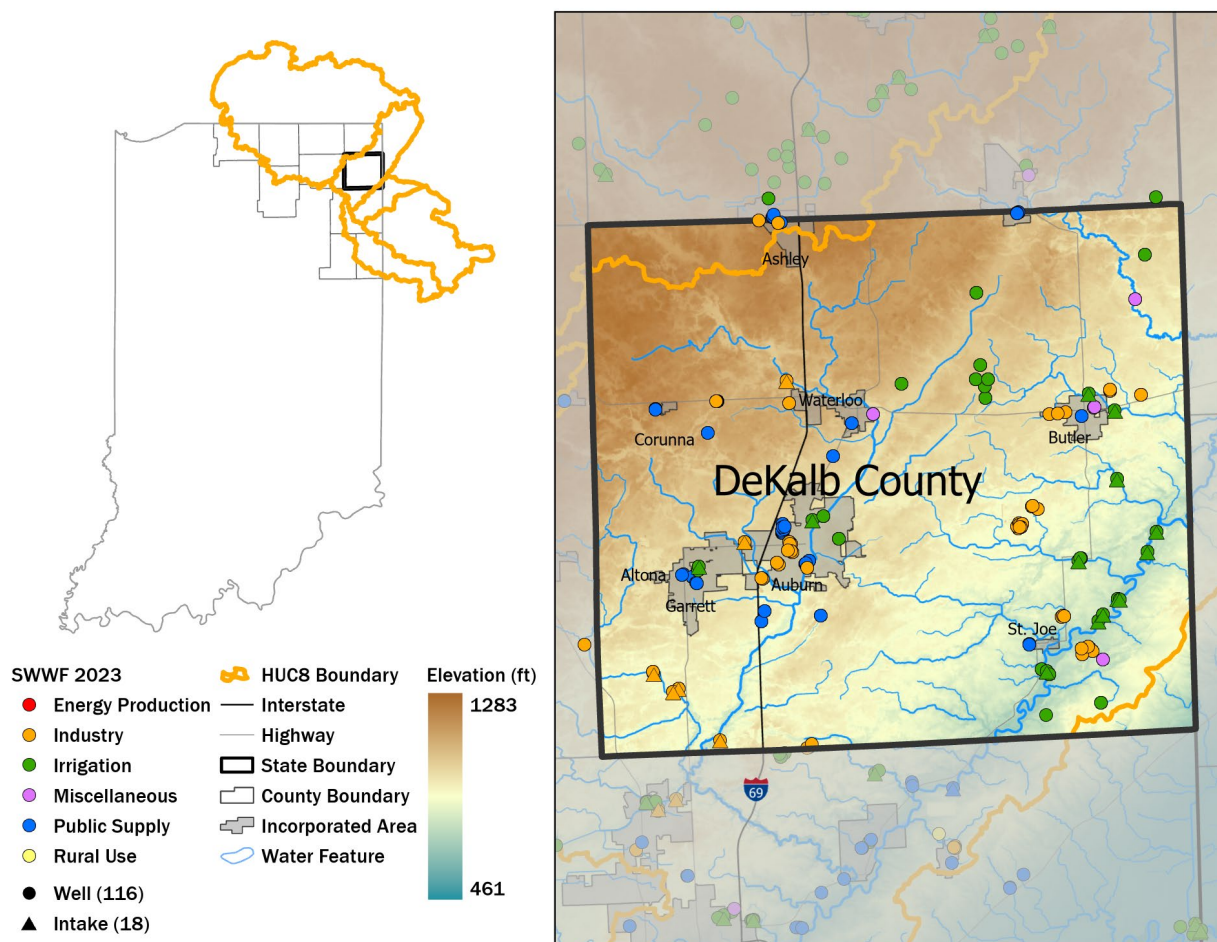


Figure F-7. Water withdrawal locations in DeKalb County, Northeast Indiana Region (1985-2023).

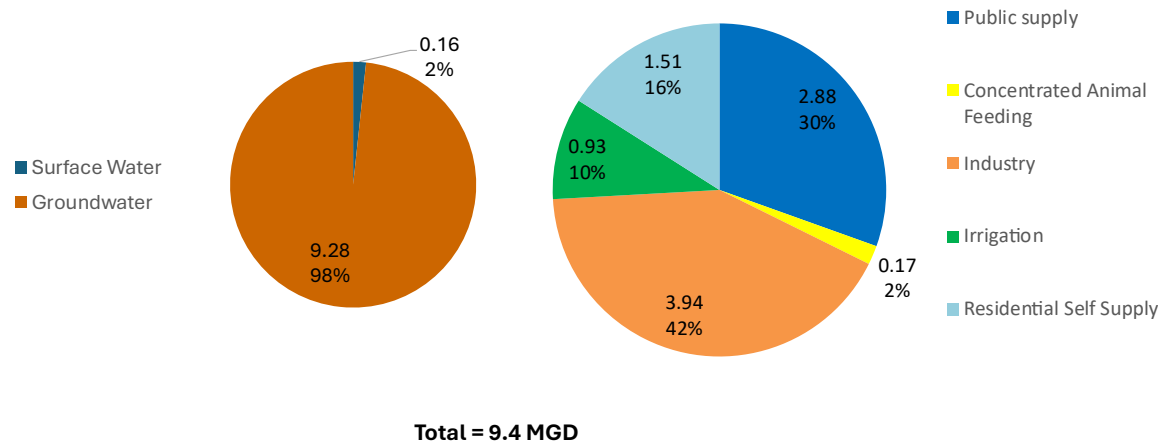


Figure F-8. 2020 water withdrawals in MGD in DeKalb County.

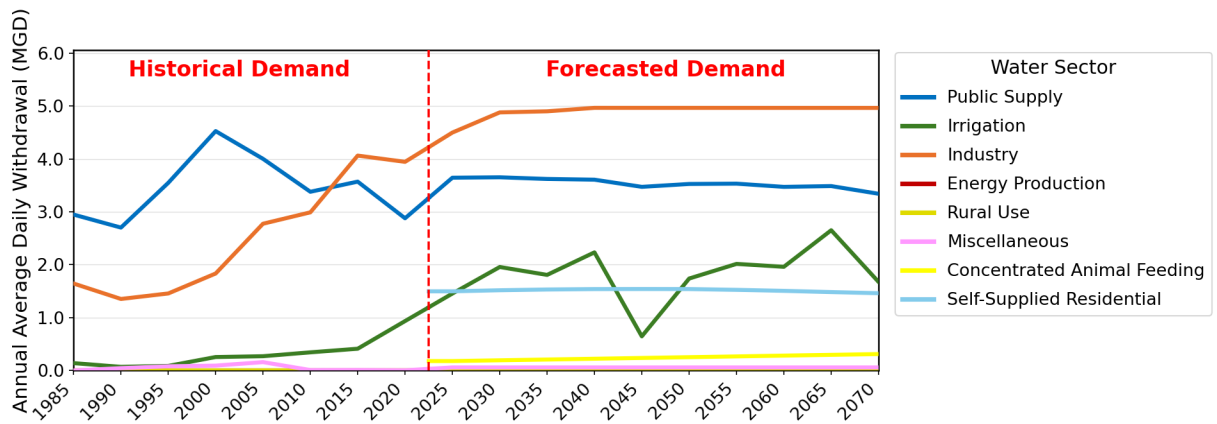


Figure F-9. Historical and forecasted water withdrawals in DeKalb County in MGD from 1985-2070.

4 Elkhart

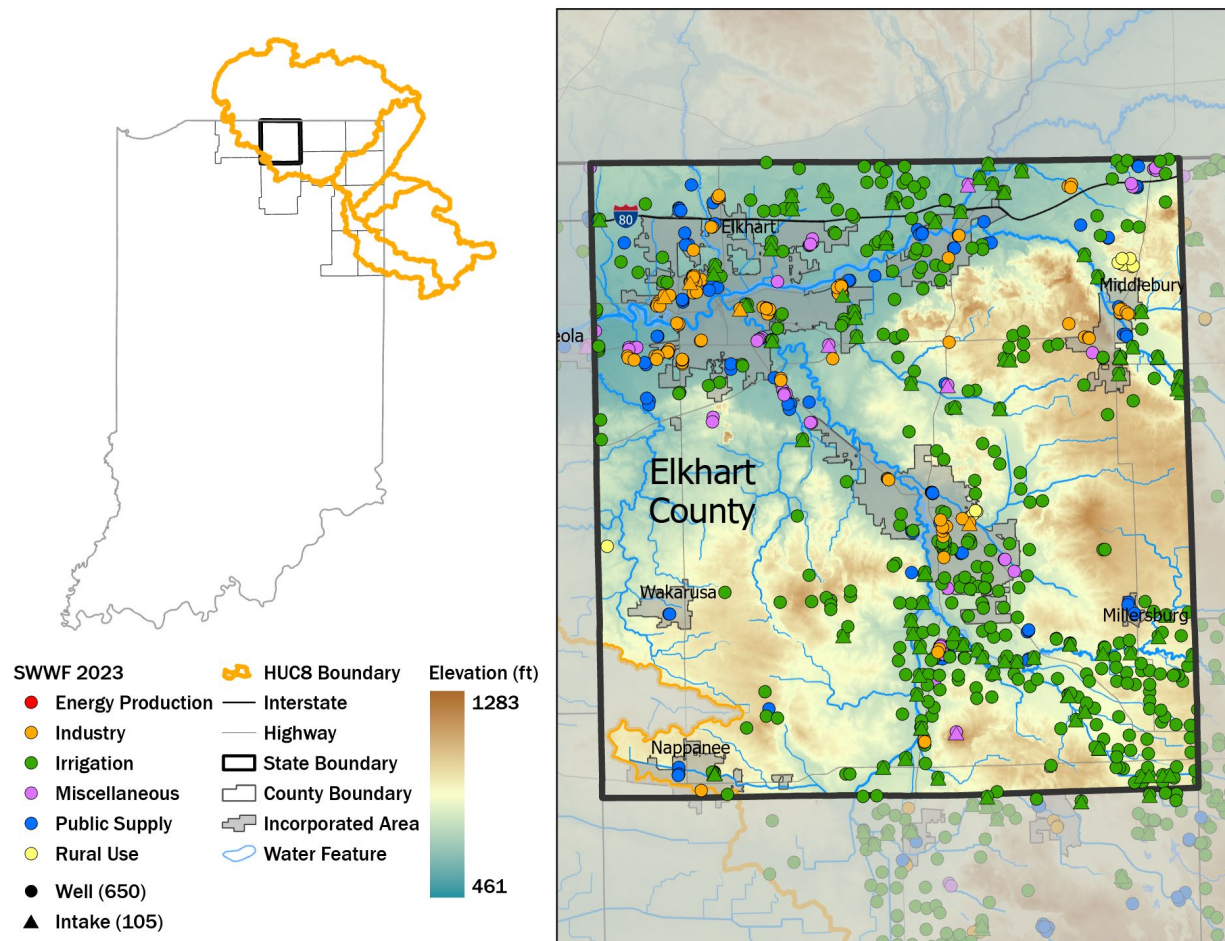


Figure F-10. Water withdrawal locations in Elkhart County, Northeast Indiana Region (1985-2023).

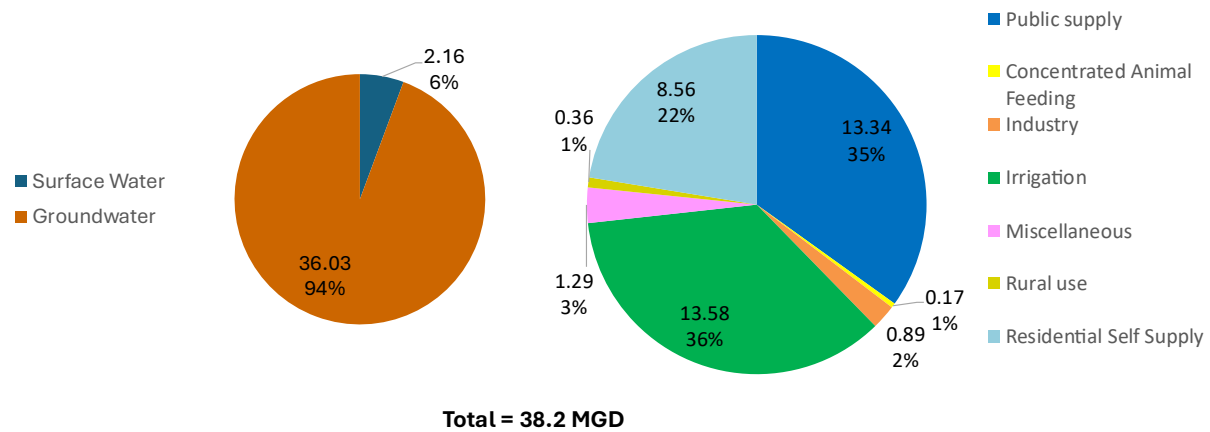


Figure F-11. 2020 water withdrawals in MGD in Elkhart County.

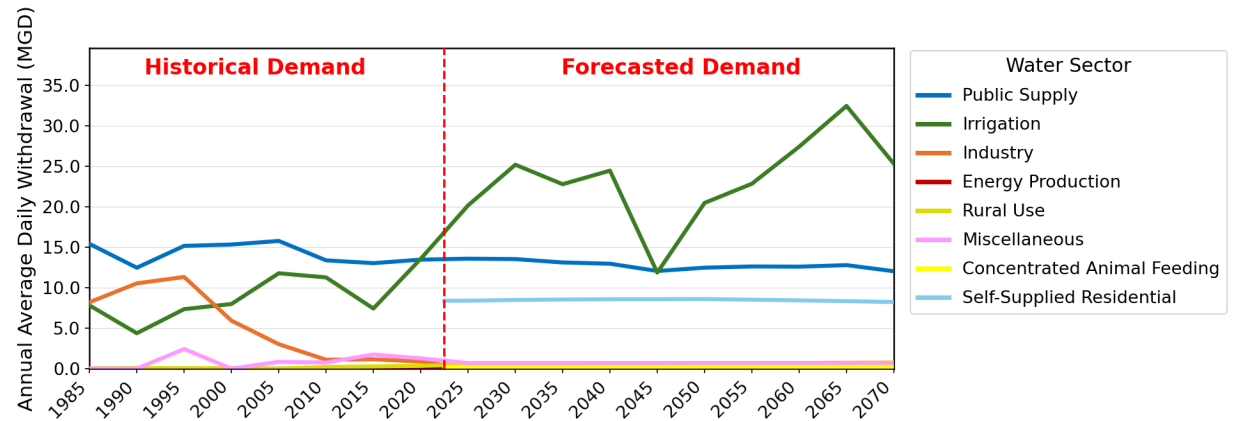


Figure F-12. Historical and forecasted water withdrawals in Elkhart County in MGD from 1985-2070.

5 Kosciusko

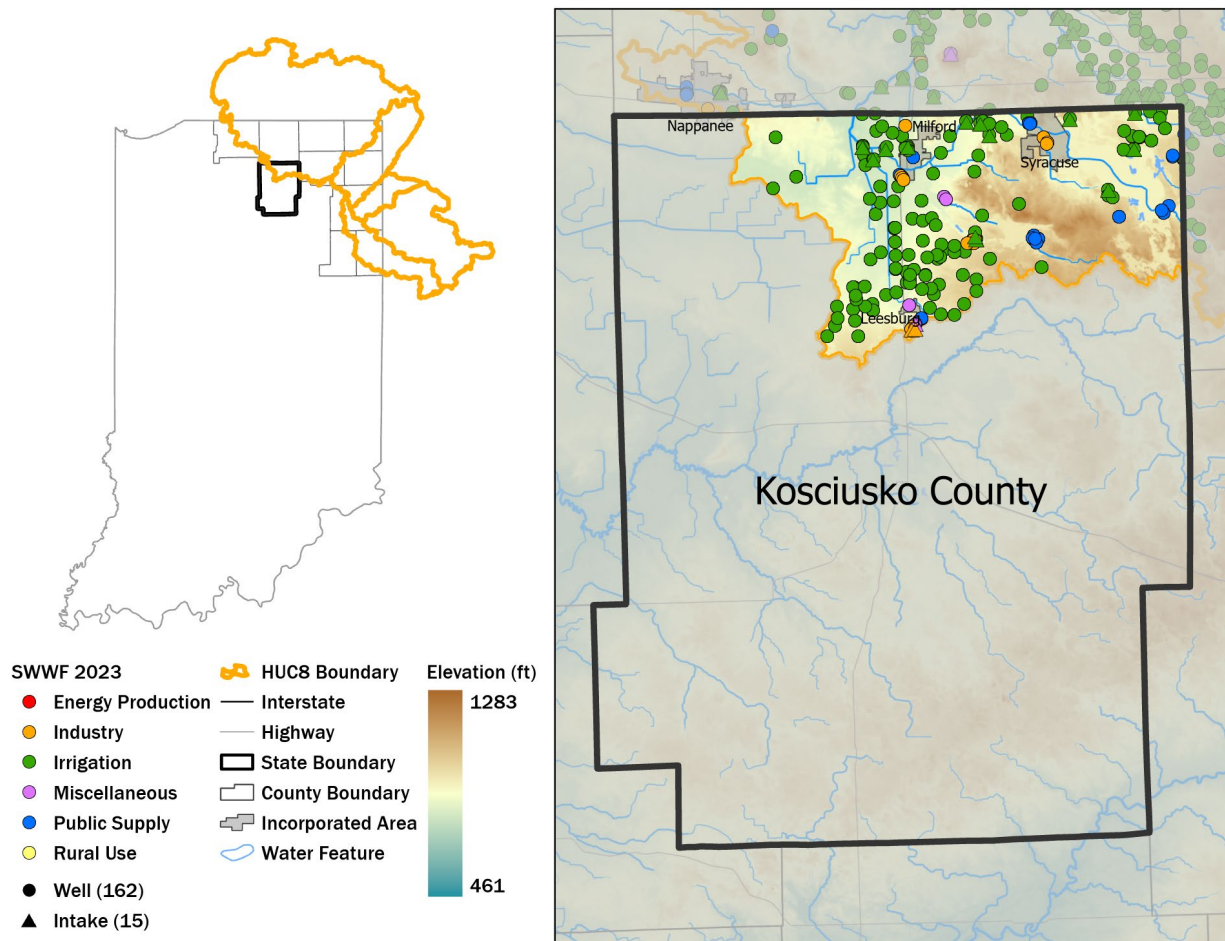


Figure F-13. Water withdrawal locations in Kosciusko County, Northeast Indiana Region (1985-2023). Kosciusko County lies partially within the Northeast Region.

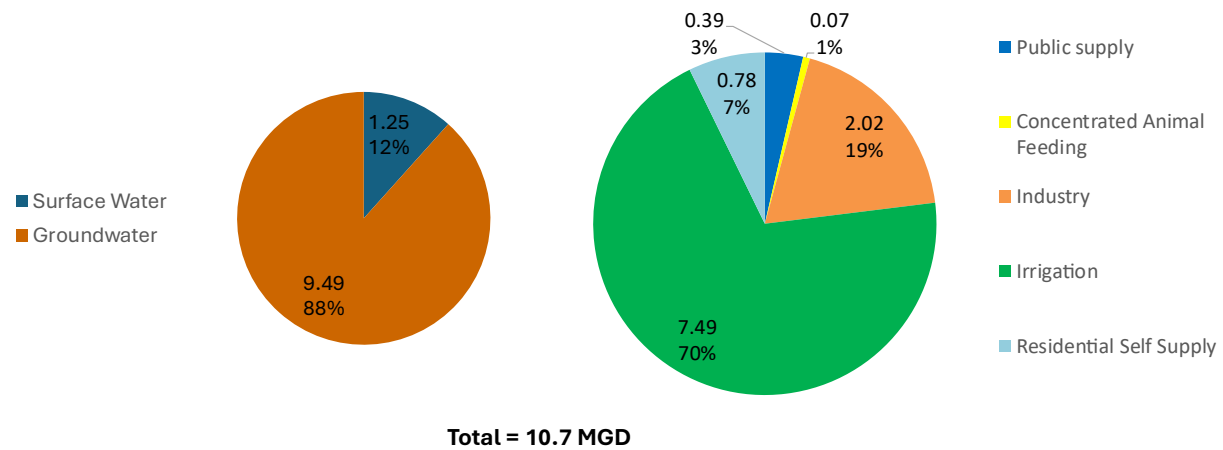


Figure F-14. 2020 water withdrawals in MGD in Kosciusko County. Kosciusko County lies partially within the Northeast Region. Only data from within the Region are presented.

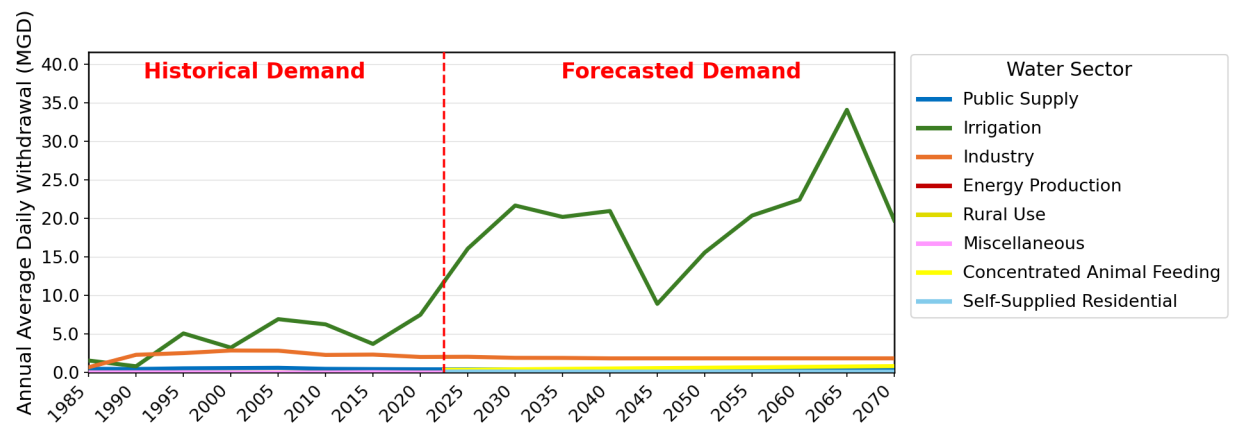


Figure F-15. Historical and forecasted water withdrawals in Kosciusko County in MGD from 1985-2070. Kosciusko County lies partially within the Northeast Region. Only data from within the Region are presented.

6 LaGrange

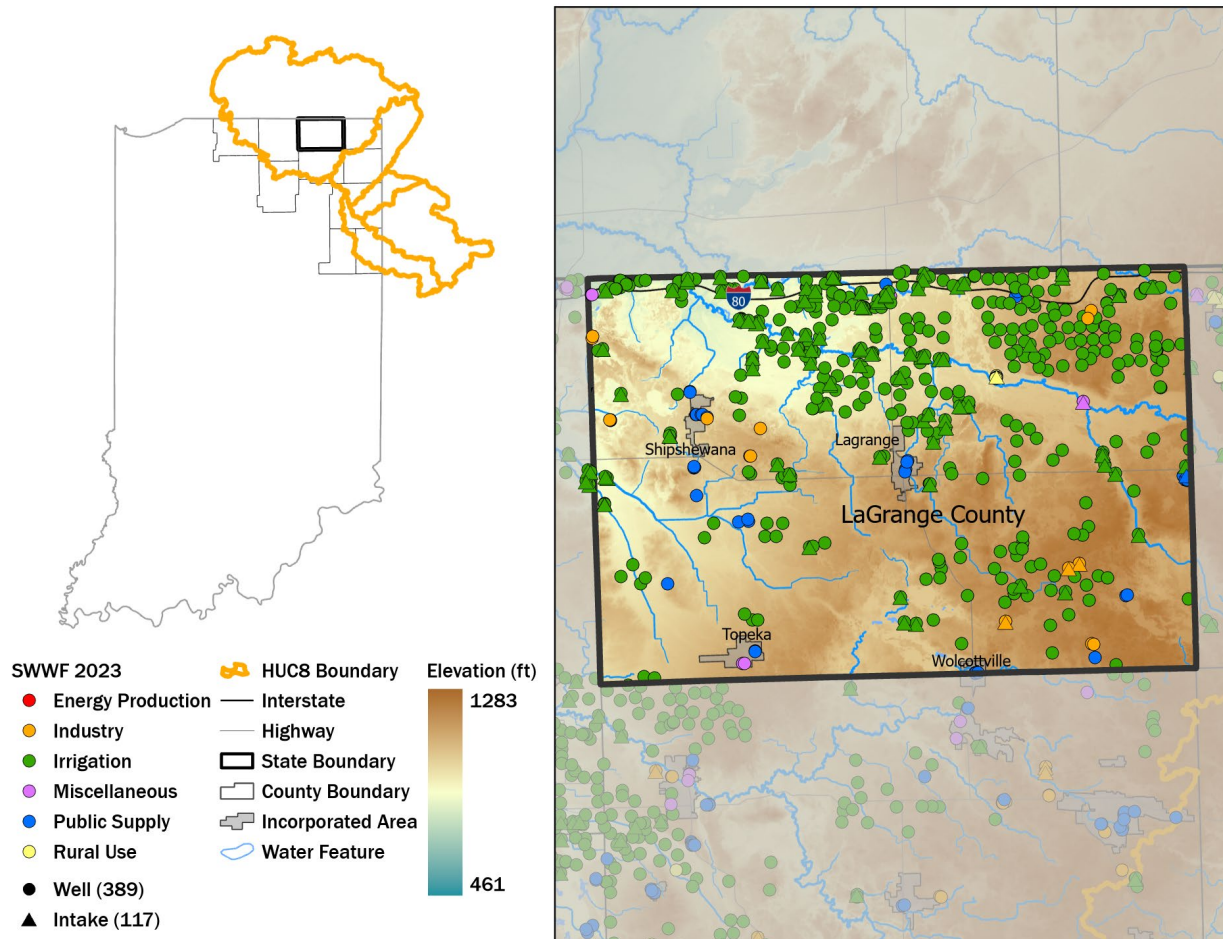


Figure F-16. Water withdrawal locations in LaGrange County, Northeast Indiana Region (1985-2023).

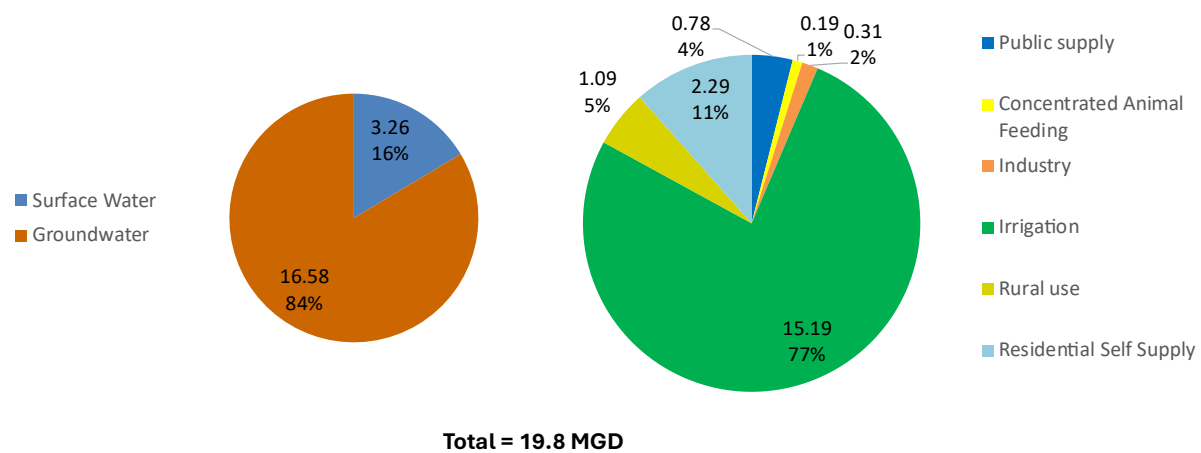


Figure F-17. 2020 water withdrawals in MGD in LaGrange County.

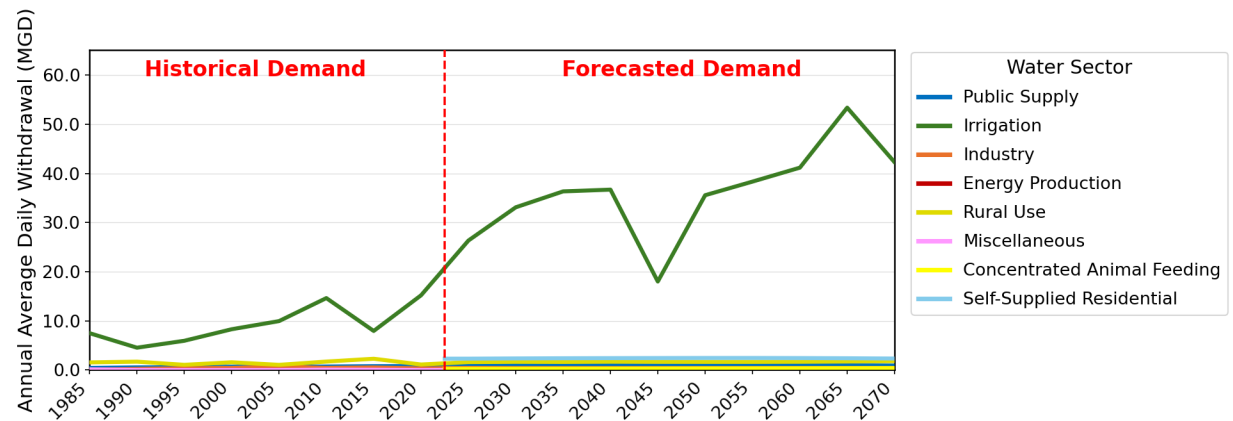


Figure F-18. Historical and forecasted water withdrawals in LaGrange County in MGD from 1985-2070.

7 Noble

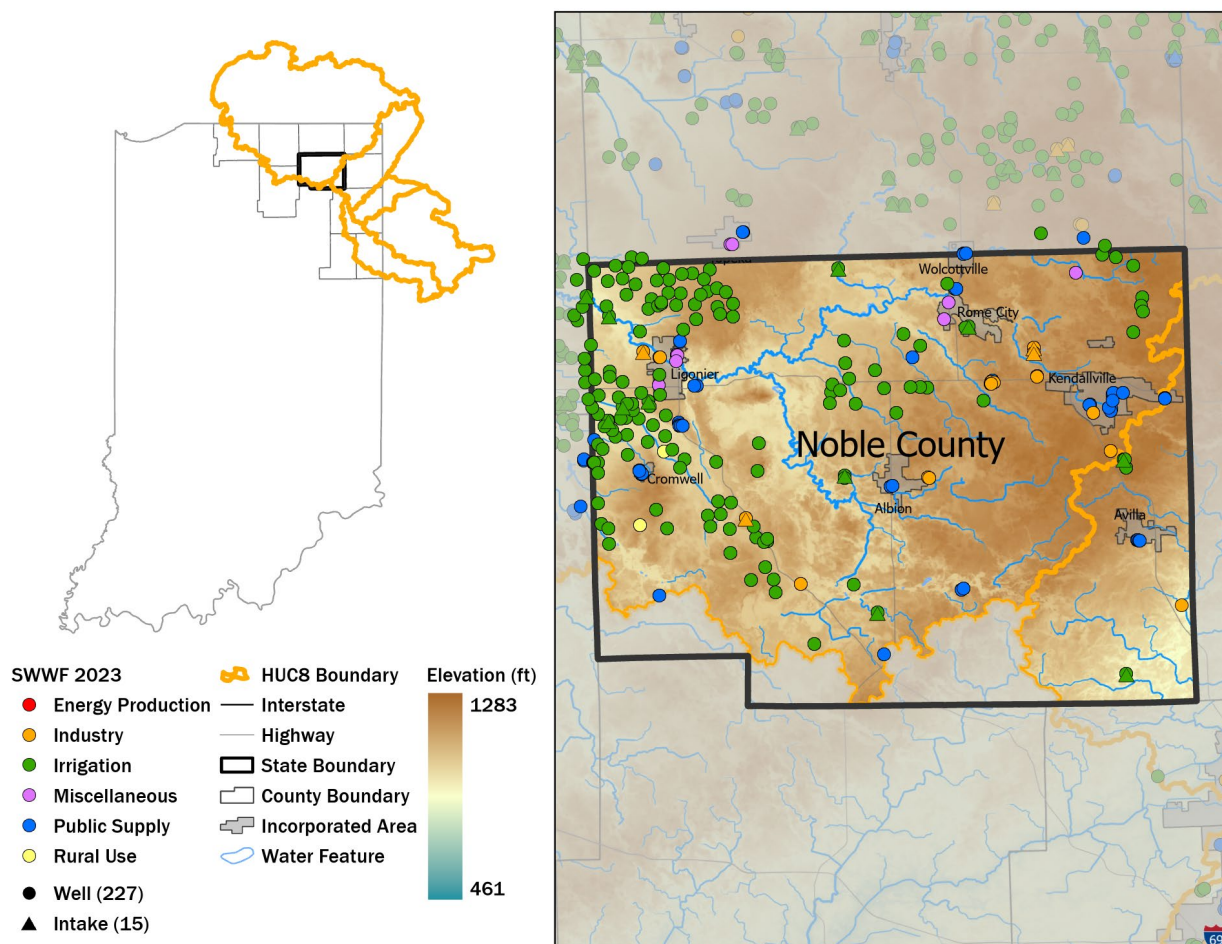


Figure F-19. Water withdrawal locations in Noble County, Northeast Indiana Region (1985-2023). Noble County lies partially within the Northeast Region.

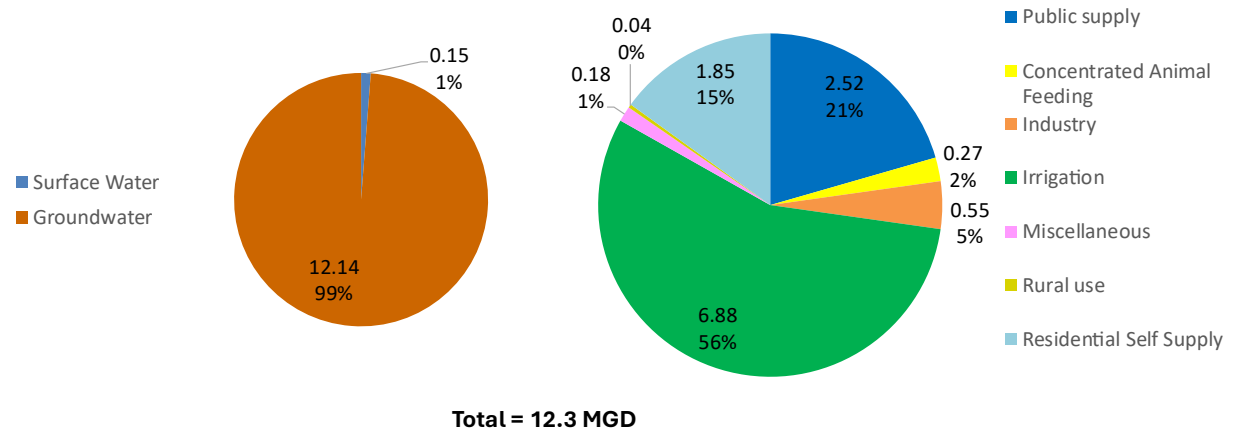


Figure F-20. 2020 water withdrawals in MGD in Noble County. Noble County lies partially within the Northeast Region. Only data from within the Region are presented.

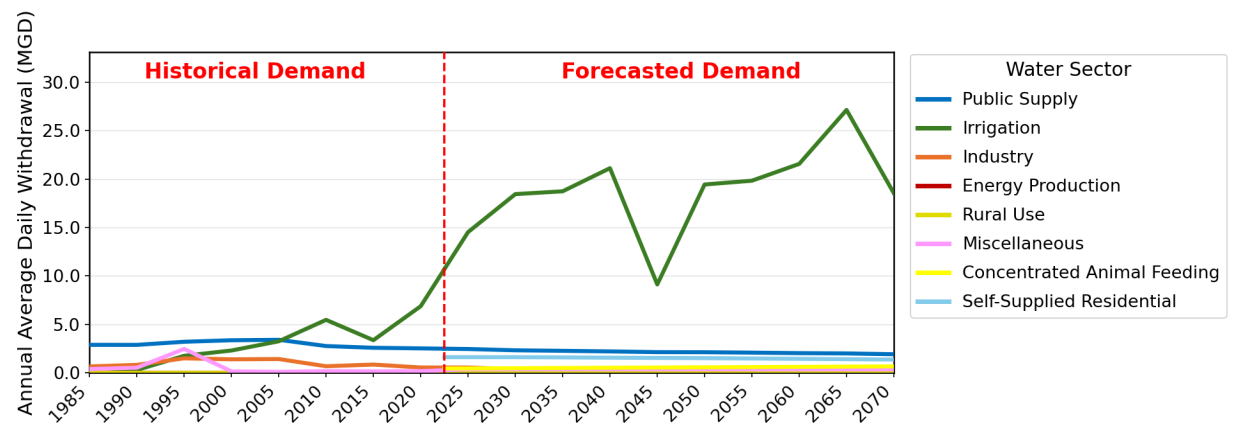


Figure F-21. Historical and forecasted water withdrawals in Noble County in MGD from 1985-2070. Noble County lies partially within the Northeast Region. Only data from within the Region are presented.

8 St. Joseph

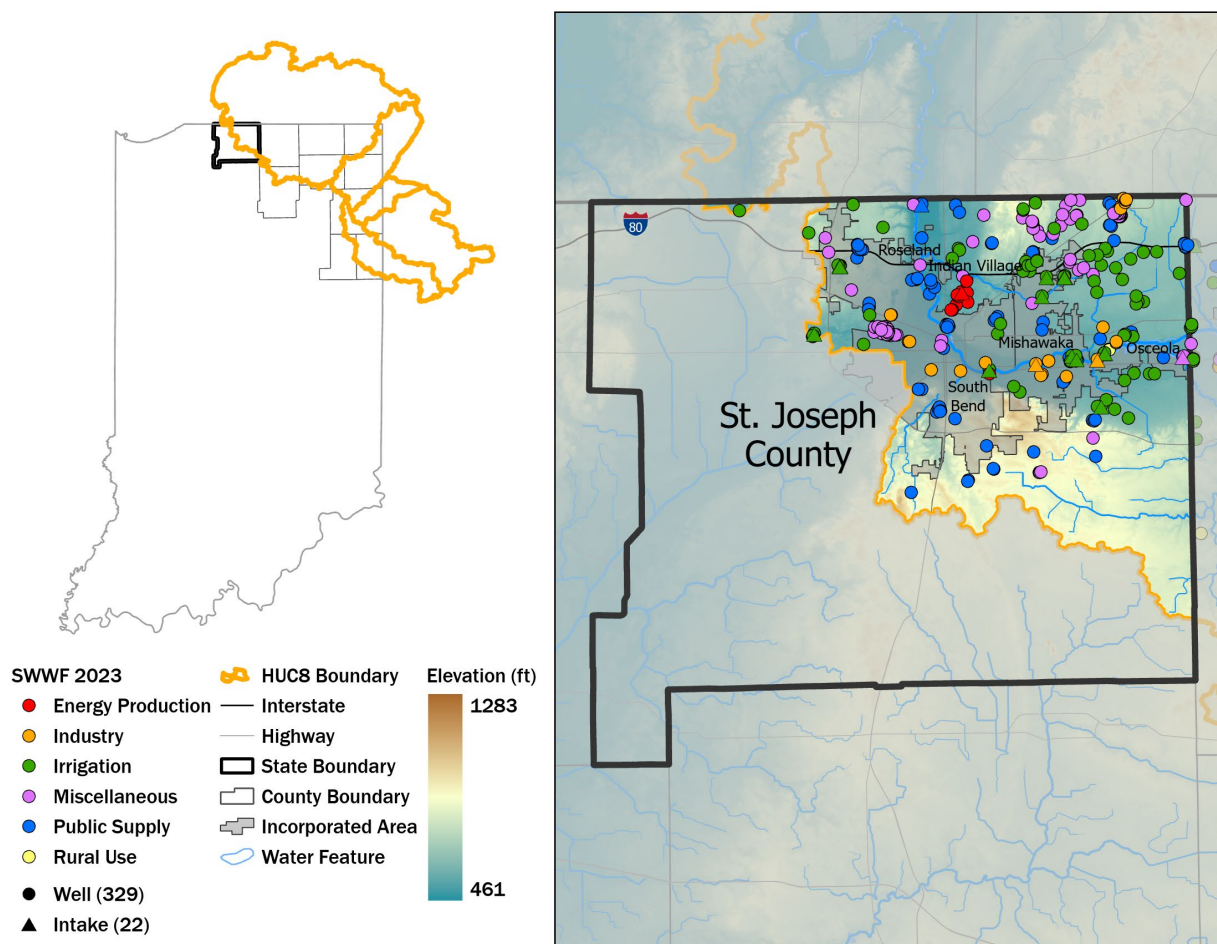


Figure F-22. Water withdrawal locations in St. Joseph County, Northeast Indiana Region (1985-2023). St. Joseph County lies partially within the Northeast Region.

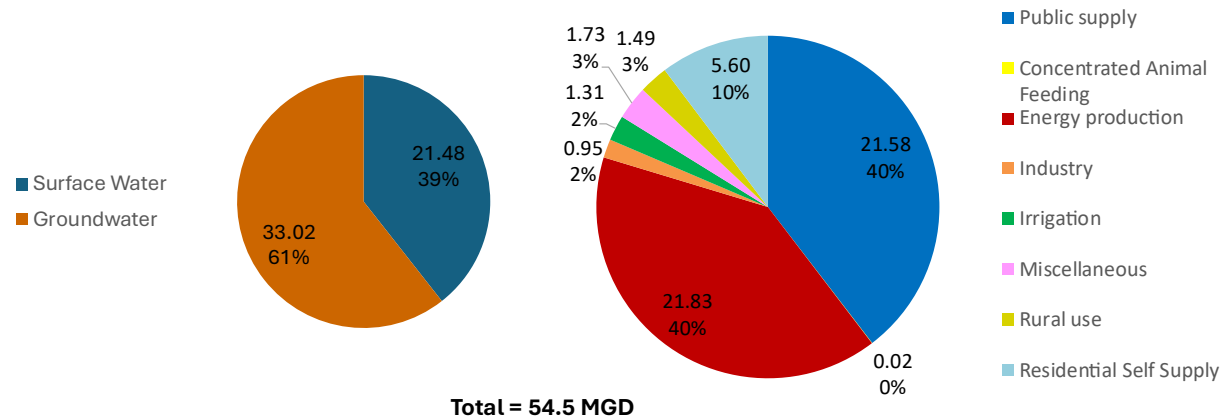


Figure F-23. 2020 water withdrawals in MGD in St. Joseph County. St. Joseph County lies partially within the Northeast Region. Only data from within the Region are presented.

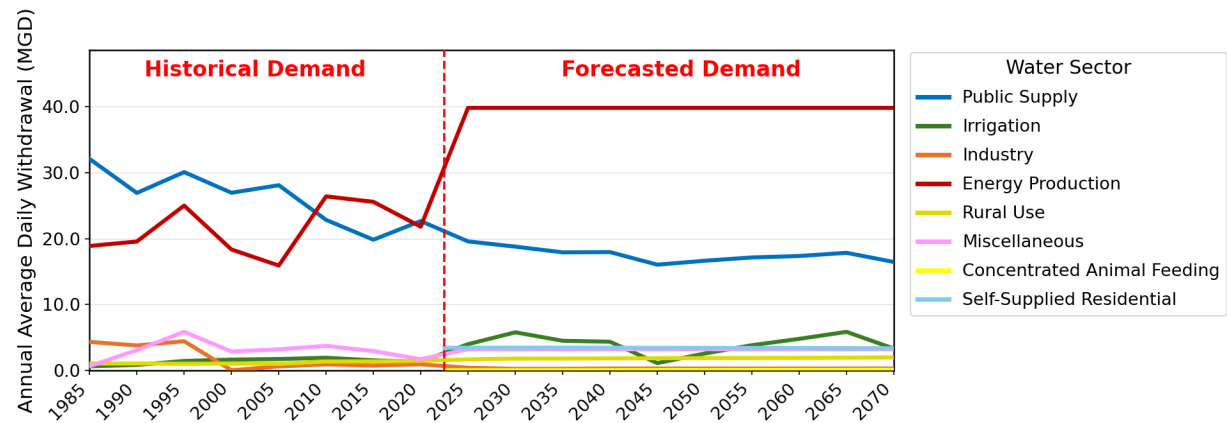


Figure F-24. Historical and forecasted water withdrawals in St. Joseph County in MGD from 1985-2070. St. Joseph County lies partially within the Northeast Region. Only data from within the Region are presented.

9 Steuben

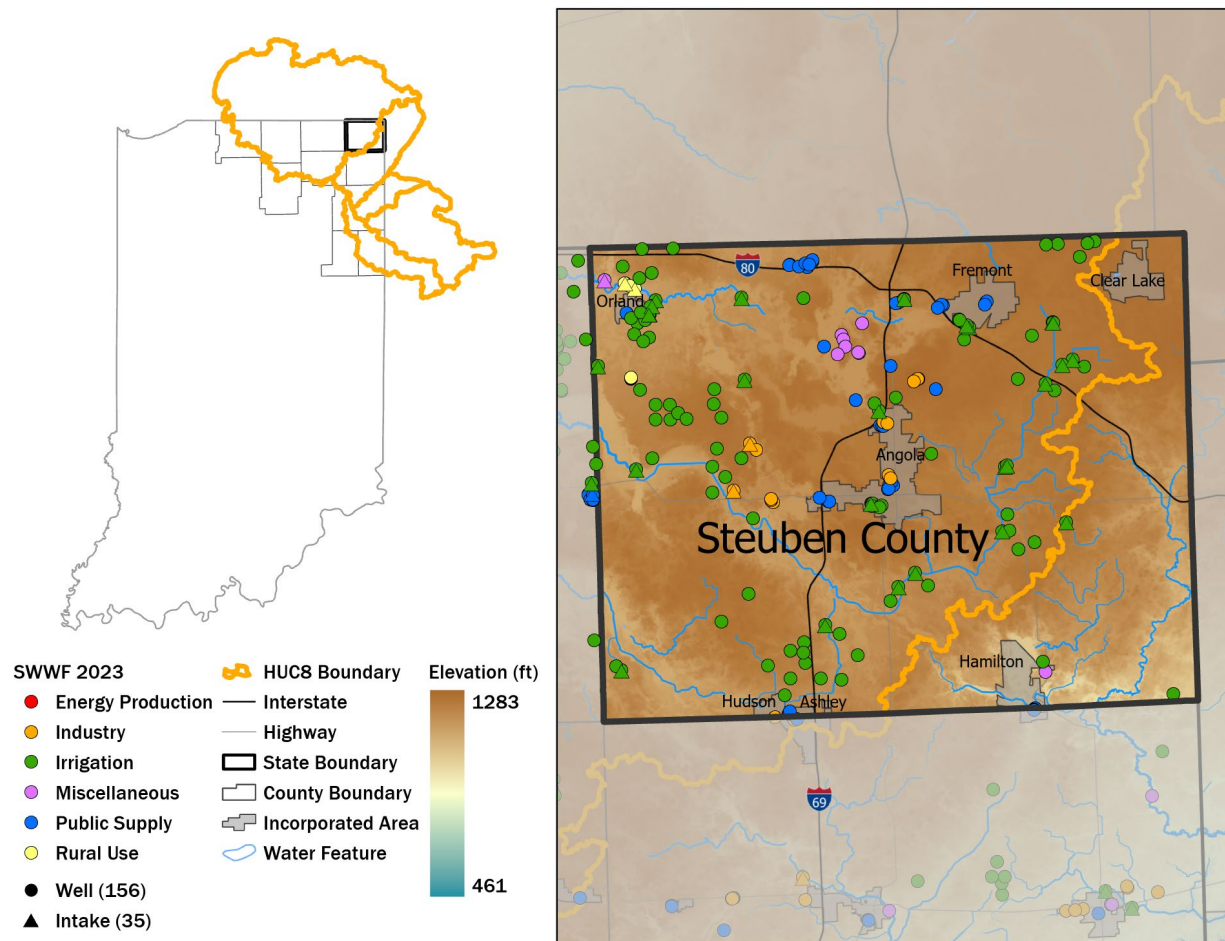


Figure F-25. Water withdrawal locations in Steuben County, Northeast Indiana Region (1985-2023).

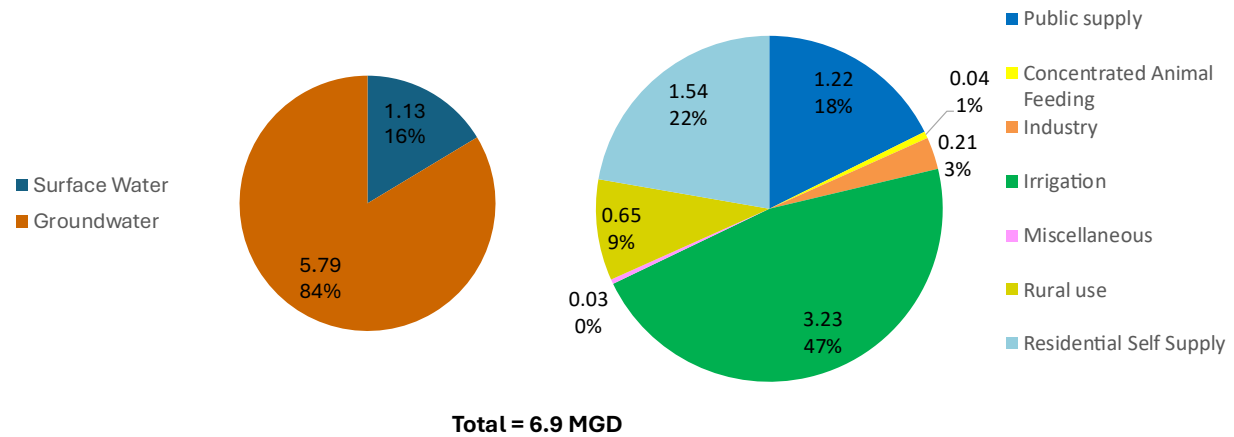


Figure F-26. 2020 water withdrawals in MGD in Steuben County.

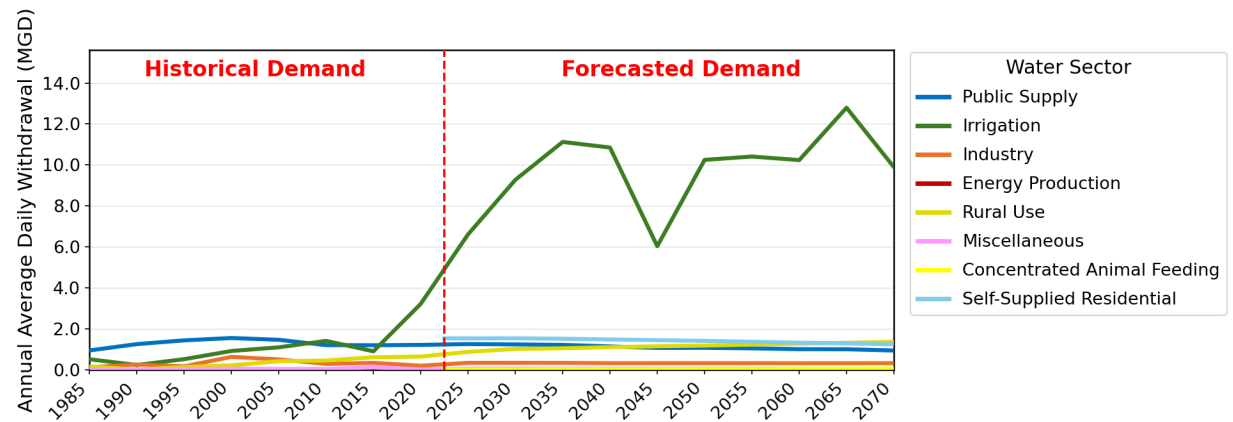


Figure F-27. Historical and forecasted water withdrawals in Steuben County in MGD from 1985-2070.