Modeling and Regulatory Support Workgroup Meeting
February 4, 2020

Agenda

- Status updates
  - 3rd party and internal review of land use data
  - Hydrologic calibration and validation
- Other items
  - DWR grant to expand onsite wastewater treatment simulations
  - Discuss Re-examination MOA with DWR

3rd Party Review of Processed Land Use Data

3rd Party and Internal Review of Processed Land Use Data

- DOT contractor has accepted the baseline (2005 to 2007) and recent (2015 to 2018) land use data summaries for DOT-maintained roads and rights of way
- NC Department of Agriculture has accepted the baseline land use data summaries for cropland and pasture; their review of the recent period is underway
- UNRBA MRSW and PFC members have been provided the baseline land use data and provided input on developing the recent land use data
- UNRBA MRSW and PFC members will receive the processed recent land use data after NC Department of Agriculture has reviewed

Hydrologic Calibration and Validation – Recent Period

Hydrologic Model Performance Criteria

- The UNRBA Modeling Quality Assurance Project Plan includes the following performance criteria for hydrologic calibration
- Note that the error in monthly flows should be consistent with the other metrics and read “error in volume of monthly flows”
- The performance metrics for monthly statistics should not be “tighter” than the seasonal statistics – **discuss with MRSW**
  - Correct typo’s in QAPP and submit addendum to DWR?
  - Address in reporting and leave QAPP as is?

Table A.7-1 Hydrology Calibration Criteria

Prediction Error	Very Good	Good	Fair
Error in total volume	≤ 5%	5-10%	10-15%
Error in monthly flows	≤ 10%	10-15%	15-25%
Error in volume of 50% lowest flows	≤ 10%	10-15%	15-25%
Error in volume of 10% highest flows	≤ 10%	10-15%	15-25%
Seasonal volume error – Summer	≤ 15%	15-30%	30-50%
Seasonal volume error – Fall	≤ 15%	15-30%	30-50%
Seasonal volume error – Winter	≤ 15%	15-30%	30-50%
Seasonal volume error – Spring	≤ 15%	15-30%	30-50%

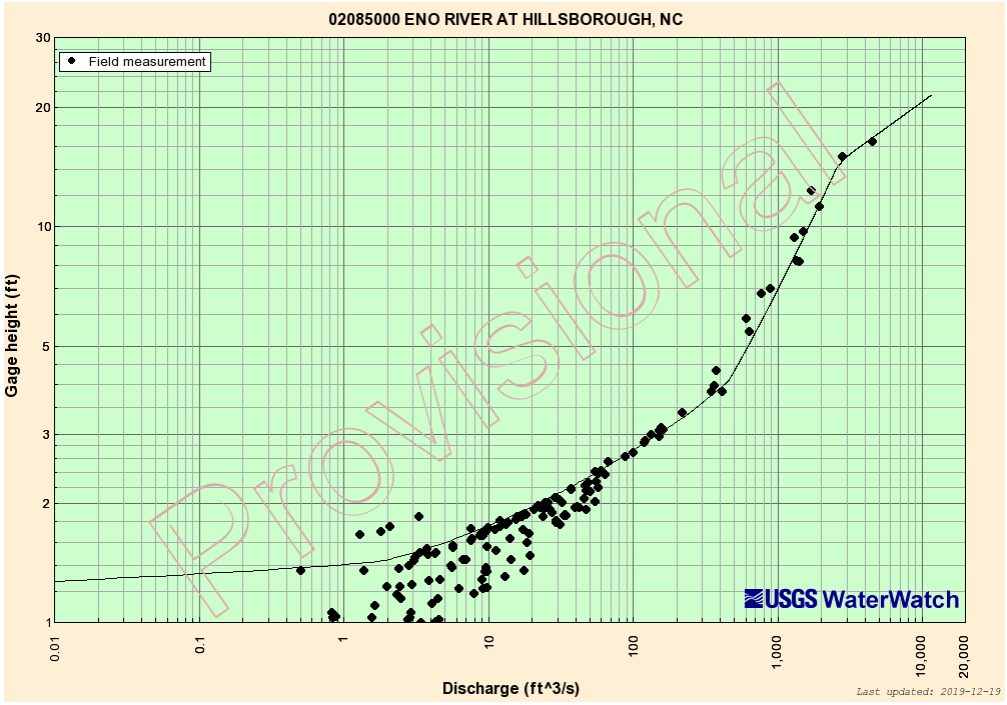
Uncertainties in Flow Measurements Used for Calibration and Validation

- During the January MRSW meeting, the team presented information on the quality of flow estimates at different gages in the watershed
- Based on literature, including evaluations conducted by USGS staff,
  - Uncertainty is greatest in the extremes of the flow regime (both high and low)
  - Uncertainty can be considerable
  - Magnitude of the uncertainty seems related to site characteristics (algae growth, erosion/deposition zones, cross-section characteristics, etc.) as well as general measurement errors
- This source of uncertainty will be described in the model report including the following references: Westerberg 2016, Coxon 2015, Kiang 2018, Domeneghetti 2012, and McMillan 2015

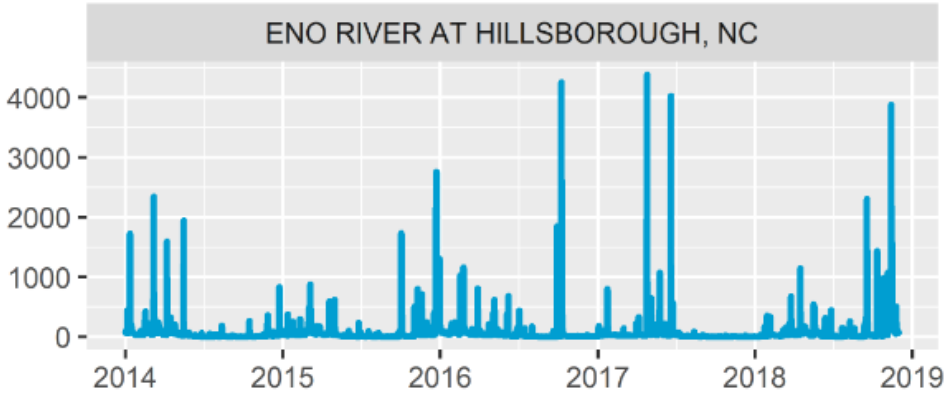
Hydrologic Calibration and Validation

- Results for the Flat River above Lake Michie and the Little River above Little River Reservoir were presented during the January MRSW meeting available here
- Model performance for these two gages was generally in the Good to Very Good categories
- Similar performance has been achieved for the other gages in the watershed

Rating Curve for Eno River at Hillsborough



- At Hillsborough, estimated flows up to 4,500 cfs are well represented by field measurements collected in the past 20 years.
- This generally covers flows observed during the recent modeling period.



Eno River at Hillsborough: Calibration

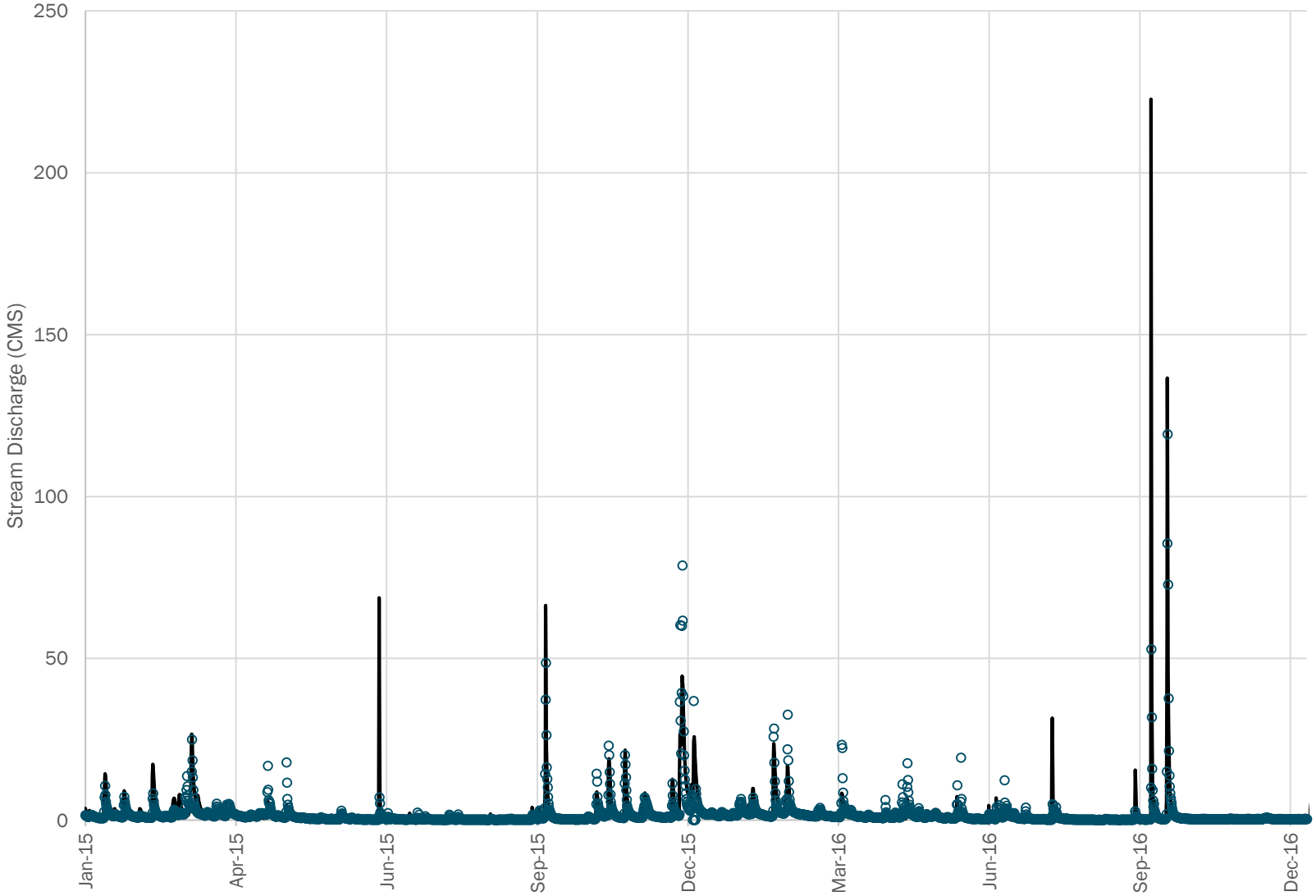


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

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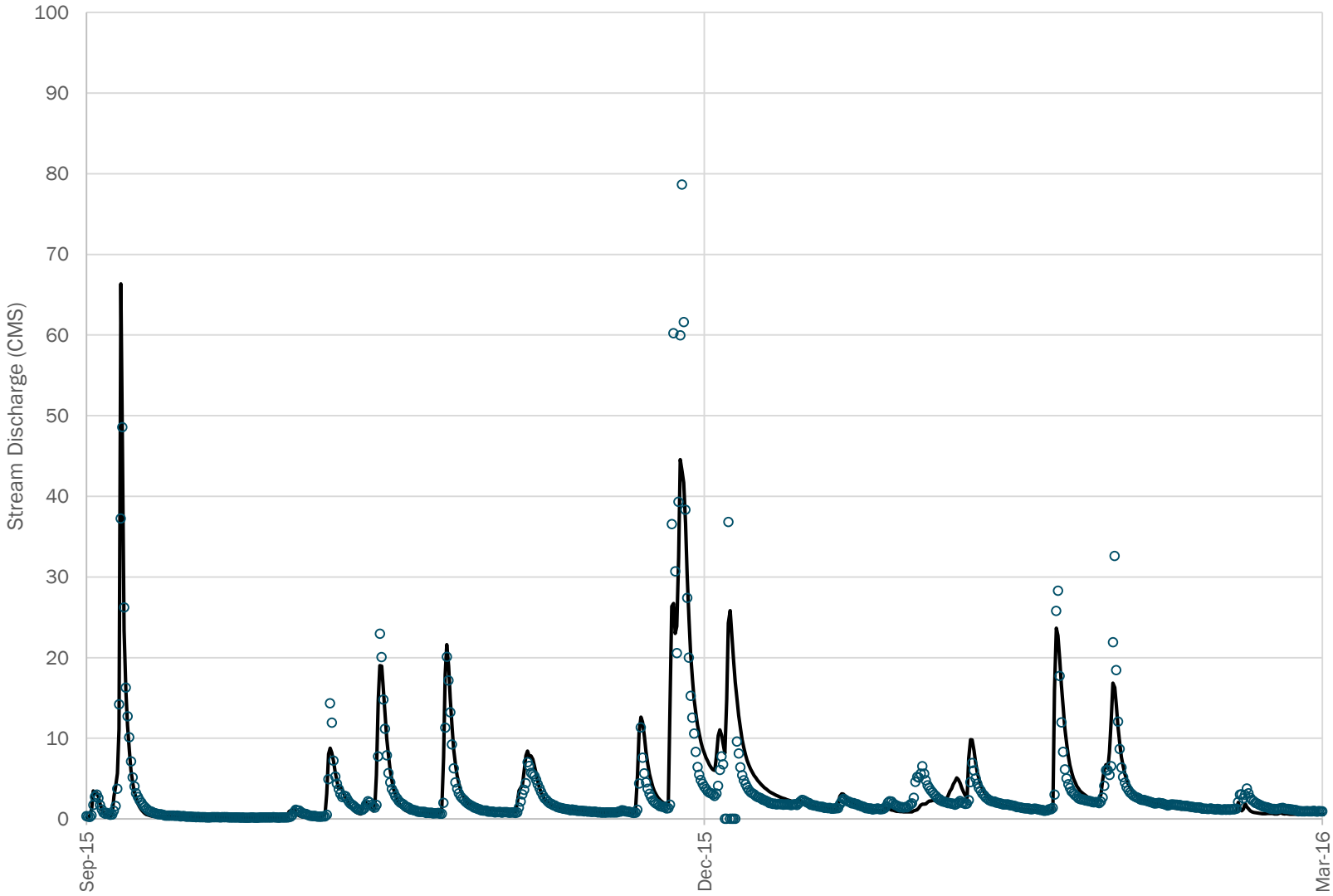

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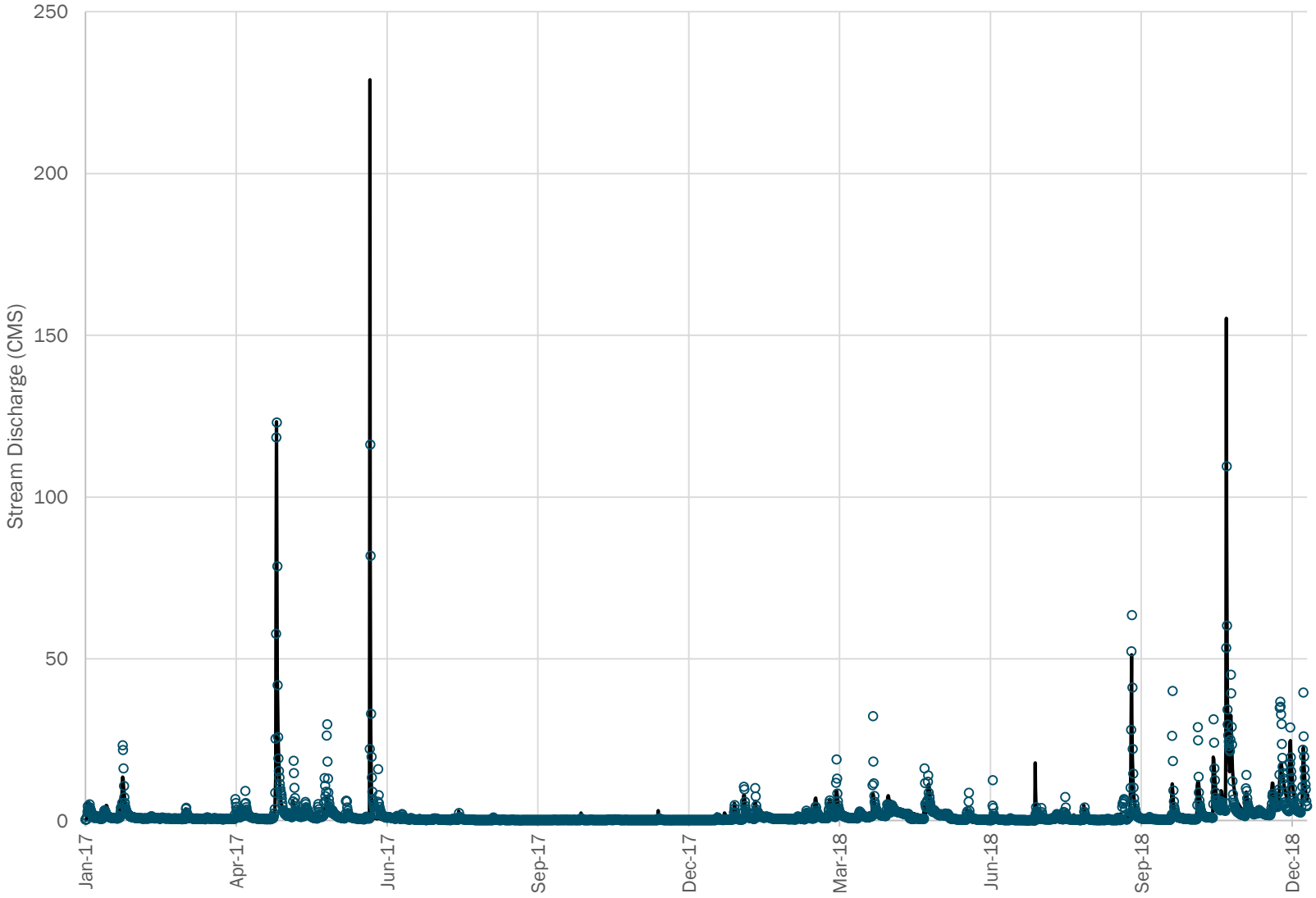

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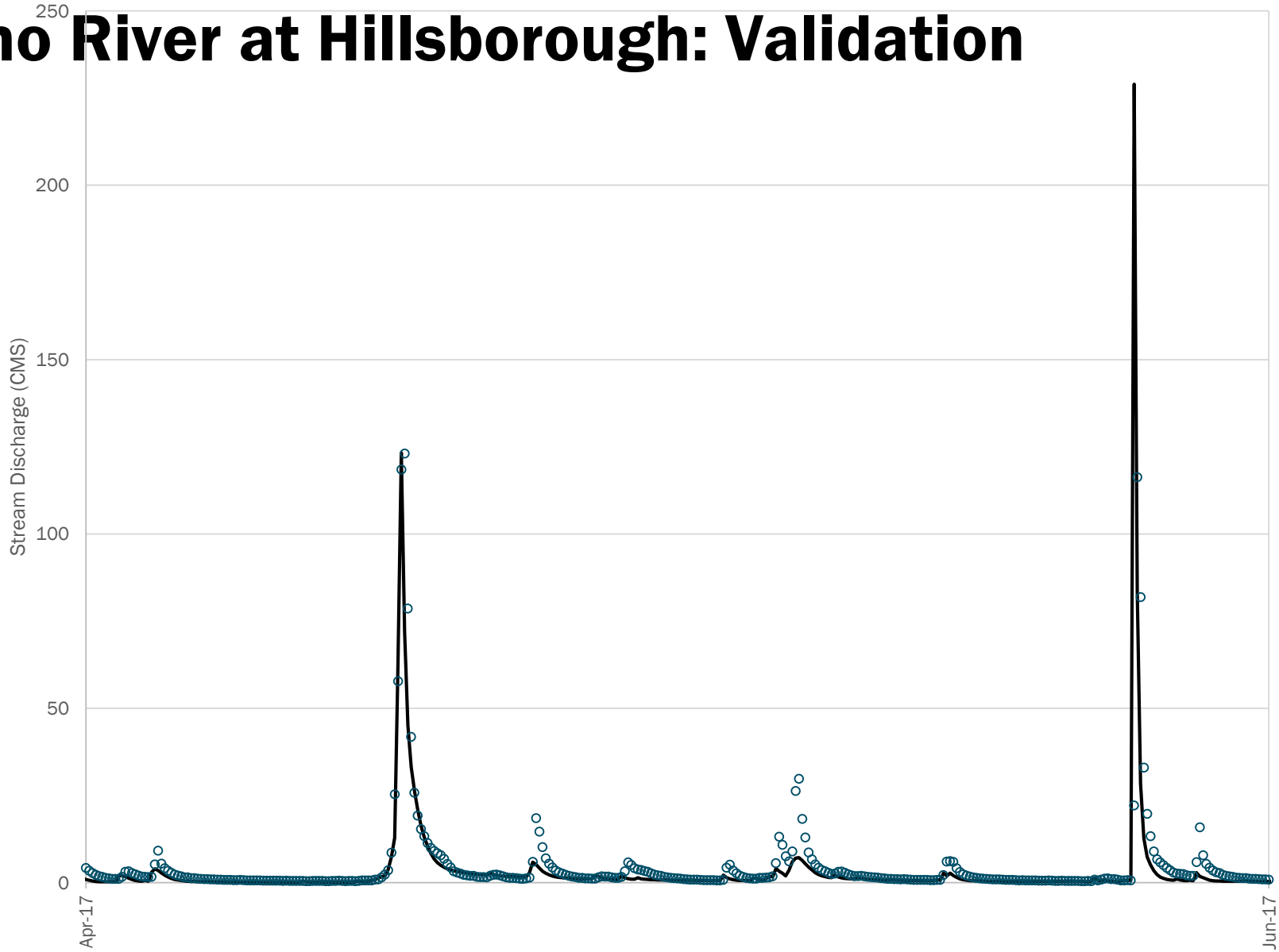

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Eno River at Hillsborough: Performance Criteria

	Time Period					
	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	0.743		0.557		0.635	
Observed 90th Percentile Discharge	3.189		3.752		3.489	
Simulation Error:						
Total Volume	7.7%	Good	-9.9%	Good	-1.8%	Very Good
Peak Flow	8.3%	Very Good	-13.9%	Good	-4.7%	Very Good
High Flow	9.1%	Very Good	-10.8%	Good	-1.8%	Very Good
Low Flow	-10.2%	Good	3.8%	Very Good	-2.5%	Very Good
Winter	23.1%	Good	-1.5%	Very Good	12.5%	Very Good
Spring	-29.5%	Good	-23.3%	Good	-25.8%	Good
Summer	-6.7%	Very Good	-10.5%	Very Good	-9.1%	Very Good
Fall	29.4%	Good	-0.5%	Very Good	12.6%	Very Good

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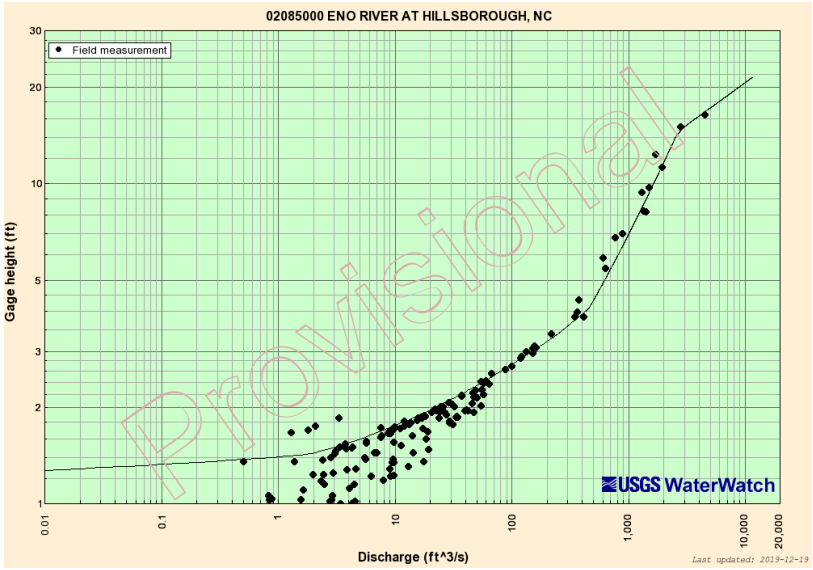
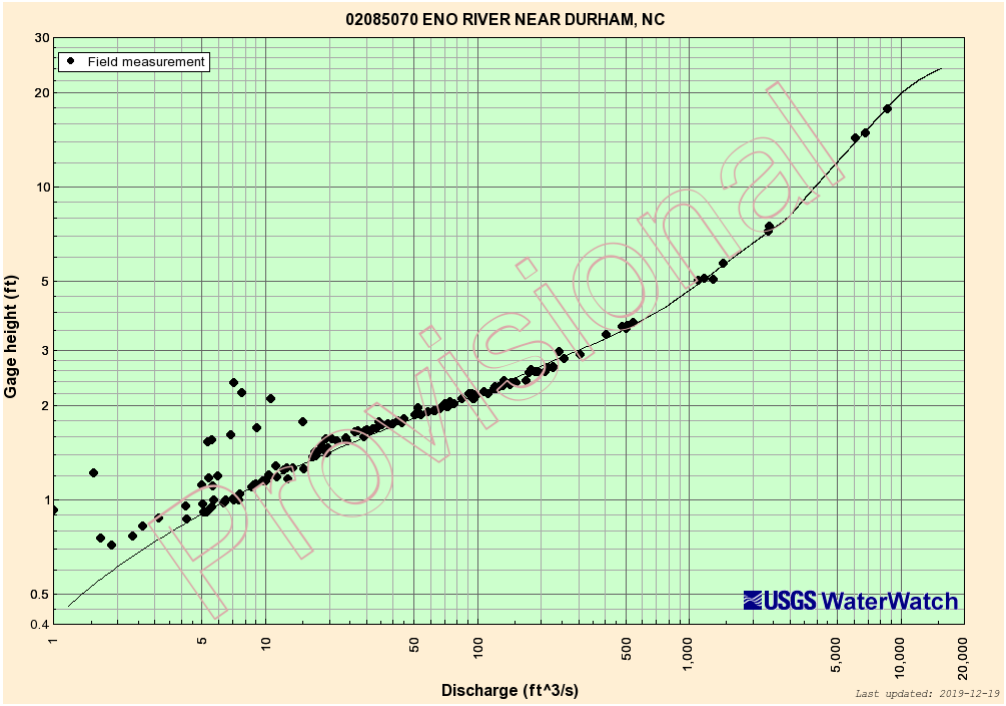
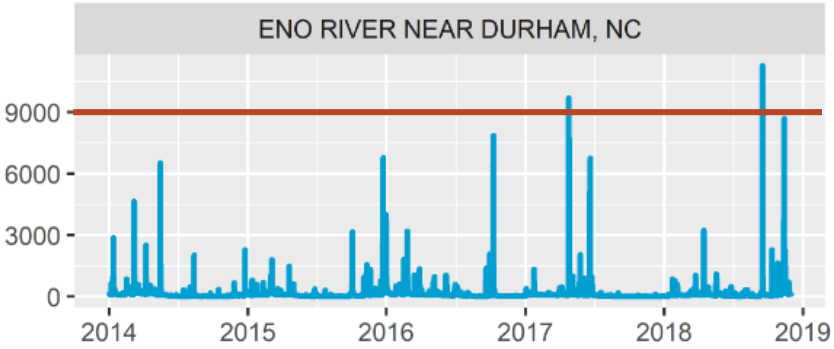


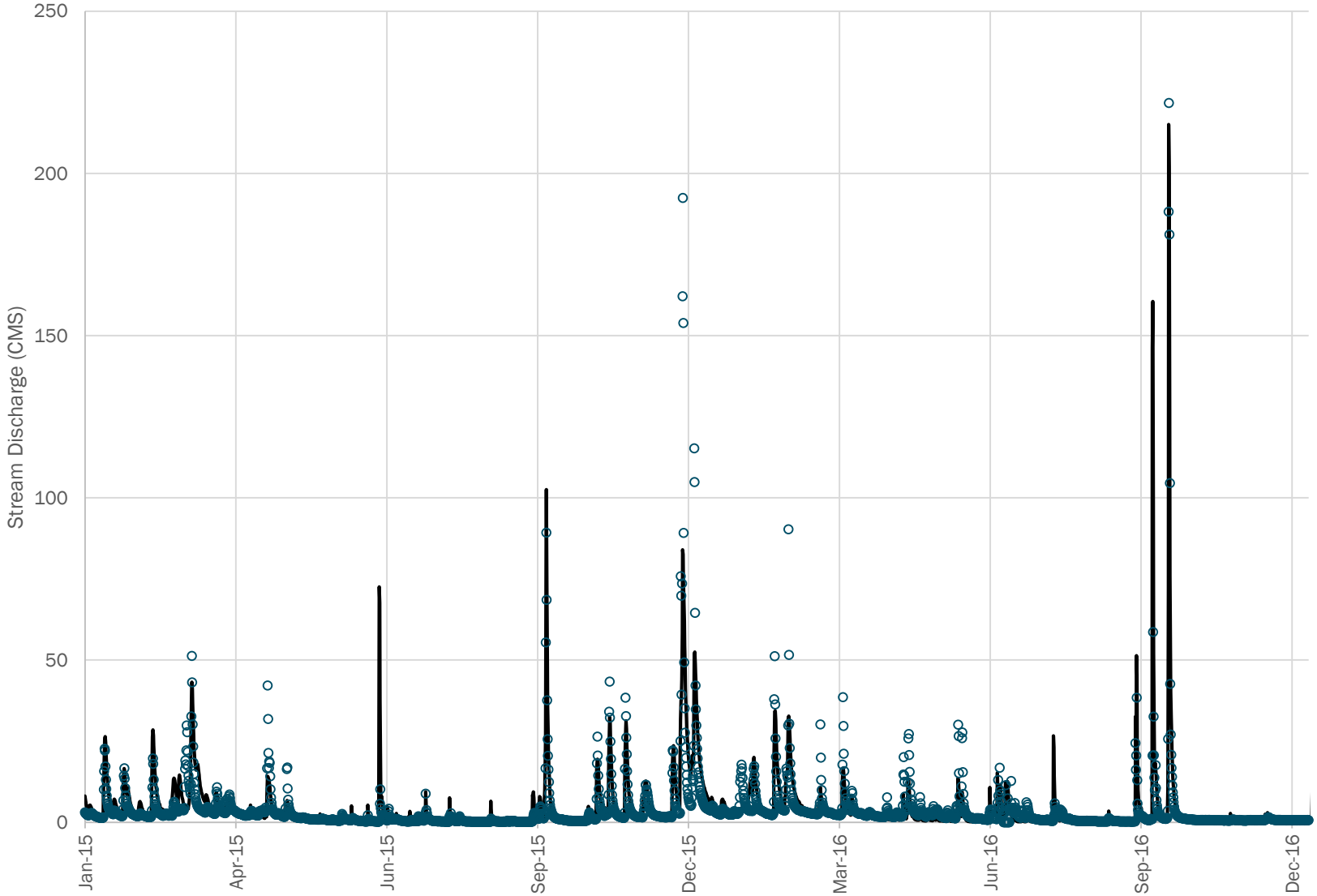
Rating Curve for Eno River Near Durham



- Near Durham, estimated flows up to 9,000 cfs are well represented by field measurements collected in the past 20 years.
- This generally covers flows observed during the recent modeling period though there are some exceedances.



Eno River Near Durham: Calibration



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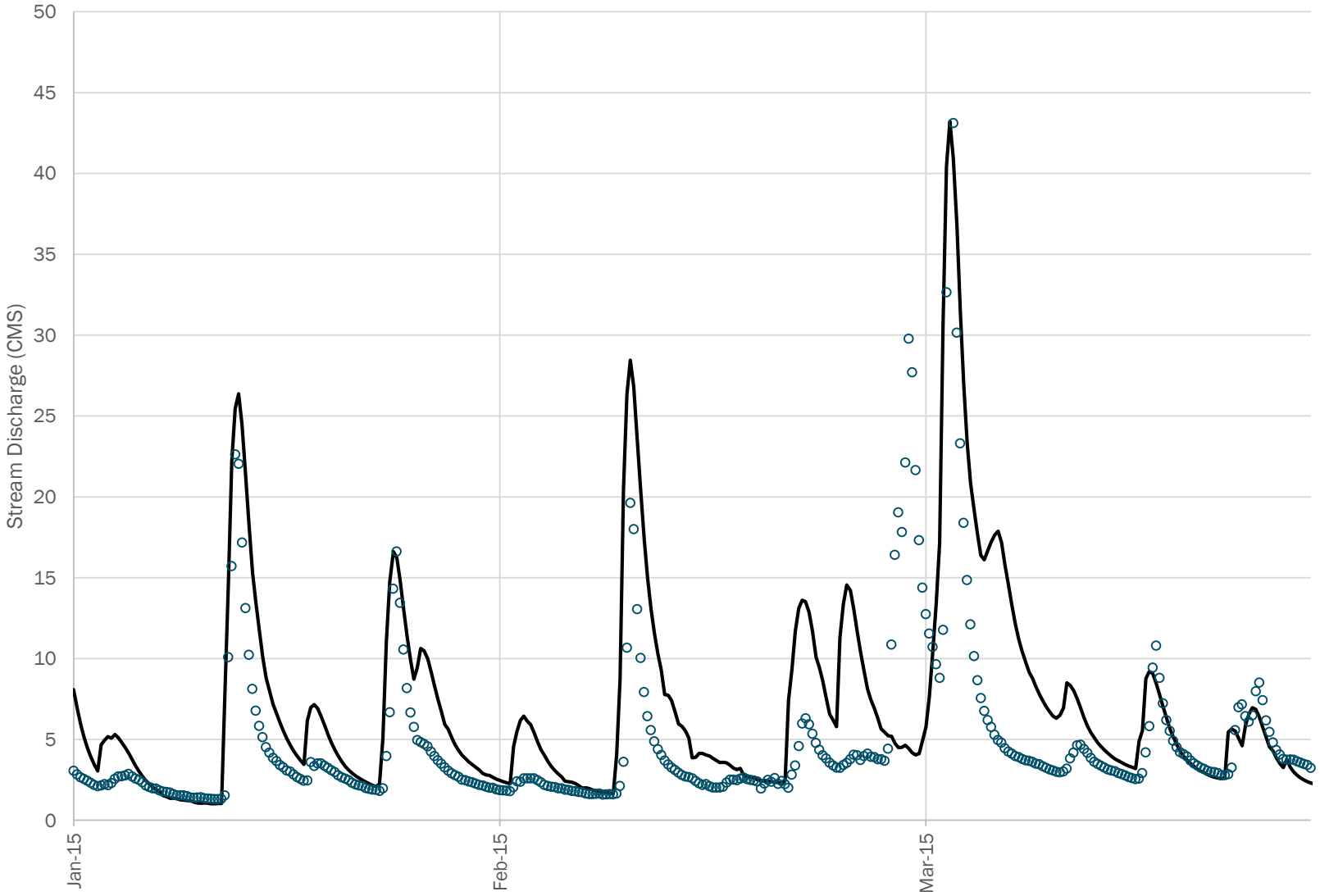

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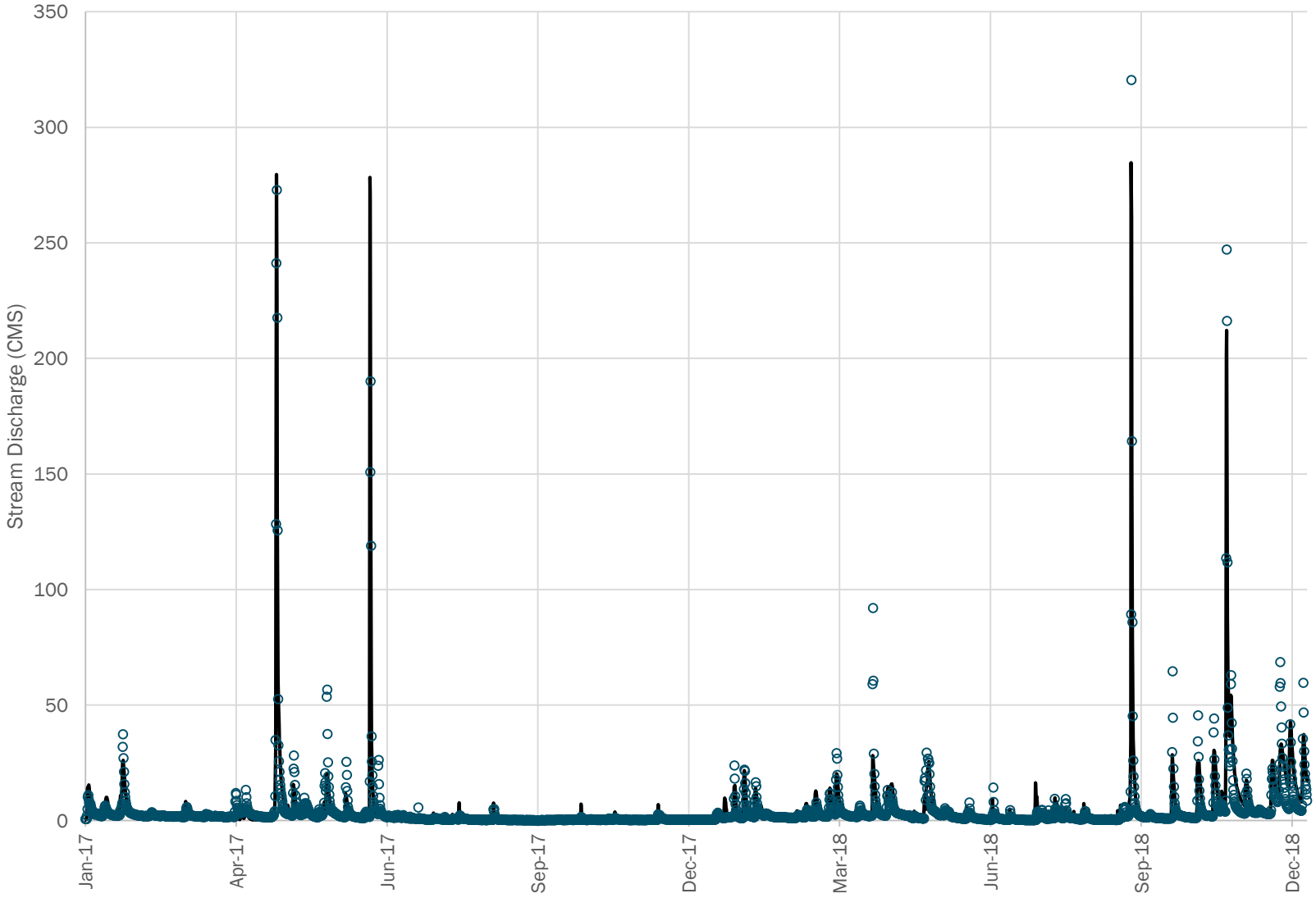
Eno River Near Durham: Validation



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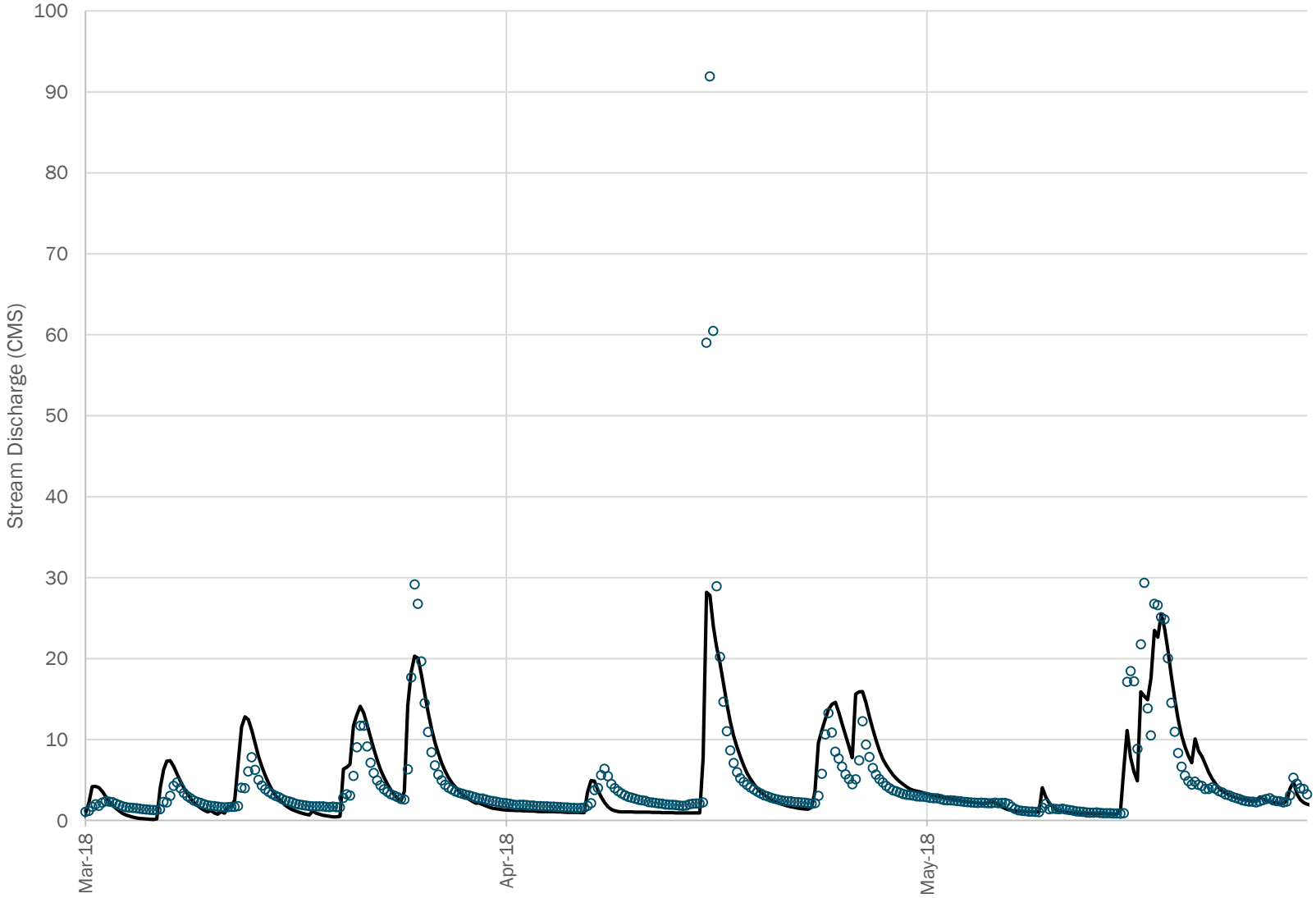

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Eno River Near Durham: Performance Criteria

	Time Period					
	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	1.745		1.615		1.655	
Observed 90th Percentile Discharge	6.719		6.627		6.677	
Simulation Error:						
Total Volume	9.6%	Good	6.1%	Good	7.8%	Good
Peak Flow	-0.6%	Very Good	5.9%	Very Good	2.9%	Very Good
High Flow	10.4%	Good	8.1%	Very Good	9.3%	Very Good
Low Flow	1.2%	Very Good	-16.6%	Fair	-8.1%	Very Good
Winter	21.0%	Good	17.9%	Good	19.8%	Good
Spring	-18.0%	Good	-10.1%	Very Good	-13.4%	Very Good
Summer	-7.7%	Very Good	0.2%	Very Good	-2.9%	Very Good
Fall	27.3%	Good	19.3%	Good	22.9%	Good

Table A.7-1 Hydrology Calibration Criteria

Prediction Error	Very Good	Good	Fair
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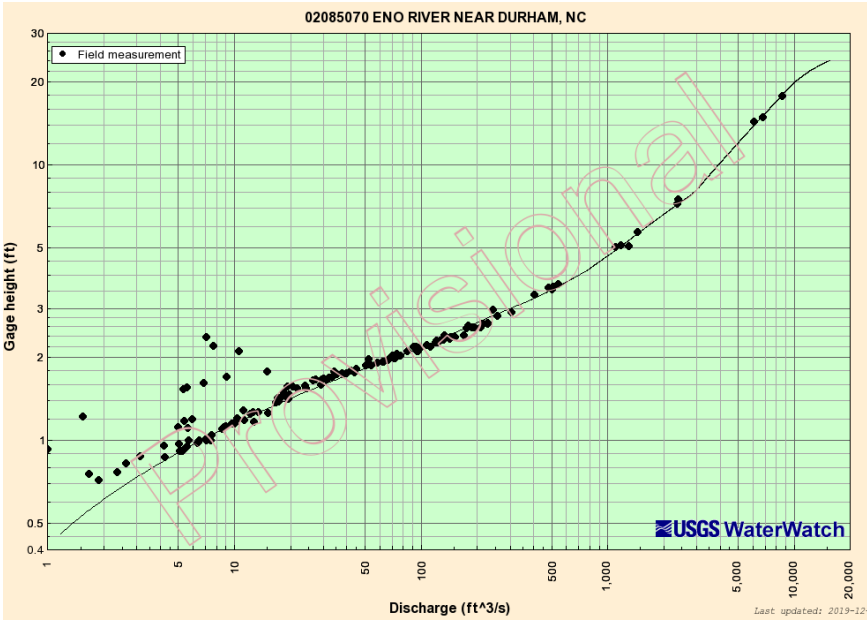
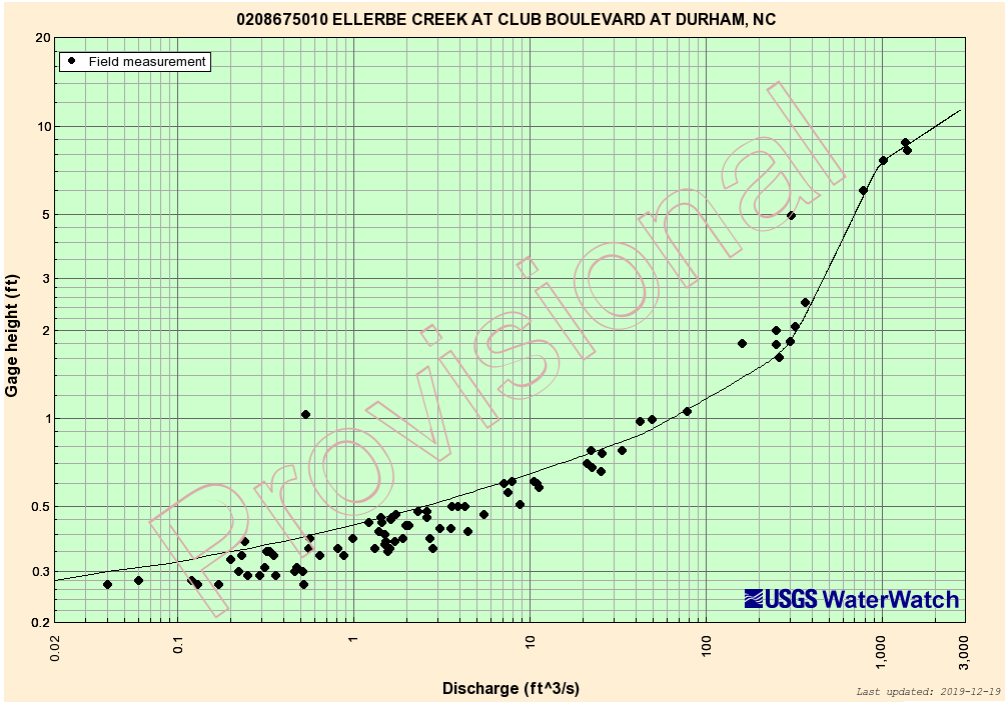
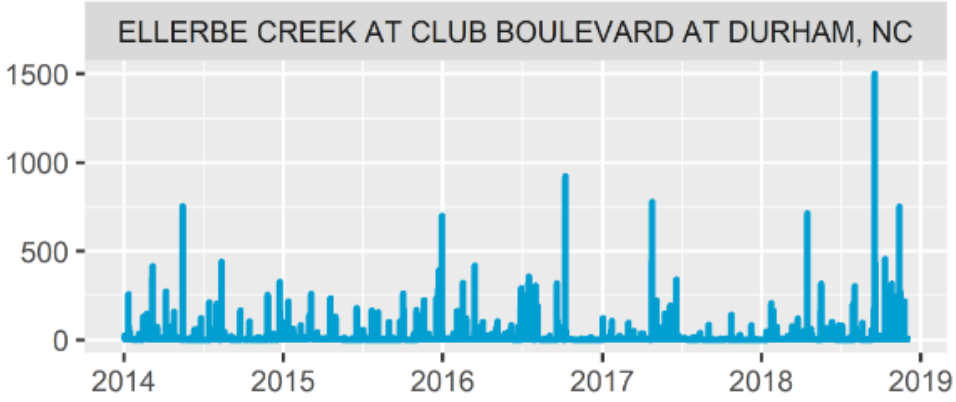


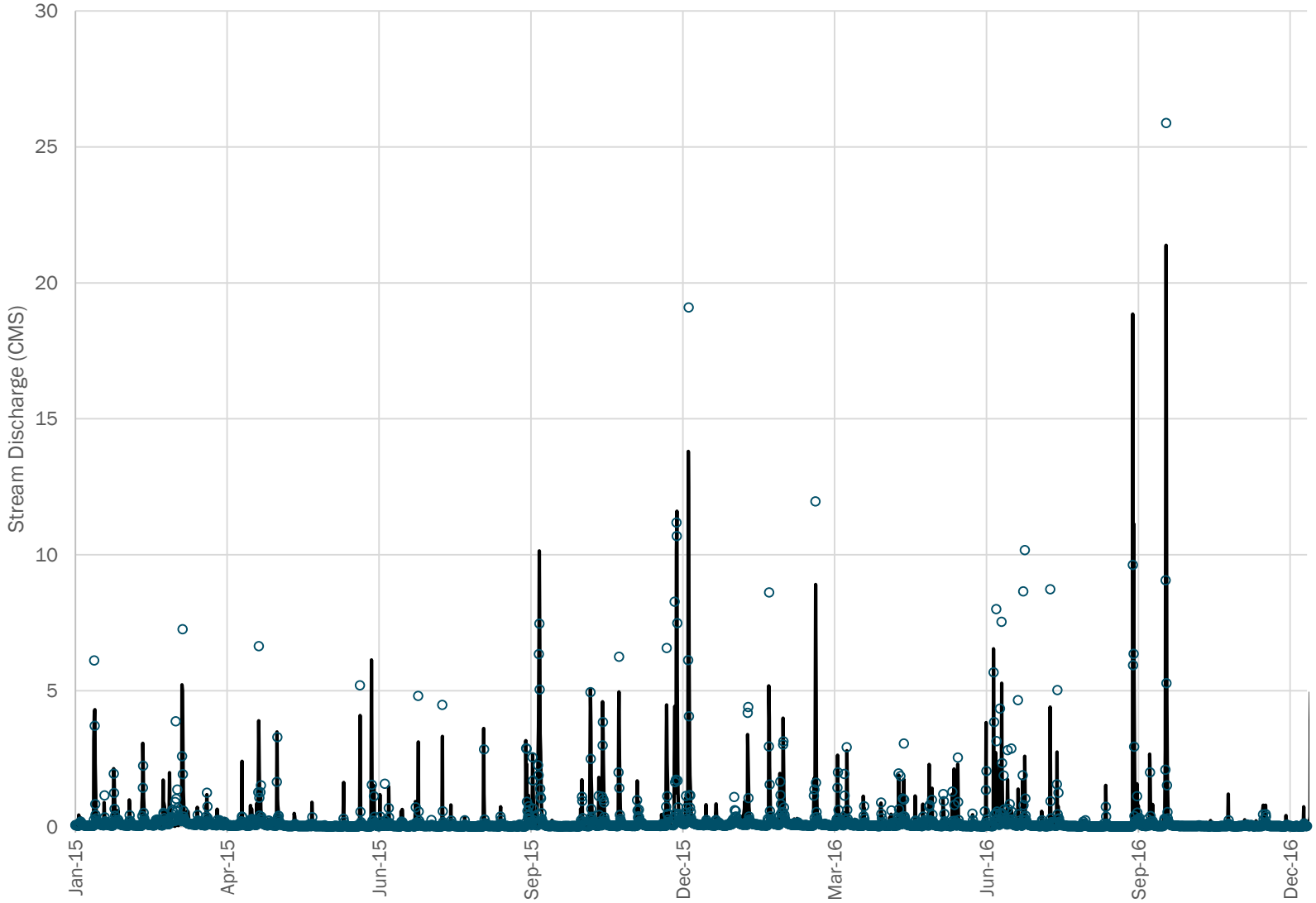
Rating Curve for Ellerbe Creek at Durham



- Estimated flows up to 1,500 cfs are represented by field measurements collected in the past 20 years.
- This covers the range of 6-hr flows observed during the recent modeling period.



Ellerbe Creek Near Durham: Calibration



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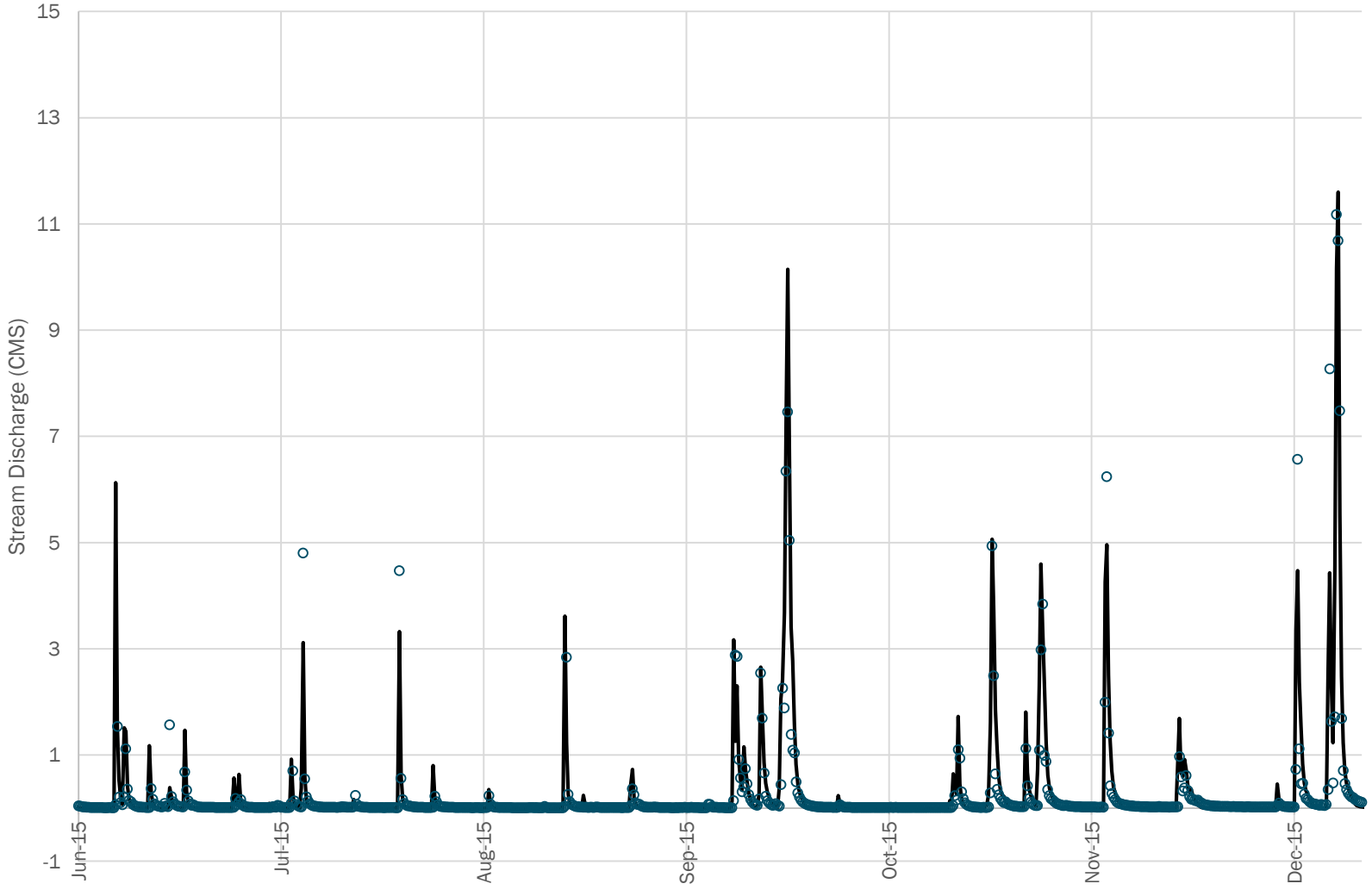

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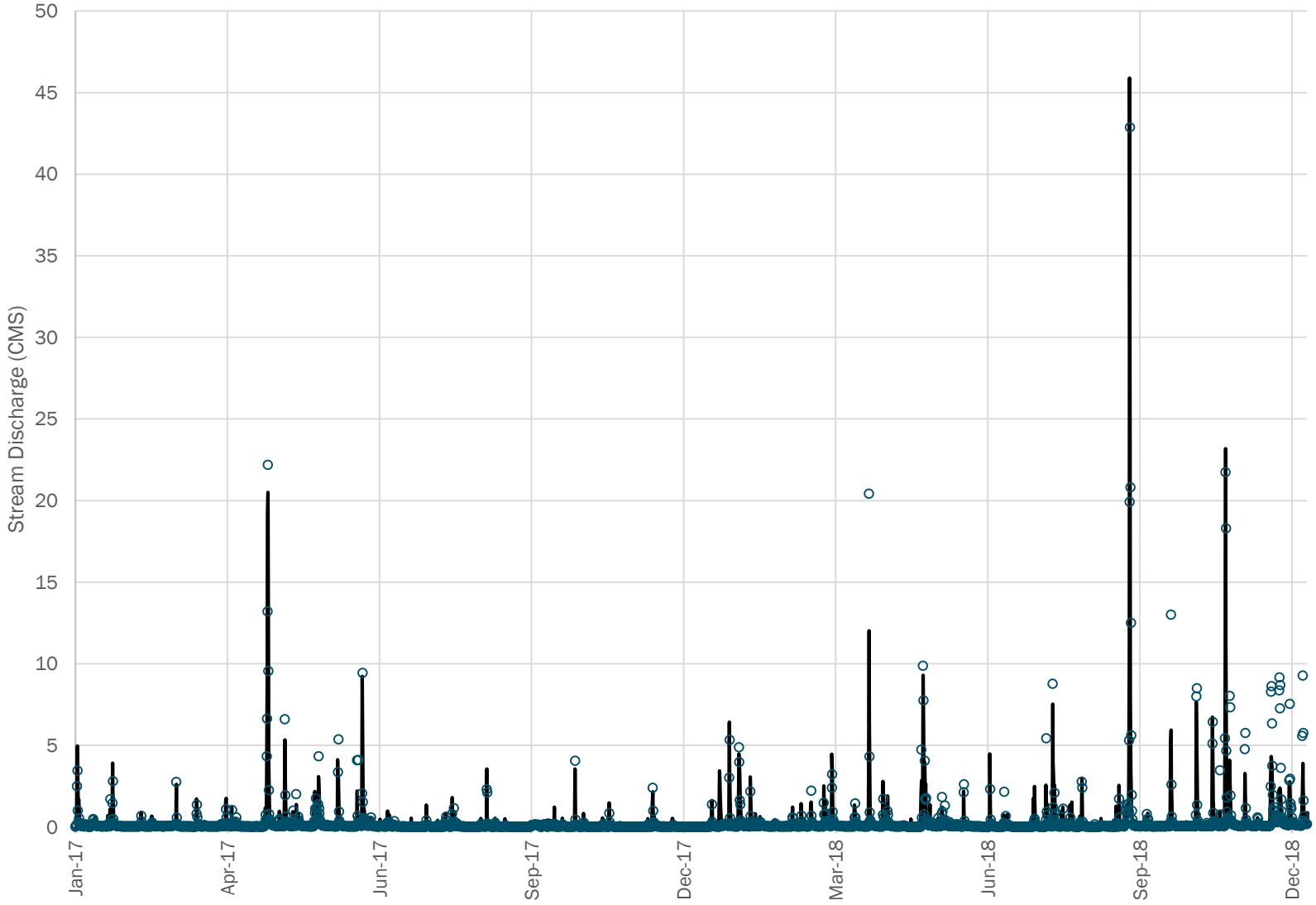
Ellerbe Creek Near Durham: Validation



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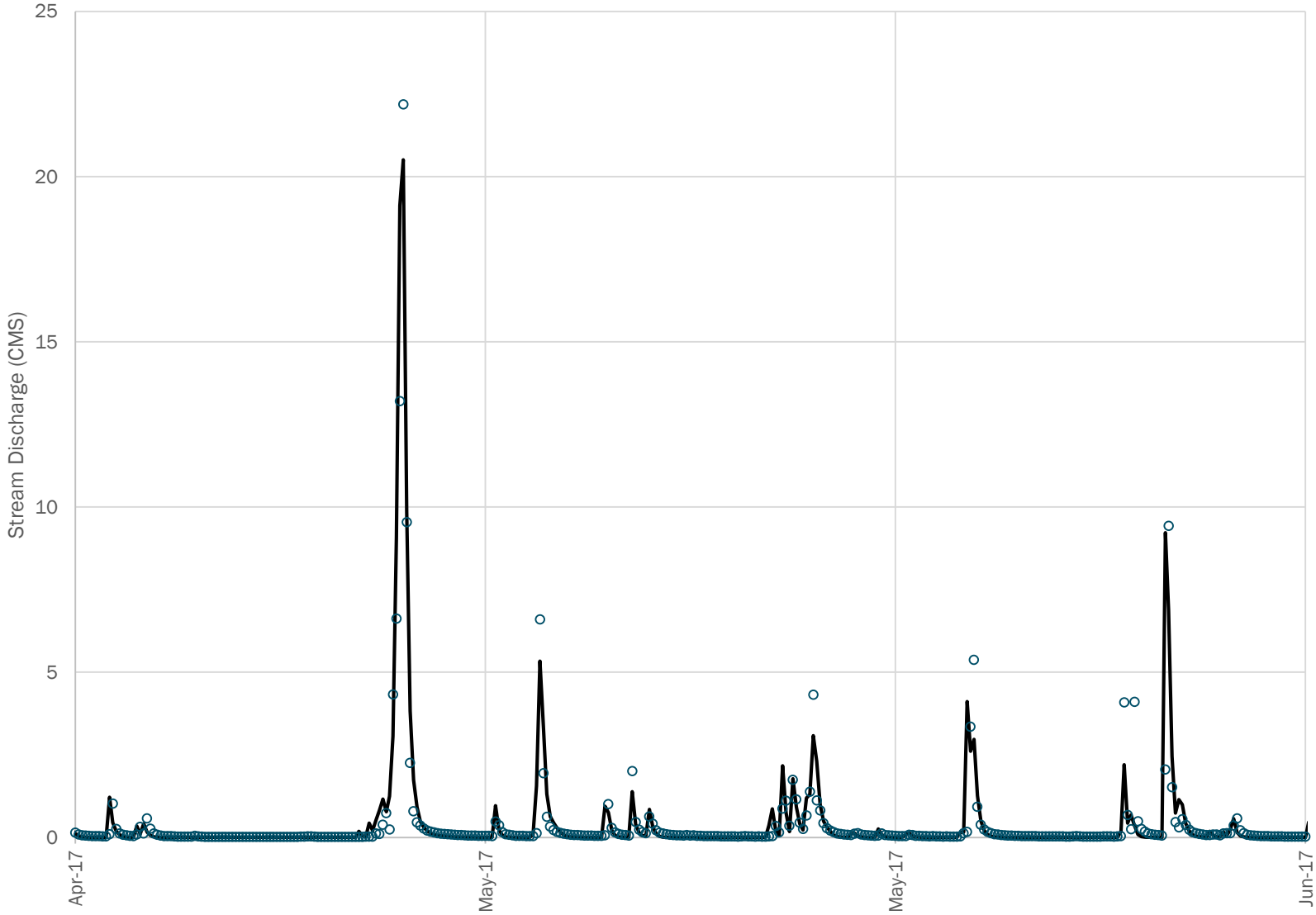

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Ellerbe Creek Near Durham: Performance Criteria

	Time Period					
	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	0.035		0.033		0.034	
Observed 90th Percentile Discharge	0.281		0.289		0.285	
Simulation Error:						
Total Volume	8.7%	Good	-3.6%	Very Good	1.8%	Very Good
Peak Flow	3.6%	Very Good	-9.8%	Very Good	-4.1%	Very Good
High Flow	10.1%	Good	-4.4%	Very Good	2.0%	Very Good
Low Flow	-29.7%	Poor	22.4%	Fair	-1.8%	Very Good
Winter	14.8%	Very Good	-10.3%	Very Good	2.2%	Very Good
Spring	-1.1%	Very Good	9.9%	Very Good	5.8%	Very Good
Summer	-28.3%	Good	5.4%	Very Good	-14.5%	Very Good
Fall	42.6%	Fair	-12.7%	Very Good	7.6%	Very Good

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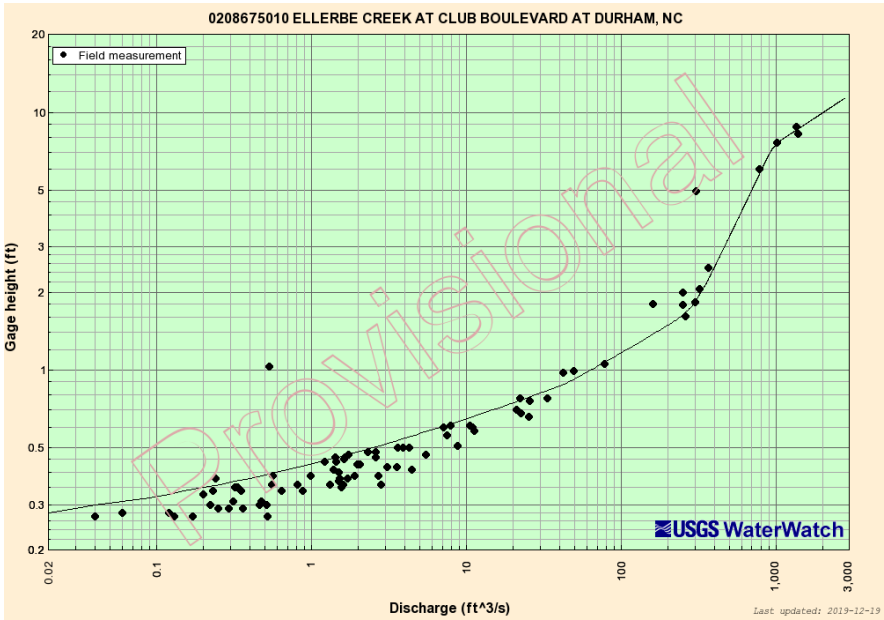
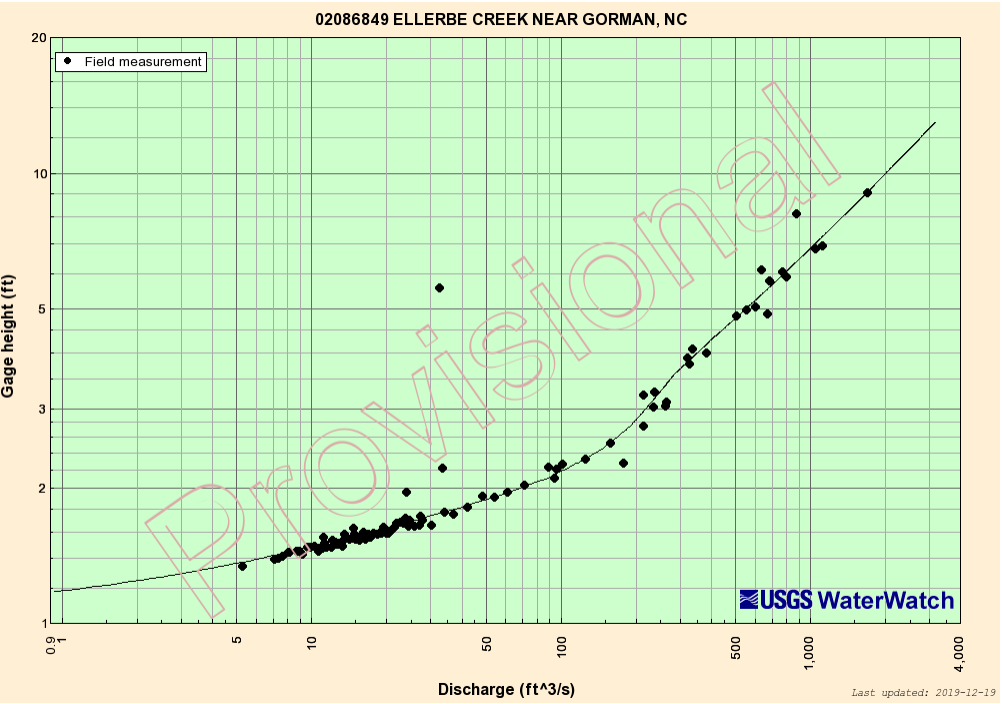
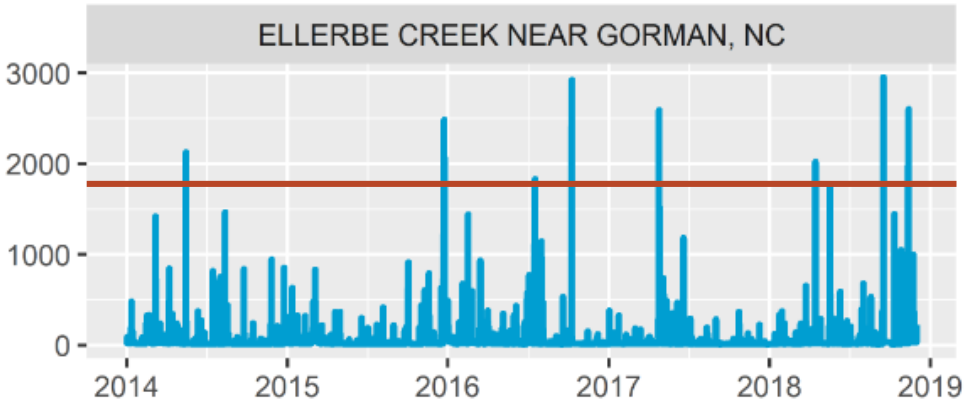


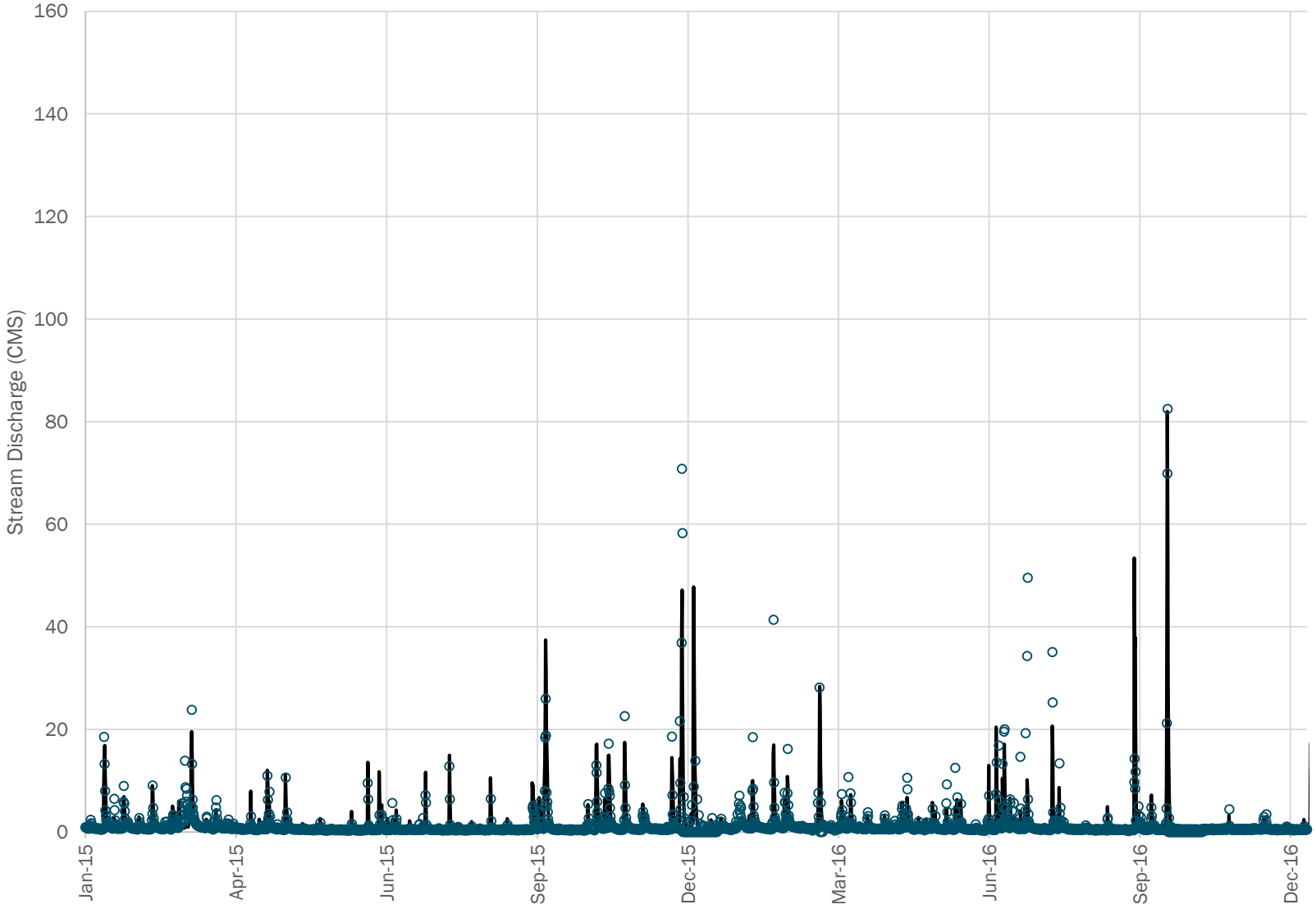
Rating Curve for Ellerbe Creek Near Gorman



- Estimated flows up to 1,700 cfs are represented by field measurements collected in the past 20 years.
- There are several exceedances of 6-hr flows observed during the recent modeling period.
- Flows above 1,700 cfs may be omitted for the purposes of calibration (in progress).



Ellerbe Creek Near Gorman: Calibration



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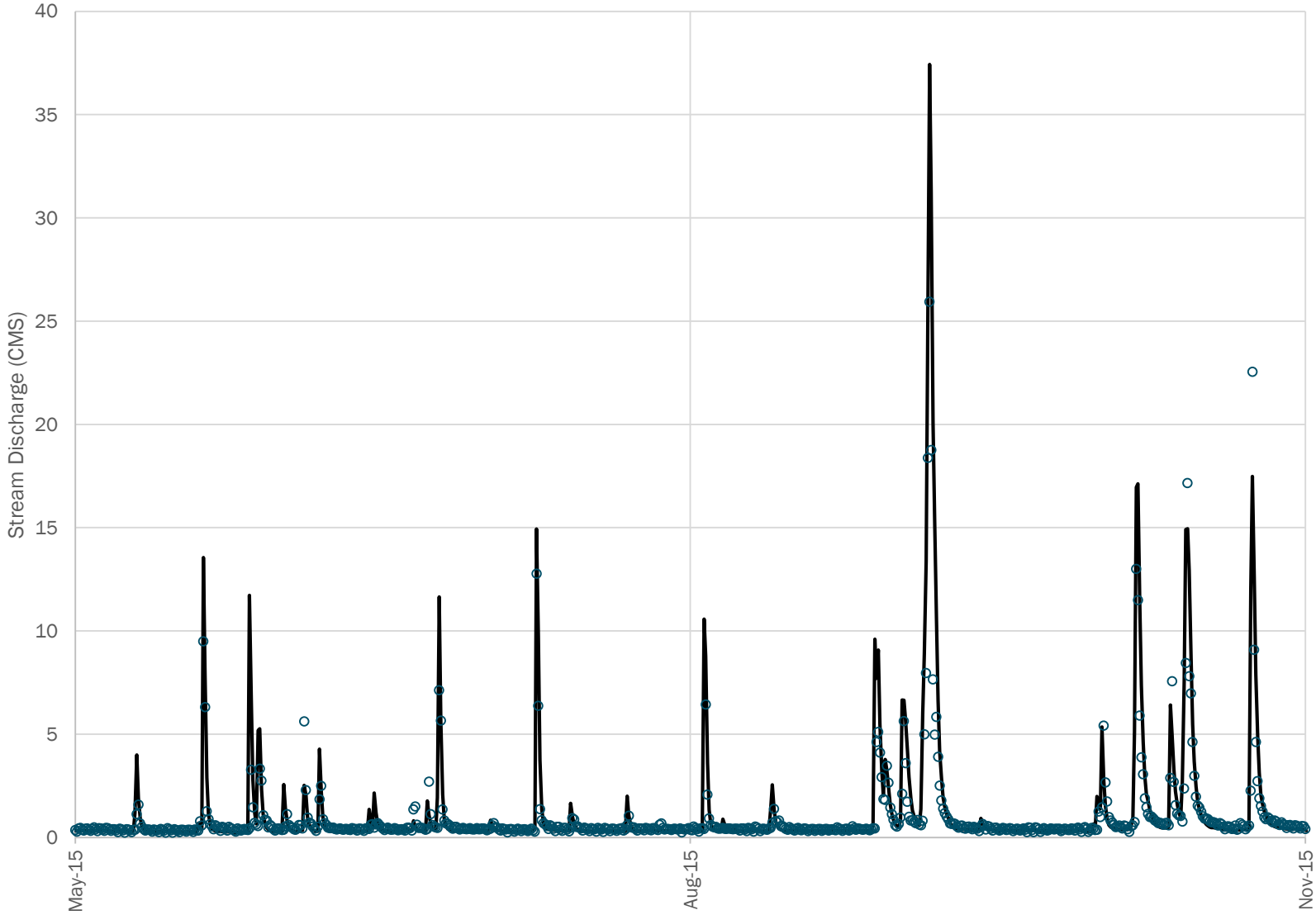

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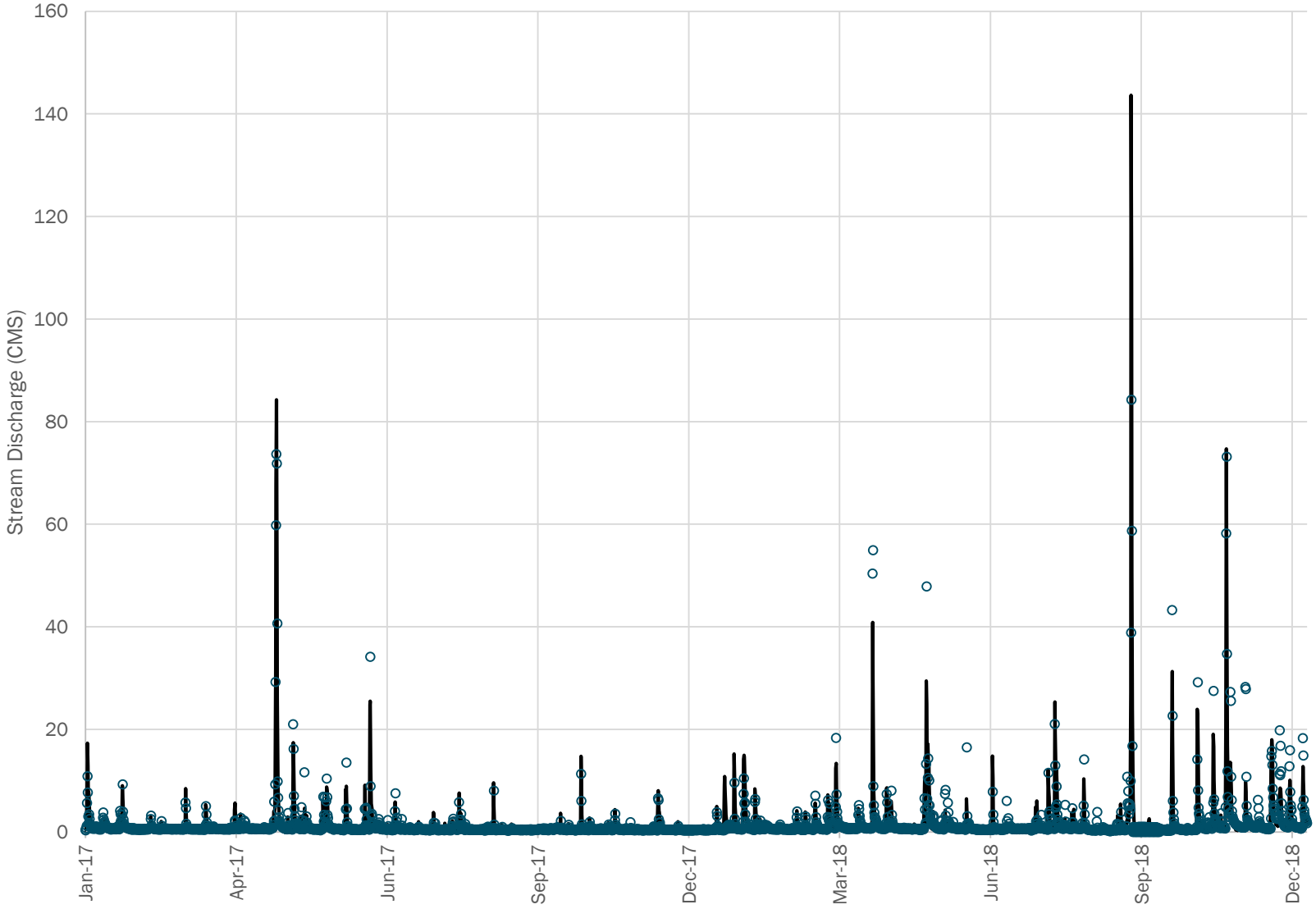
Ellerbe Creek Near Gorman: Validation



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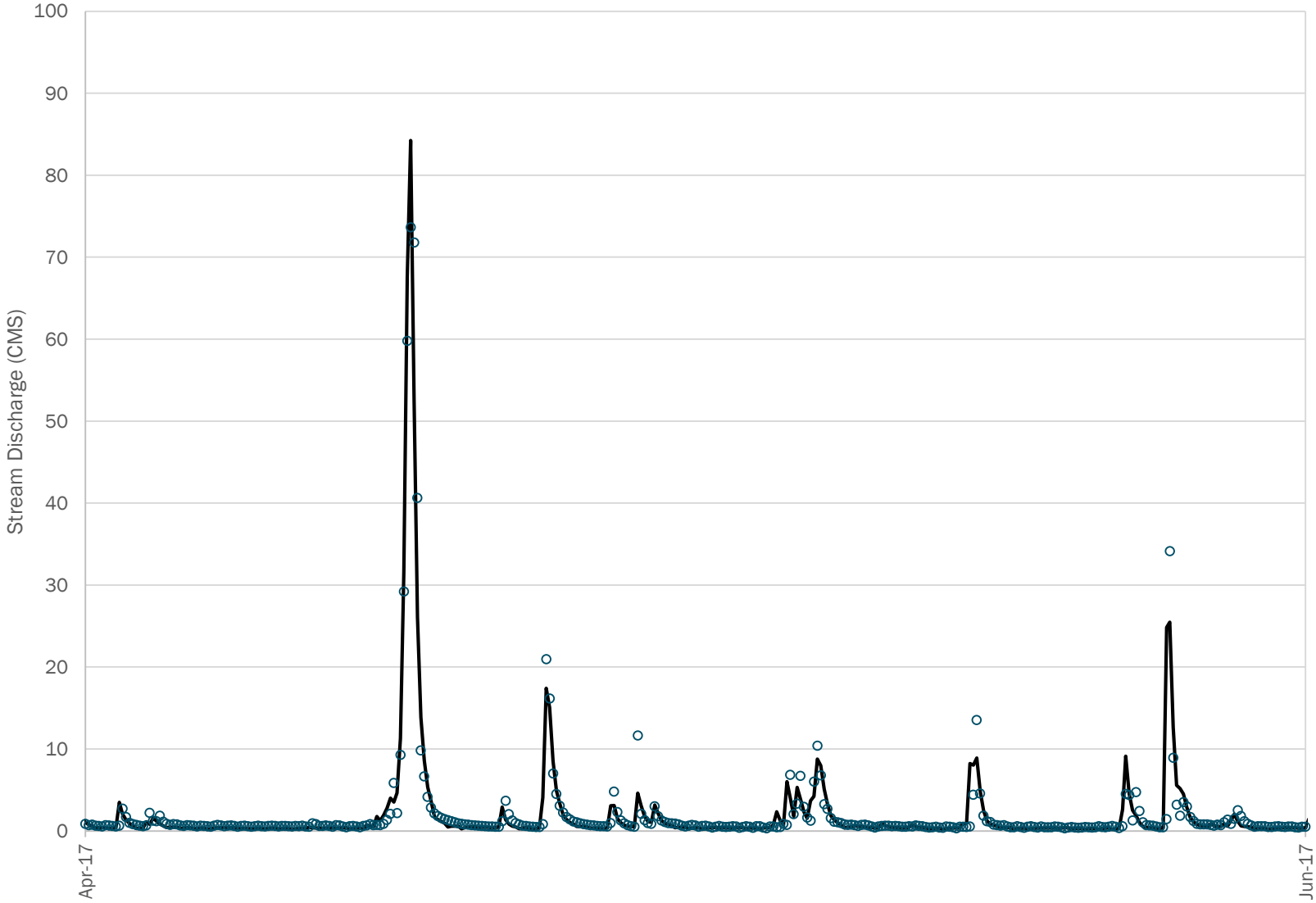

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	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	0.595		0.589		0.592	
Observed 90th Percentile Discharge	2.220		2.224		2.226	
Simulation Error:						
Total Volume	-1.0%	Very Good	0.2%	Very Good	-0.4%	Very Good
Peak Flow	-1.5%	Very Good	2.0%	Very Good	0.4%	Very Good
High Flow	-1.0%	Very Good	0.8%	Very Good	0.1%	Very Good
Low Flow	-1.5%	Very Good	-3.0%	Very Good	-2.9%	Very Good
Winter	-5.7%	Very Good	7.9%	Very Good	0.4%	Very Good
Spring	-14.6%	Very Good	-6.0%	Very Good	-9.4%	Very Good
Summer	-16.3%	Good	-4.1%	Very Good	-10.8%	Very Good

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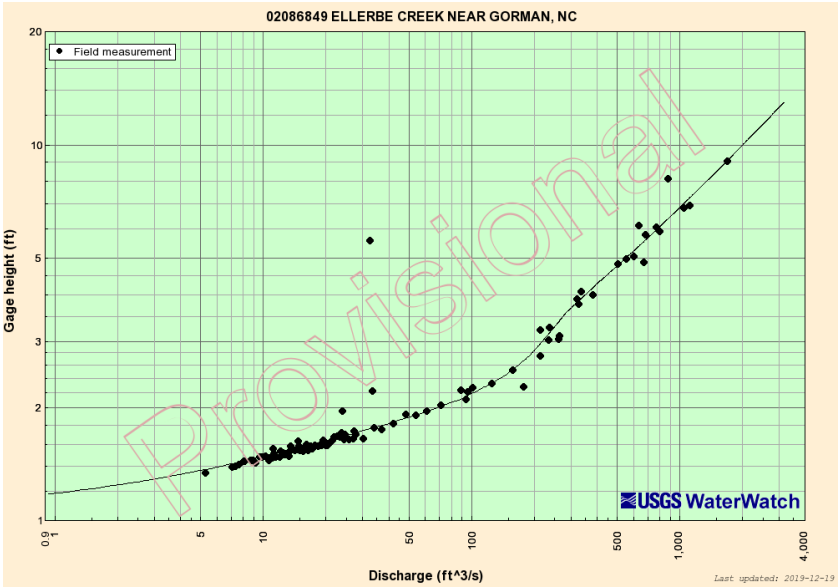
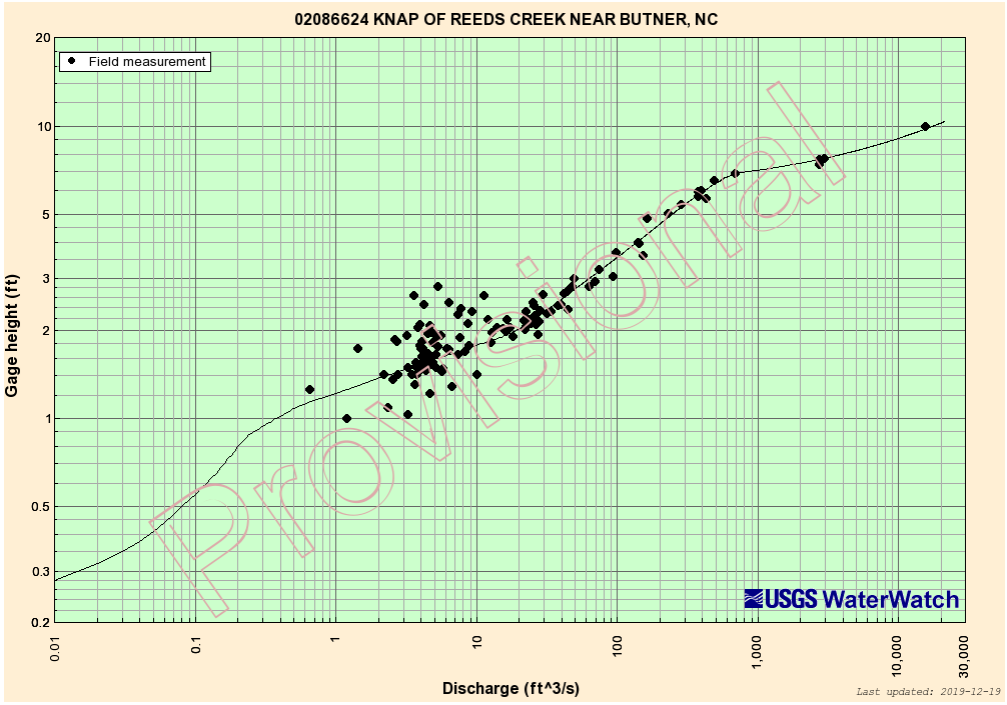
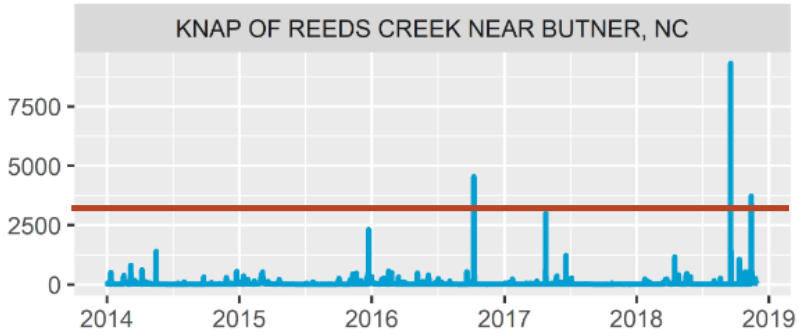


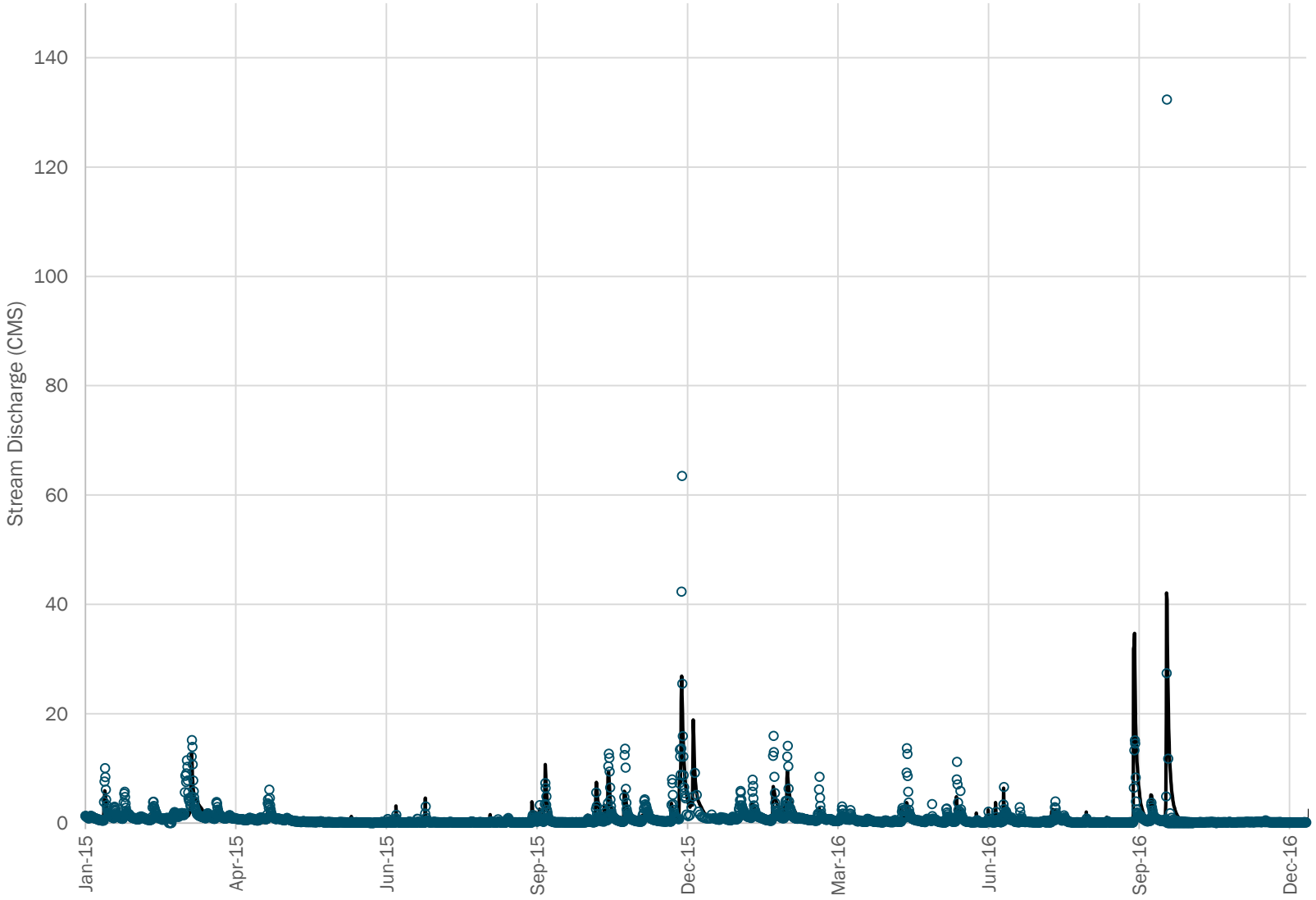
Rating Curves at Knap of Reeds Creek Gage





- Estimated flows up to 15,500 cfs are represented by field measurements collected in the past 20 years (this gage is downstream of the SGWASA WWTP).
- Highest flow measurement (15,500 cfs) was collected in 2018 and rated poor.
- The next highest was 3,300 cfs; also rated poor.
- The highest flow measurement rated fair was 2,950 cfs collected in 2018.
- Flows above 3,000 cfs may be omitted for the purpose of model calibration (in progress).

Knap of Reeds Creek: Calibration



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Knap of Reeds Creek: Calibration

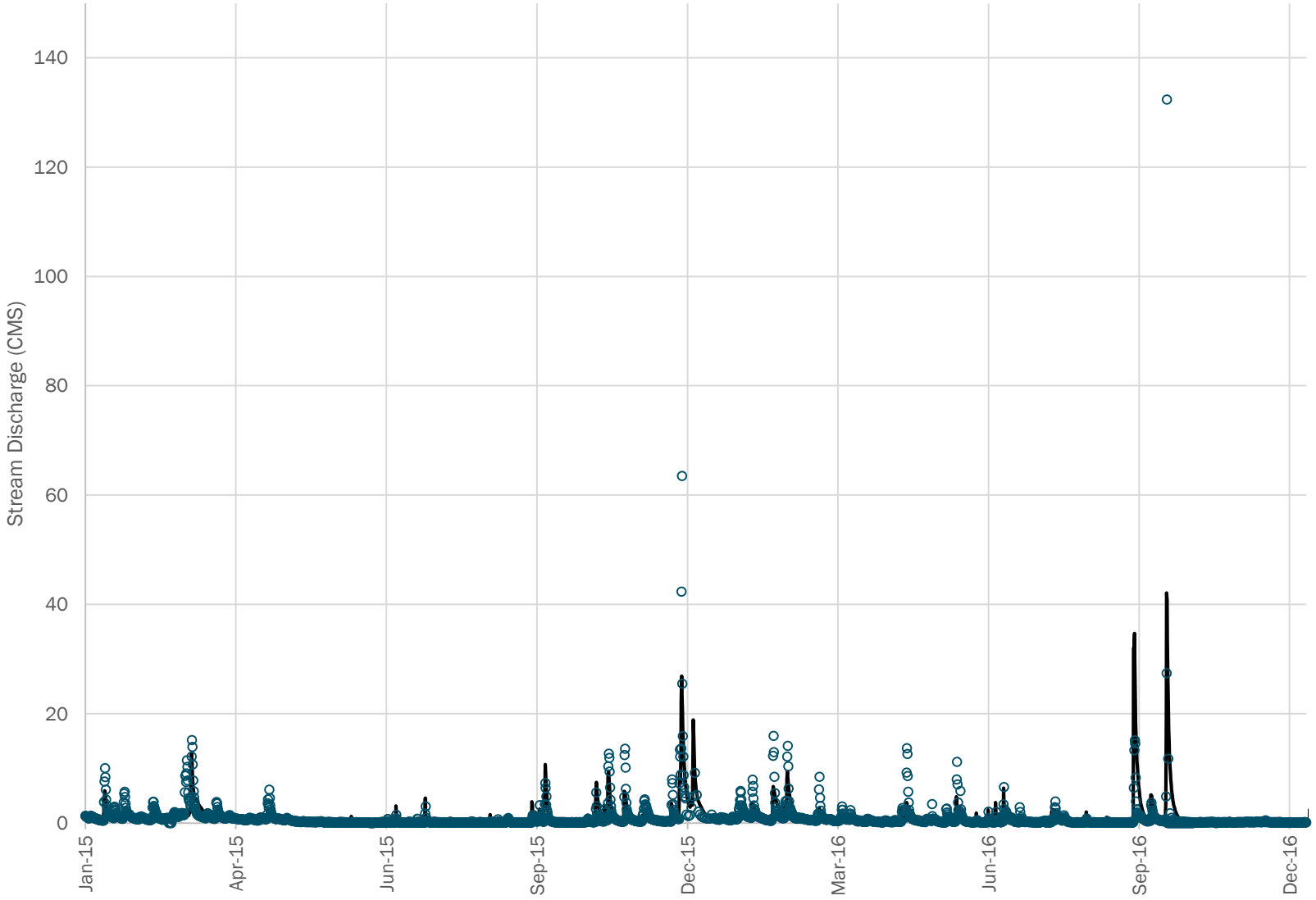


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Knap of Reeds Creek: Validation

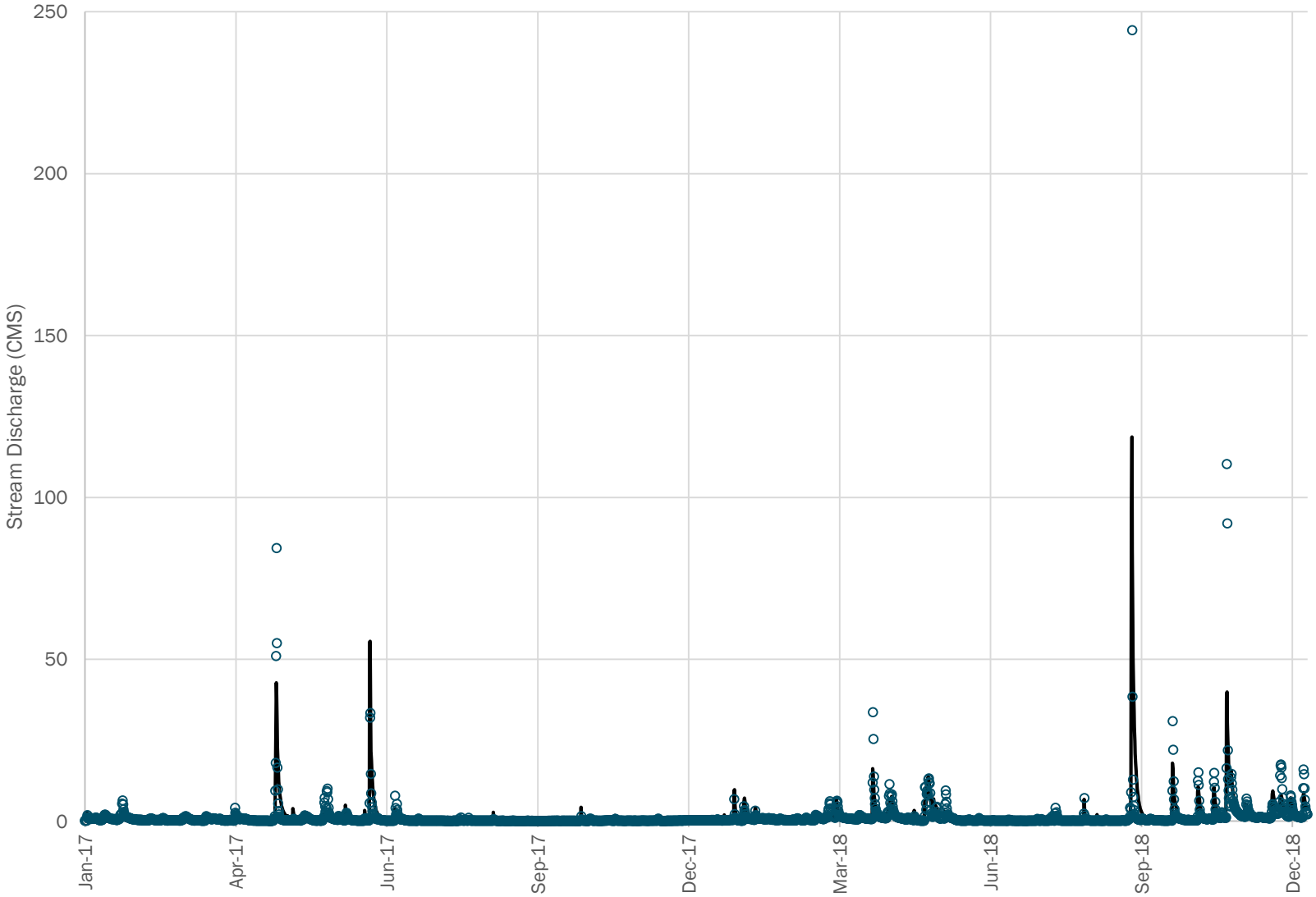


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Knap of Reeds Creek: Validation

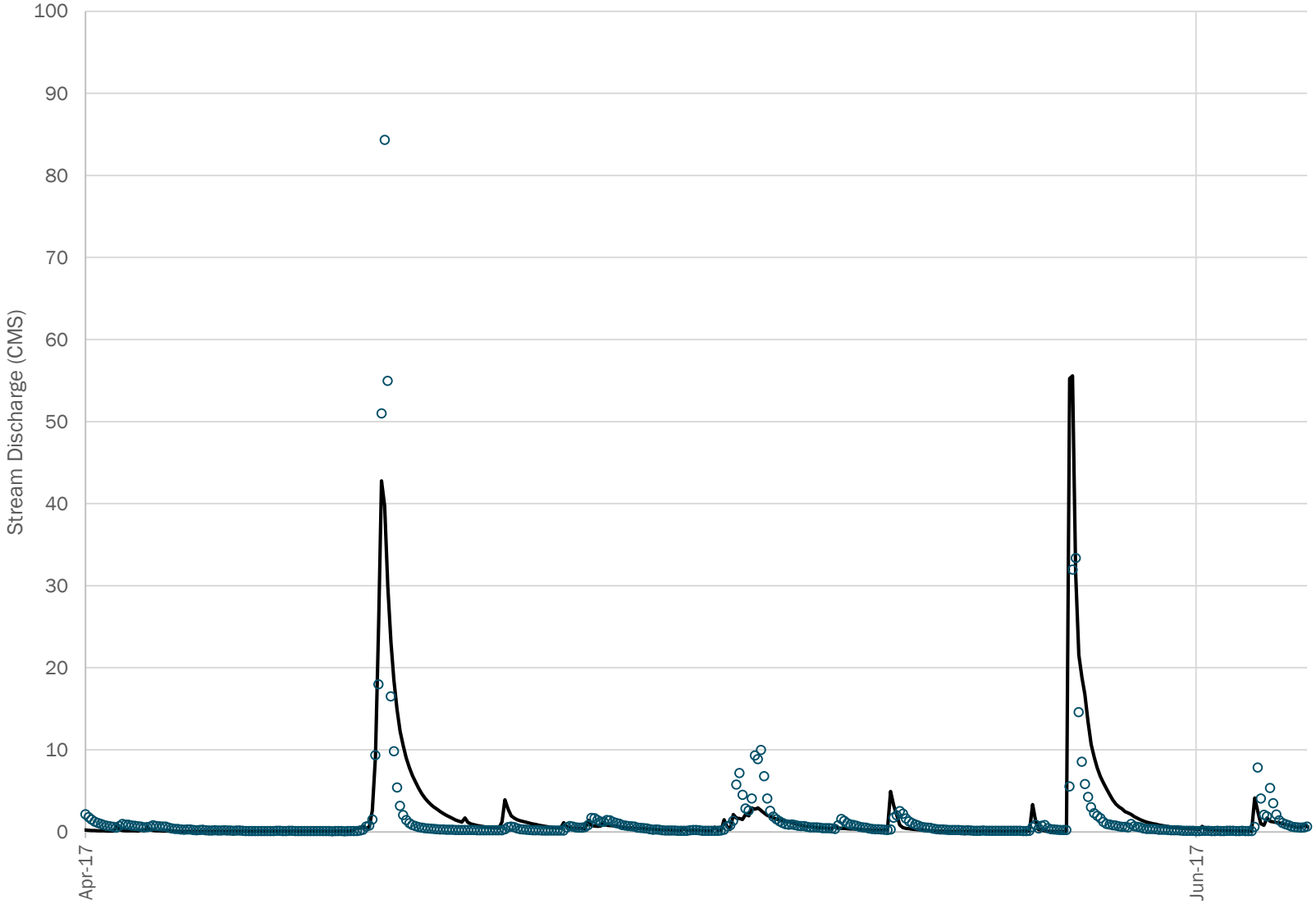


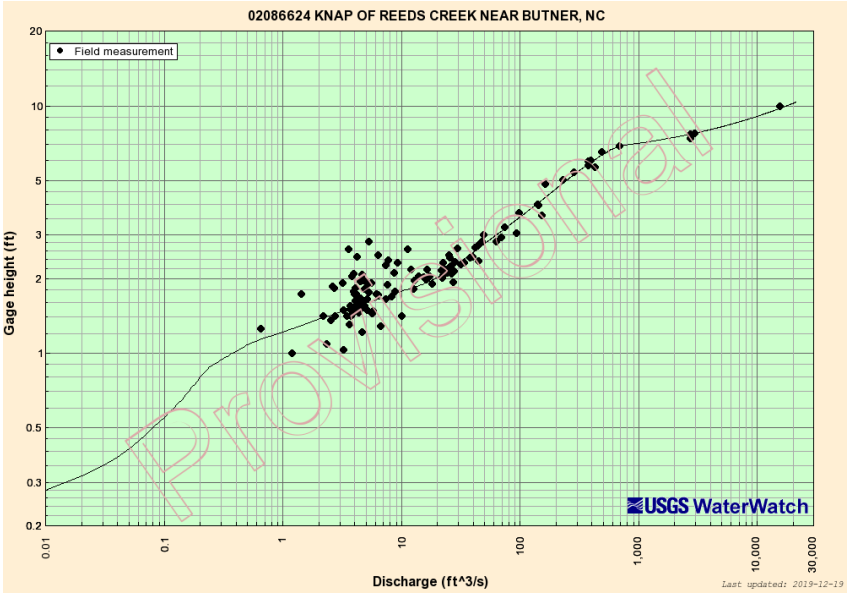
Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Knap of Reeds Creek: Performance Criteria

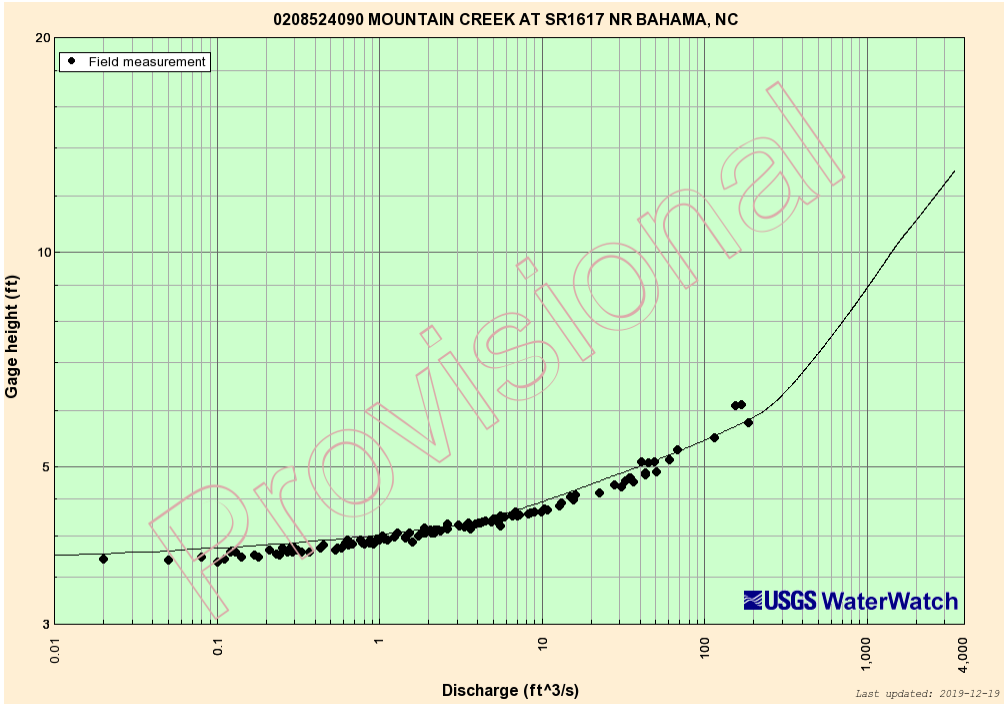
	Time Period					
	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	0.325		0.248		0.280	
Observed 90th Percentile Discharge	1.715		1.925		1.790	
Simulation Error:						
Total Volume	-5.6%	Good	3.7%	Very Good	-0.2%	Very Good
Peak Flow	-18.8%	Fair	-6.0%	Very Good	-11.3%	Good
High Flow	-6.6%	Very Good	3.0%	Very Good	-1.0%	Very Good
Low Flow	9.4%	Very Good	17.0%	Fair	13.1%	Good
Winter	-10.4%	Very Good	1.7%	Very Good	-5.7%	Very Good
Spring	-40.7%	Fair	-10.6%	Very Good	-22.1%	Good
Summer	-10.3%	Very Good	41.5%	Fair	19.7%	Good
Fall	47.6%	Fair	8.1%	Very Good	19.8%	Good

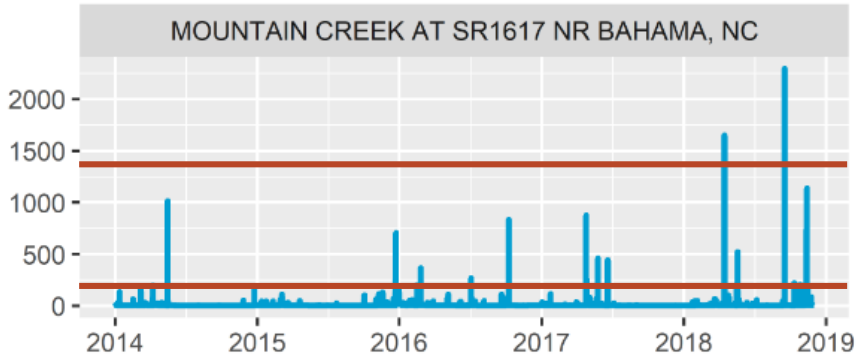
Table A.7-1 Hydrology Calibration Criteria

Prediction Error	Very Good	Good	Fair
Error in total volume	≤ 5%	5-10%	10-15%
Error in monthly flows	≤ 10%	10-15%	15-25%
Error in volume of 50% lowest flows	≤ 10%	10-15%	15-25%
Error in volume of 10% highest flows	≤ 10%	10-15%	15-25%
Seasonal volume error – Summer	≤ 15%	15-30%	30-50%
Seasonal volume error – Fall	≤ 15%	15-30%	30-50%
Seasonal volume error – Winter	≤ 15%	15-30%	30-50%
Seasonal volume error – Spring	≤ 15%	15-30%	30-50%



Rating Curve at Mountain Creek Gage





- Estimated flows up to 185 cfs are represented by field measurements collected in the past 20 years.
- Measurement up to 1,880 cfs was recorded in 1996, but the rating for the measurement was poor
- A measurement in 1995 of 1,430 cfs was recorded and rated fair.
- The third highest measurement was 185 cfs in 2017.
- Model calibration may omit flows greater than 200 cfs (or 1,430 cfs) for the comparison of simulated to observed flows (in progress).

Mountain Creek: Calibration

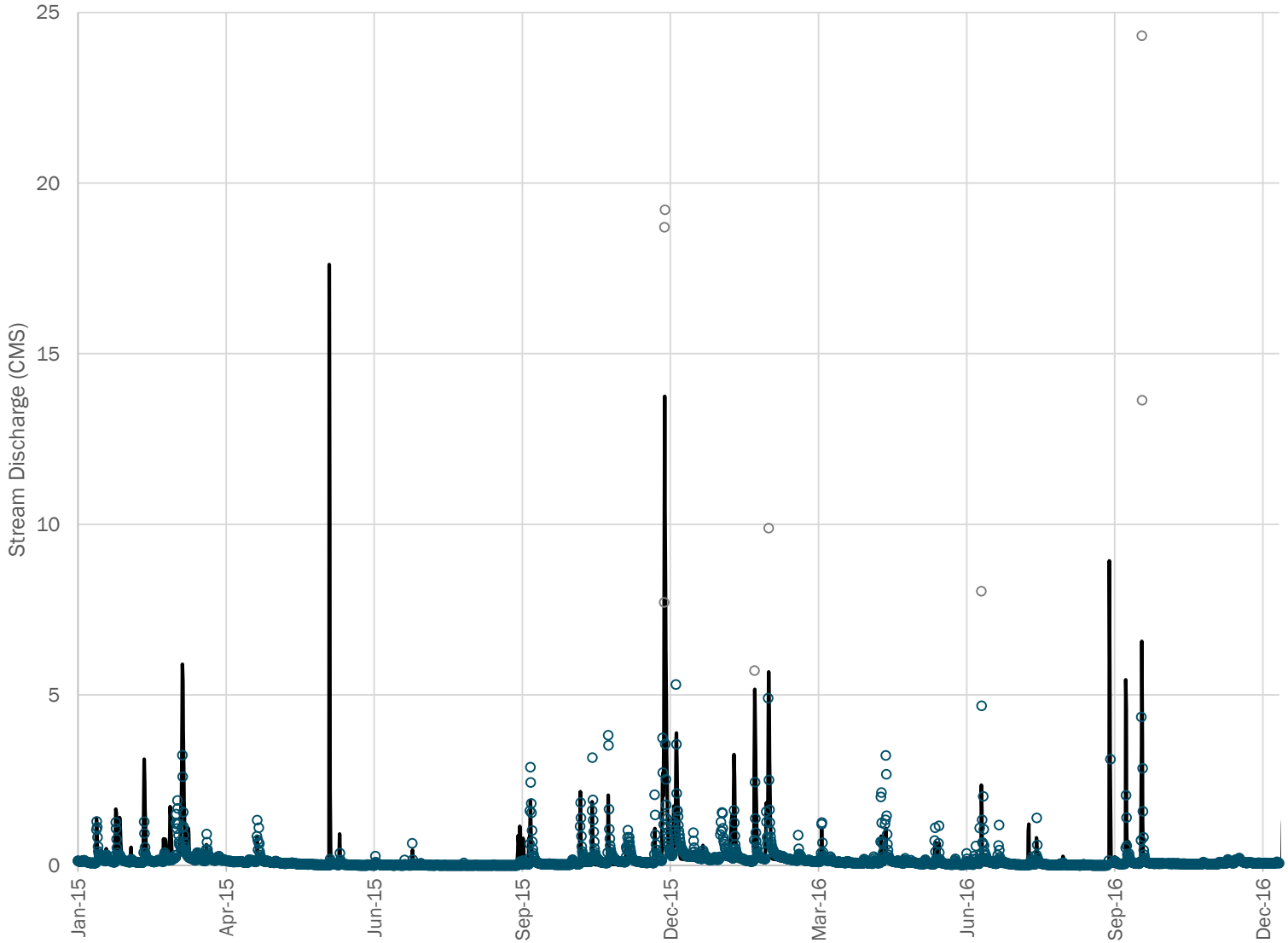


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Mountain Creek: Calibration

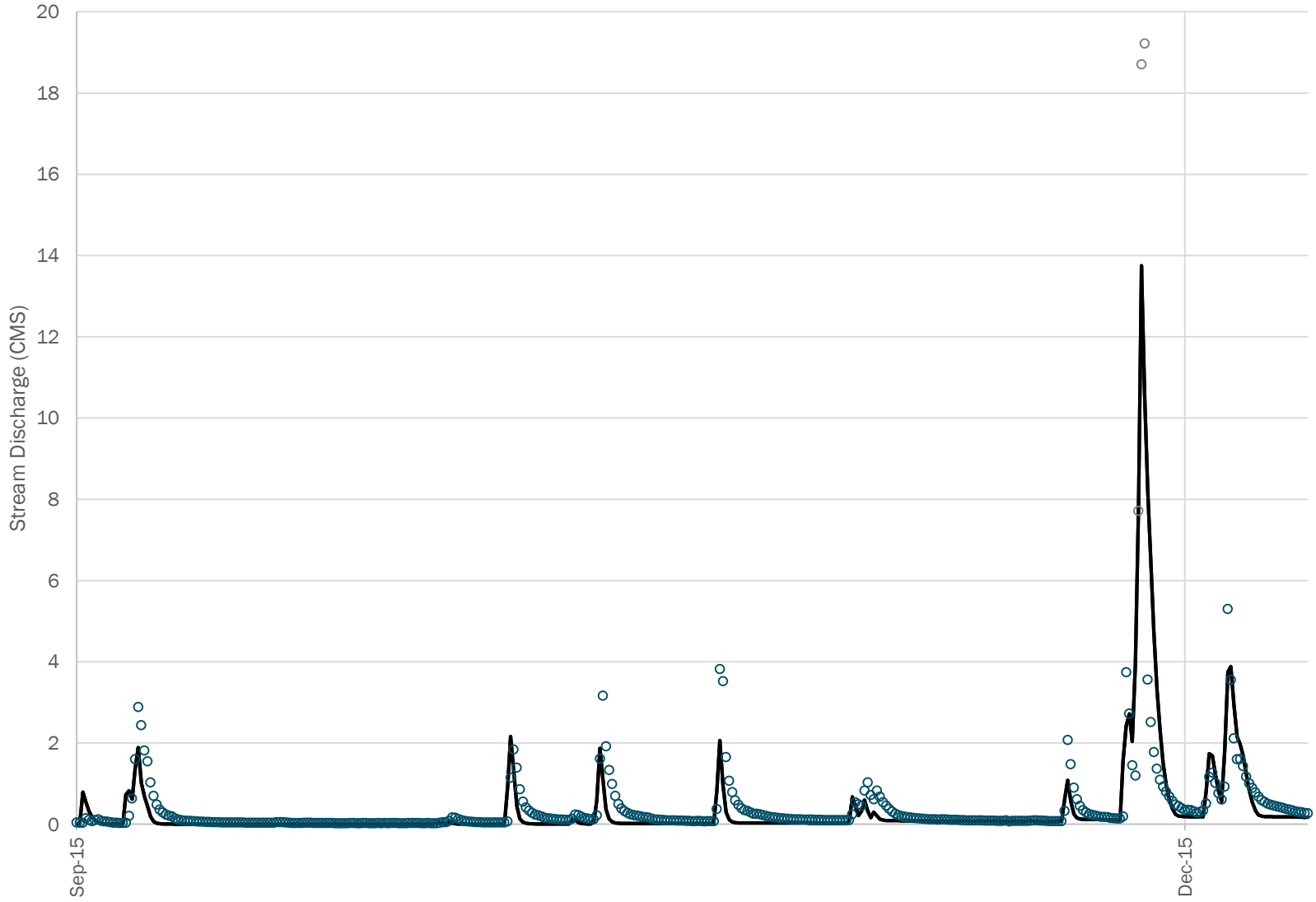


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Mountain Creek: Validation

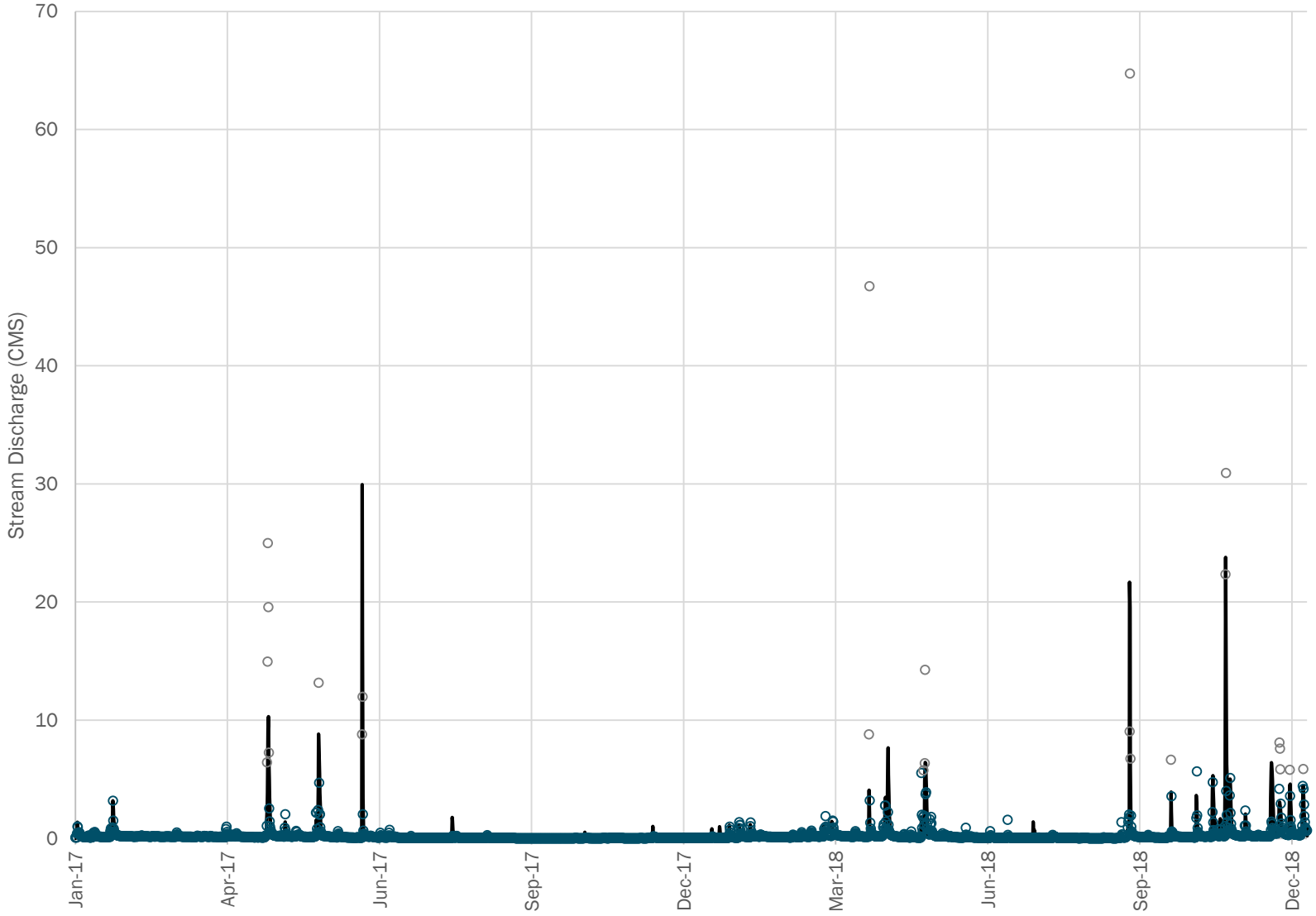


Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Mountain Creek: Validation

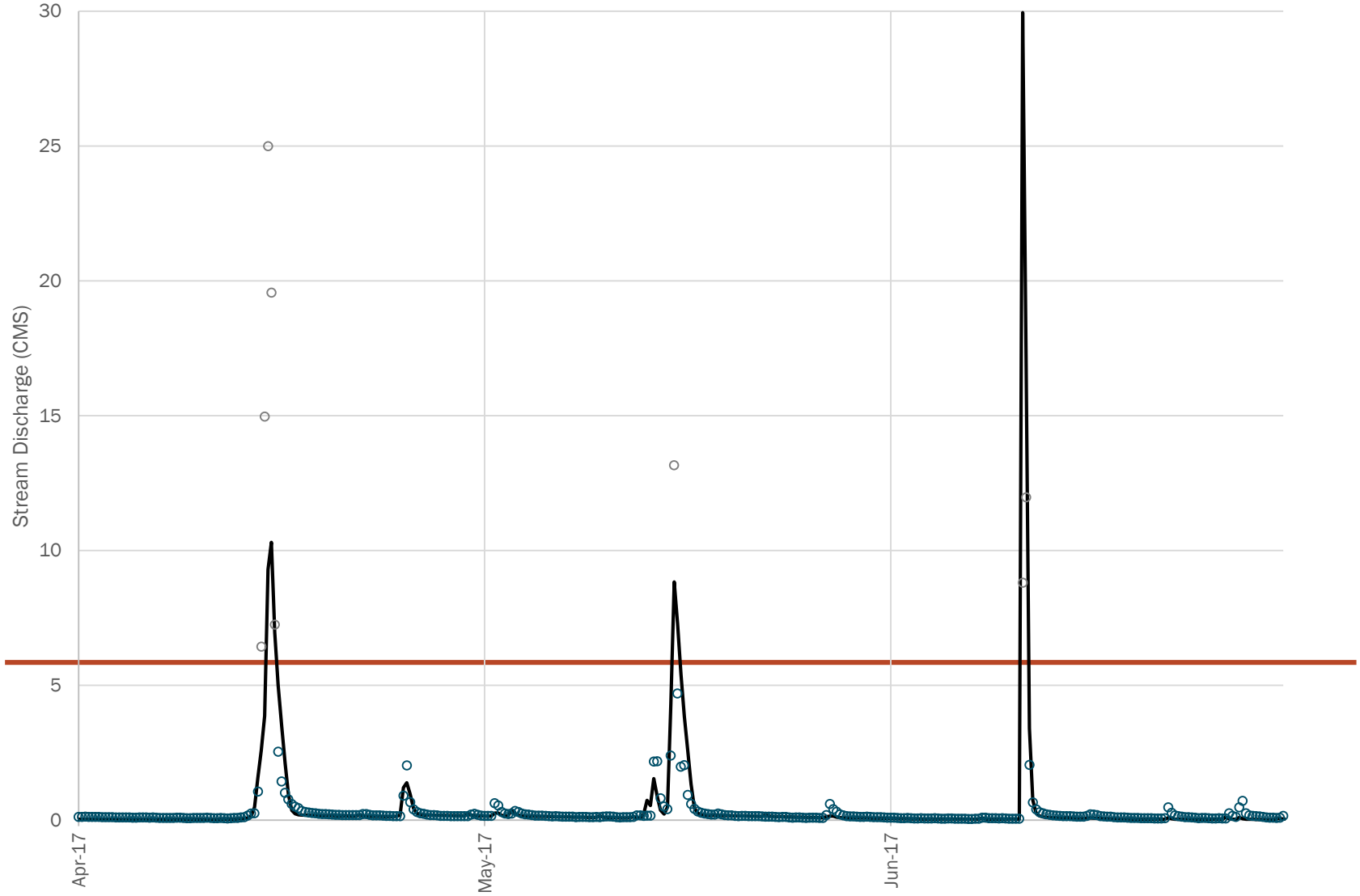


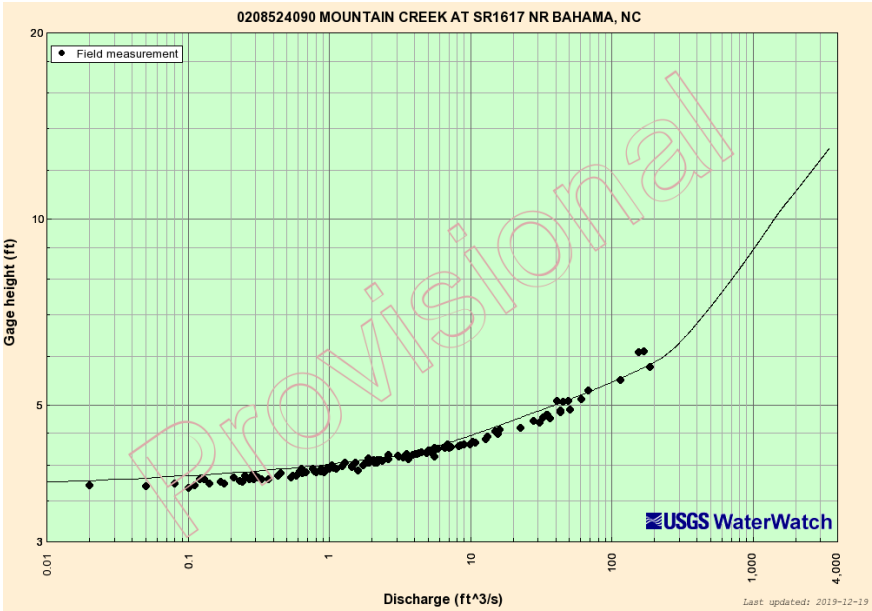
Figure displays flow in cubic meters per second (CMS) consistent with WARMF output

Mountain Creek: Performance Criteria

	Time Period					
	Calibration (2015-2016)		Validation (2017-2018)		Complete (2015-2018)	
	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)	Statistic	Interpretation (QAPP)
Observed Median Discharge	0.077		0.097		0.085	
Observed 90th Percentile Discharge	0.322		0.319		0.322	
Simulation Error:						
Total Volume	-6.7%	Good	2.1%	Very Good	-2.3%	Very Good
Peak Flow	-10.2%	Good	23.0%	Fair	6.5%	Very Good
High Flow	-10.7%	Good	3.0%	Very Good	-3.8%	Very Good
Low Flow	33.0%	Poor	-7.8%	Very Good	14.5%	Good
Winter	16.8%	Good	8.2%	Very Good	13.3%	Very Good
Spring	-26.8%	Good	-9.9%	Very Good	-16.7%	Good
Summer	12.5%	Very Good	-25.1%	Good	-5.6%	Very Good
Fall	-38.7%	Fair	26.8%	Good	-4.2%	Very Good

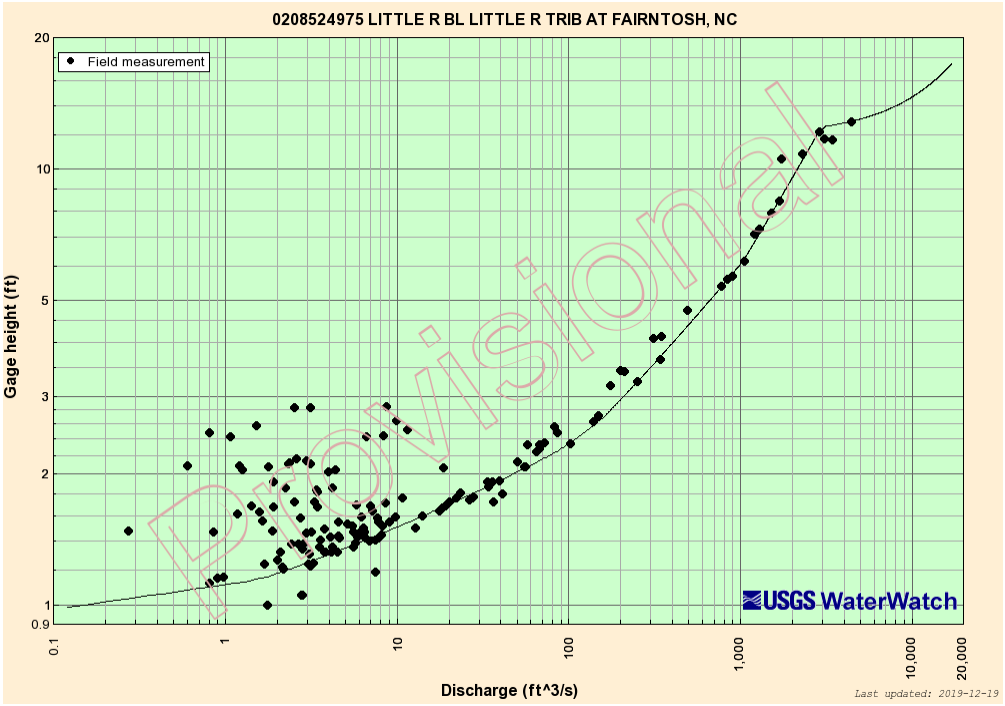
Table A.7-1 Hydrology Calibration Criteria

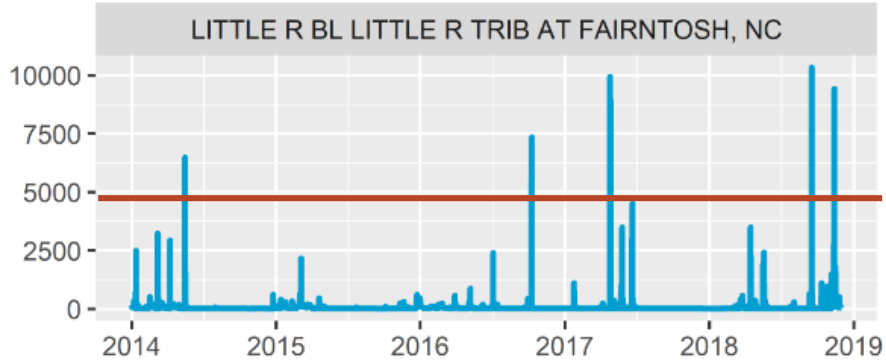
Prediction Error	Very Good	Good	Fair
Error in total volume	≤ 5%	5-10%	10-15%
Error in monthly flows	≤ 10%	10-15%	15-25%
Error in volume of 50% lowest flows	≤ 10%	10-15%	15-25%
Error in volume of 10% highest flows	≤ 10%	10-15%	15-25%
Seasonal volume error – Summer	≤ 15%	15-30%	30-50%
Seasonal volume error – Fall	≤ 15%	15-30%	30-50%
Seasonal volume error – Winter	≤ 15%	15-30%	30-50%
Seasonal volume error – Spring	≤ 15%	15-30%	30-50%



Rating Curves for Gages Used to Estimate Releases from Impoundments

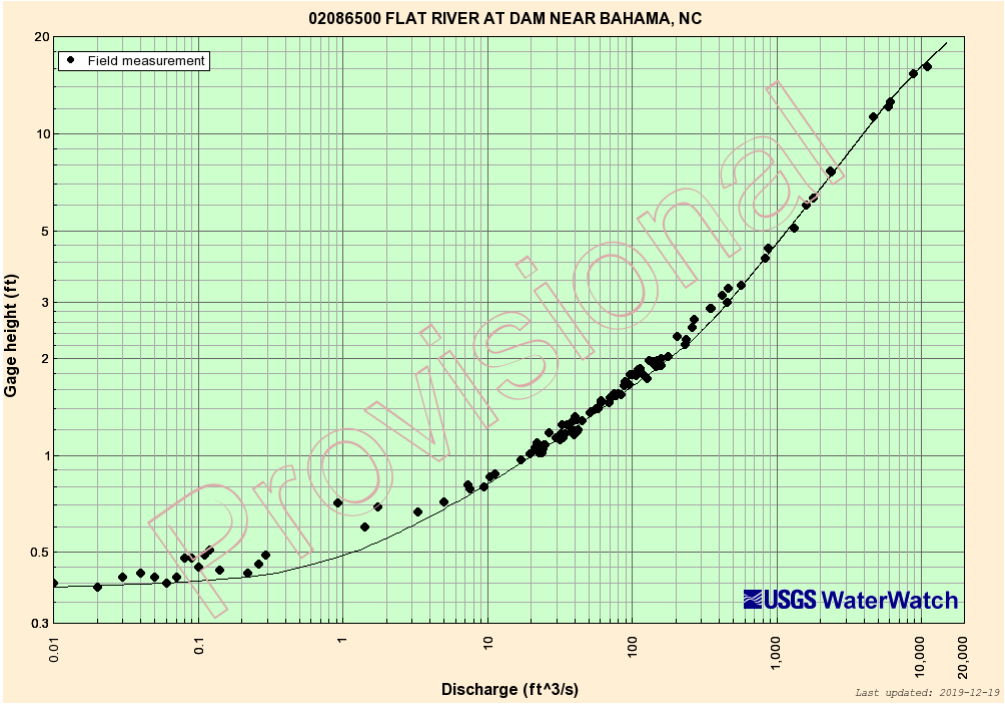
Rating Curve at Little River Below LRR



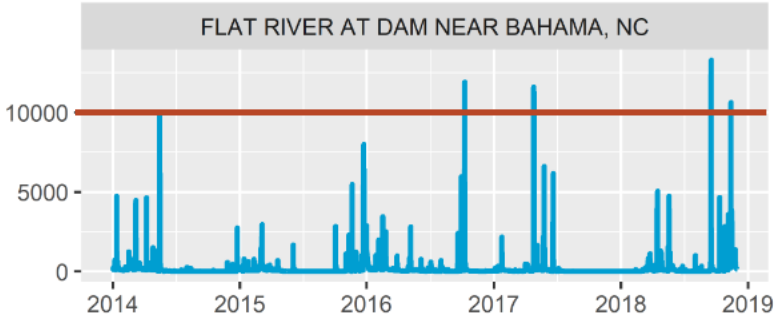


- Estimated flows greater than 4,440 cfs are not represented by field measurements collected in the past 20 years.
- Flows of 10,900 cfs and 16,600 cfs were collected in 1998 and 1996 respectively with ratings of fair.
- Flows above 4,500 cfs may be omitted (gage is used to estimate releases from LRR).

Rating Curves for Flat River below Lake Michie



- Estimated flows up to 10,000 cfs are represented by field measurements collected in the past 20 years.
- 6-hr average flows exceed this level in the recent modeling period.
- Flows above 10,000 cfs may be omitted (gage is used to estimate releases from Lake Michie).



Assessment of Ungaged Tributaries

Hydrologic Assessment of Ungaged Tributaries

- Five of the 17 tributaries that discharge to Falls Lake have USGS flow gages
- Previous flow estimation techniques were developed to support the loading analyses related to the UNRBA monitoring program
- These flow estimates provide a comparison to the simulated flows to ensure the model is generating expected ranges of flows at ungaged locations
  - Based on basinwide average flows excluding gages with upstream impoundments or WWTPs
  - Does not account for basin specific differences (small impoundments, land use differences, etc.)
- After applying the calibrated model parameters to watersheds without gages, all but three tributaries generated total volumes, peak flows, and high flows within +-20% of the

Comparison of Simulated Flow to Estimated Flow

Statistic	Beaverdam	Robertson	Ledge	Smith
Total Volume	-8%	5%	-18%	-11%
Peak Flow	-22%	-13%	-19%	-16%
High Flow	-10%	-1%	-20%	-13%
Statistic	**Newlight**	**Horse**	**Honeycutt**	**Low. Barton**
Total Volume	-7%	10%	20%	20%
Peak Flow	-16%	-10%	-3%	-1%
High Flow	-9%	1%	7%	9%
Statistic	**Upp. Barton**	**Lick**	**Little Lick**	**Panther**
Total Volume	20%	28%	43%	25%
Peak Flow	-3%	-2%	9%	-2%
High Flow	13%	20%	33%	16%

- All but three of the lake loading stations have simulated flows within 20% of those predicted based on flows observed on Flat River above Lake Michie, Eno River at Hillsborough, Eno River near Durham, Little River above Reservoir, Mountain Creek, and Tar River near Tar River.
- The three that are not within 20% are more similar to the Ellerbe Creek watershed than those gaged included in the flow estimation (Triassic Basin soils and urban development would be expected to generate higher volumes of flow).

Other Items

319 Grant Application Process for Custom Model Code Development

- Board authorized use of Task 321 (Modeling Linkages and Testing) of the UNRBA Modeling and Regulatory Support Contract with Brown and Caldwell as match for this project
- Application has been submitted to EPA through DWR

Re-examination MOA with DWR

- Authorizing Legislation: Session Law 2010-155
- UNRBA is drafting definitions for the draft MOA for submittal to DEQ
- Additional items to consider
  - Agency review time (DWR/EPA), point of contact, milestones
  - Upper versus lower – potential silos
  - Expectations for DWR to provide comments throughout the process, not just formal submissions
  - Third party reviewers
  - Education of the EMC / UNRBA presentation of re-examination findings to the EMC
  - Conflict resolution, agency level

Closing Comments
Additional Discussion