Water Quality Sediment Transport Model (WQSTM) Accuracy Assessment

Greg Busch, Guido Yactayo
MDE

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Chesapeake Bay Program – Modeling Quarterly Meeting

Objective

Tasked with conducting a review of the Chesapeake Bay Model framework in order to …

- evaluate the appropriateness of the framework for fulfilling Maryland's responsibilities under Section 303(d) of the Clean Water Act
  - Responsibilities include the development of TMDLs, Water Quality Analyses and implementation plans
  - Maryland uses elements of the framework to address impairments in both the Chesapeake Bay and the State's non-tidal waters
- recommend improvements to the framework for Phase 6 and subsequent model iterations
- increase MDE's in-house understanding of the model framework

This presentation focuses on the review of the WQSTM

Approach

- Focus on tidal tributaries of the Bay
  - Most of Maryland’s tidal water DO impairments are in Bay tributaries, not the mainstem
  - These are areas where many citizens interact with the tidal waters
- Comparison of model cell output for calibration scenario with instantaneous water quality observations

Caveats

- These results are for Beta 3, and we expect them to change in later iterations
- This analysis only looks at a handful of tributaries, limiting generalizations

Model Output

- Calibration period of 1991 to 2000
- Surface layer hourly output
- Initial review focusing on : Gunpowder (GUNOH), Patuxent (PAXTF), Wicomico (WICMH), Mattawoman (MATTF), Sassafras (SASOH), and Patapsco (PATMH)
- Variables: chlorophyll-a , dissolved oxygen, salinity, nutrients, total suspended sediment, water temperature and light attenuation.

Observations

Observations were downloaded from the CBPO datahub

http://data.chesapeakebay.net/WaterQuality

Observations were used if:

- Not below the detection limit
- Sample depth not greater than model surface layer cells (2.14 meters)
- Taken within the calibration period

Model Evaluation Techniques

- Graphical

I. Time series
II. Boxplots
III. Target plots
IV. 1:1

- Statistical

I. Standard regression: r
II. Dimensionless: NSE
III. Error index: PBIAS

Calibration Statistics

Correlation coefficient (r) is an index of the degree of linear relationship between simulated and observed data. If r = 0, no linear relationship exists. If r = 1 or −1, a perfect positive or negative linear relationship exists.

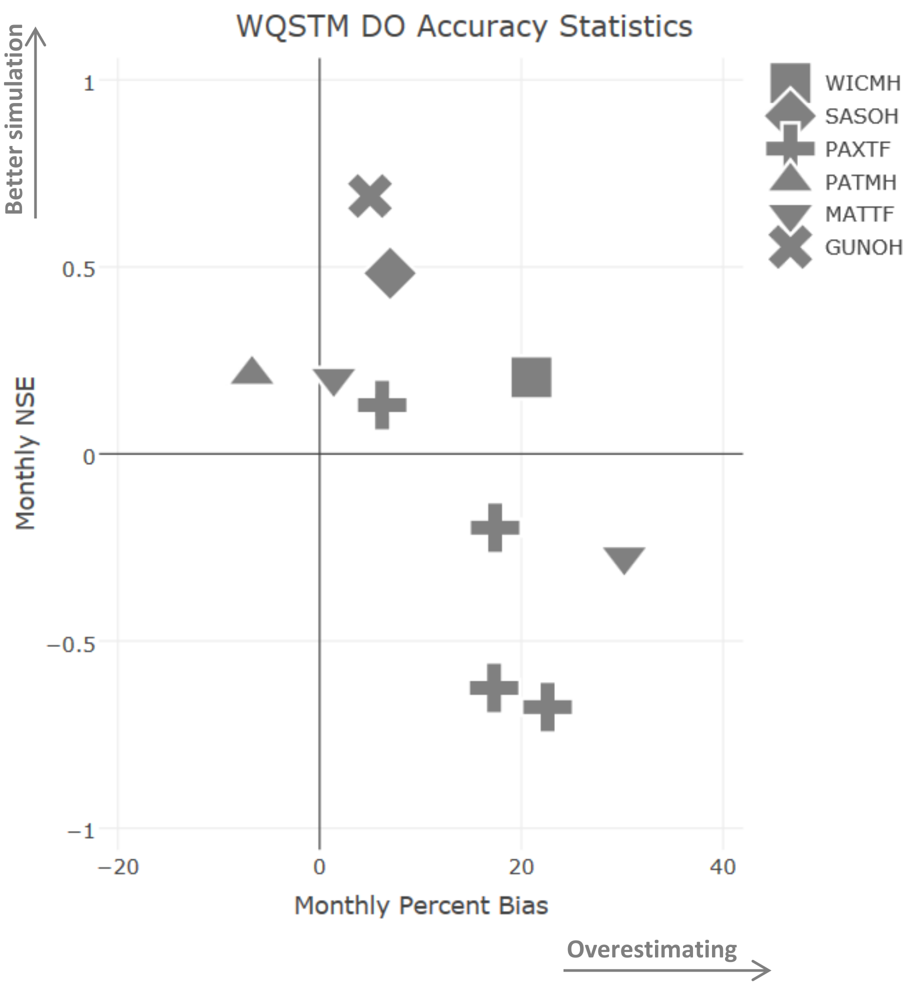
The Nash-Sutcliffe efficiency (NSE) is a normalized statistic that indicates how well the plot of observed versus simulated data fits the 1:1 line. The optimal value of NSE is 1.

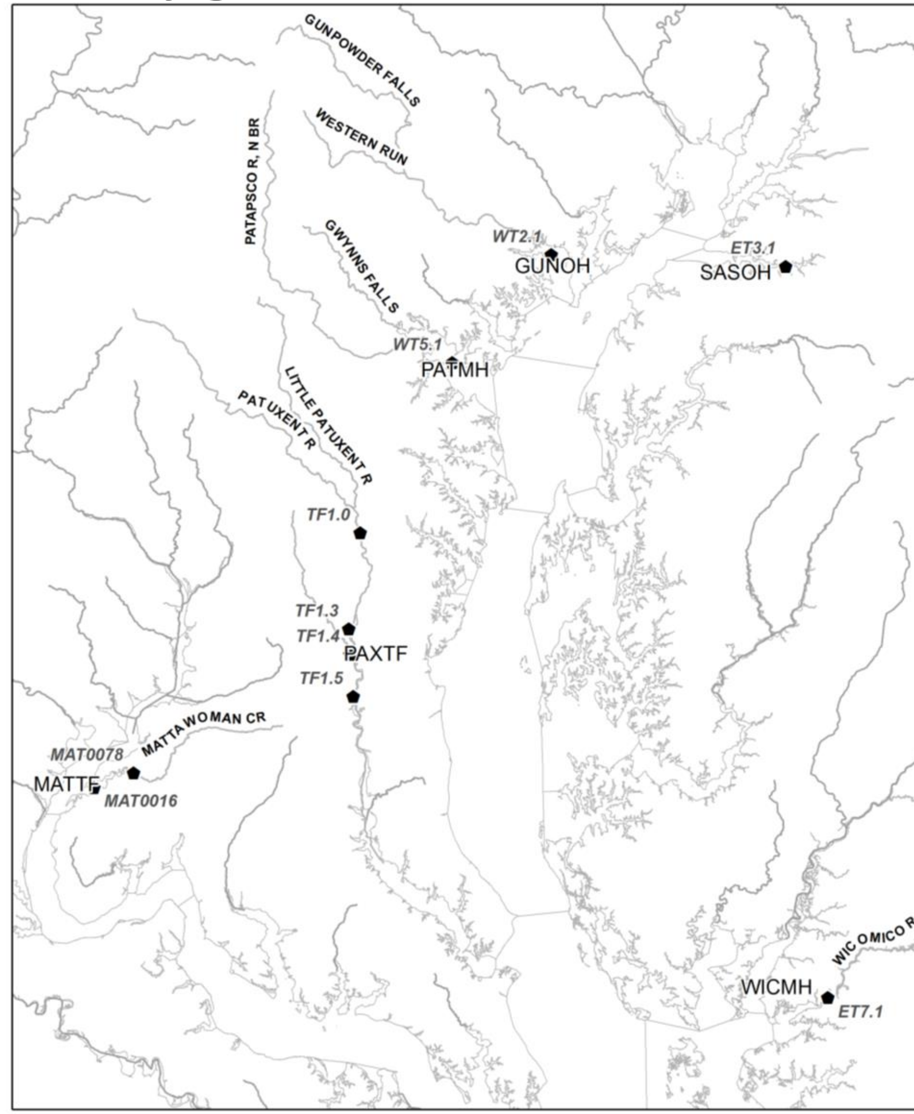
$$mNSE = 1 - \frac{\sum_{i=1}^{N} \left|S_i - O_i\right|^j}{\sum_{i=1}^{N} \left|O_i - \bar{O}\right|^j}$$

Percent bias (PBIAS) measures the average tendency of the simulated data to be larger or smaller than their observed counterparts. The optimal value of PBIAS is 0.

$$PBIAS = 100 \frac{\sum_{i=1}^{N} (S_i - O_i)}{\sum_{i=1}^{N} O_i}$$

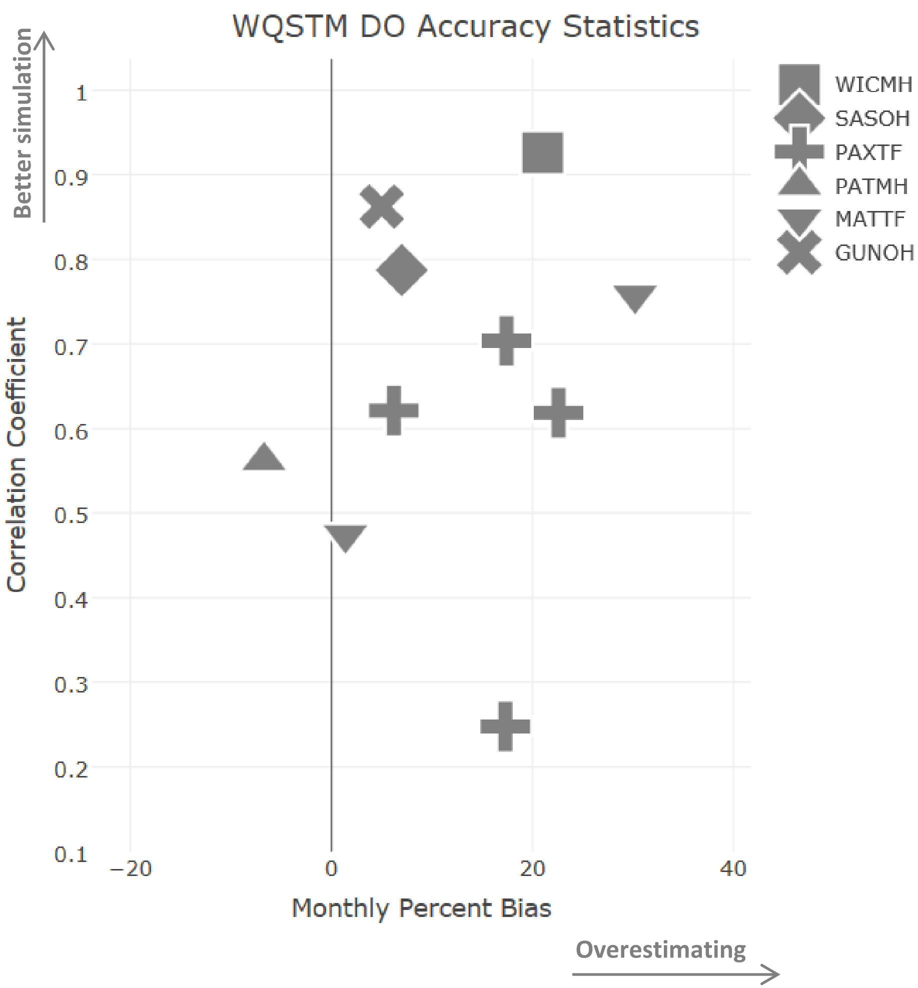
Dissolved oxygen

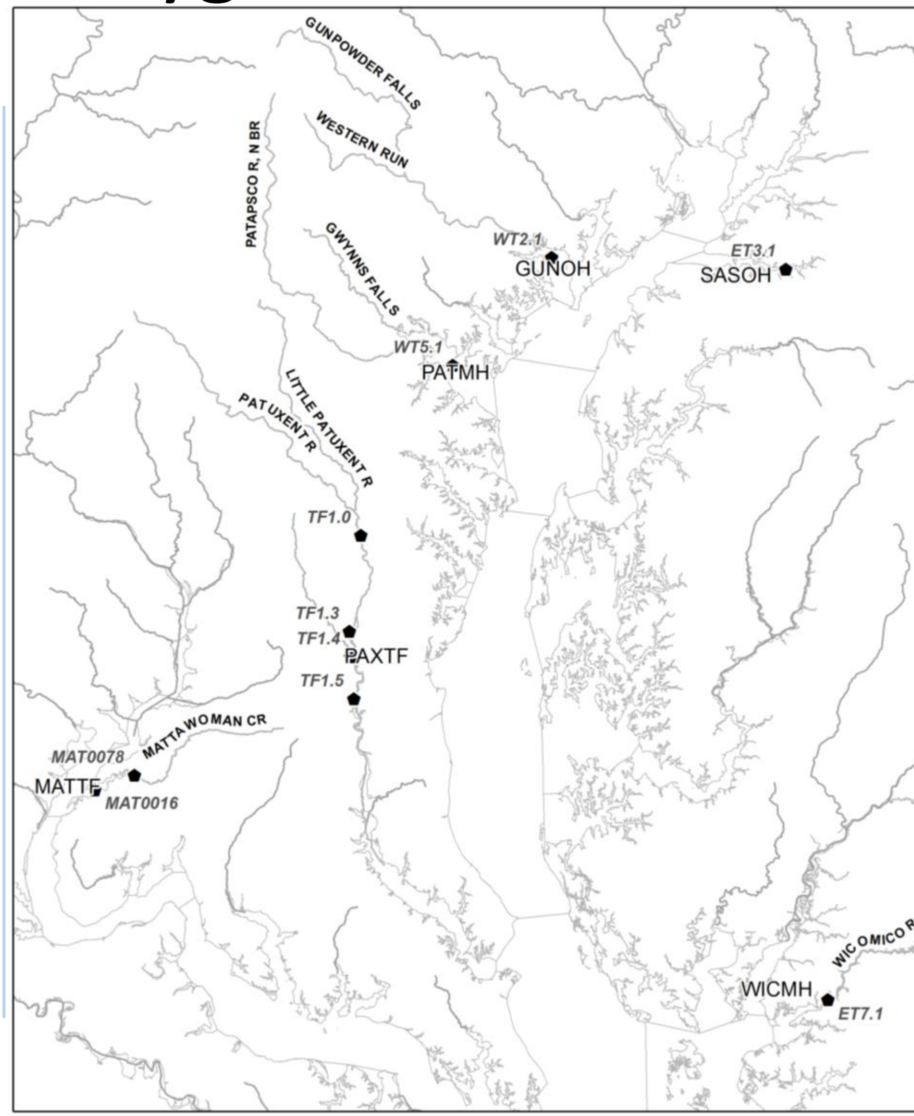




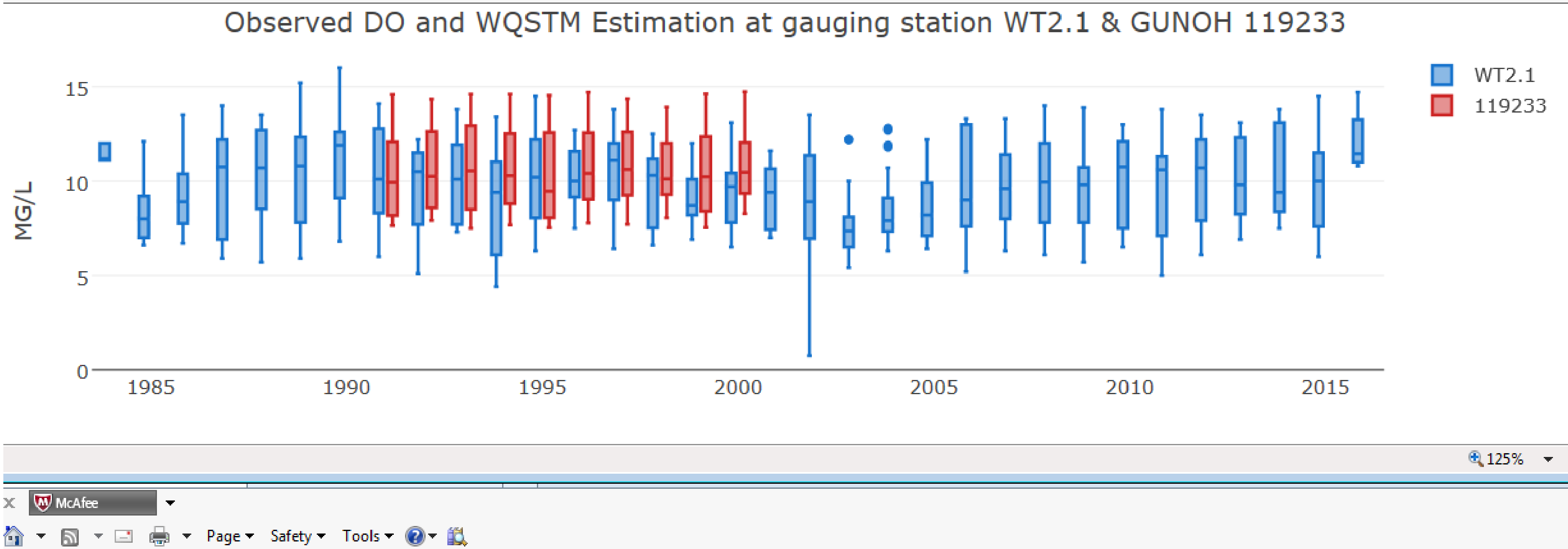
The optimal value of NSE is 1 and percent bias is 0

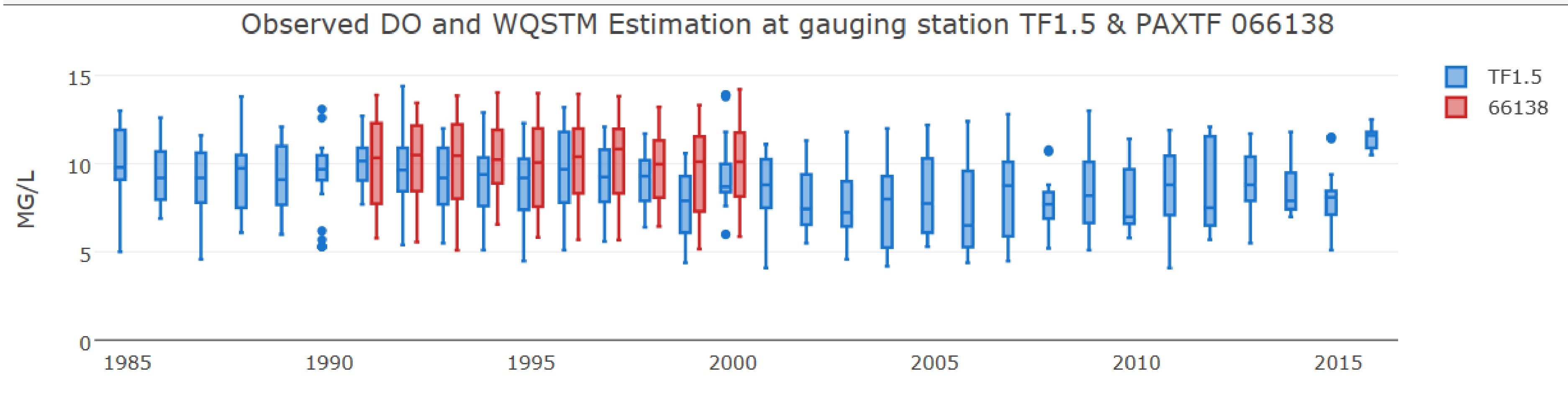
Dissolved oxygen





The optimal value of correlation coefficient is 1 and percent Bias is 0


Observed DO and WQSTM Estimation at gauging station WT2.1 & GUNOH 119233
MG/L
0
5
10
15
1985
1990
1995
2000
2005
2010
2015
WT2.1
119233
125%
McAfee
Page
Safety
Tools


Observed DO and WQSTM Estimation at gauging station TF1.5 & PAXTF 066138
MG/L
0
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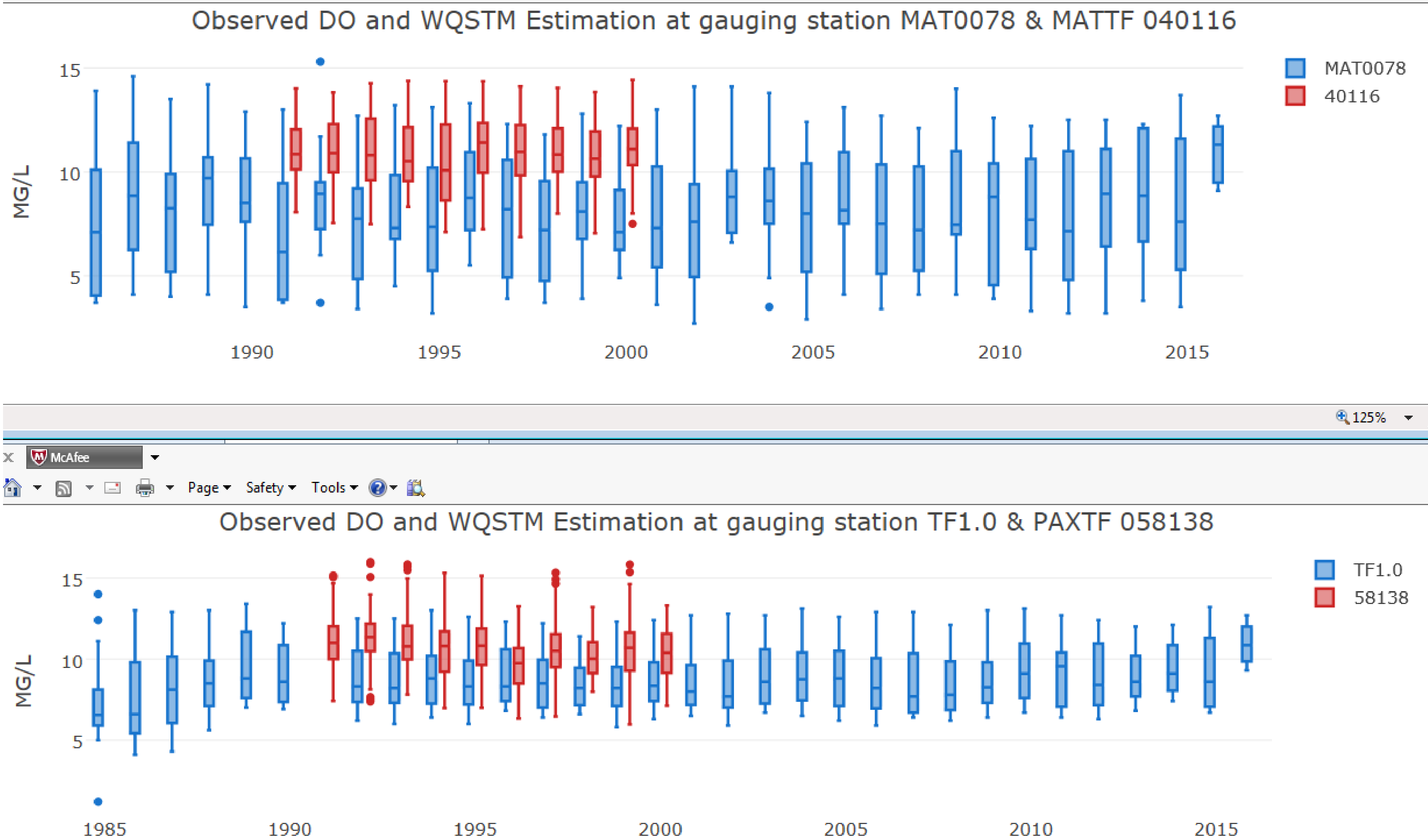
2005
2010
2015
TF1.5
66138


Observed DO and WQSTM Estimation at gauging station MAT0078 & MATTF 040116
MG/L
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10
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1995
2000
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2010
2015
MAT0078
40116
125%
McAfee
Page
Safety
Tools
Observed DO and WQSTM Estimation at gauging station TF1.0 & PAXTF 058138
MG/L
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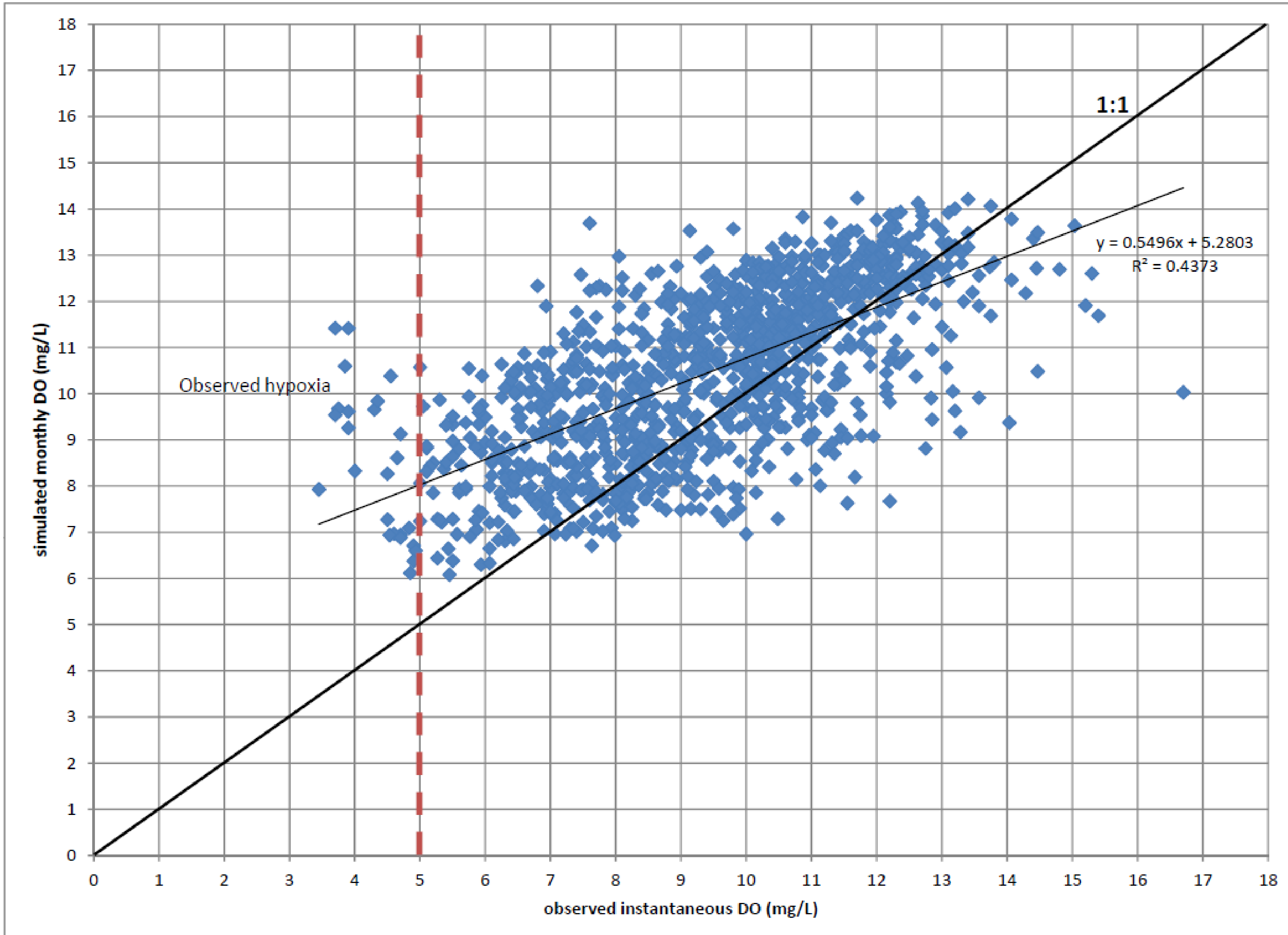
TF1.0
58138


simulated monthly DO (mg/L)
observed instantaneous DO (mg/L)
1:1
y = 0.5496x + 5.2803
R² = 0.4373
Observed hypoxia
0
1
2
3
4
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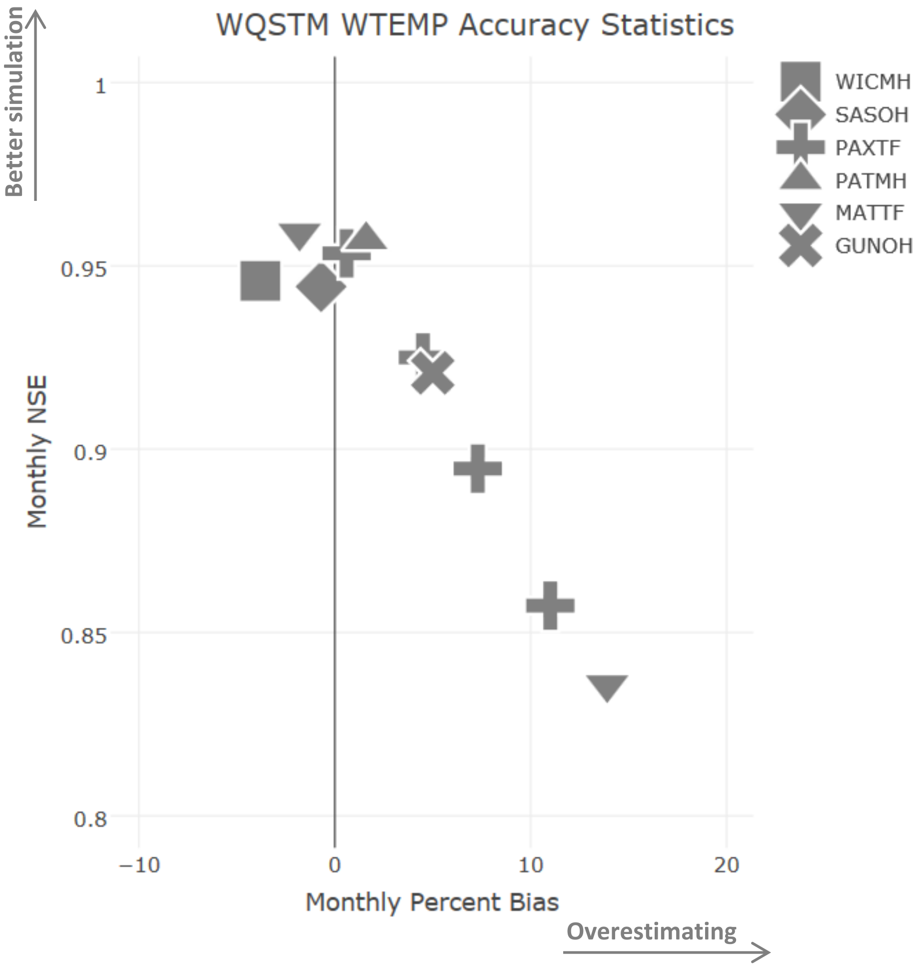
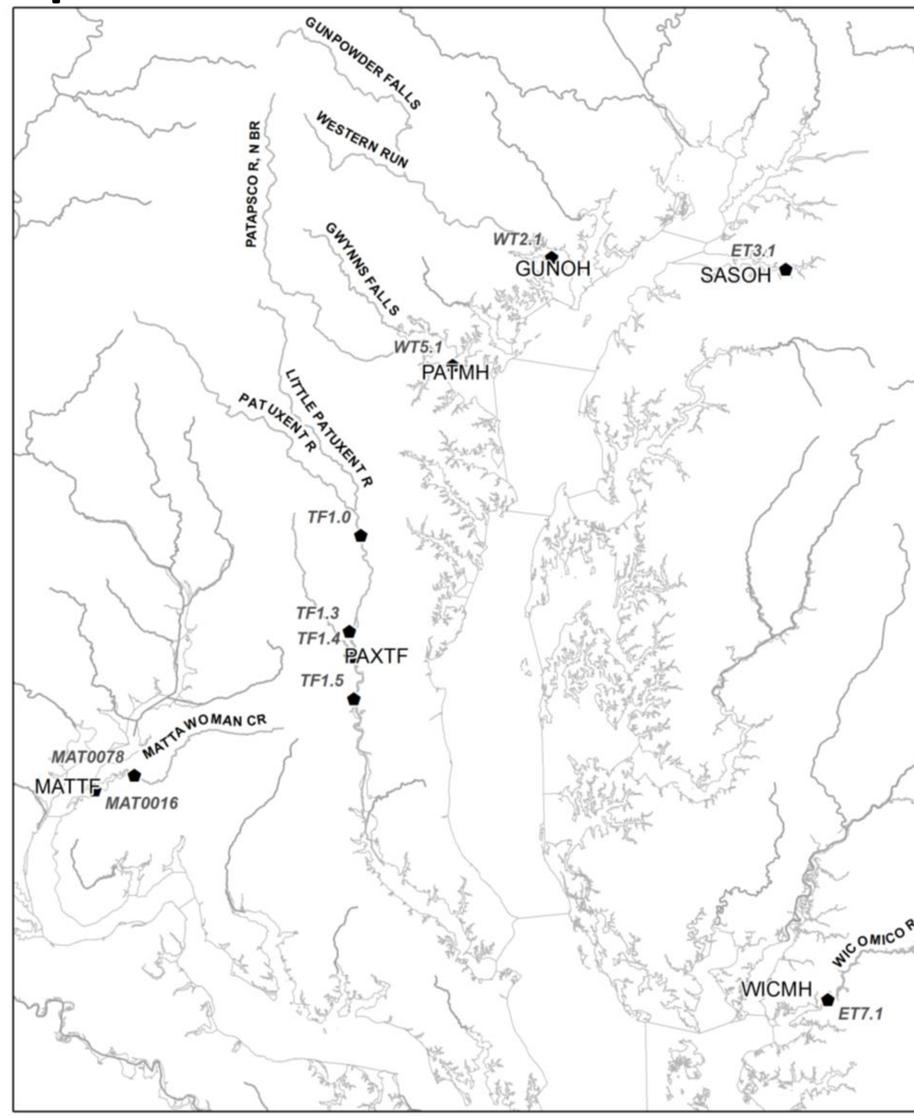
7
8
9
10
11
12
13
14
15
16
17
18

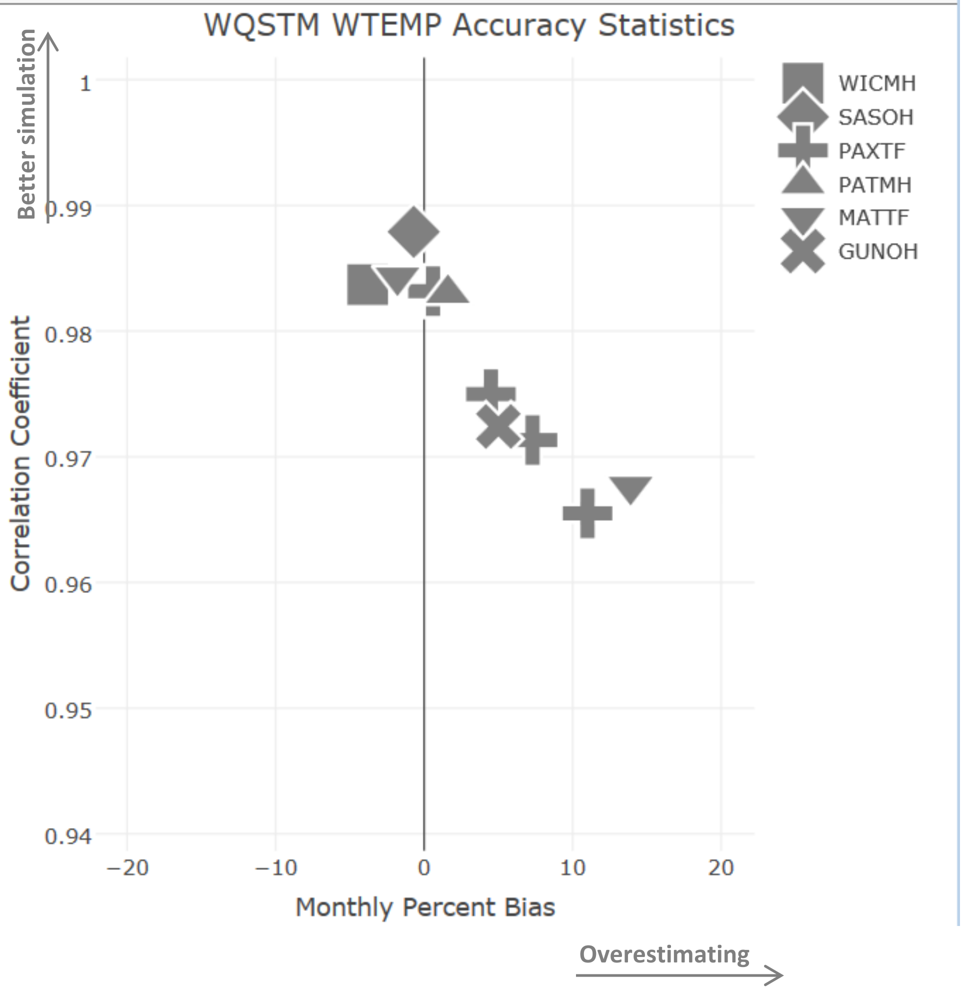
Water temperature

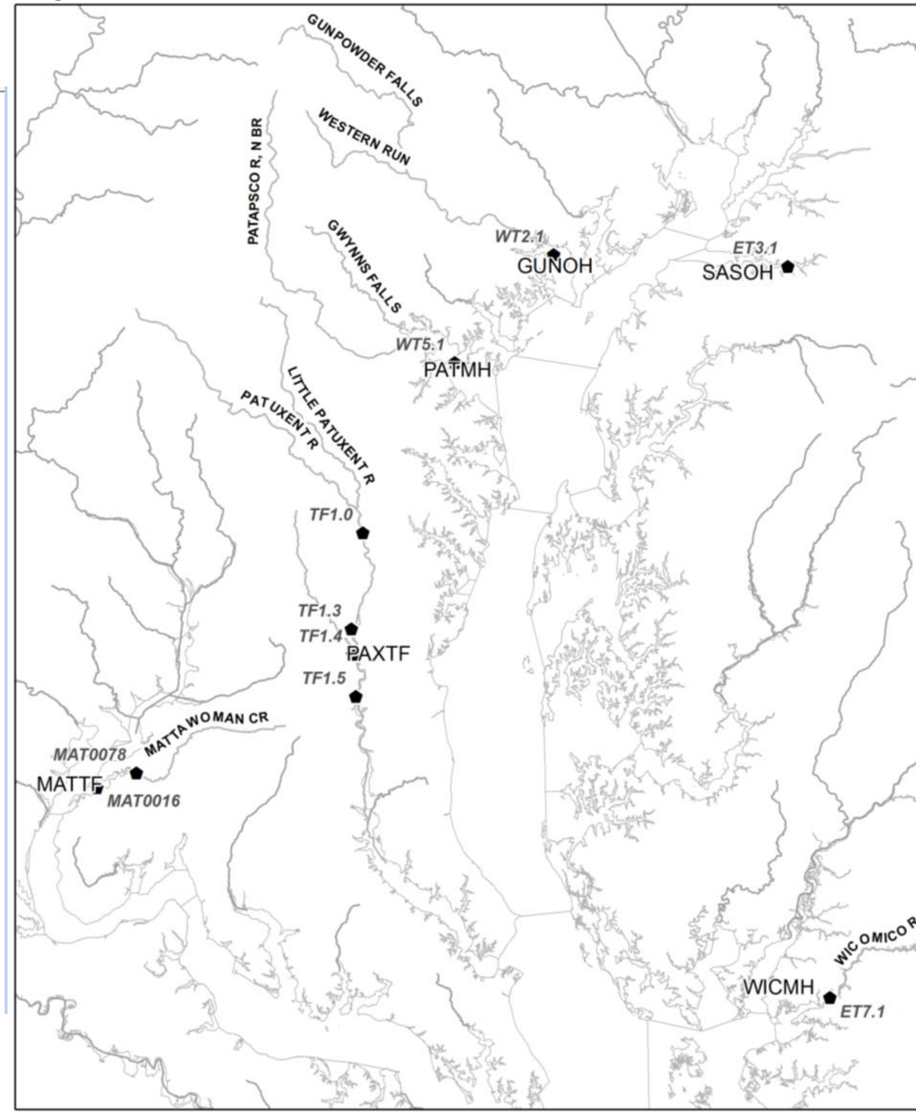




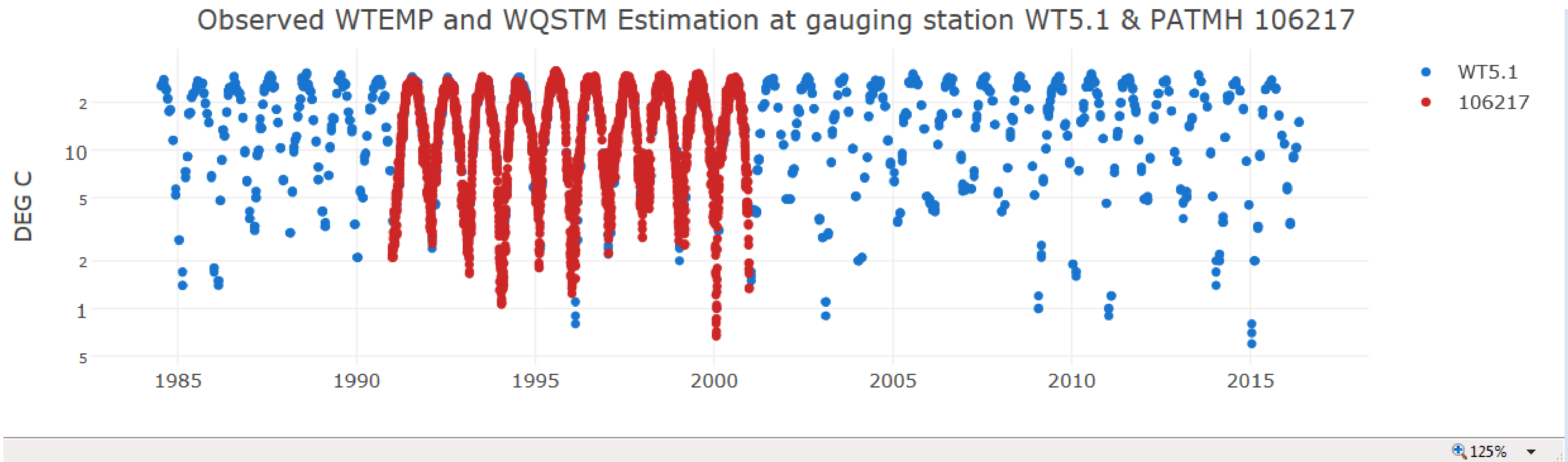
The optimal value of NSE is 1 and percent bias is 0

Water temperature





The optimal value of correlation coefficient is 1 and percent bias is 0


Observed WTEMP and WQSTM Estimation at gauging station WT5.1 & PATMH 106217
DEG C
WT5.1
106217
1985
1990
1995
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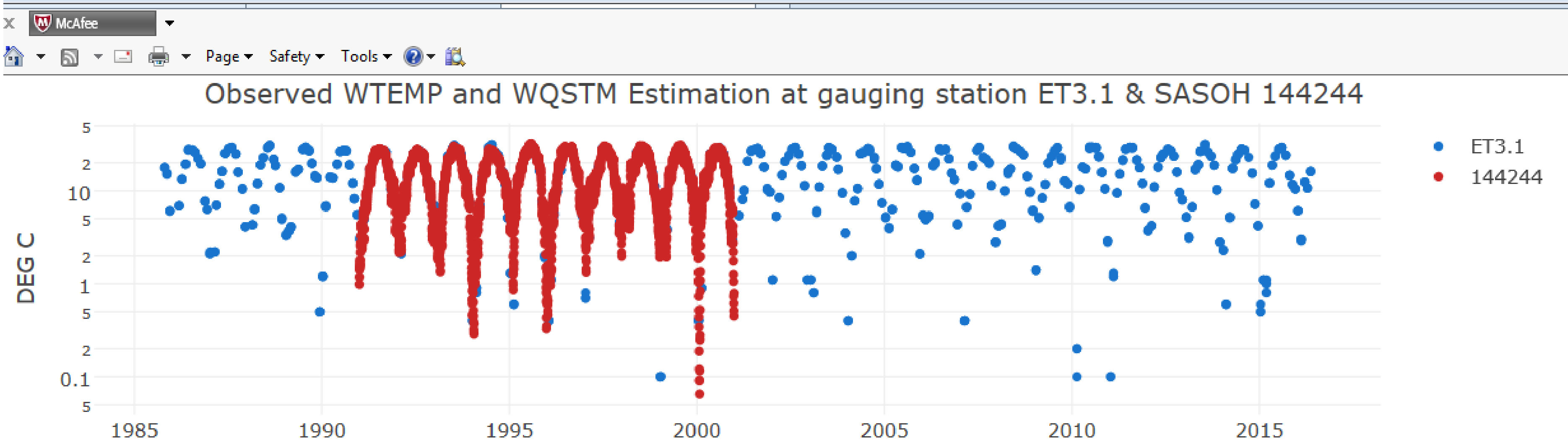
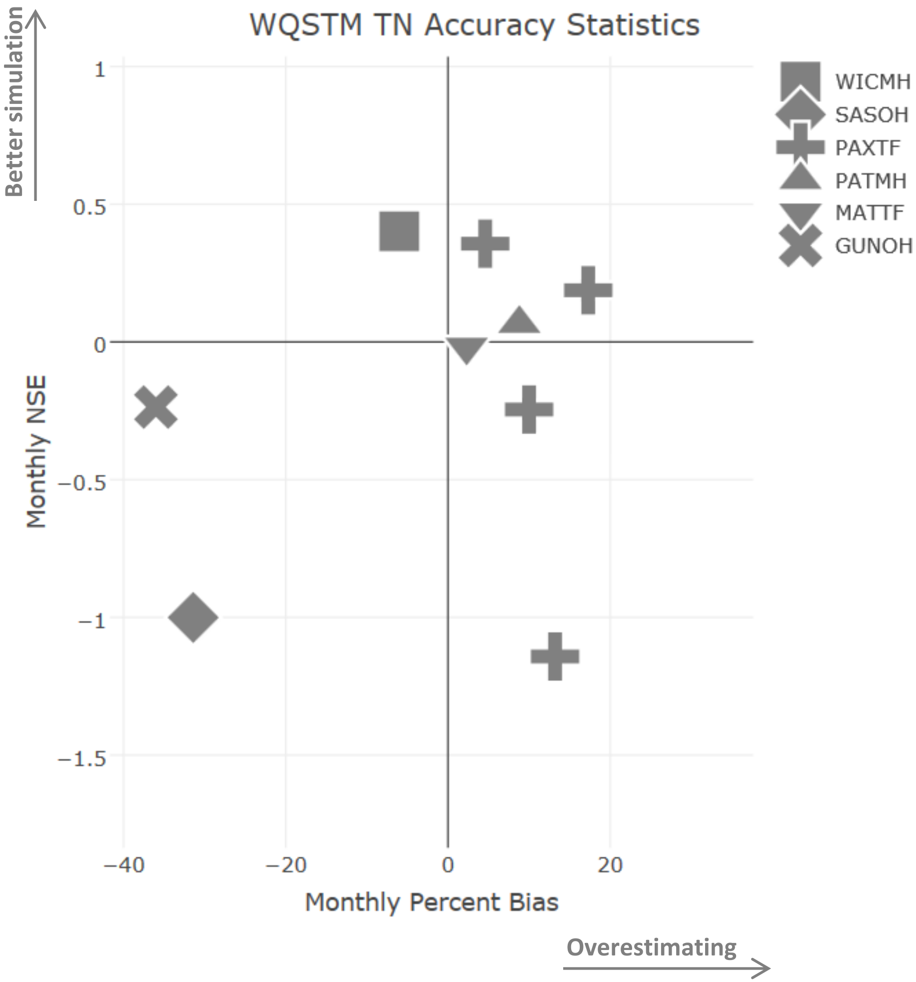
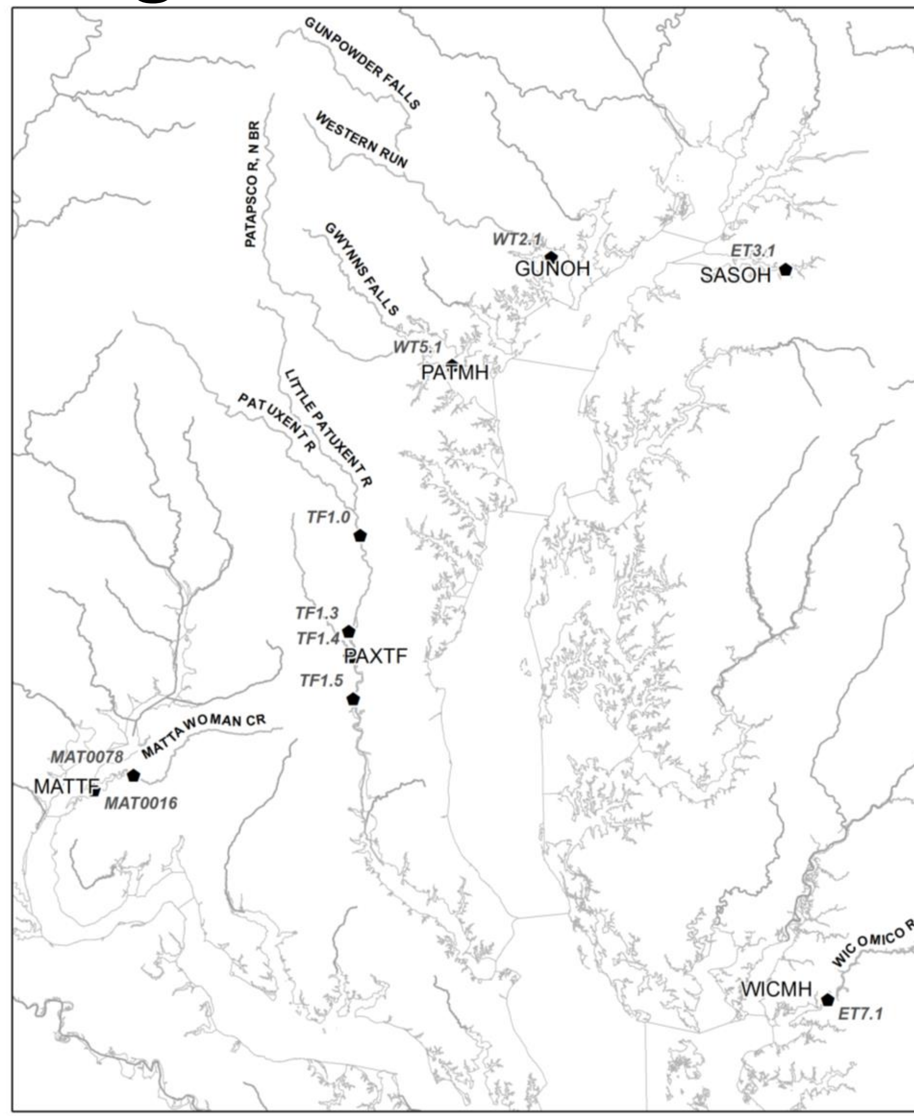
2005
2010
2015
125%


McAfee
Page
Safety
Tools
Observed WTEMP and WQSTM Estimation at gauging station ET3.1 & SASOH 144244
DEG C
ET3.1
144244
1985
1990
1995
2000
2005
2010
2015

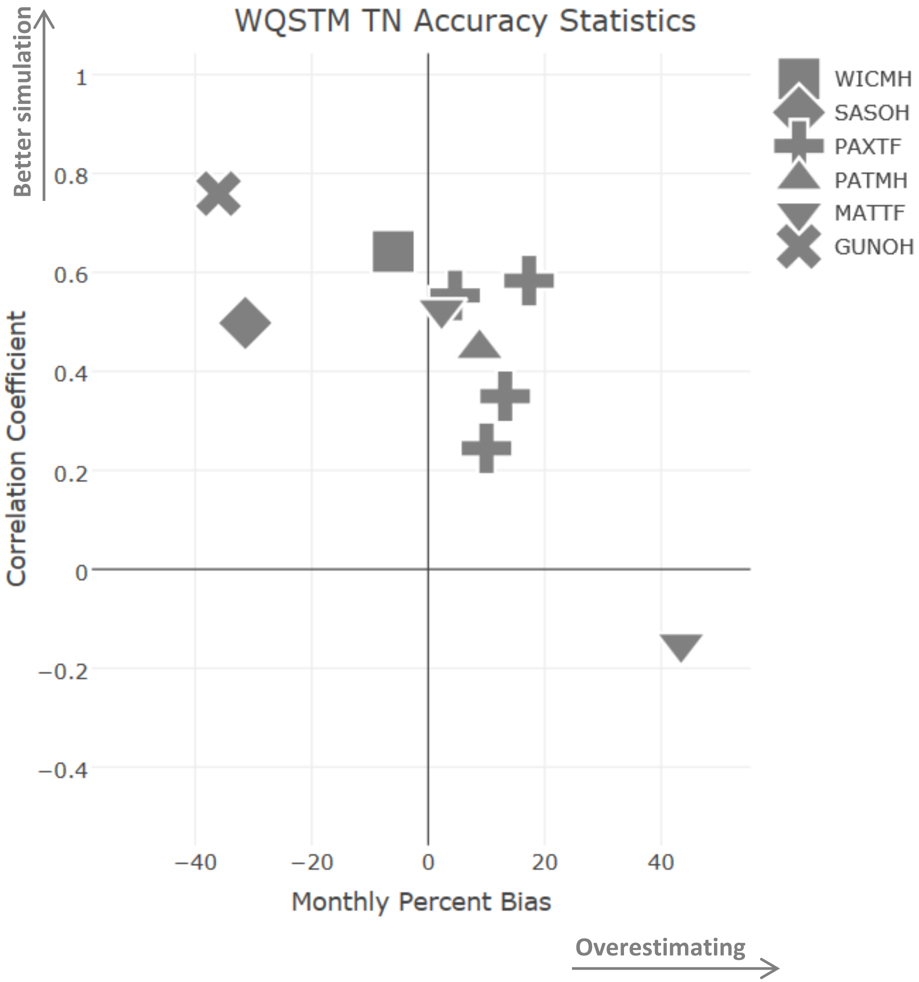
Total nitrogen

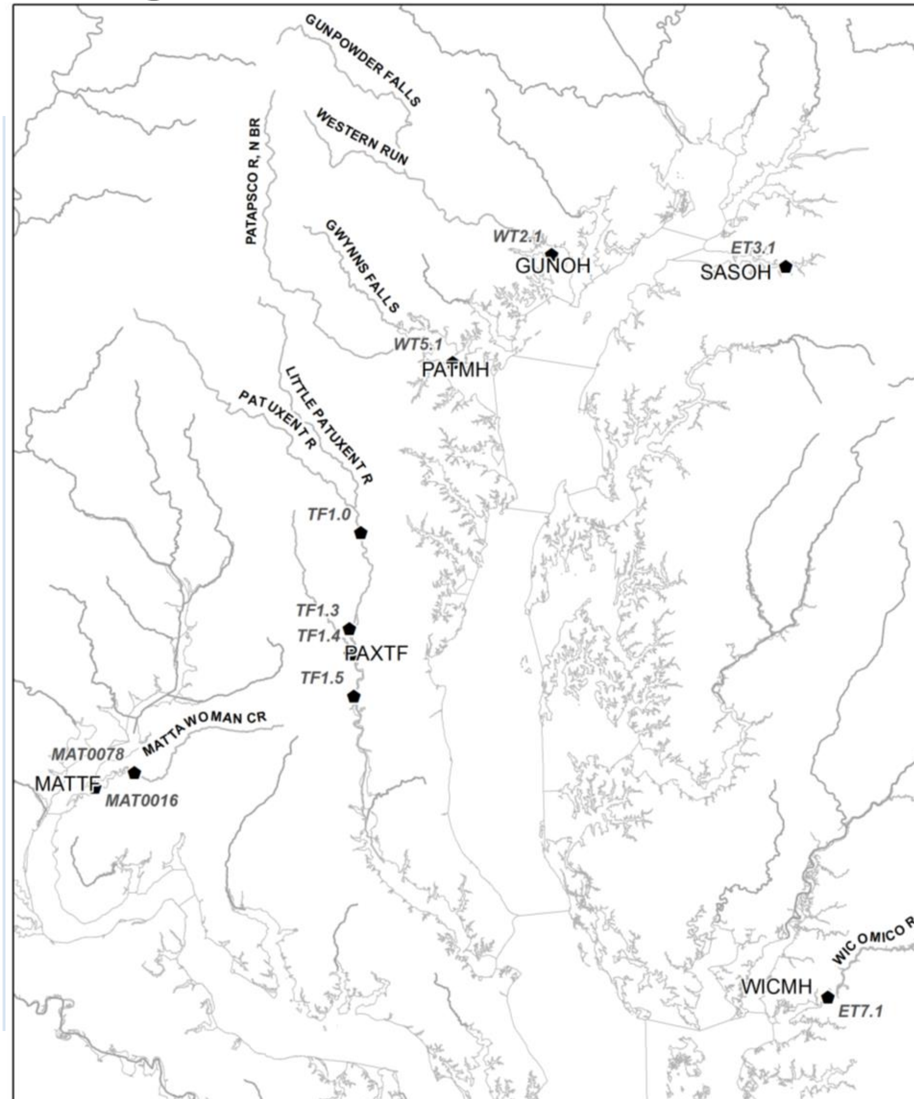




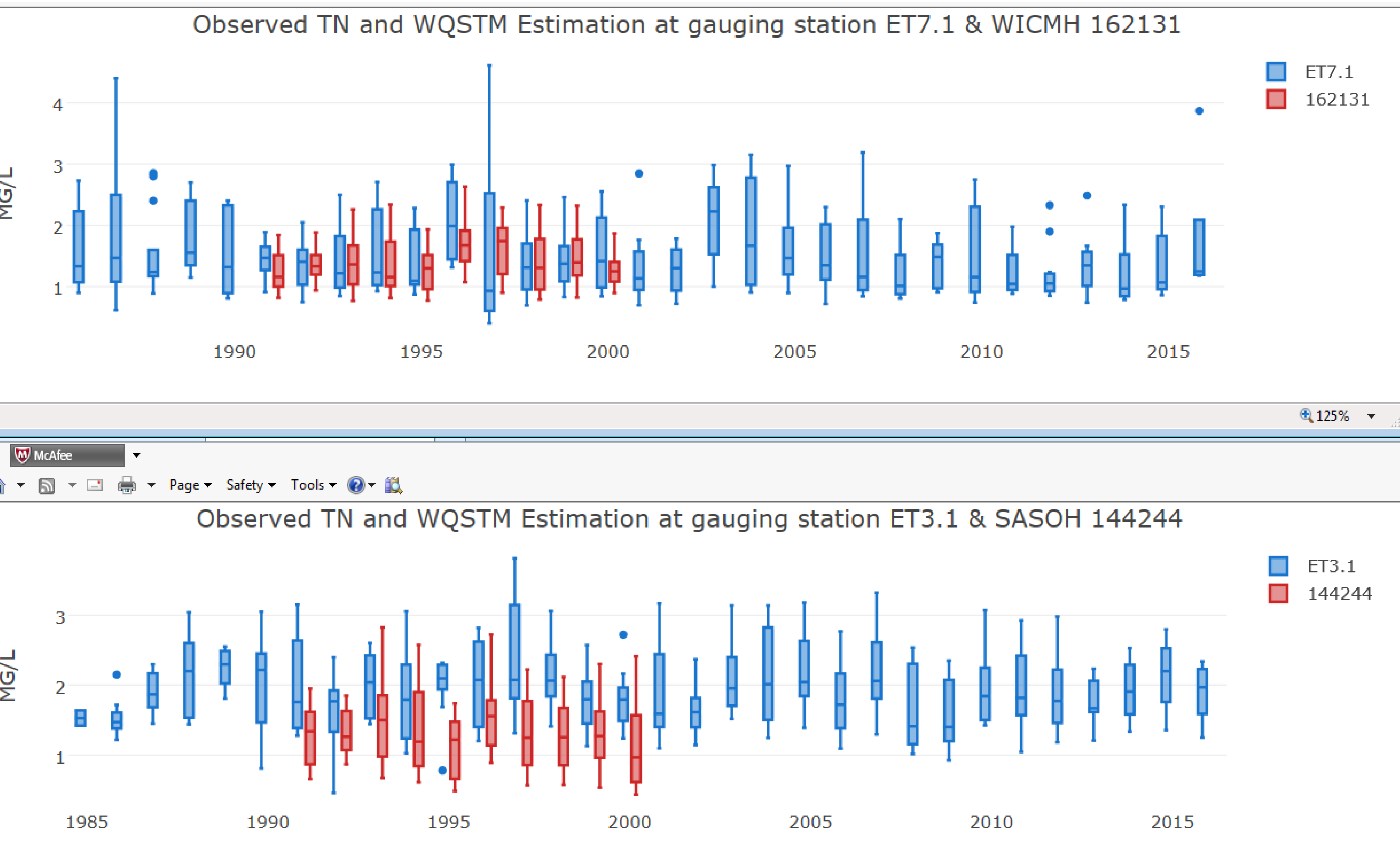
The optimal value of NSE is 1 and percent bias is 0

Total nitrogen





The optimal value of correlation coefficient is 1 and percent bias is 0


Observed TN and WQSTM Estimation at gauging station ET7.1 & WICMH 162131
ET7.1
162131
MG/L
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1990
1995
2000
2005
2010
2015
125%
McAfee
Page
Safety
Tools
Observed TN and WQSTM Estimation at gauging station ET3.1 & SASOH 144244
ET3.1
144244
MG/L
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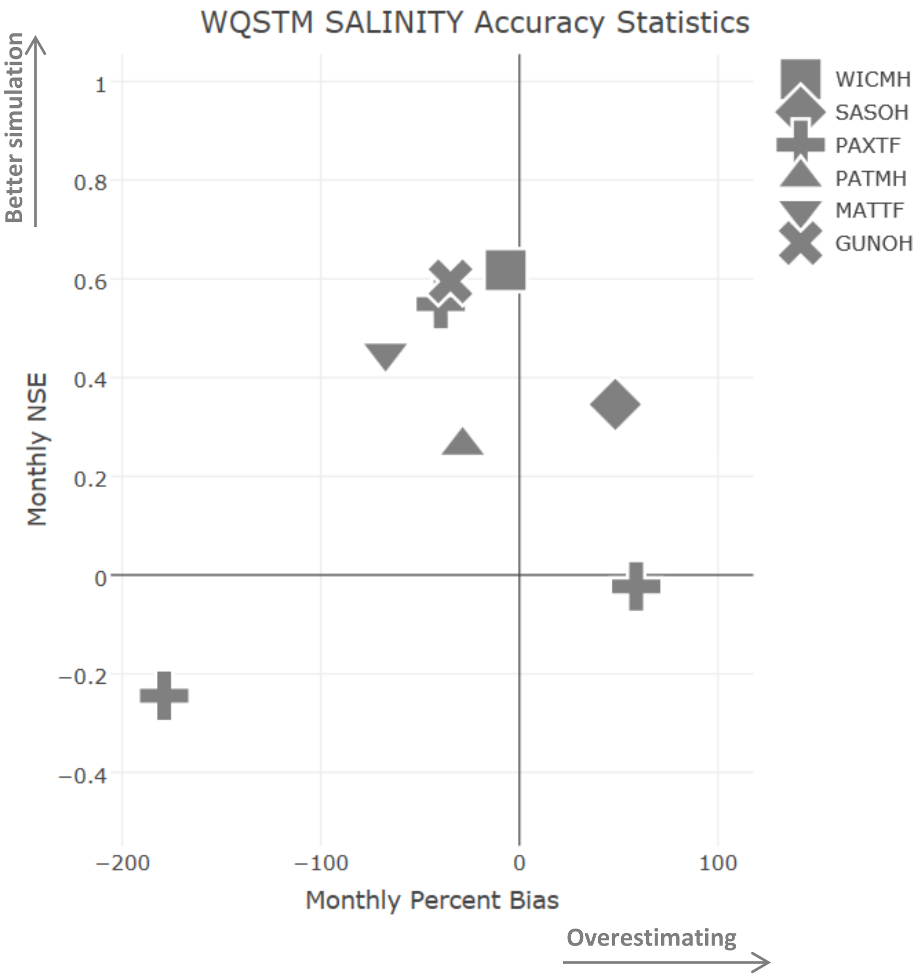
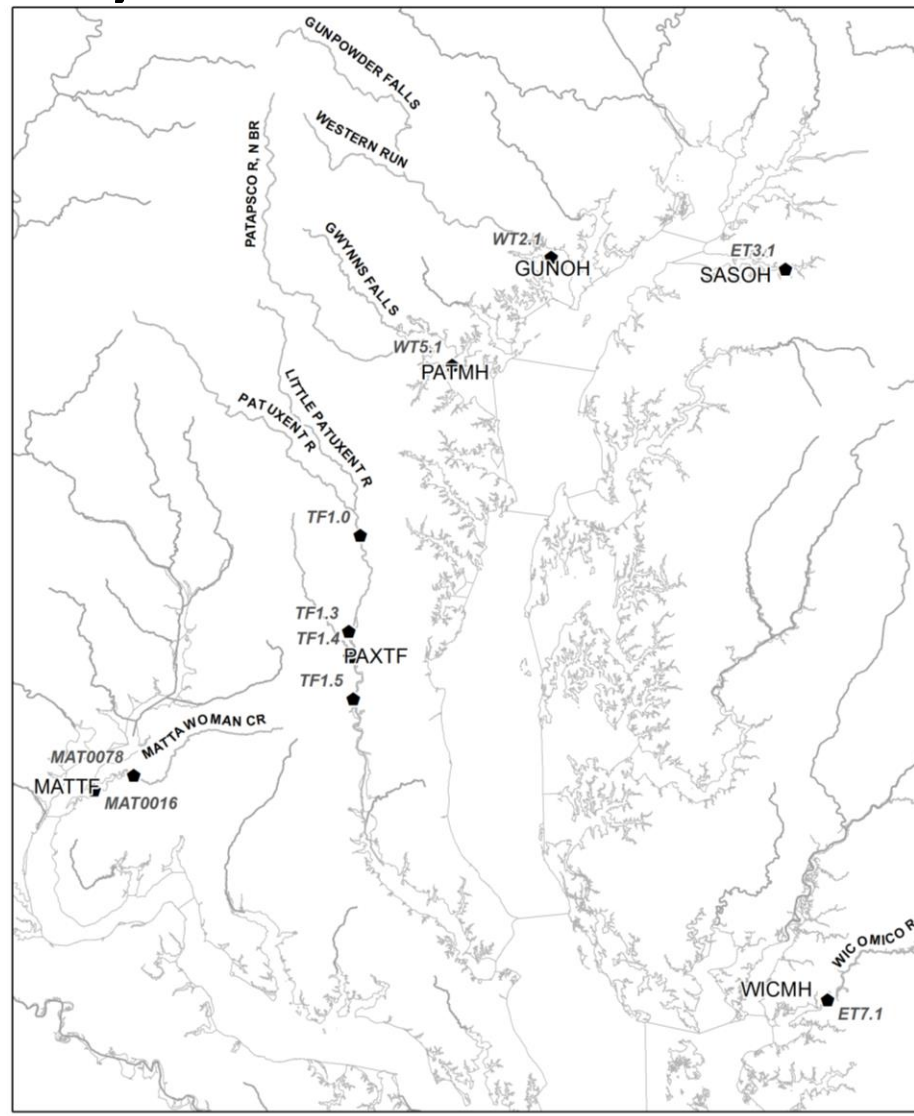
2010
2015

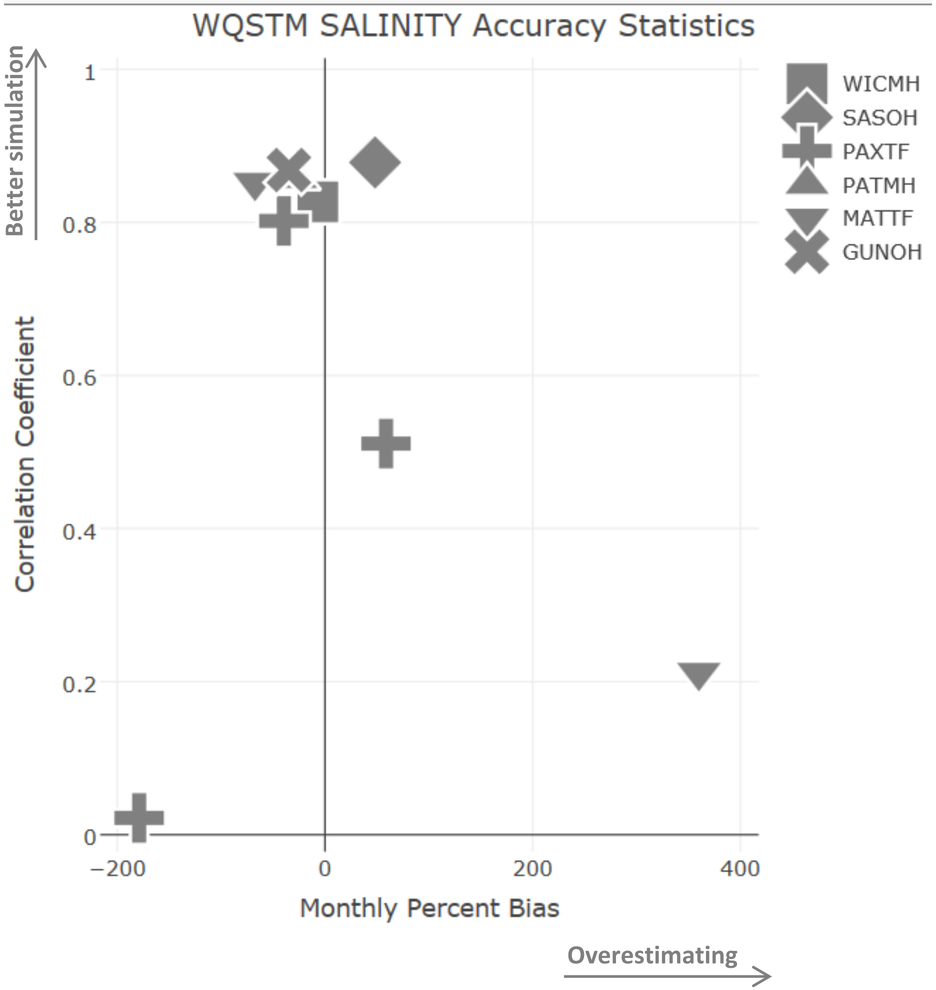
Salinity

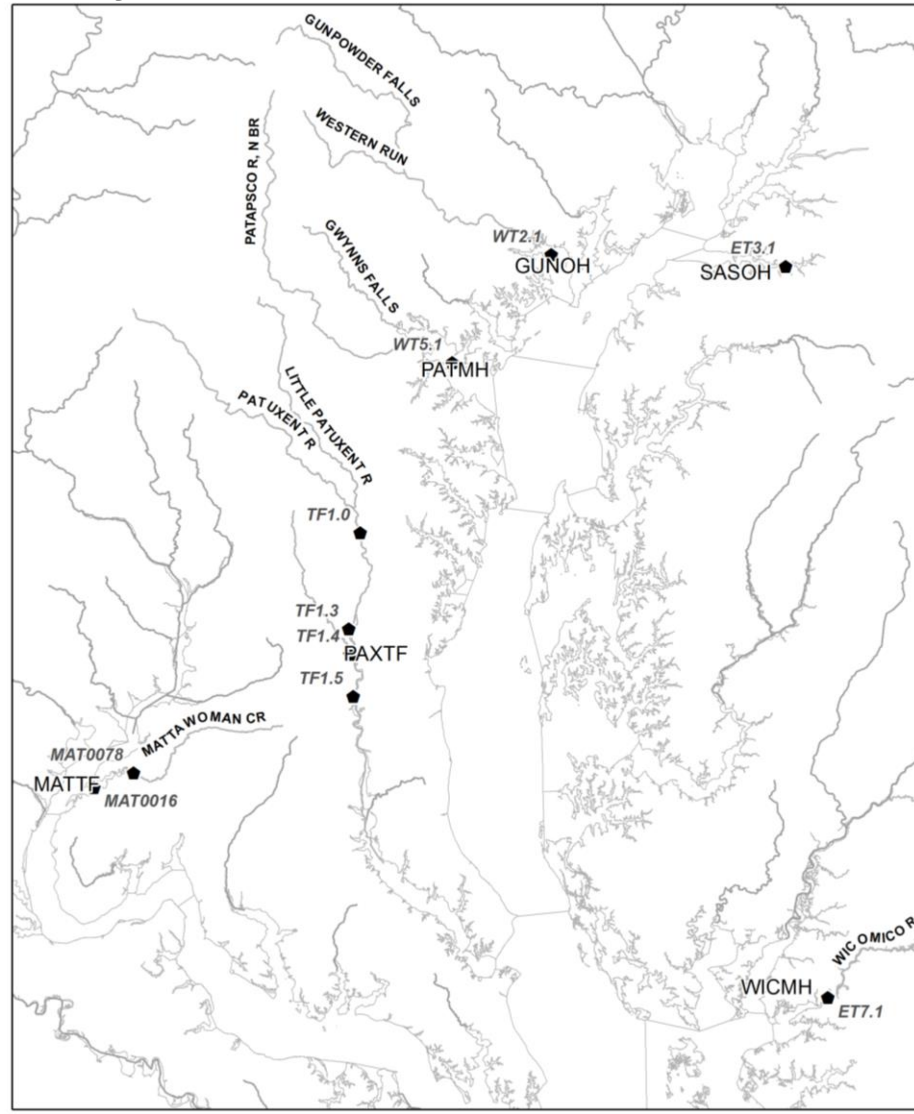




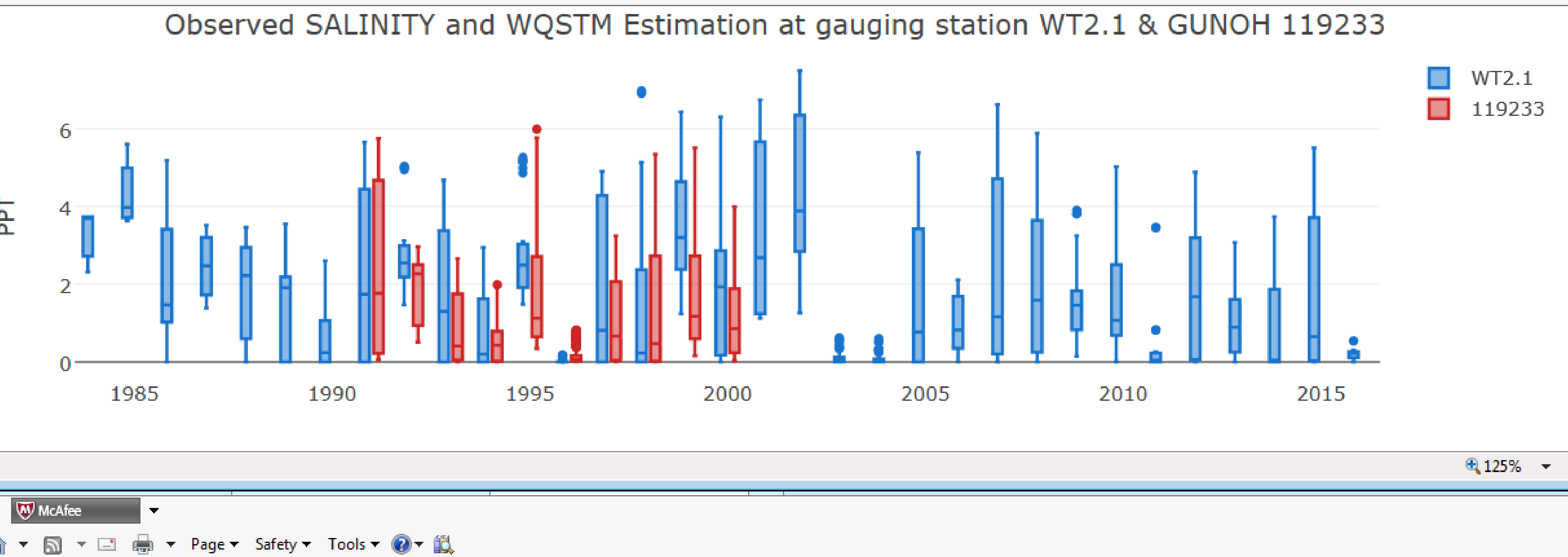
The optimal value of NSE is 1 and percent bias is 0

Salinity





The optimal value of correlation coefficient is 1 and percent bias is 0


Observed SALINITY and WQSTM Estimation at gauging station WT2.1 & GUNOH 119233
WT2.1
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PPT
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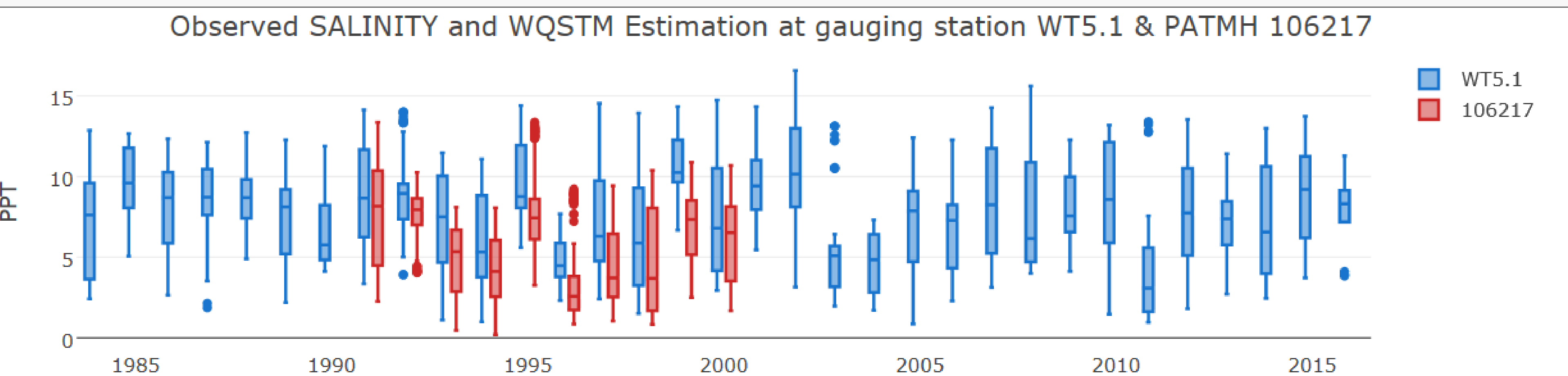
2005
2010
2015
125%
McAfee
Page
Safety
Tools


Observed SALINITY and WQSTM Estimation at gauging station WT5.1 & PATMH 106217
WT5.1
106217
PPT
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1995
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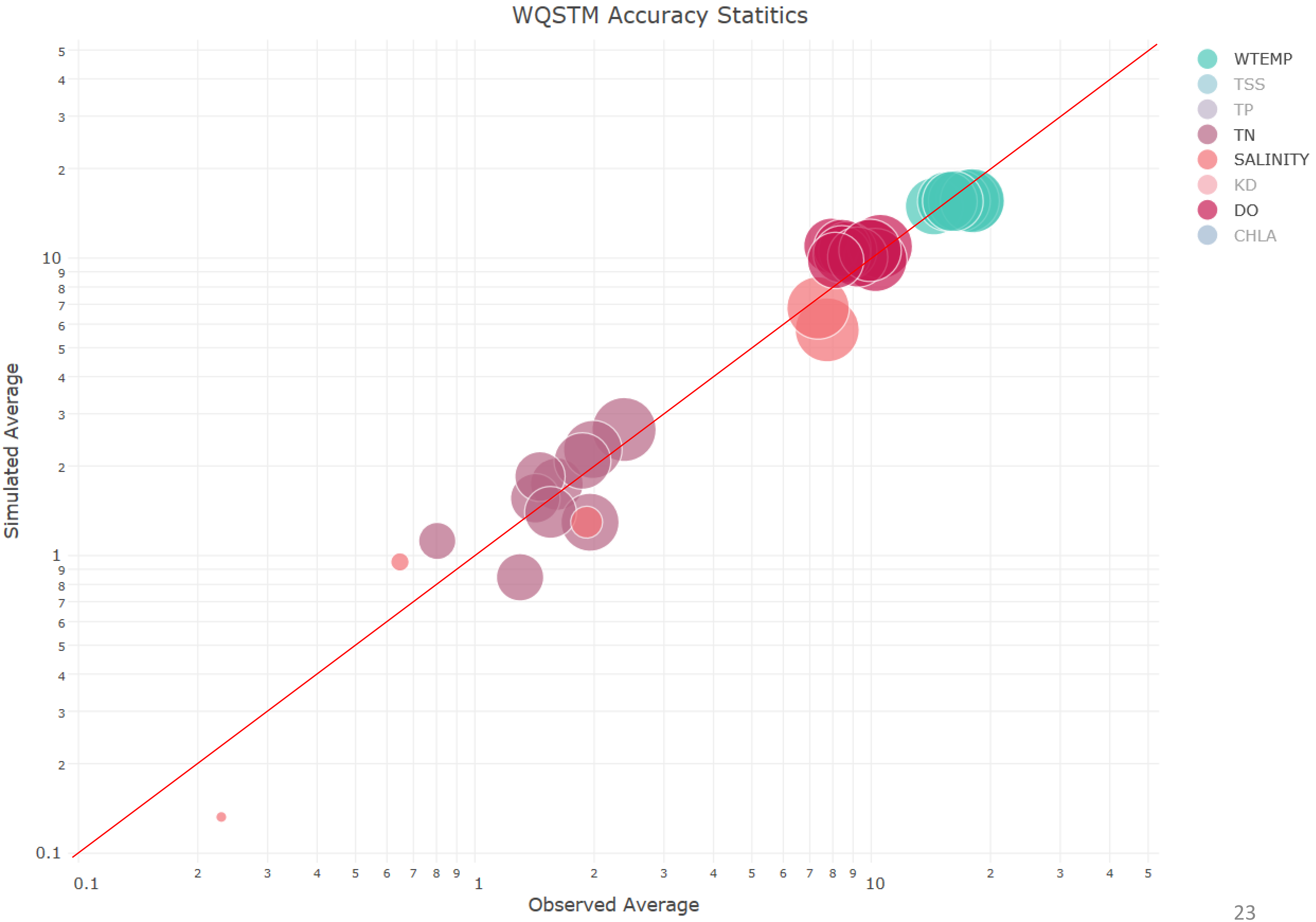
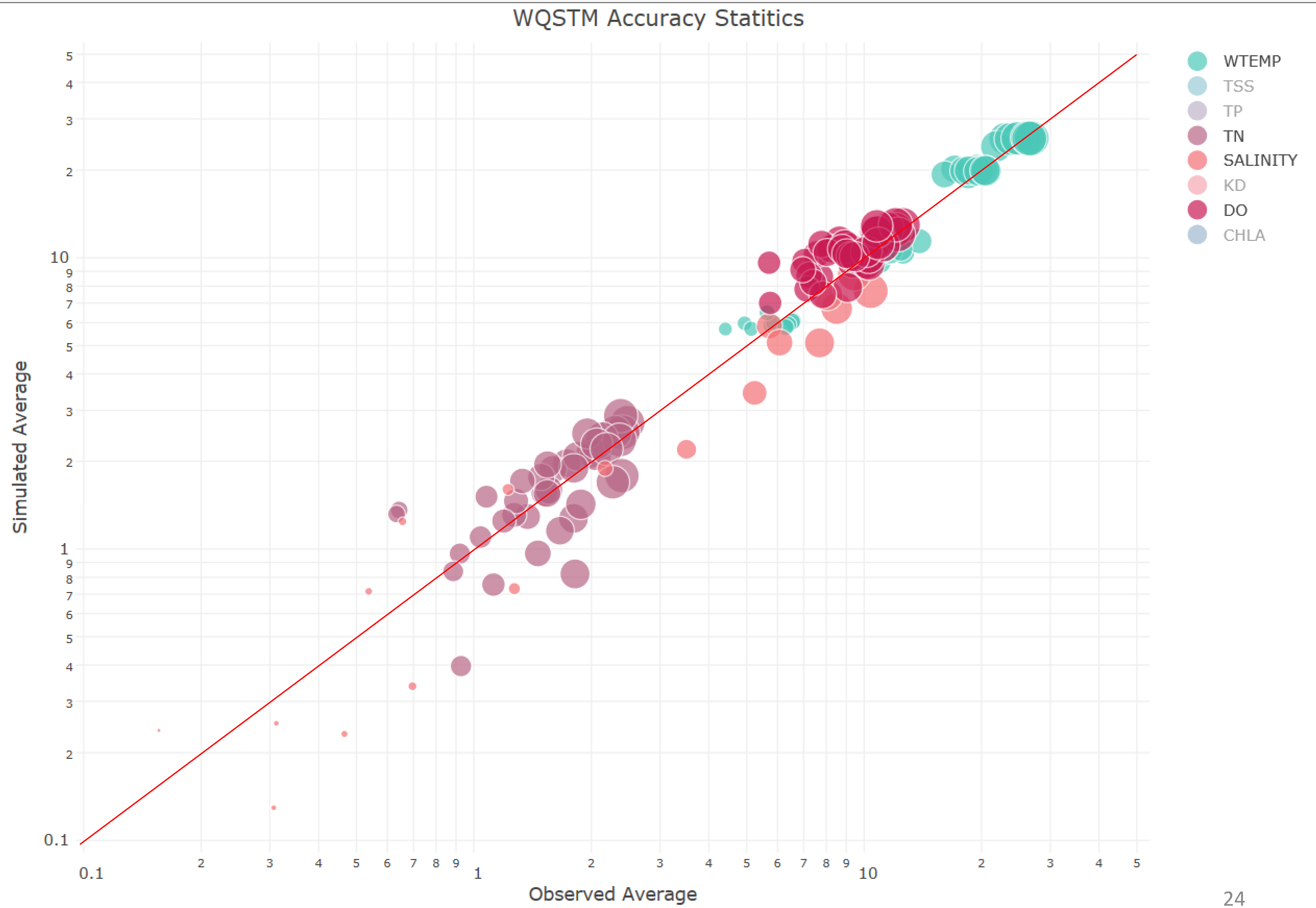
2015



WQSTM Accuracy Statitics
WTEMP
TSS
TP
TN
SALINITY
KD
DO
CHLA
Simulated Average
Observed Average
0.1
1
10


WQSTM Accuracy Statitics
Simulated Average
Observed Average
0.1
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6
7
8
9
WTEMP
TSS
TP
TN
SALINITY
KD
DO
CHLA

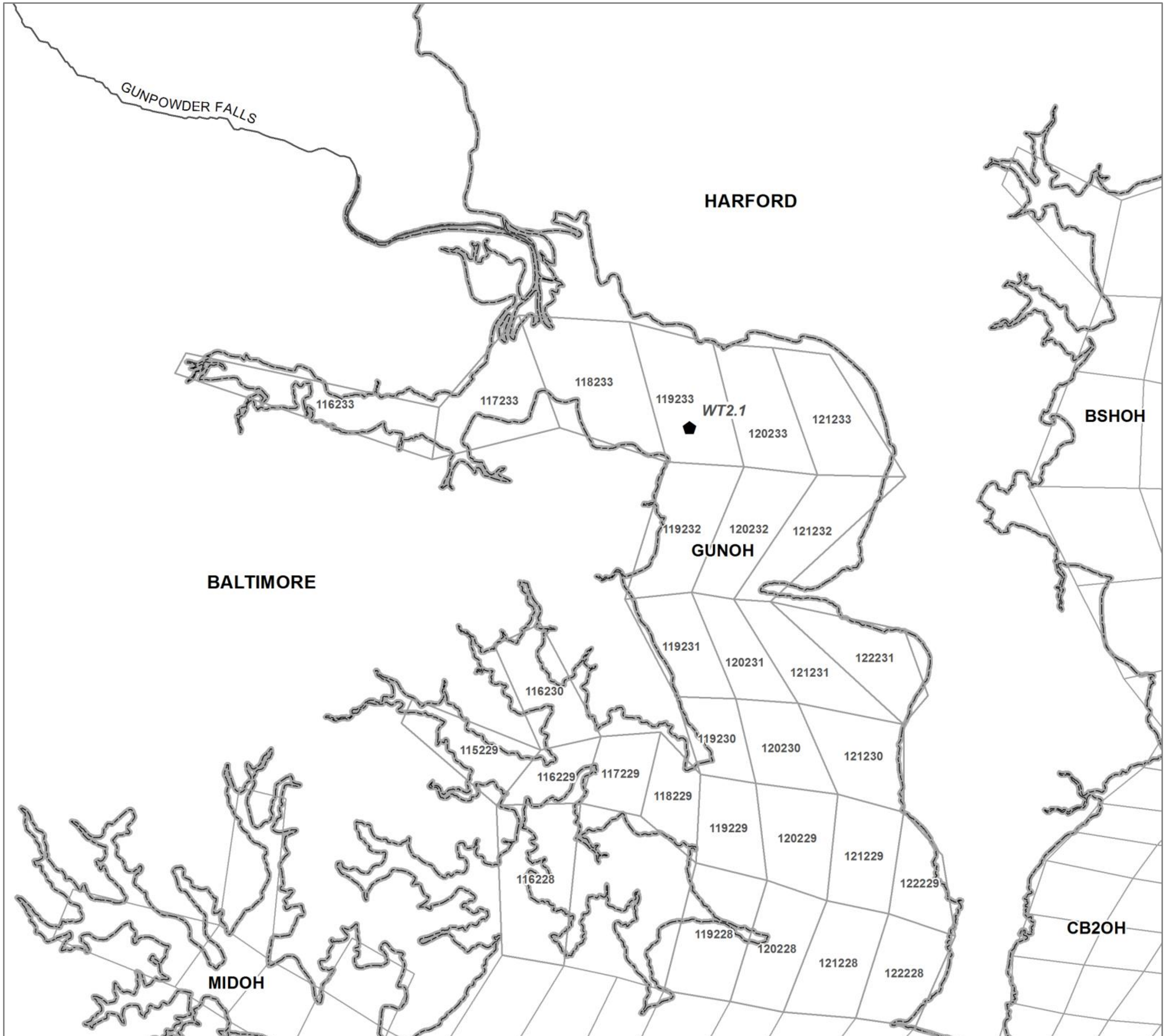
Results

- Most simulated monthly values were within the satisfactory range. Temperature, total nitrogen and dissolved oxygen simulations registered the lowest PBIAS values
- Simulated temperature was very good in terms of trends. Simulated dissolved oxygen, salinity, and total nitrogen registered NSE values greater than zero in many instances
- DO is well represented in the model calibration, though some hypoxic conditions are not captured, at least in the surface layer
- Calibration results for mesohaline and oligohaline segments were better than for tidal fresh systems. Tidal fresh systems tend to perform better at the stations near oligohaline segments

Next Steps

- Get feedback from modeling workgroup
- Re-run methodology for subsequent model calibrations and include sub-surface layers.
- Consider expanding the model review to all tributaries in Maryland and the mainstem
- Look into the sensitivity of management scenarios

Additional Figures



GUNPOWDER FALLS
HARFORD
116233
117233
118233
119233
WT2.1
120233
121233
BSHOH
119232
120232
121232
GUNOH
BALTIMORE
119231
120231
121231
122231
116230
119230
120230
121230
115229
116229
117229
118229
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120229
121229
122229
116228
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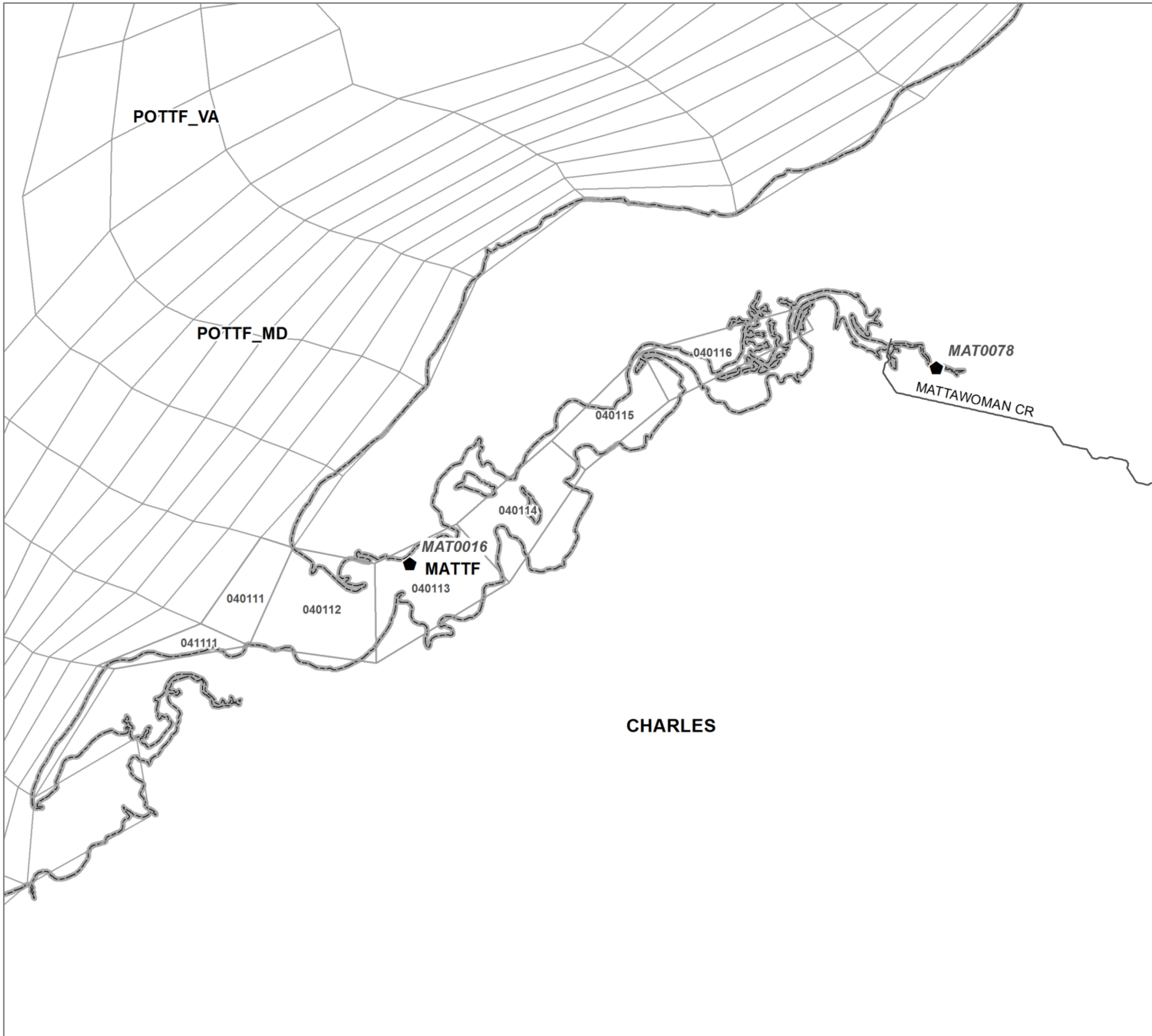
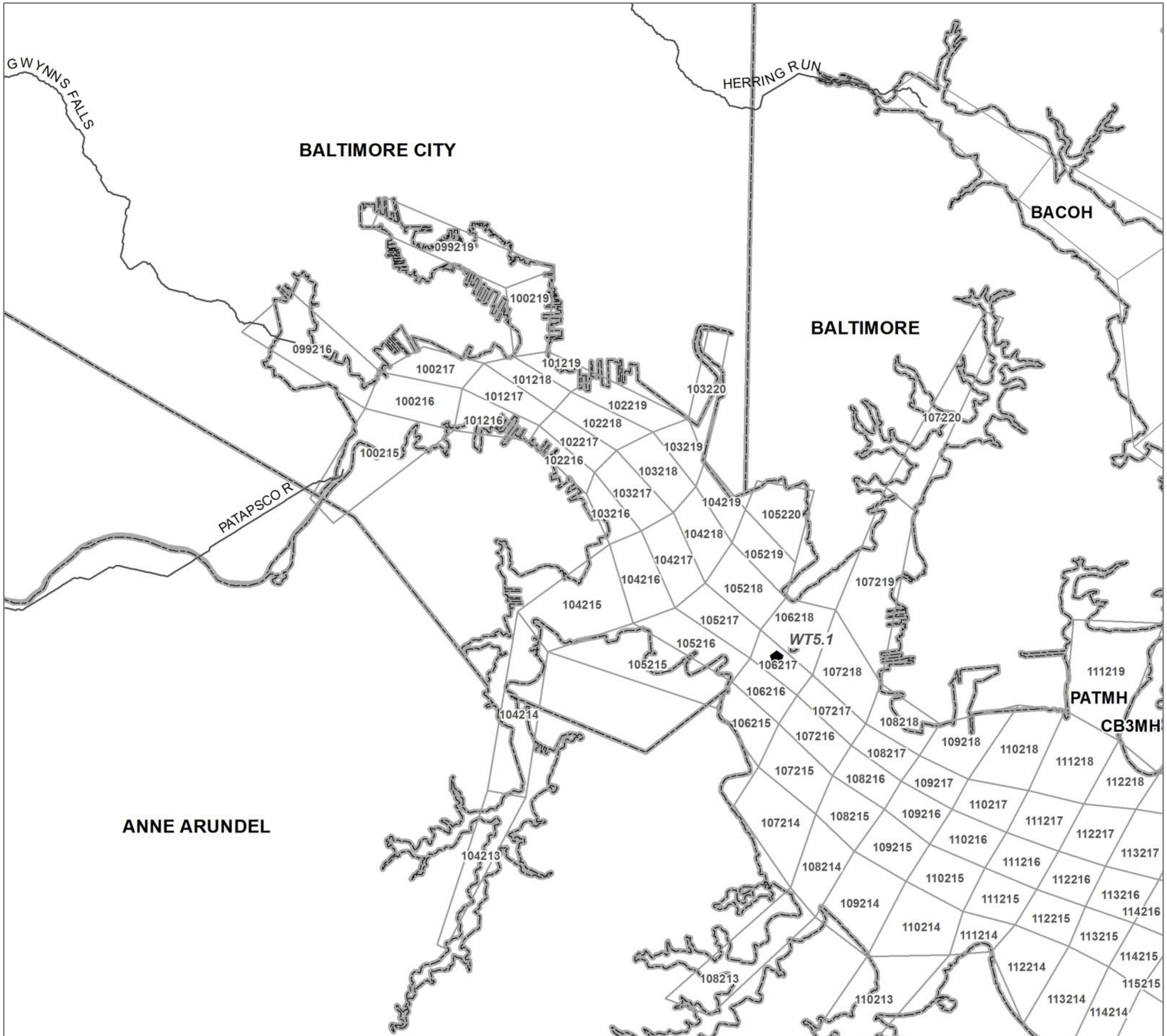
122228
CB2OH
MIDOH


POTTF_VA
POTTF_MD
040116
MAT0078
MATTAWOMAN CR
040115
040114
MAT0016
MATTF
040113
040111
040112
041111
CHARLES


GWYNNS FALLS
HERRING RUN
BALTIMORE CITY
BACOH
BALTIMORE
PATAPSCO R
ANNE ARUNDEL
WT5.1
PATMH
CB3MH
099219
100219
099216
100217
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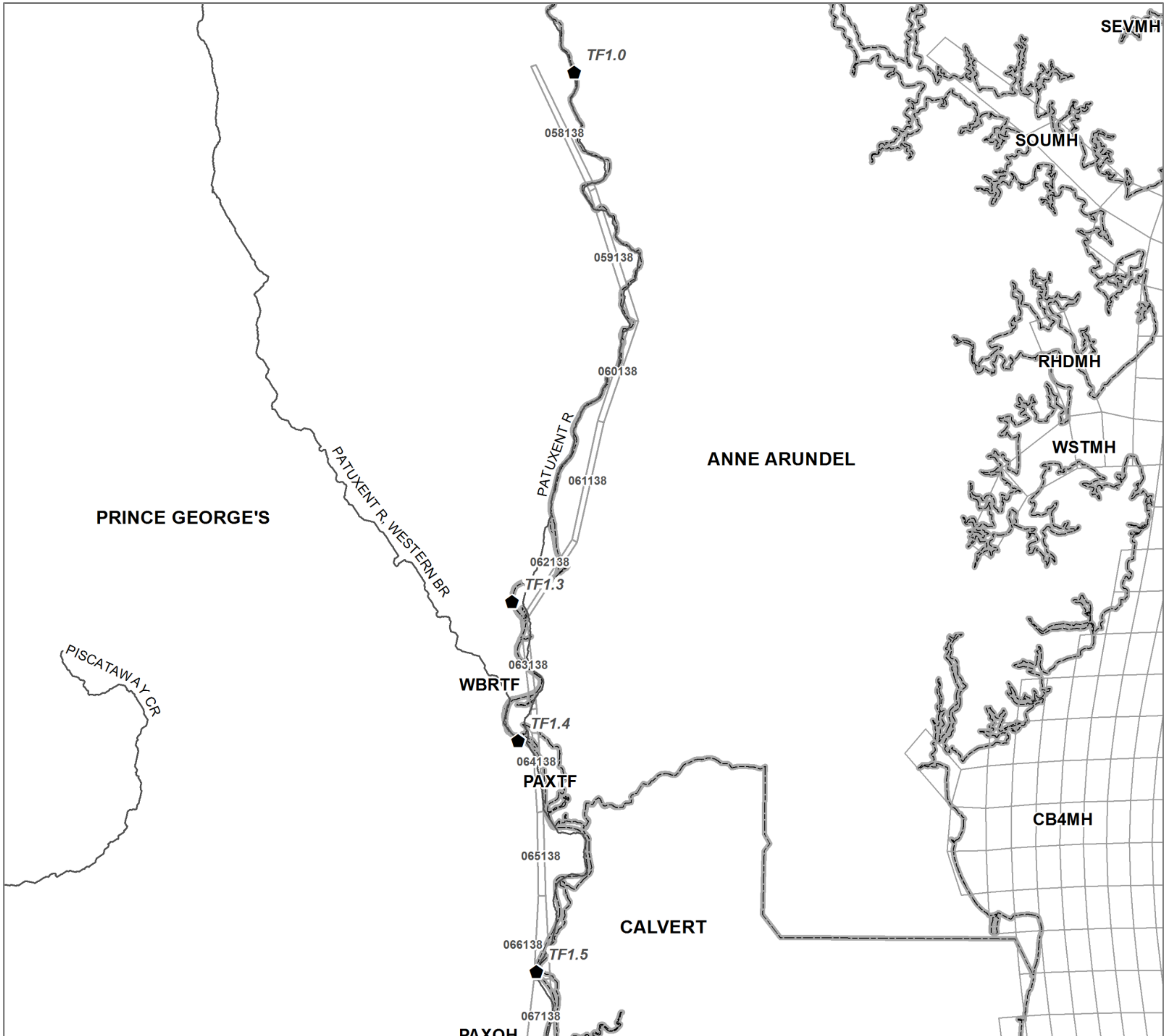
SEVMH
TF1.0
058138
SOUMH
059138
RHDMH
060138
PATUXENT R
WSTMH
ANNE ARUNDEL
061138
PATUXENT R, WESTERN BR
PRINCE GEORGE'S
062138
TF1.3
PISCATAWAY CR
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TF1.4
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PAXTF
CB4MH
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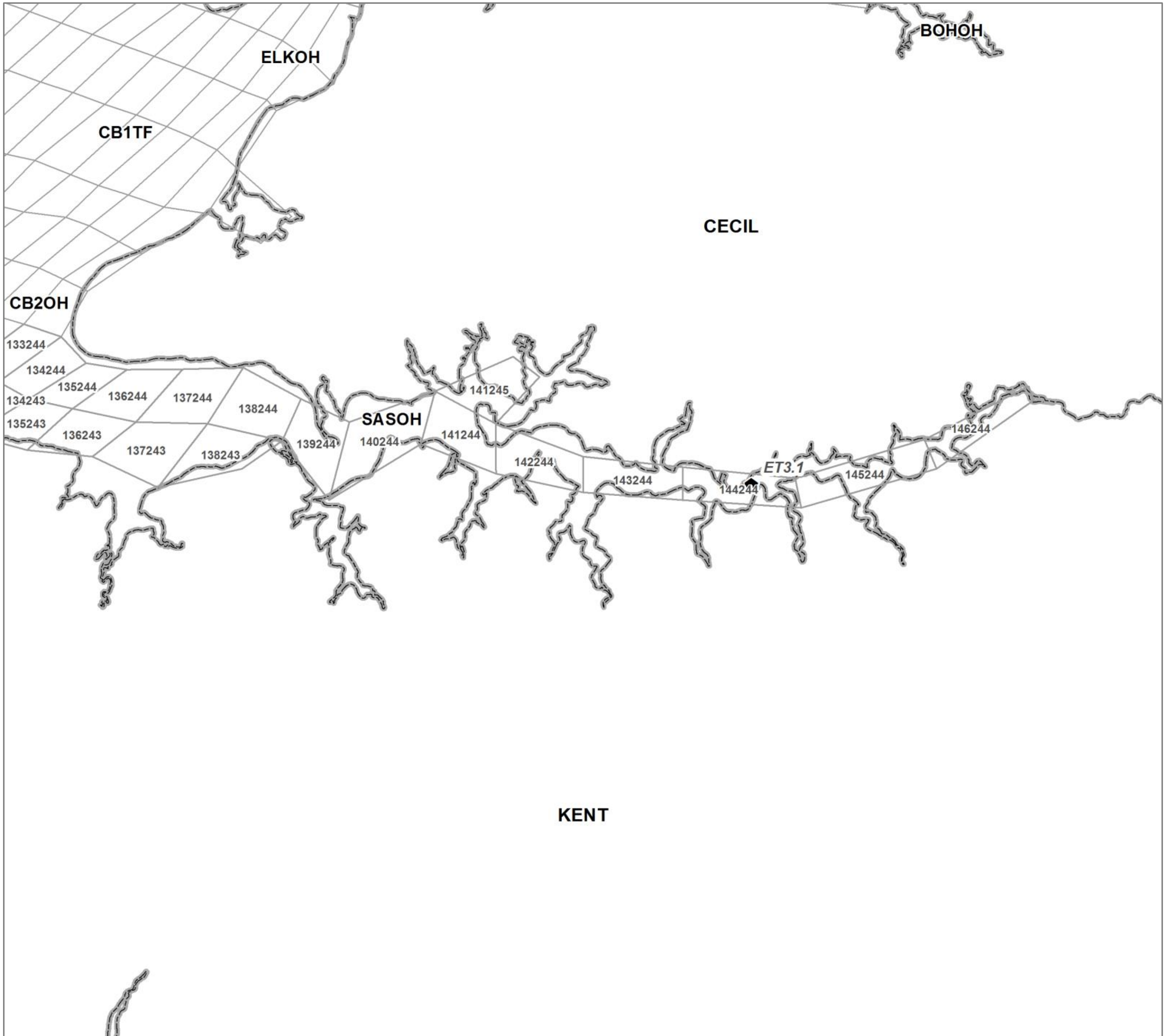
CALVERT
066138
TF1.5
067138
PAXOH


ELKOH
BOHOH
CB1TF
CECIL
CB2OH
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136243
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SASOH
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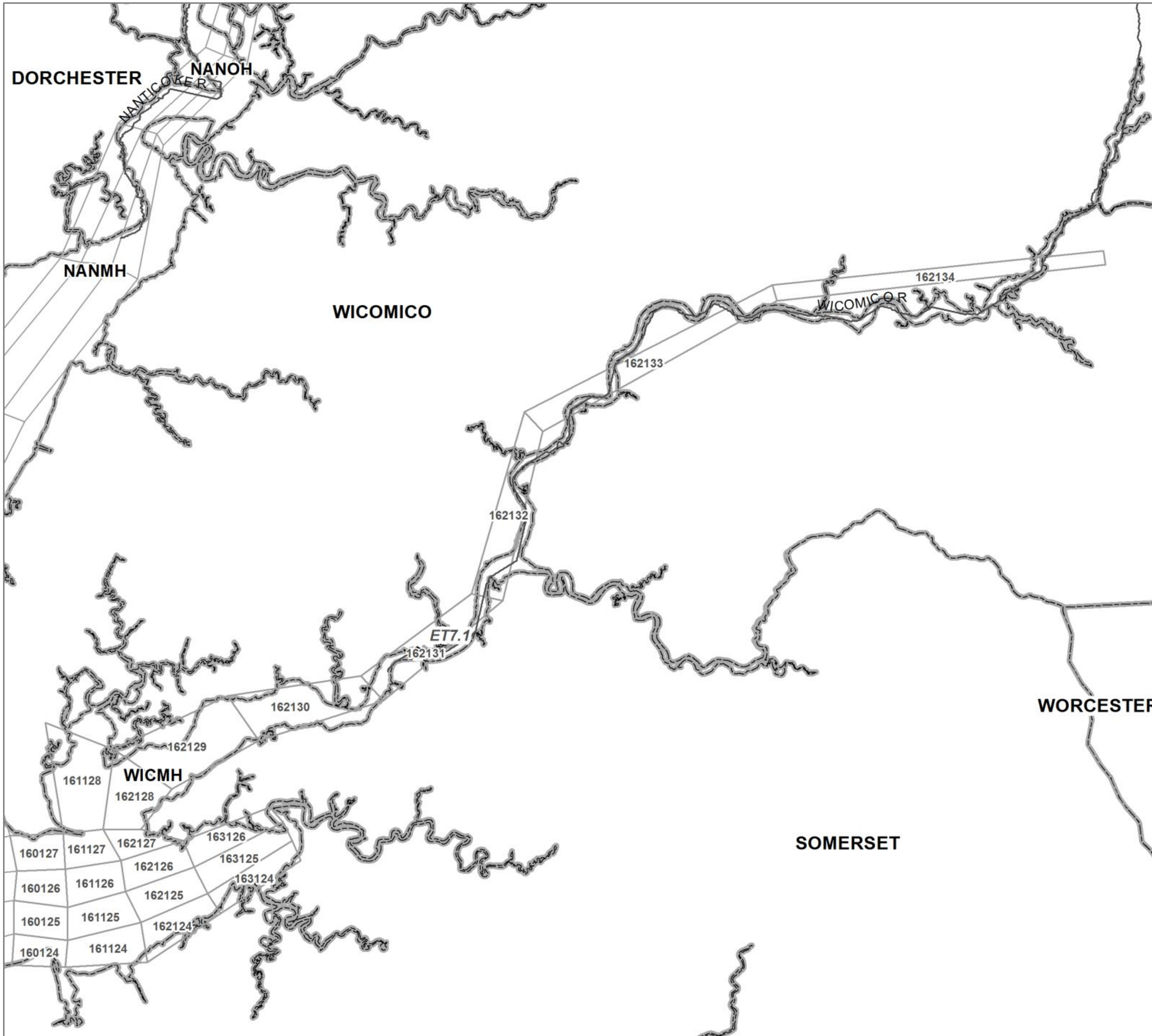
143244
ET3.1
144244
145244
146244
KENT


DORCHESTER
NANOH
NANTICOKE R
NANMH
WICOMICO
162134
WICOMICO R
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WICMH
161128
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163126
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160124
161124
WORCESTER
SOMERSET