Water Quality Trends in the Brandywine Christina Cluster along the Arc Boundary of Delaware

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Delaware Watershed Research Conference

Academy of Natural Sciences

Philadelphia, PA

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Water Resources Center

Newark, Del.

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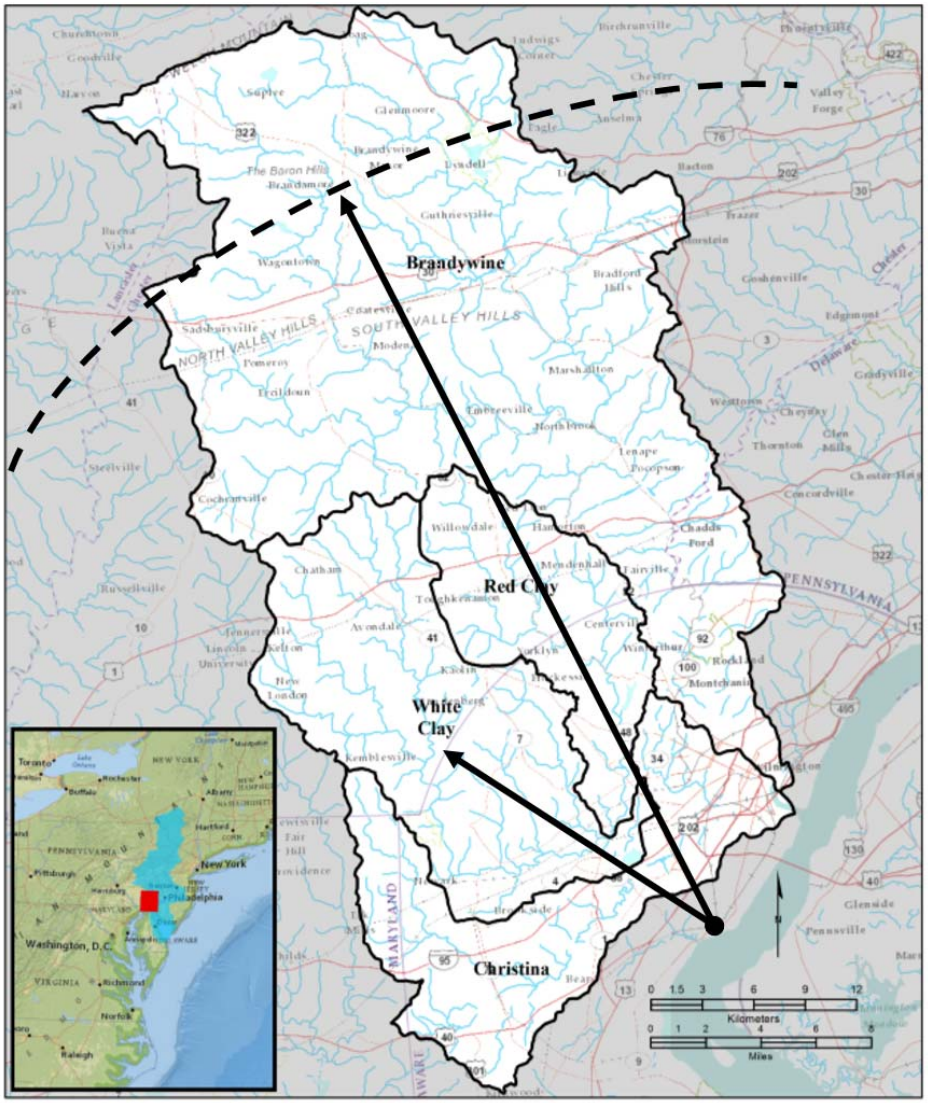
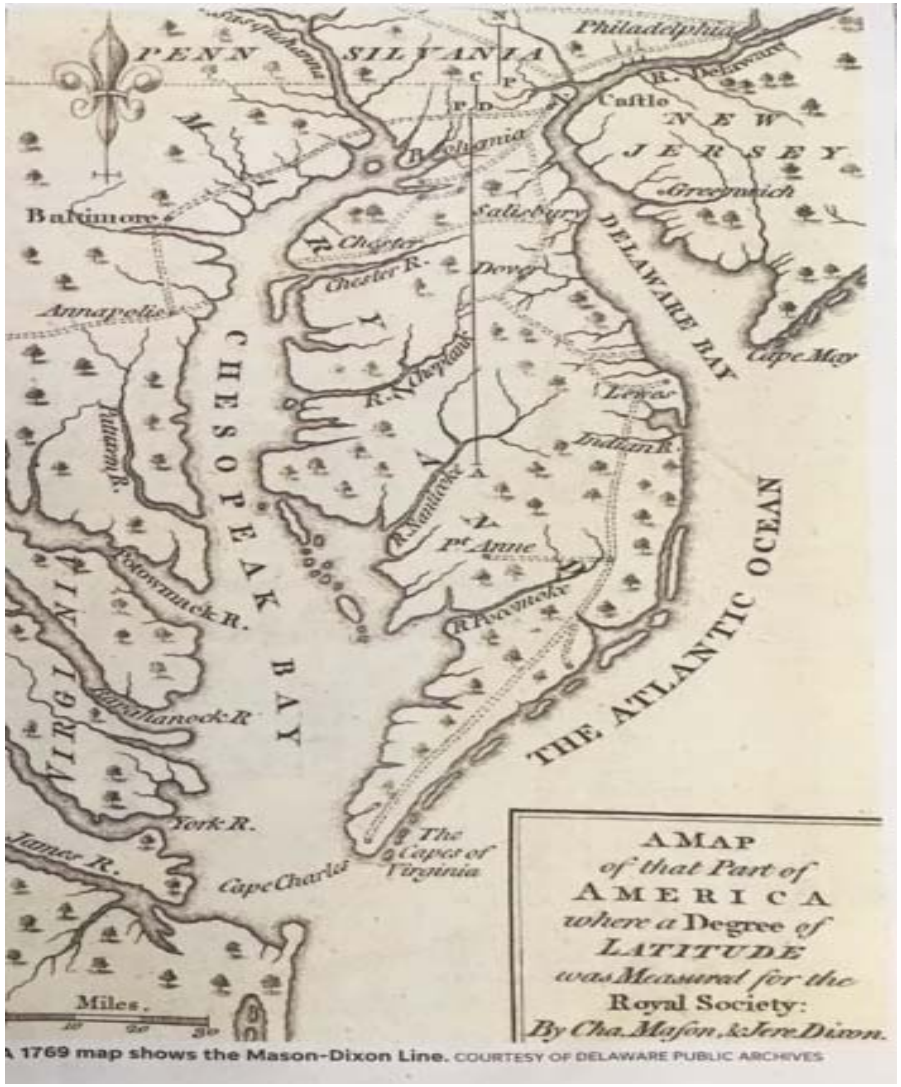
Over the last two decades, water quality has mostly improved in the four main streams of the Brandywine Christina Cluster along William Penn's 1682 arc boundary between Delaware and Pennsylvania. Since 1995, water quality sampled by the State of Delaware at **14 of 20 monitoring stations have improved**, **5 have remained constant**, and **1 has degraded** for levels of dissolved oxygen, enterococcus bacteria, nitrogen, phosphorus, and total suspended sediment. The full weight of investment in watershed restoration in the headwaters by public, private, and nonprofit partners seems to be paying off and with continued attention the fishable and swimmable goals of the Clean Water Act along several streams are just a few years from being achieved.





1769 map shows the Mason-Dixon Line. COURTESY OF DELAWARE PUBLIC ARCHIVES

In 1680, "The Duke of York wanted a circle of 20 or 30 miles drawn around New Castle."

Clean Water

A Bi-State Solution

May 3, 2018 | Mendenhall, PA

Analysis by DWRC scientists Martha Narvaez & Andrew Homsey, and graduate students Jillian Young and Jordan Martin.

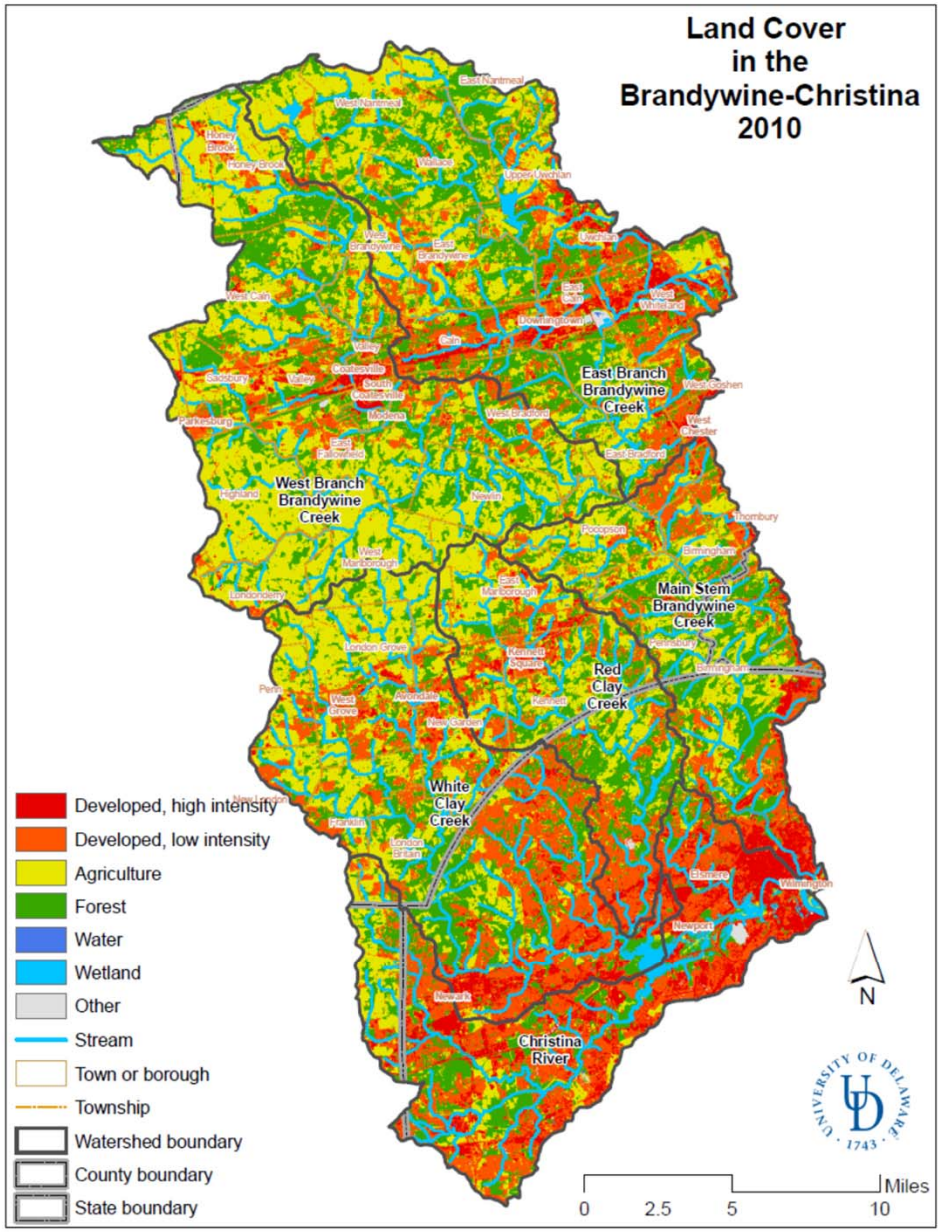
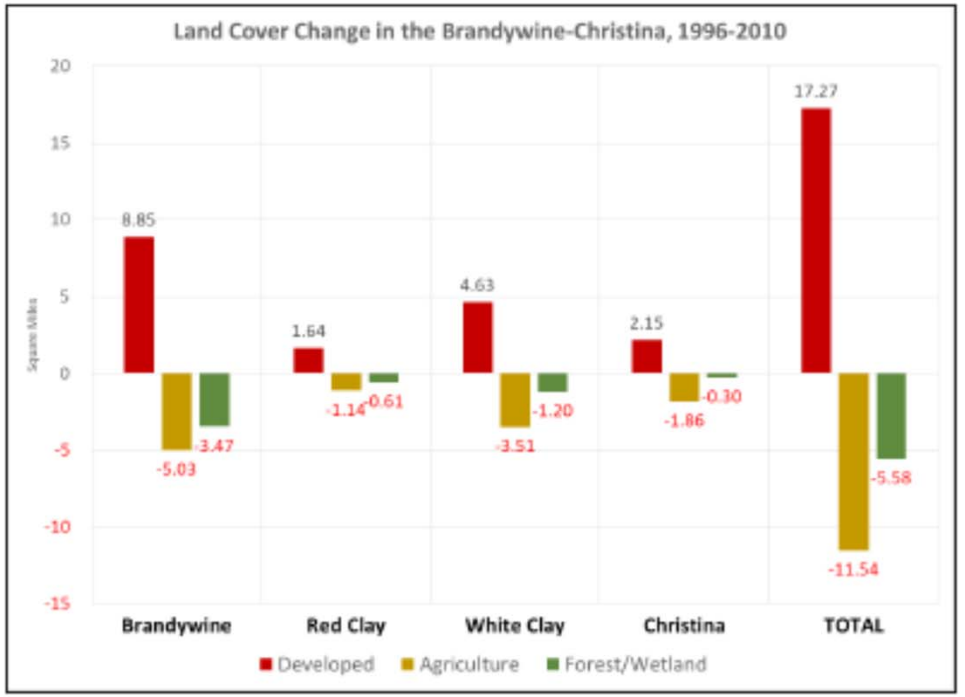
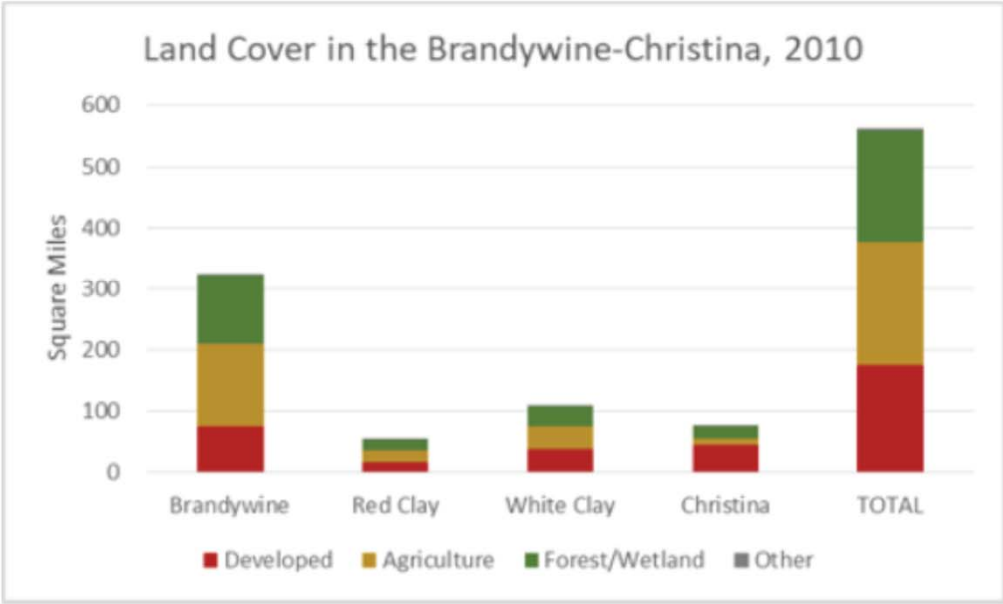
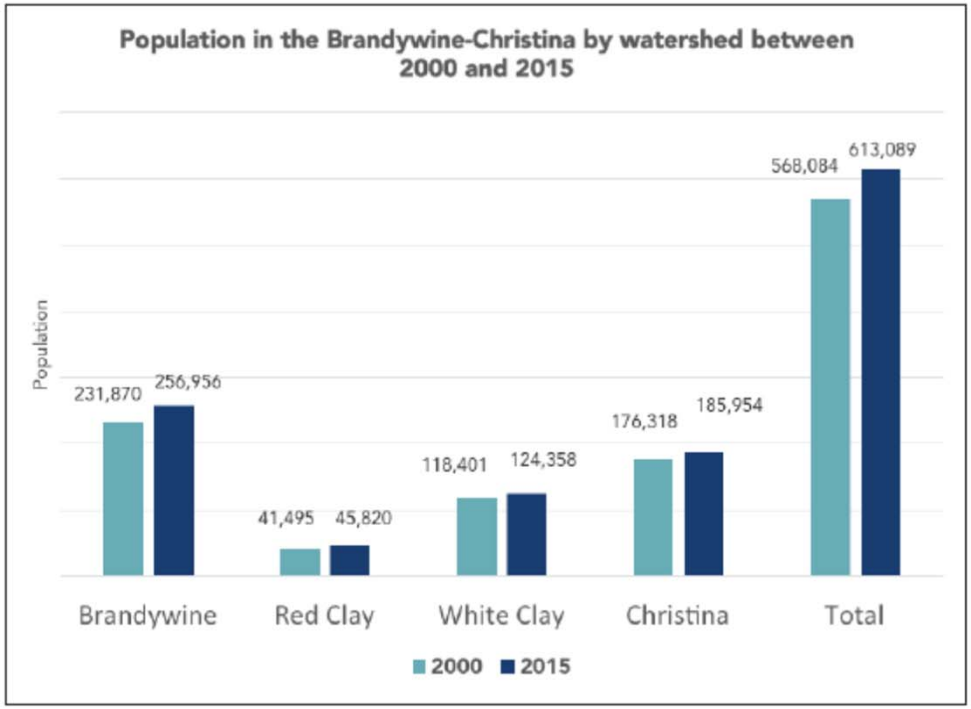
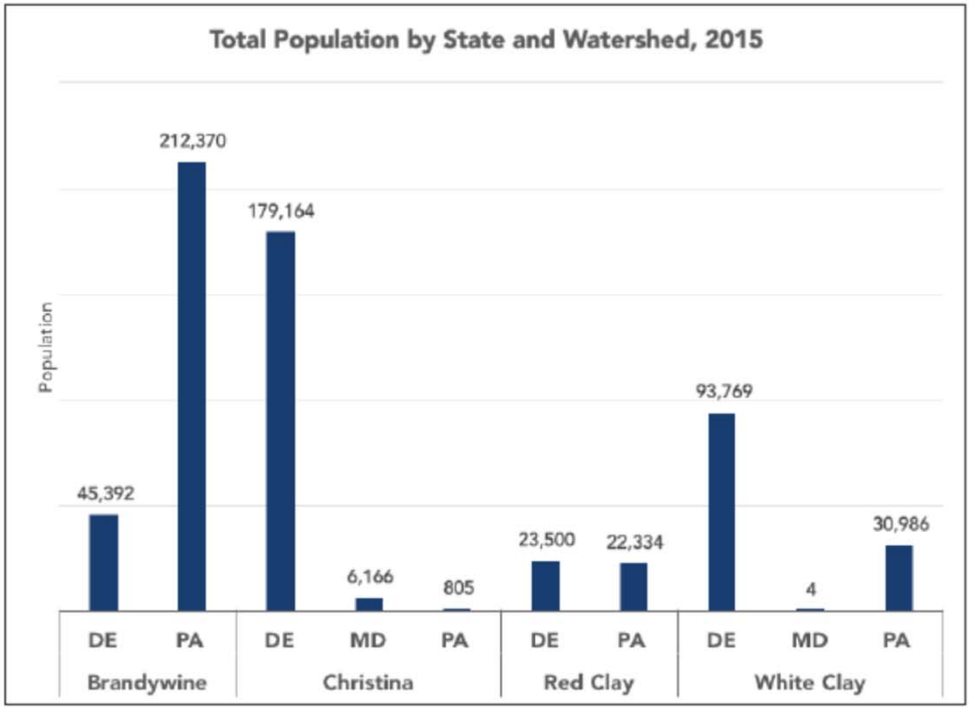


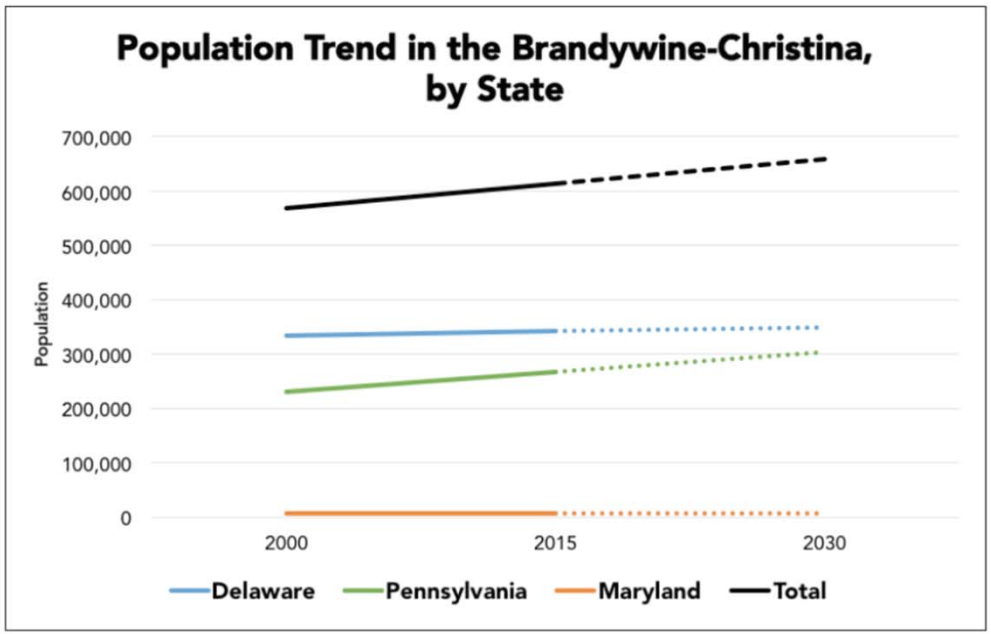
FIGURE 5-1 Land cover in the Brandywine-Christina watershed, based on 2010 NOAA CSC C-CAP.

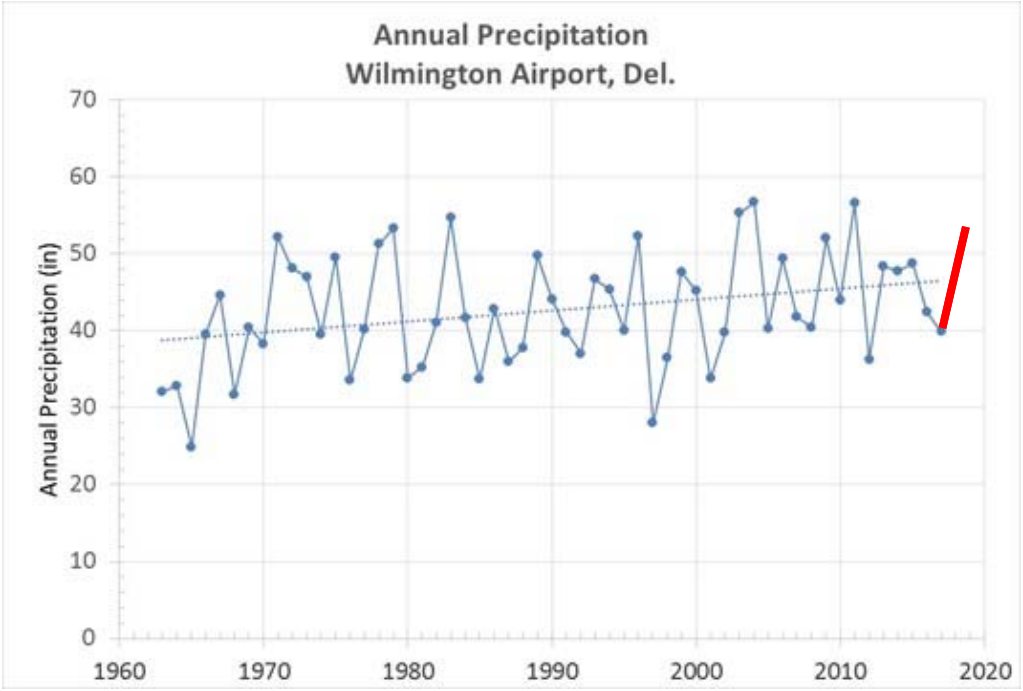


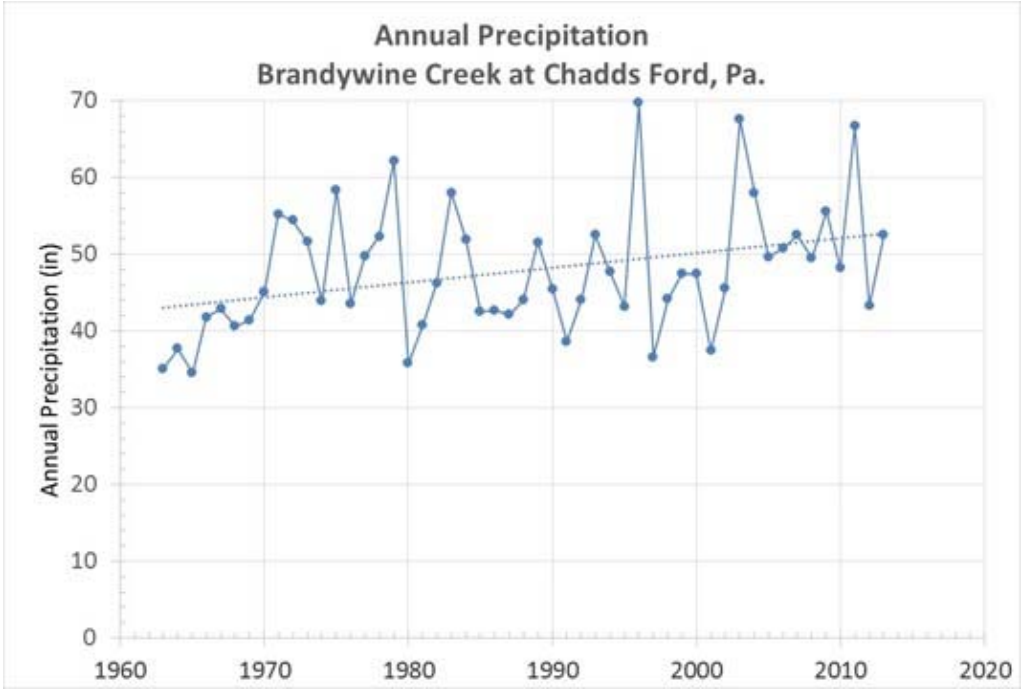


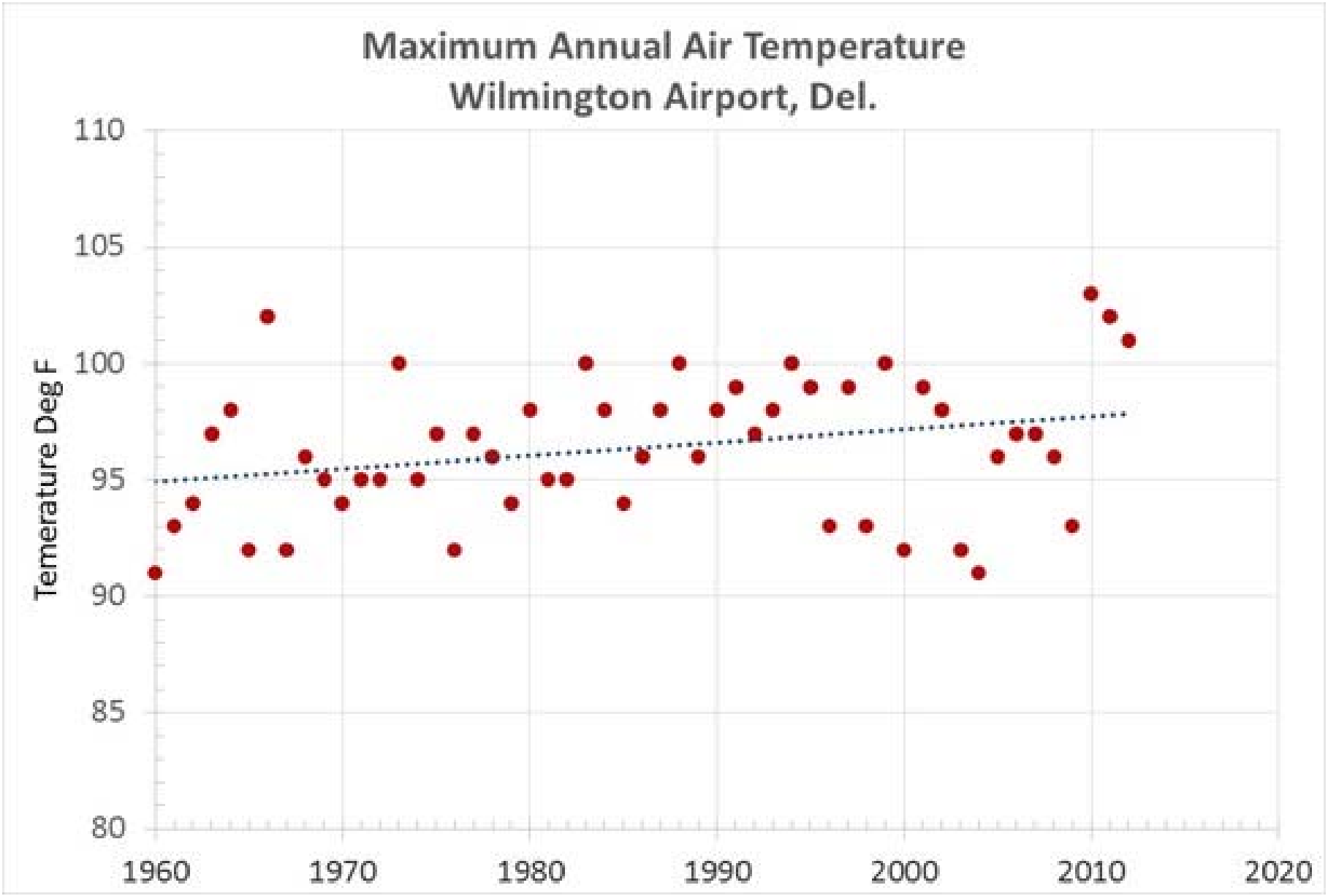

Population in the Brandywine-Christina by watershed between 2000 and 2015
Population
231,870
256,956
41,495
45,820
118,401
124,358
176,318
185,954
568,084
613,089
Brandywine
Red Clay
White Clay
Christina
Total
2000
2015

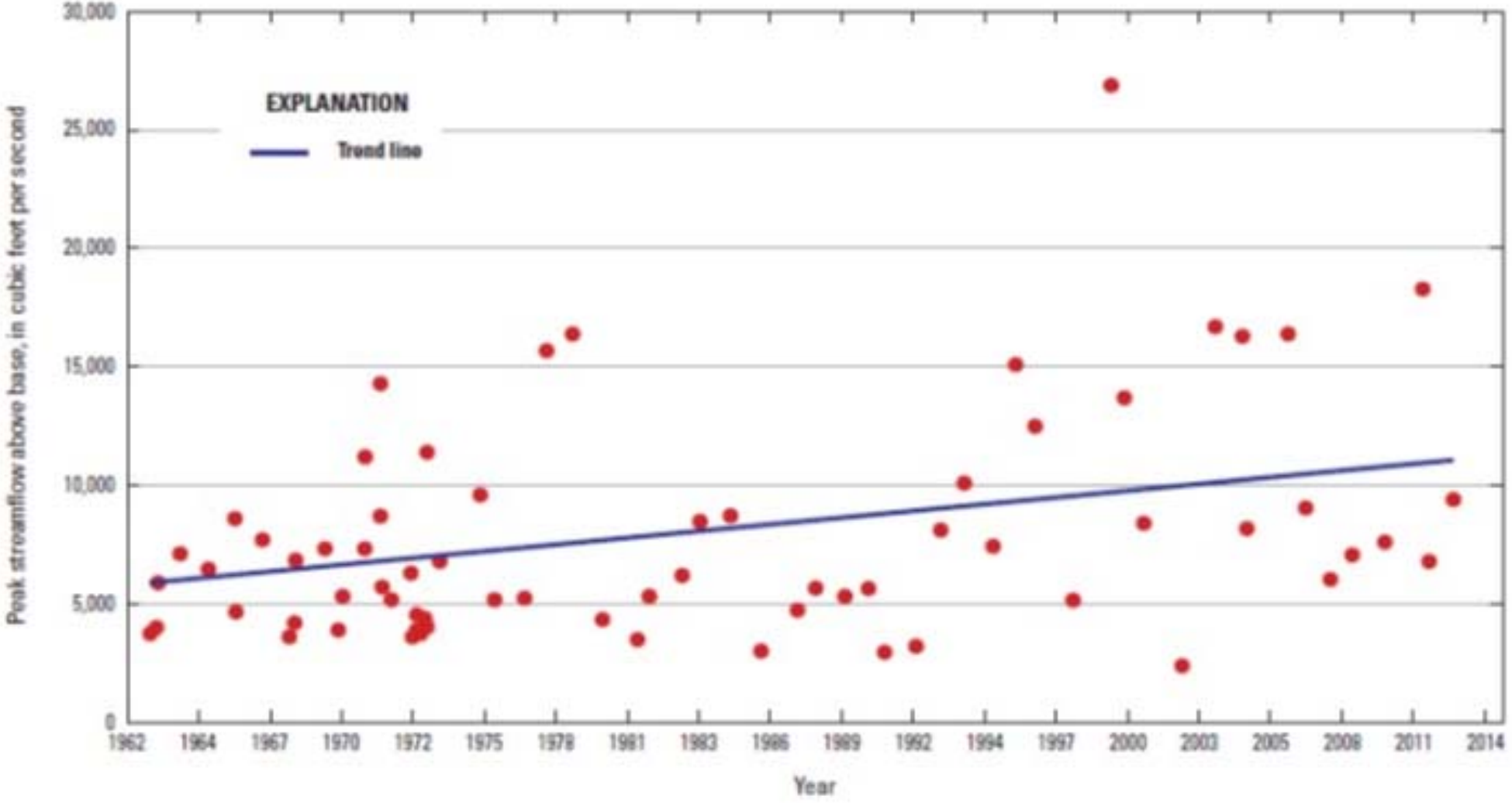

Total Population by State and Watershed, 2015
Population
45,392
212,370
179,164
6,166
805
23,500
22,334
93,769
4
30,986
DE
PA
DE
MD
PA
DE
PA
DE
MD
PA
Brandywine
Christina
Red Clay
White Clay


Population Trend in the Brandywine-Christina, by State
Population
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
2000
2015
2030
Delaware
Pennsylvania
Maryland
Total

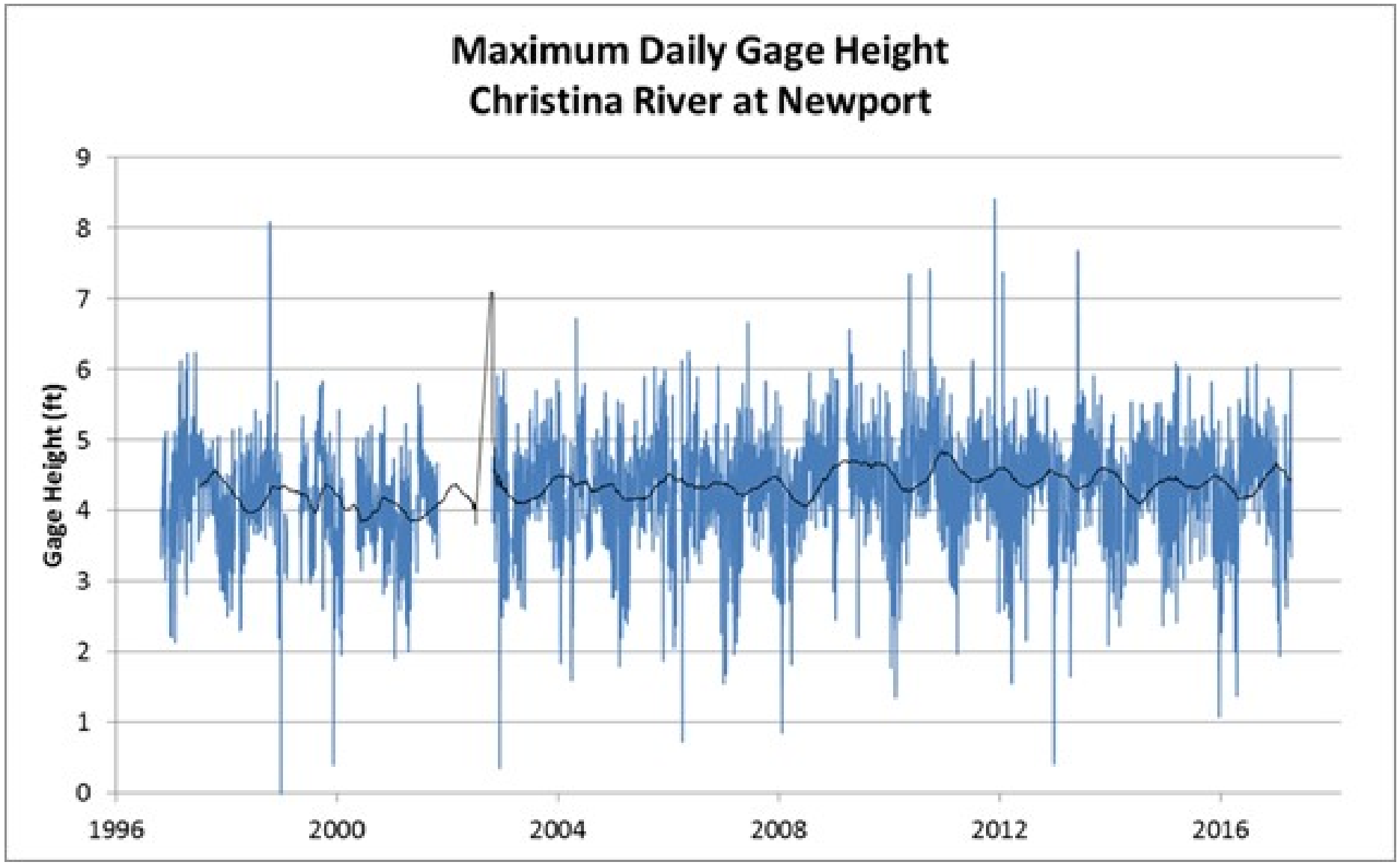

Annual Precipitation
Wilmington Airport, Del.
Annual Precipitation (in)
70
60
50
40
30
20
10
0
1960
1970
1980
1990
2000
2010
2020


Annual Precipitation
Brandywine Creek at Chadds Ford, Pa.
Annual Precipitation (in)
70
60
50
40
30
20
10
0
1960
1970
1980
1990
2000
2010
2020


Maximum Annual Air Temperature
Wilmington Airport, Del.
Temerature Deg F
110
105
100
95
90
85
80
1960
1970
1980
1990
2000
2010
2020



Peak streamflow at Brandywine Creek at Chadds Ford, Pennsylvania, 1962-2012 (Sloto and Reif 2017)

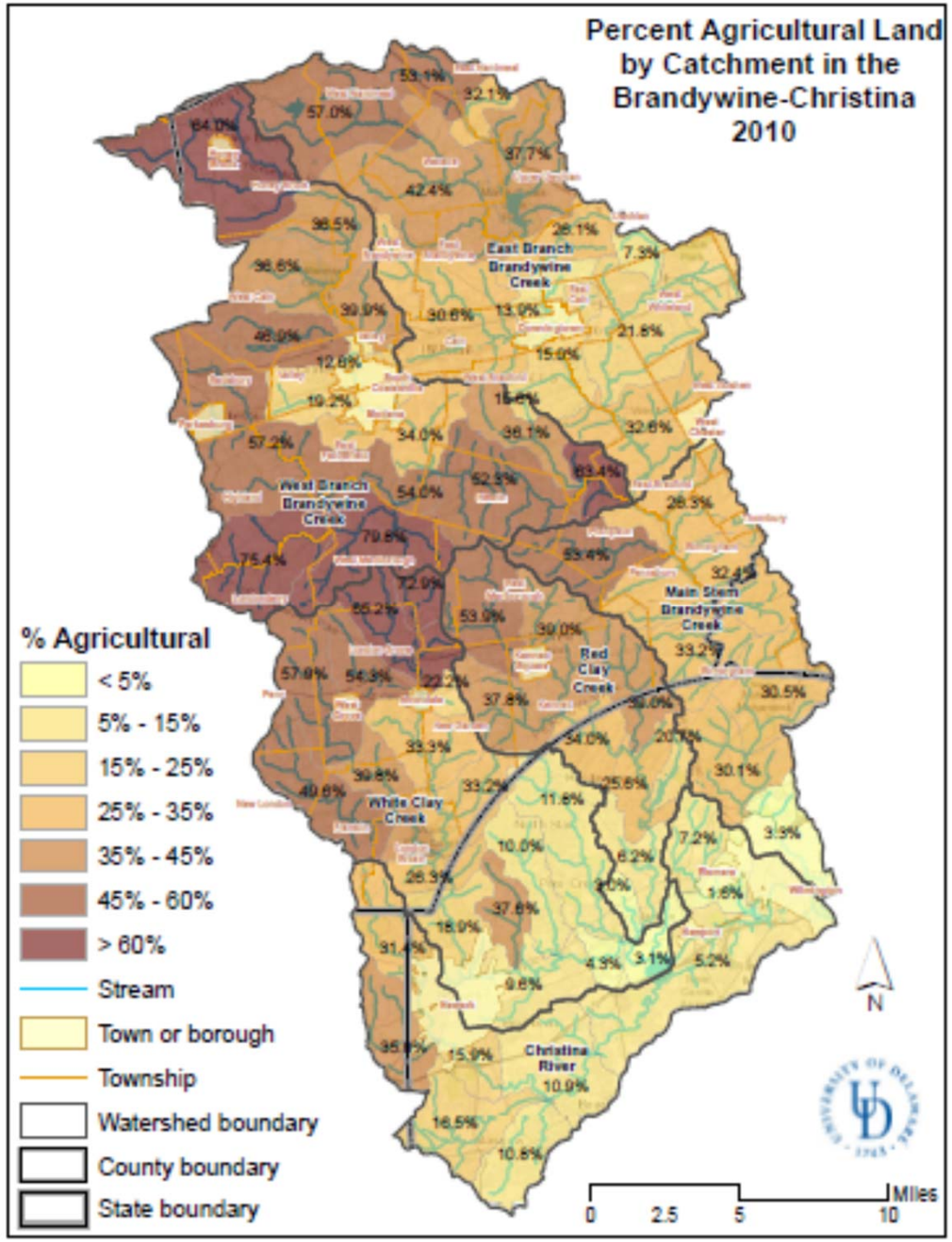

Maximum Daily Gage Height
Christina River at Newport
Gage Height (ft)
9
8
7
6
5
4
3
2
1
0
1996
2000
2004
2008
2012
2016

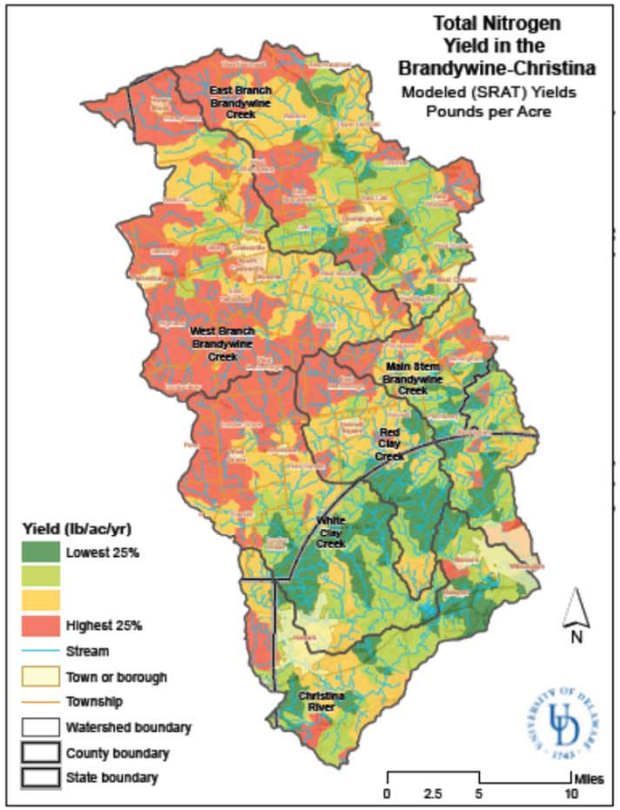
BRANDYWINE CREEK AT WILMINGTON, DE			
Date	Peak Discharge (cfs)	Named Storm	Flood Frequency
6/23/72	29,000	Agnes	>50-yr
9/17/99	28,700	Floyd	>50-yr
5/1/14	24,000	Unnamed	>25-yr
1/25/79	22,400	Unnamed	>25-yr
9/13/71	21,300	Unnamed	25-yr
9/29/04	20,800	Jeanne	25-yr
9/15/03	17,900	Henri	>10-yr
8/19/55	17,800	Unnamed	>10-yr
1/20/96	17,800	Blizzard of '96	>10-yr
1/26/78	17,200	Unnamed	>10-yr

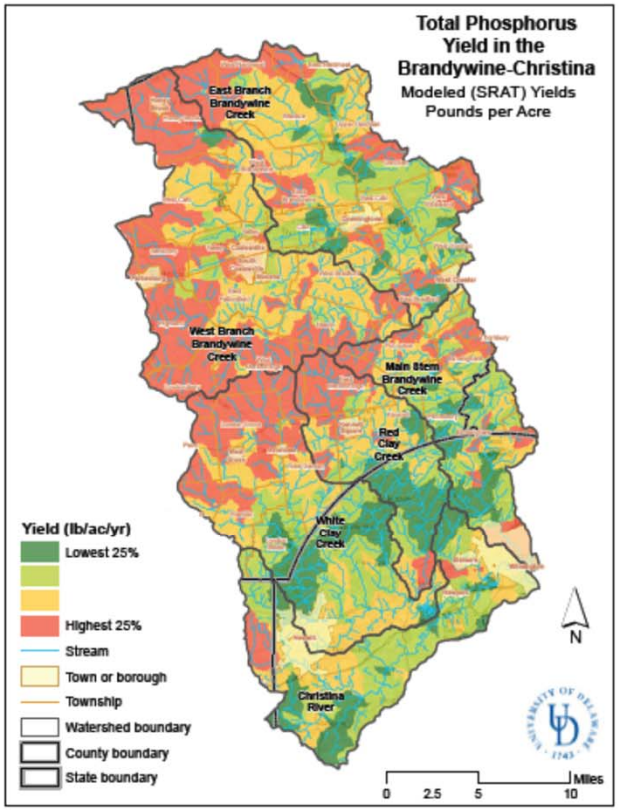
Figure 3-17 Mean Daily Peak Discharge at Brandywine Creek at Wilmington, DE. (USGS 01481500)

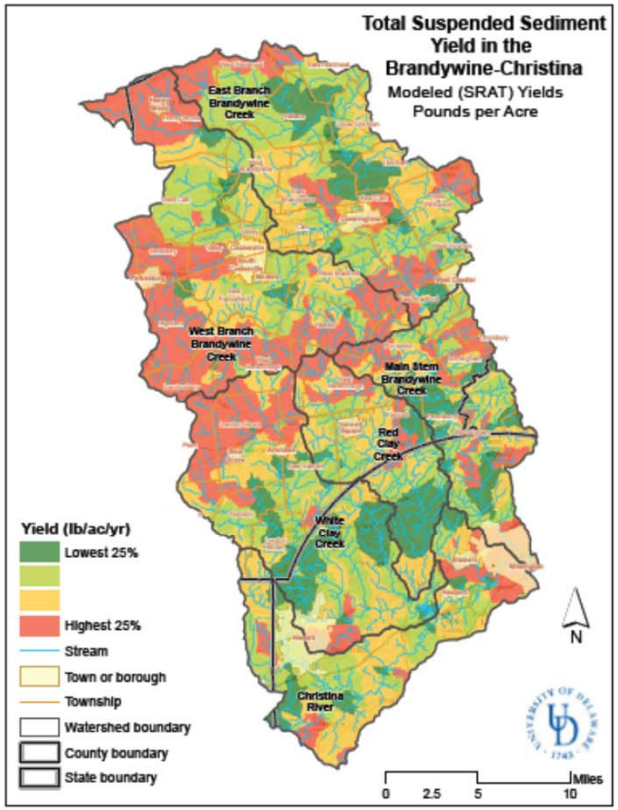
WHITE CLAY CREEK NEAR NEWARK, DE			
Date	Peak Discharge (cfs)	Named Storm	Flood Frequency
9/16/99	19,500	Floyd	>100-yr
8/28/11	17,000	Irene	>100-yr
9/29/04	15,000	Jeanne	100-yr
4/30/14	14,600	Unnamed	>50-yr
9/15/03	13,900	Henri	>50-yr
7/5/89	11,600	4th of July	>25-yr
10/1/10	9,600	Unnamed	>10-yr
1/19/96	9,150	Blizzard of '96	>10-yr
6/22/72	9,080	Unnamed	>10-yr
3/22/00	7,130	Unnamed	<10-yr

Figure 3-12 Mean Daily Peak Discharge at White Clay Creek near Newark, DE. (USGS 01479000)


Percent Agricultural Land by Catchment in the Brandywine-Christina 2010
% Agricultural
< 5%
5% - 15%
15% - 25%
25% - 35%
35% - 45%
45% - 60%
> 60%
Stream
Town or borough
Township
Watershed boundary
County boundary
State boundary
East Branch Brandywine Creek
West Branch Brandywine Creek
Main Stem Brandywine Creek
Red Clay Creek
White Clay Creek
Christina River
N
0 2.5 5 10 Miles

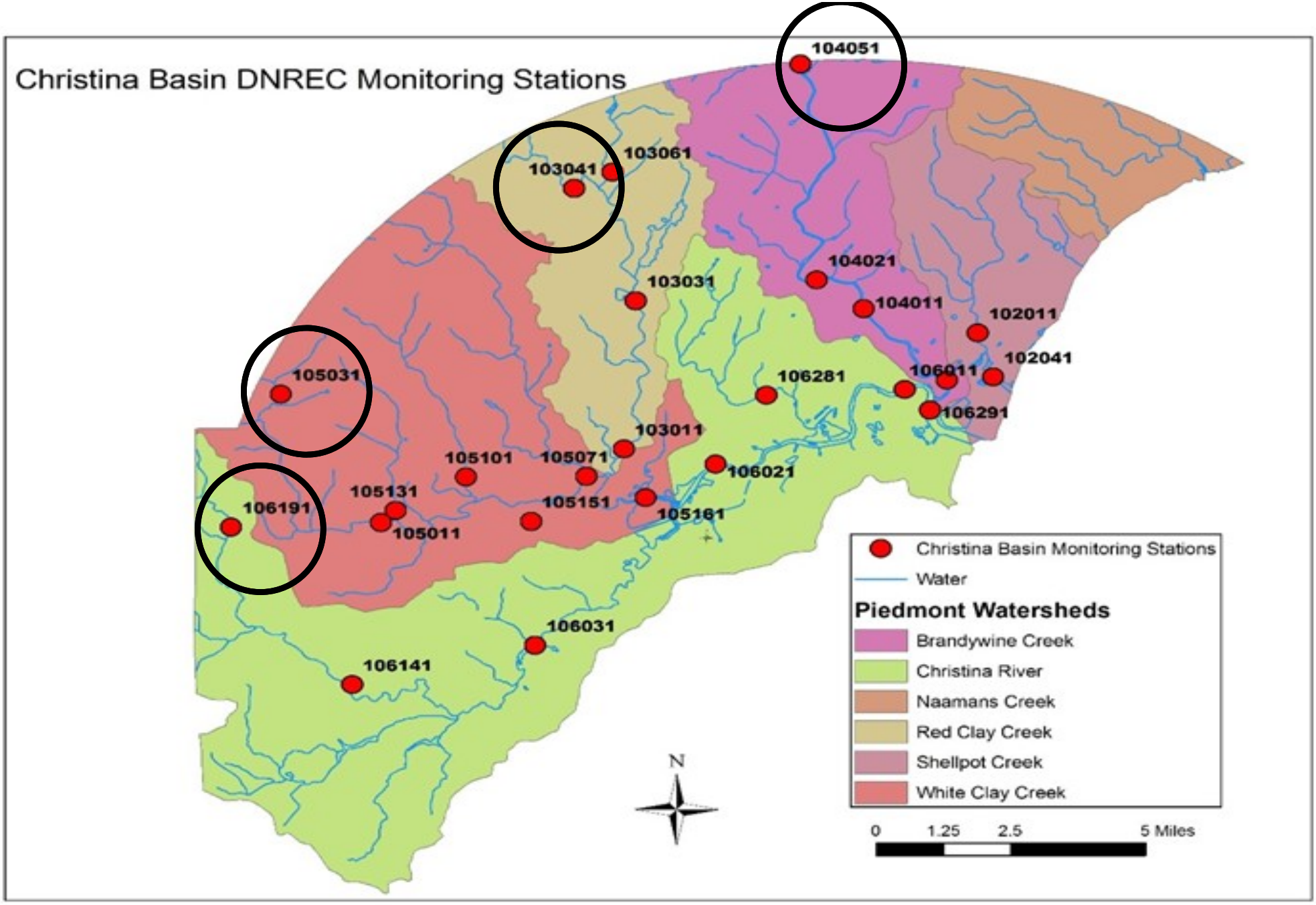

Total Nitrogen Yield in the Brandywine-Christina
Modeled (SRAT) Yields
Pounds per Acre
East Branch Brandywine Creek
West Branch Brandywine Creek
Main Stem Brandywine Creek
Red Clay Creek
White Clay Creek
Christina River
Yield (lb/ac/yr)
Lowest 25%
Highest 25%
Stream
Town or borough
Township
Watershed boundary
County boundary
State boundary
N
0 2.5 5 10
Miles

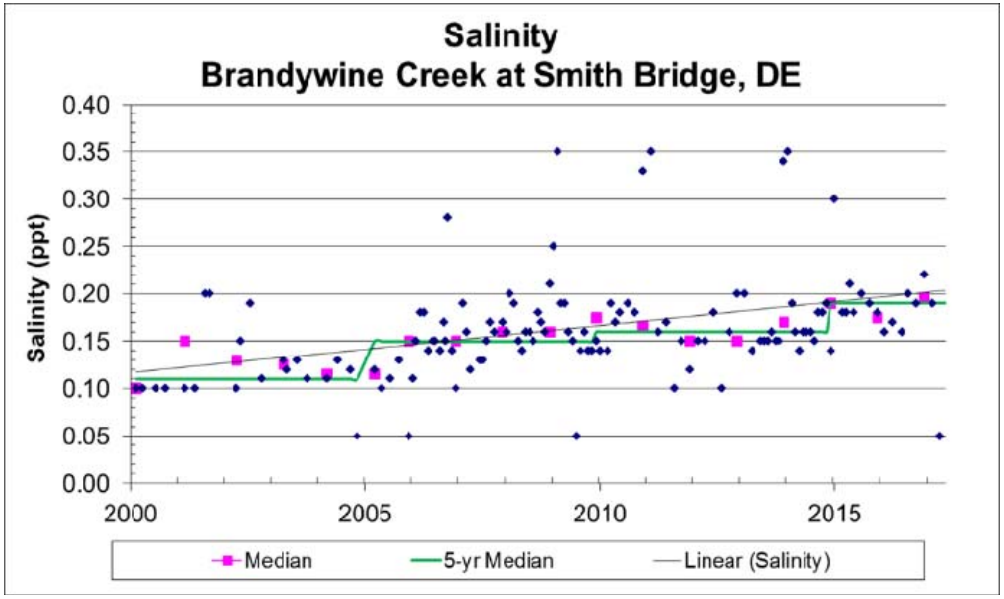

Total Phosphorus Yield in the Brandywine-Christina
Modeled (SRAT) Yields
Pounds per Acre
East Branch Brandywine Creek
West Branch Brandywine Creek
Main Stem Brandywine Creek
Red Clay Creek
White Clay Creek
Christina River
Yield (lb/ac/yr)
Lowest 25%
Highest 25%
Stream
Town or borough
Township
Watershed boundary
County boundary
State boundary
N
0 2.5 5 10
Miles

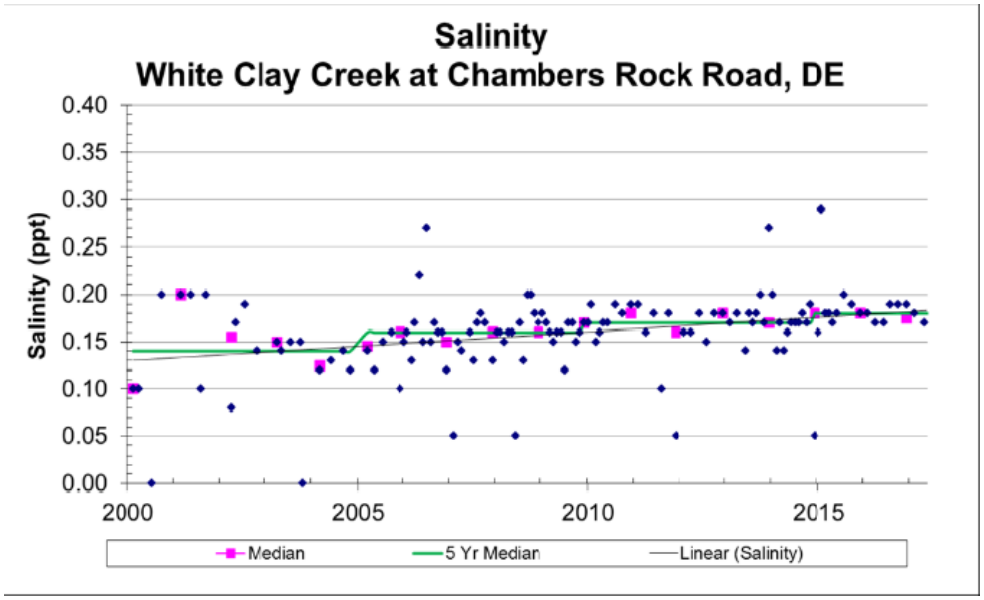

Total Suspended Sediment Yield in the Brandywine-Christina
Modeled (SRAT) Yields
Pounds per Acre
East Branch Brandywine Creek
West Branch Brandywine Creek
Main Stem Brandywine Creek
Red Clay Creek
White Clay Creek
Christina River
Yield (lb/ac/yr)
Lowest 25%
Highest 25%
Stream
Town or borough
Township
Watershed boundary
County boundary
State boundary
N
0 2.5 5 10
Miles

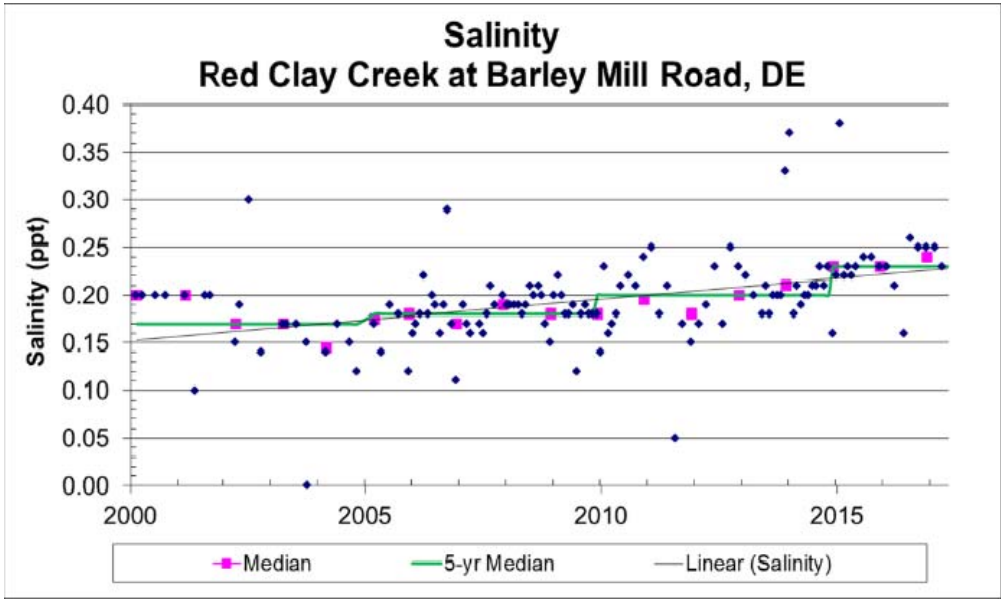
Delaware Stream Water Quality Criteria

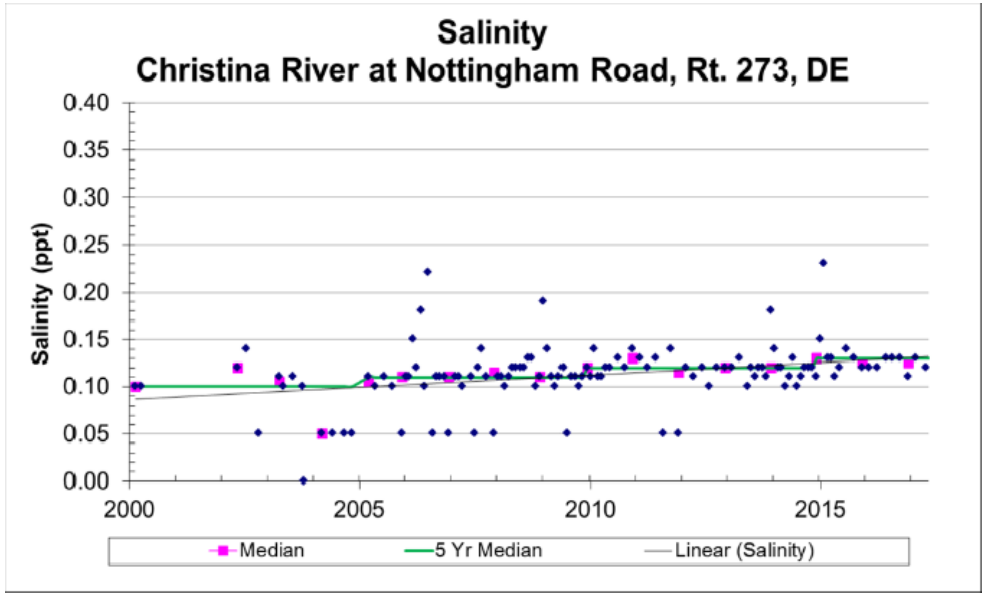
Dissolved Oxygen	4.0 mg/l	Fishable
Enterococcus Bacteria	100 col./100 ml	Swimmable
Total Phosphorus	0.05-0.10 mg/l	TMDL Target
Total Nitrogen	1.0-2.0 mg/l	TMDL Target
Total Susp. Sediment	20 mg/l	DE Inland Bays


Christina Basin DNREC Monitoring Stations
104051
103061
103041
104021
103031
104011
102011
102041
105031
106281
106011
106291
103011
105101
105071
106021
105131
105151
105161
106191
105011
106031
106141
N
Christina Basin Monitoring Stations
Water
Piedmont Watersheds
Brandywine Creek
Christina River
Naamans Creek
Red Clay Creek
Shellpot Creek
White Clay Creek
0
1.25
2.5
5 Miles

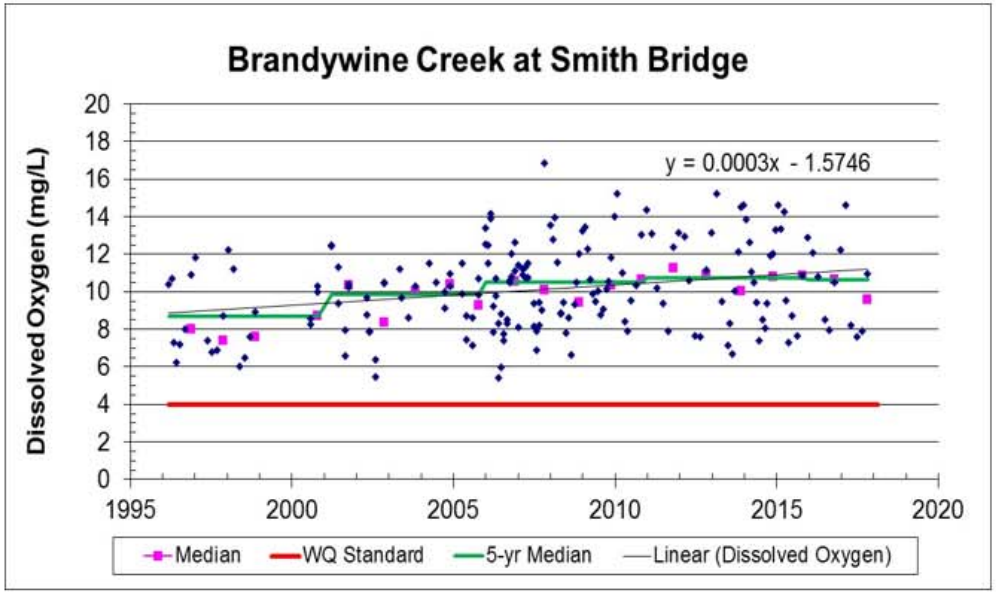


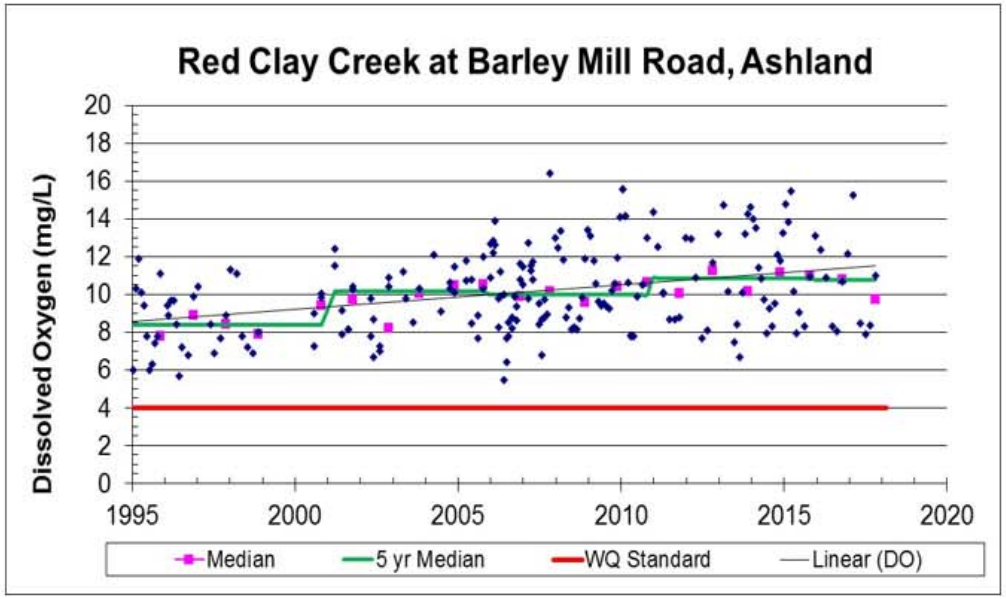


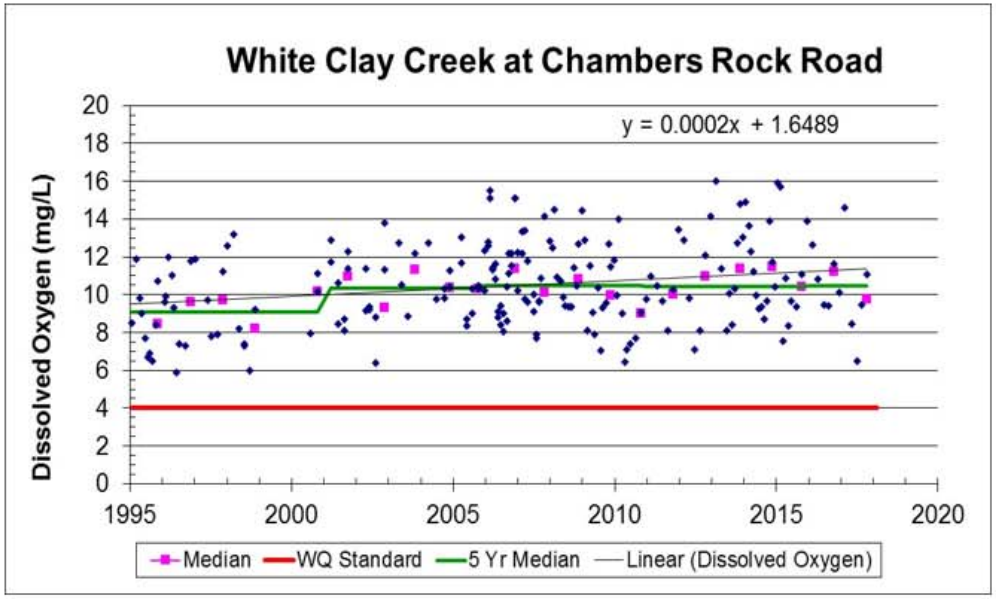


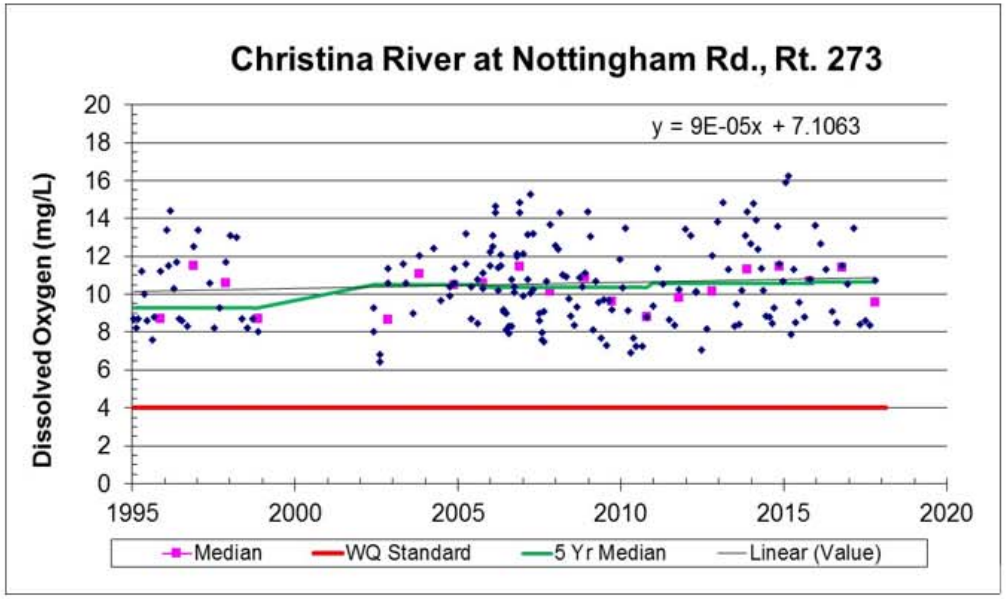


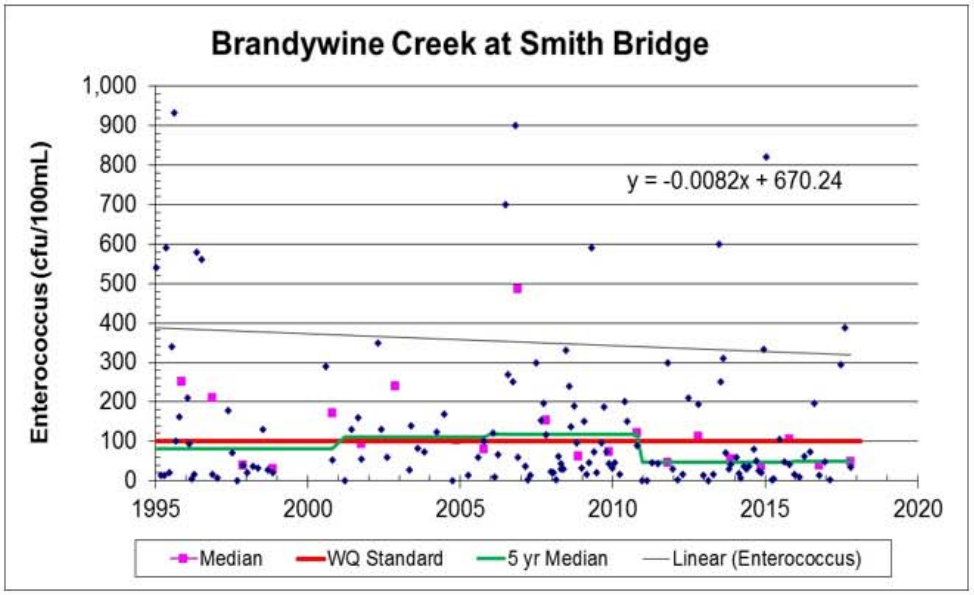
1 ppt salinity = 500 mg/l chloride

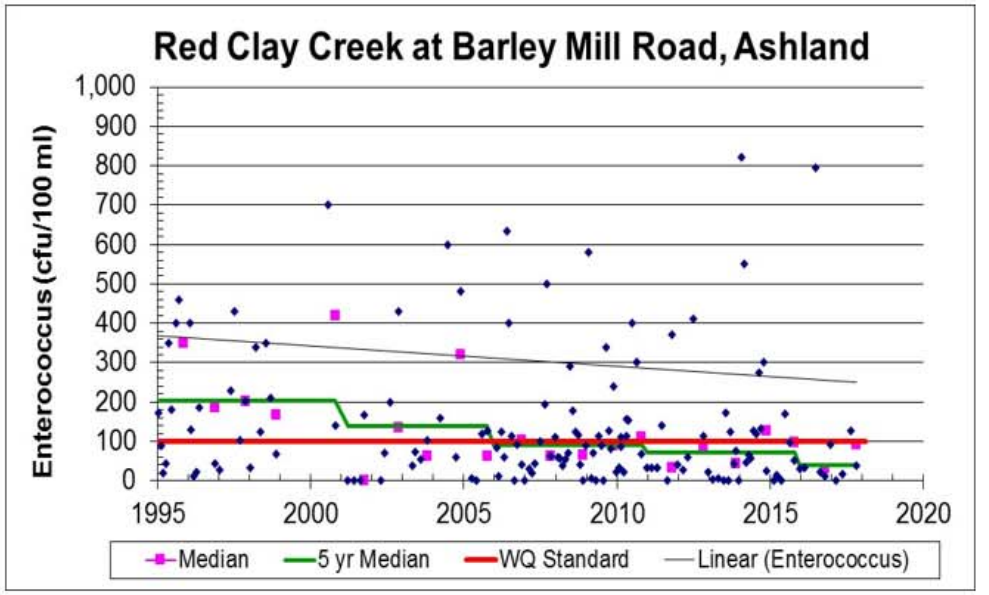

Brandywine Creek at Smith Bridge
y = 0.0003x - 1.5746
Dissolved Oxygen (mg/L)
Median
WQ Standard
5-yr Median
Linear (Dissolved Oxygen)

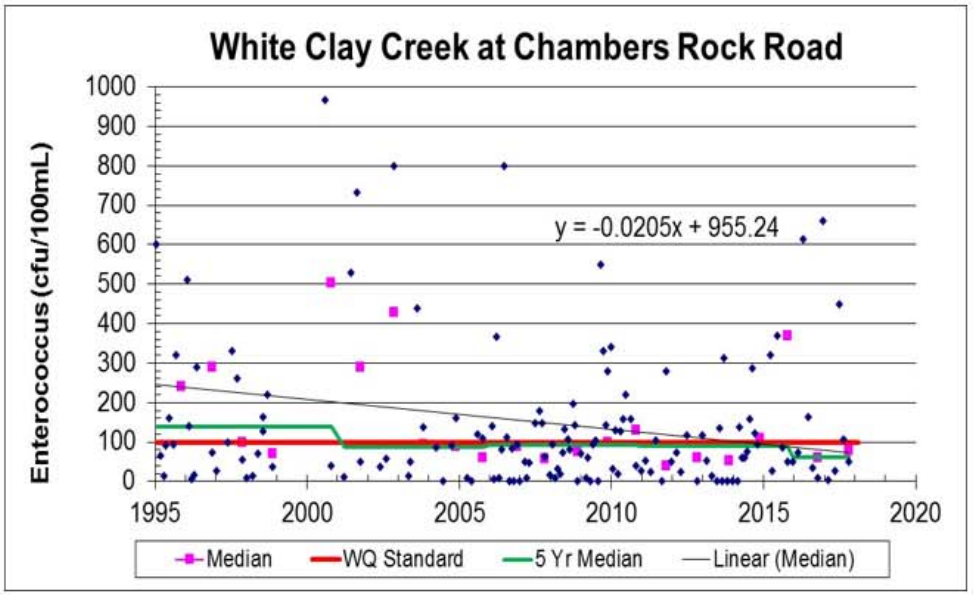

Red Clay Creek at Barley Mill Road, Ashland
Dissolved Oxygen (mg/L)
Median
5 yr Median
WQ Standard
Linear (DO)

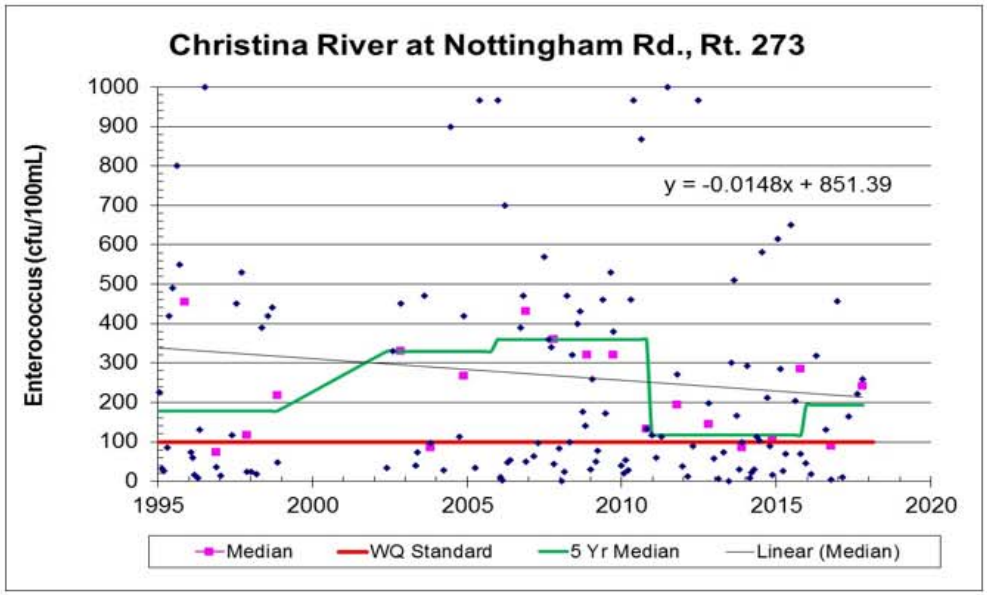

White Clay Creek at Chambers Rock Road
y = 0.0002x + 1.6489
Dissolved Oxygen (mg/L)
Median
WQ Standard
5 Yr Median
Linear (Dissolved Oxygen)

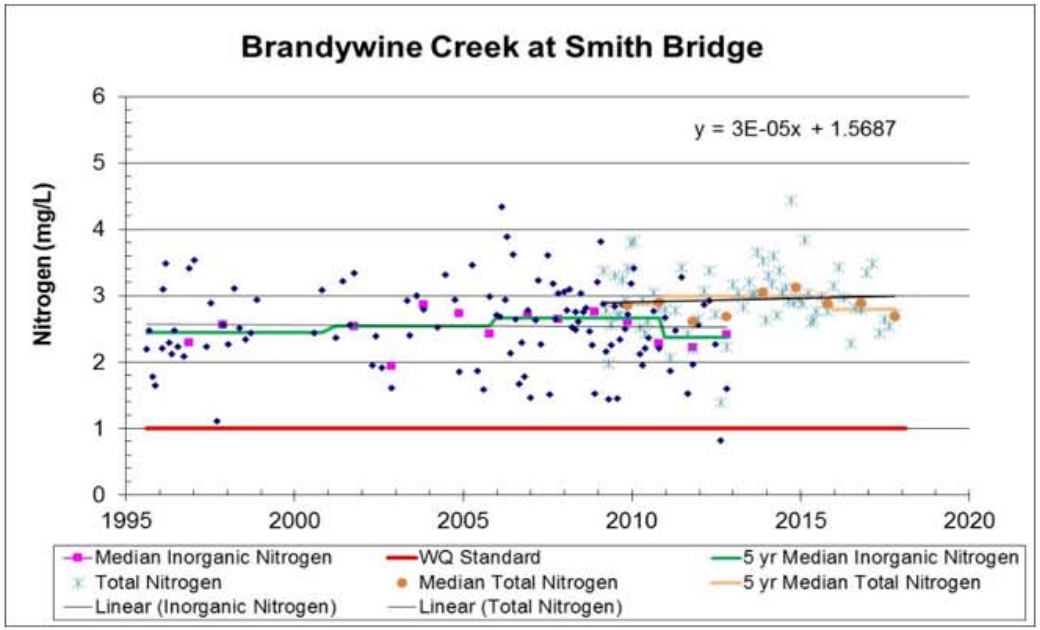

Christina River at Nottingham Rd., Rt. 273
y = 9E-05x + 7.1063
Dissolved Oxygen (mg/L)
Median
WQ Standard
5 Yr Median
Linear (Value)

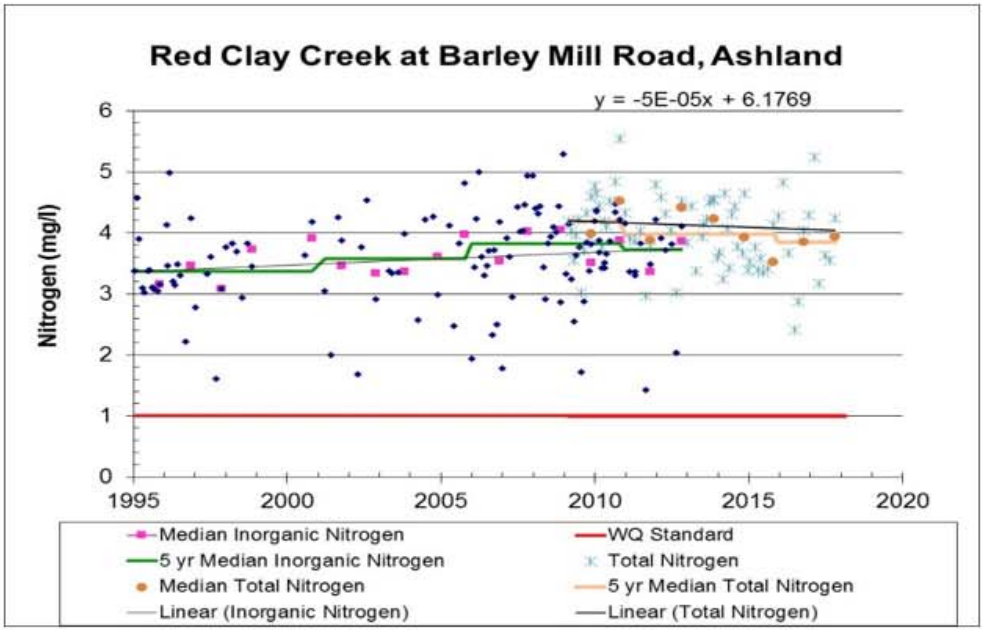

Brandywine Creek at Smith Bridge
Enterococcus (cfu/100mL)
y = -0.0082x + 670.24
Median
WQ Standard
5 yr Median
Linear (Enterococcus)

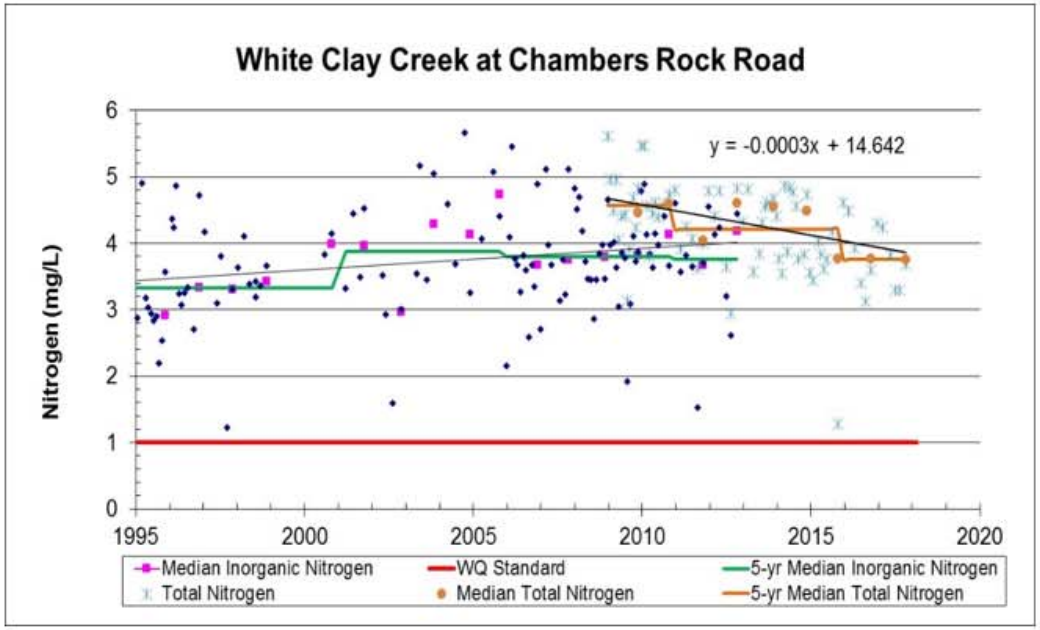

Red Clay Creek at Barley Mill Road, Ashland
Enterococcus (cfu/100 ml)
Median
5 yr Median
WQ Standard
Linear (Enterococcus)

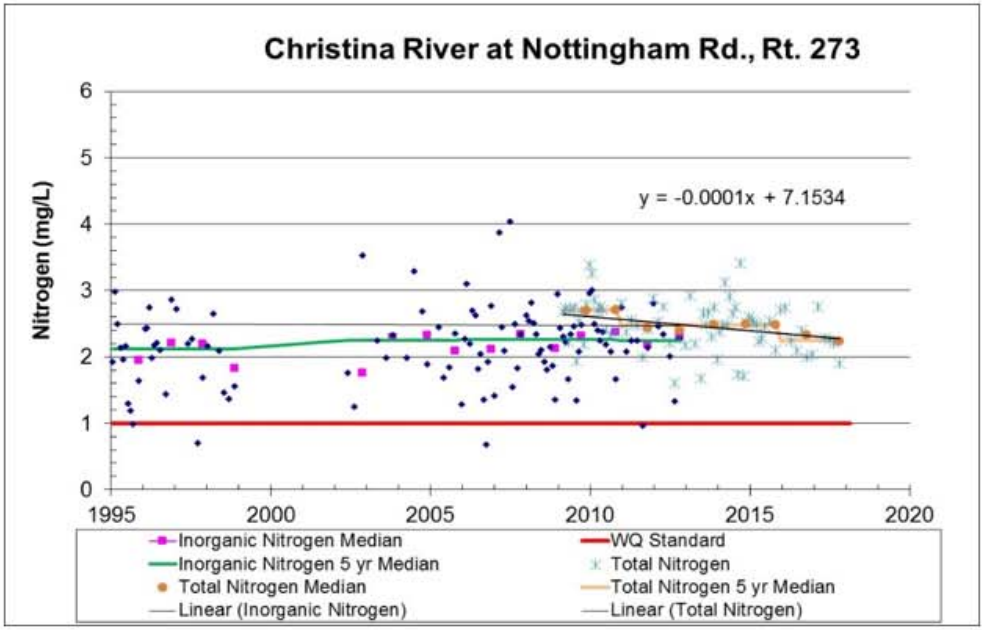

White Clay Creek at Chambers Rock Road
Enterococcus (cfu/100mL)
y = -0.0205x + 955.24
Median
WQ Standard
5 Yr Median
Linear (Median)

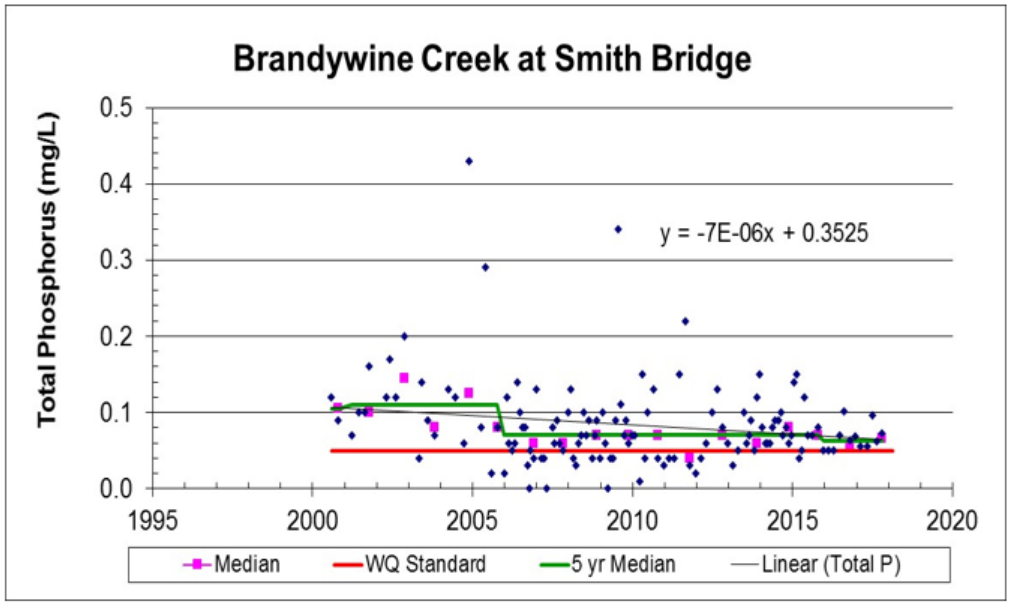

Christina River at Nottingham Rd., Rt. 273
Enterococcus (cfu/100mL)
y = -0.0148x + 851.39
Median
WQ Standard
5 Yr Median
Linear (Median)

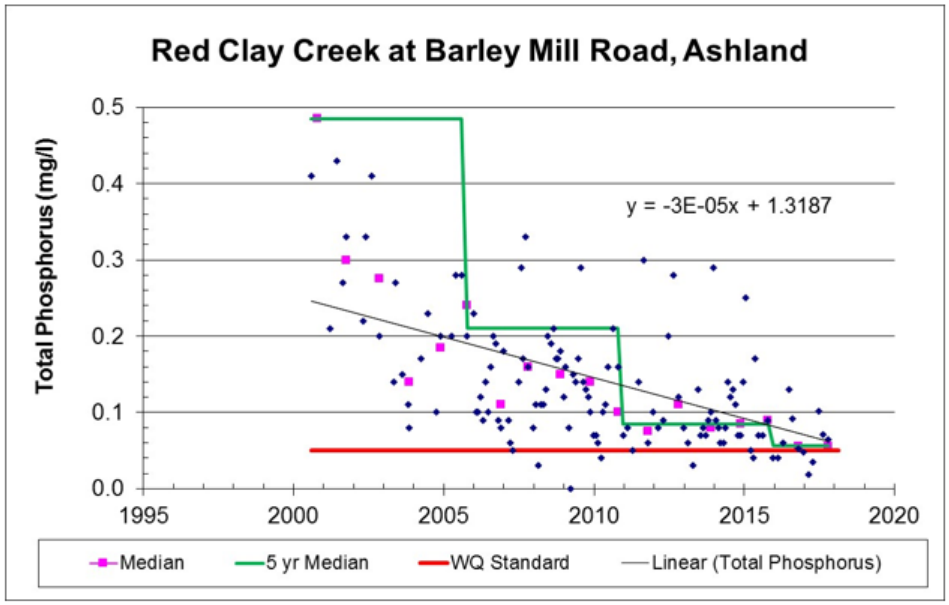

Brandywine Creek at Smith Bridge
y = 3E-05x + 1.5687
Nitrogen (mg/L)
Median Inorganic Nitrogen
WQ Standard
5 yr Median Inorganic Nitrogen
Total Nitrogen
Median Total Nitrogen
5 yr Median Total Nitrogen
Linear (Inorganic Nitrogen)
Linear (Total Nitrogen)

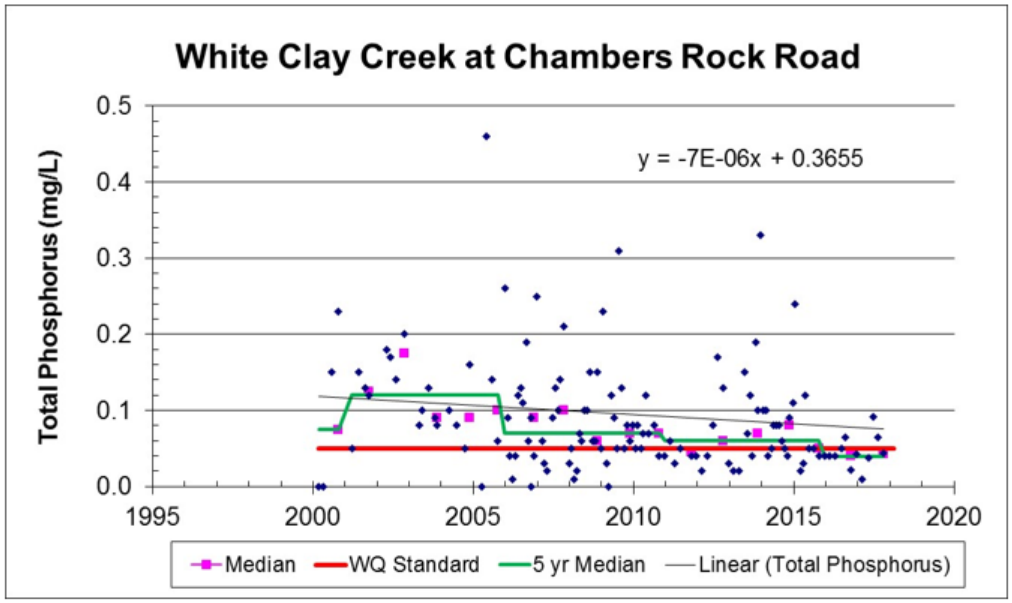

Red Clay Creek at Barley Mill Road, Ashland
y = -5E-05x + 6.1769
Nitrogen (mg/l)
Median Inorganic Nitrogen
WQ Standard
5 yr Median Inorganic Nitrogen
Total Nitrogen
Median Total Nitrogen
5 yr Median Total Nitrogen
Linear (Inorganic Nitrogen)
Linear (Total Nitrogen)

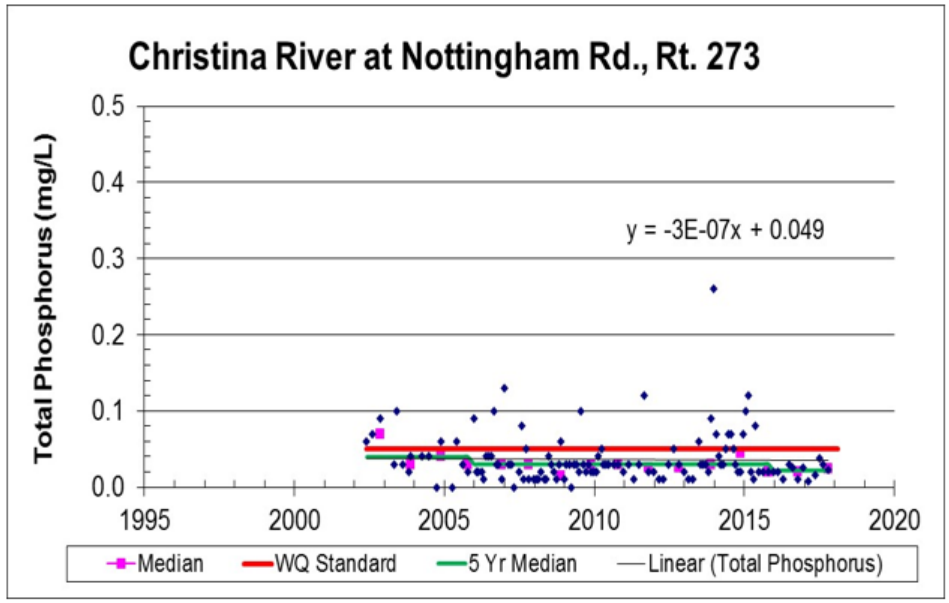

White Clay Creek at Chambers Rock Road
y = -0.0003x + 14.642
Nitrogen (mg/L)
Median Inorganic Nitrogen
WQ Standard
5-yr Median Inorganic Nitrogen
Total Nitrogen
Median Total Nitrogen
5-yr Median Total Nitrogen

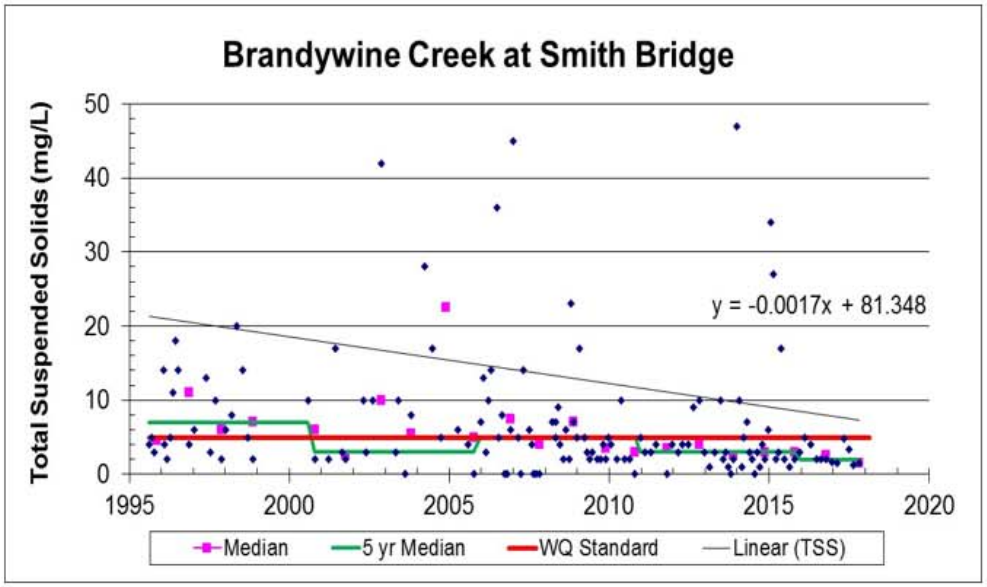

Christina River at Nottingham Rd., Rt. 273
y = -0.0001x + 7.1534
Nitrogen (mg/L)
Inorganic Nitrogen Median
WQ Standard
Inorganic Nitrogen 5 yr Median
Total Nitrogen
Total Nitrogen Median
Total Nitrogen 5 yr Median
Linear (Inorganic Nitrogen)
Linear (Total Nitrogen)

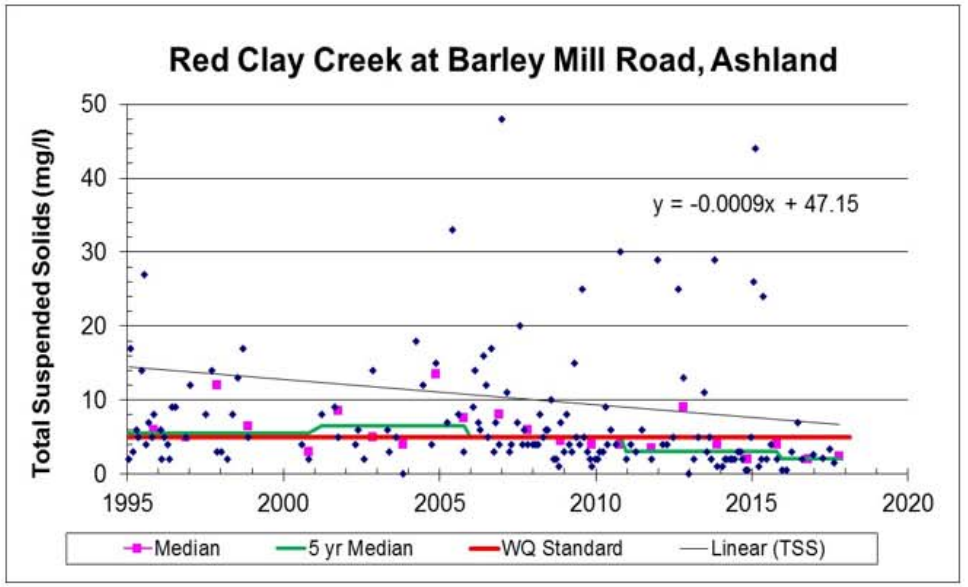

Brandywine Creek at Smith Bridge
Total Phosphorus (mg/L)
y = -7E-06x + 0.3525
Median
WQ Standard
5 yr Median
Linear (Total P)

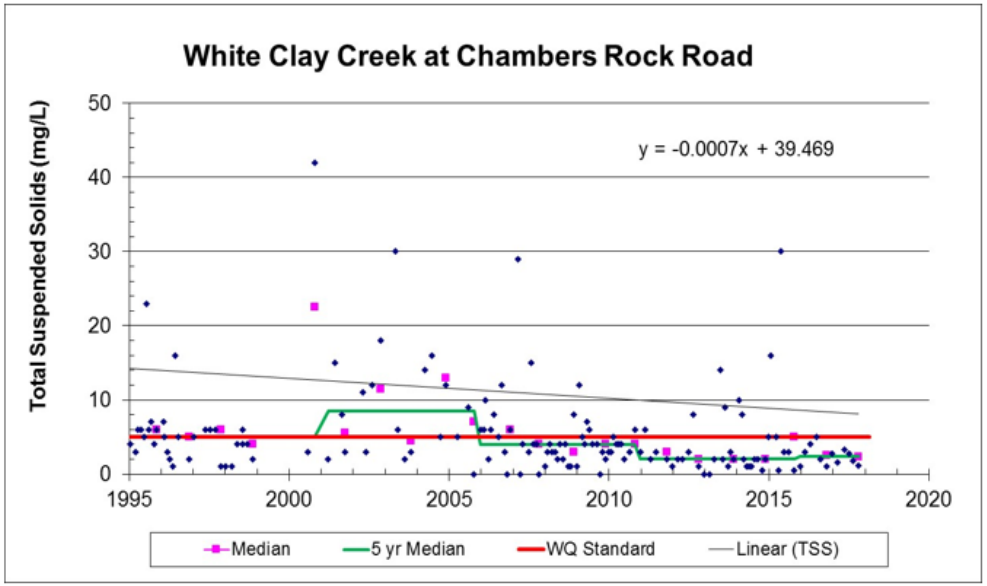

Red Clay Creek at Barley Mill Road, Ashland
Total Phosphorus (mg/l)
y = -3E-05x + 1.3187
Median
5 yr Median
WQ Standard
Linear (Total Phosphorus)

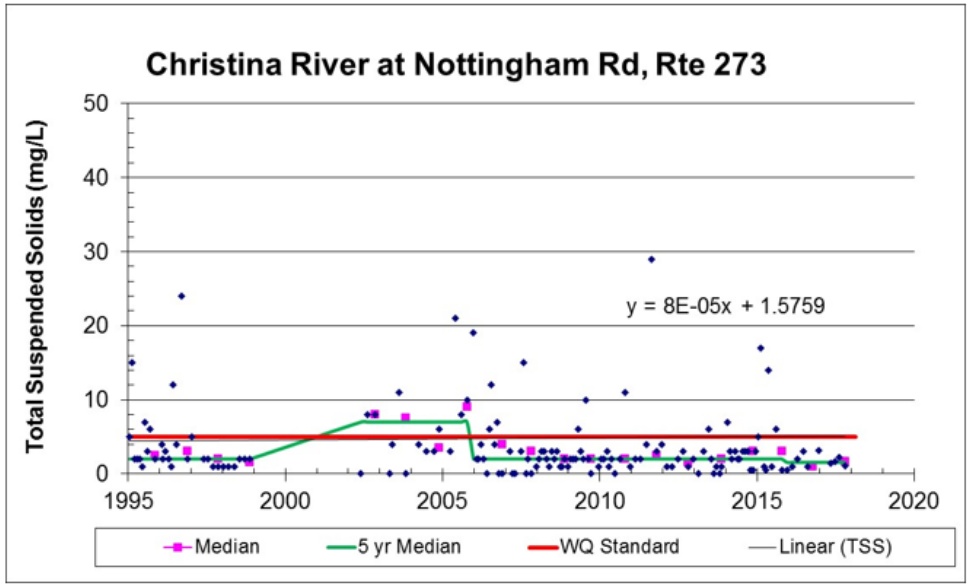

White Clay Creek at Chambers Rock Road
Total Phosphorus (mg/L)
y = -7E-06x + 0.3655
Median
WQ Standard
5 yr Median
Linear (Total Phosphorus)

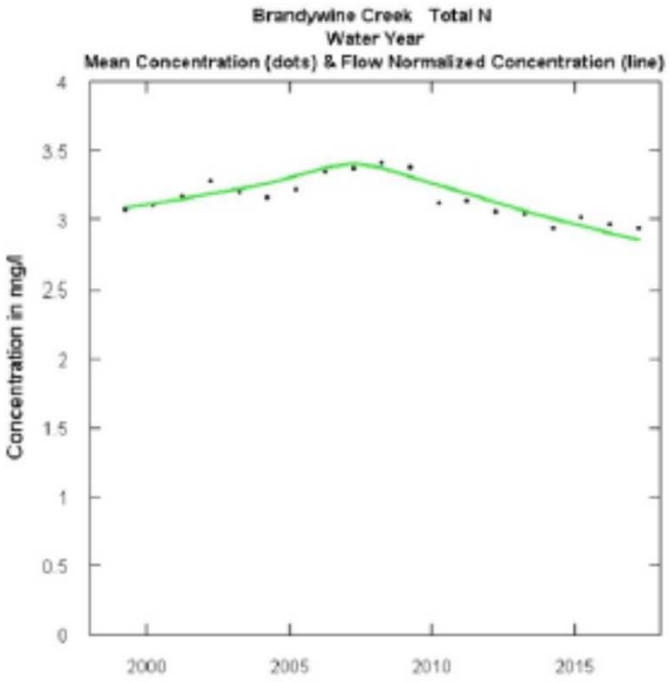

Christina River at Nottingham Rd., Rt. 273
Total Phosphorus (mg/L)
y = -3E-07x + 0.049
Median
WQ Standard
5 Yr Median
Linear (Total Phosphorus)

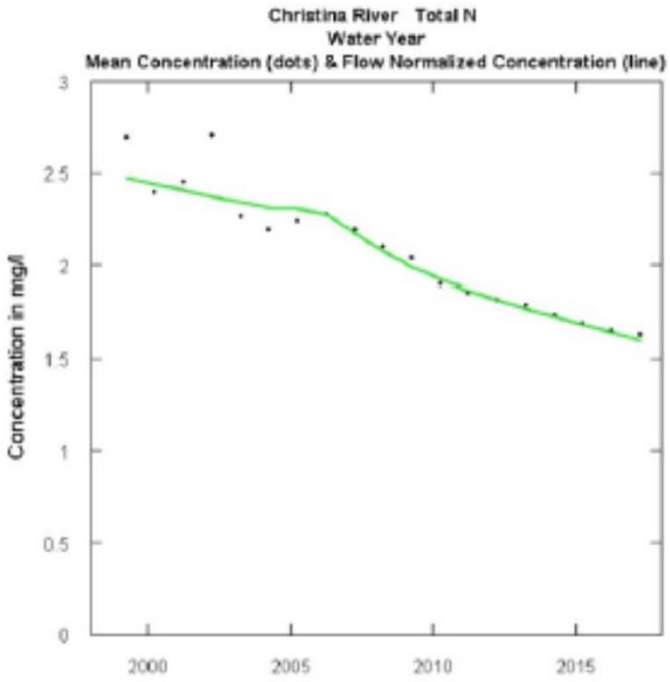

Brandywine Creek at Smith Bridge
Total Suspended Solids (mg/L)
y = -0.0017x + 81.348
Median
5 yr Median
WQ Standard
Linear (TSS)


Red Clay Creek at Barley Mill Road, Ashland
Total Suspended Solids (mg/l)
y = -0.0009x + 47.15
Median
5 yr Median
WQ Standard
Linear (TSS)


White Clay Creek at Chambers Rock Road
Total Suspended Solids (mg/L)
y = -0.0007x + 39.469
Median
5 yr Median
WQ Standard
Linear (TSS)


Christina River at Nottingham Rd, Rte 273
Total Suspended Solids (mg/L)
y = 8E-05x + 1.5759
Median
5 yr Median
WQ Standard
Linear (TSS)





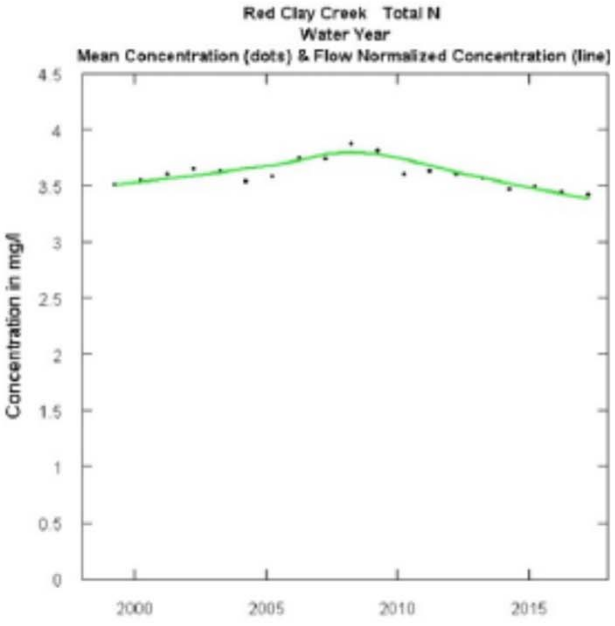
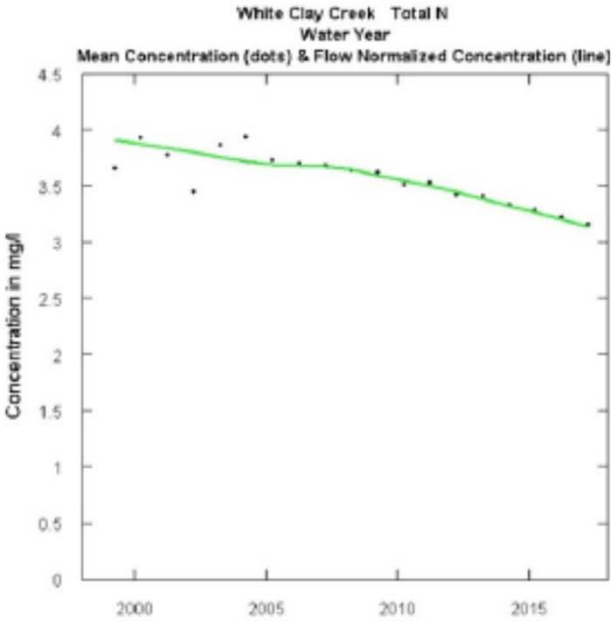
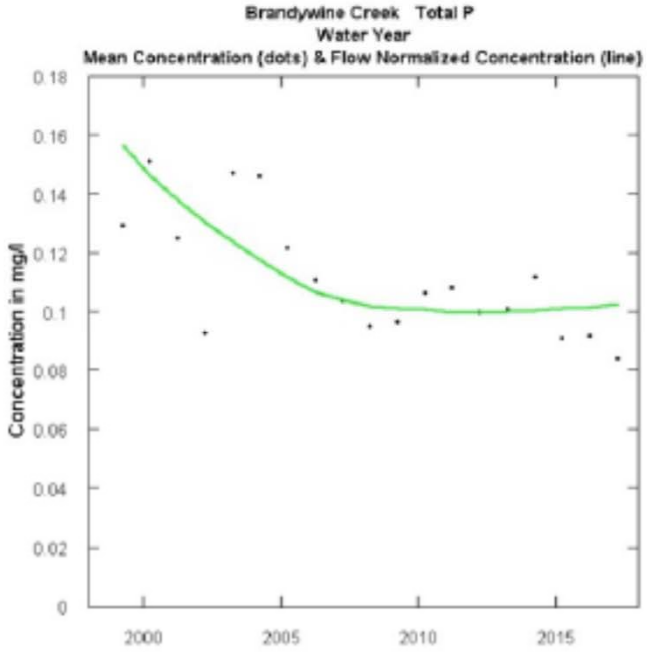
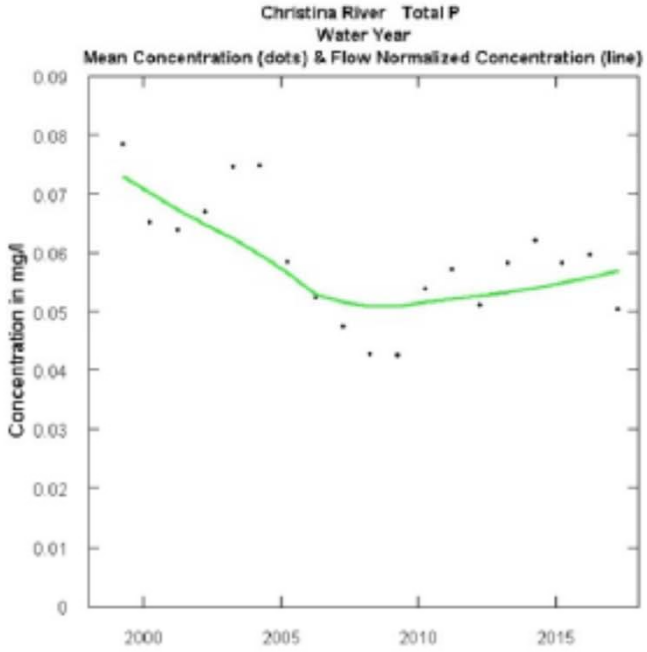


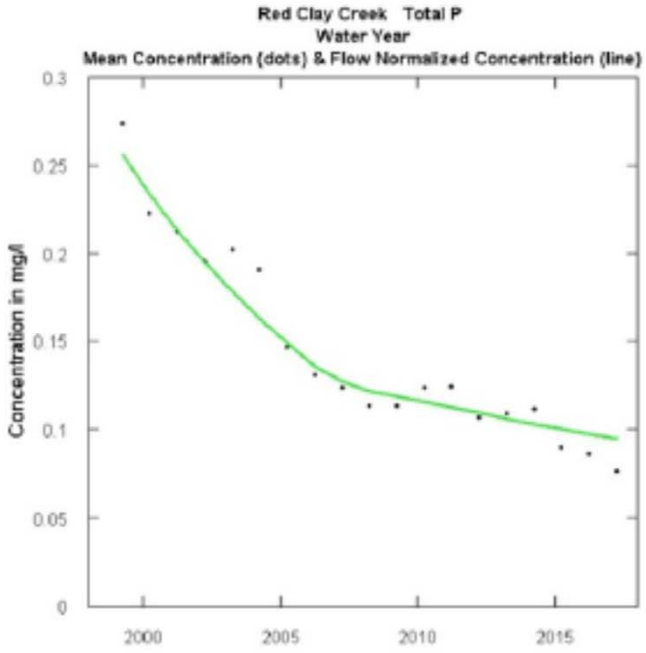
Table 3. Data period used for trend analysis of Total Nitrogen (TN) and the results

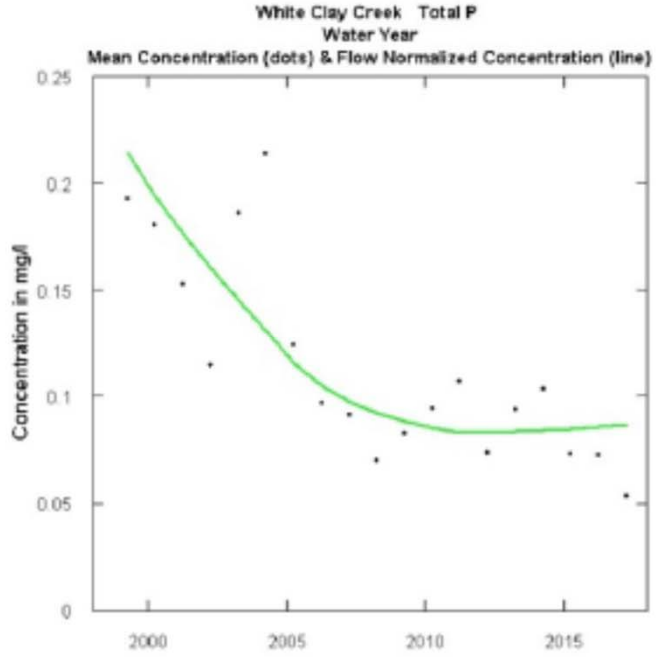
Monitoring Site ID	Site Description	Data used start year	Data used end year	Concentration change from 2008-2017 (mg/l)	Improving/ Worsening Trend
103031	Red Clay Creek at Lancaster Pike (Rt. 48)	1999	2017	-0.43	Improving
104021	Brandywine Creek at New Bridge Rd. (Rd. 279)	1999	2017	-0.53	Improving
105151	White Clay Creek at Delaware Park Blvd.	1999	2017	-0.50	Improving
106141	Christina River at Sunset Lake Rd. (Rt. 72)	1999	2017	-0.47	Improving




Brandywine Creek Total P
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2000
2005
2010
2015


Christina River Total P
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2000
2005
2010
2015


Red Clay Creek Total P
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0.3
0.25
0.2
0.15
0.1
0.05
0
2000
2005
2010
2015


White Clay Creek Total P
Water Year
Mean Concentration (dots) & Flow Normalized Concentration (line)
Concentration in mg/l
0.25
0.2
0.15
0.1
0.05
0
2000
2005
2010
2015


EVACUATION
ROUTE

Questions?

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