

# Water Quality Trends (1995-2022) in the Brandywine Christina Watershed at the DE/PA Stateline

January 20, 2022

Gerald J. Kauffman, Director  
University of Delaware  
Water Resources Center  
Biden School of Public Policy & Administration  
Newark, Del.



National Park Service  
U. S. Department of the Interior



# First State National Monument





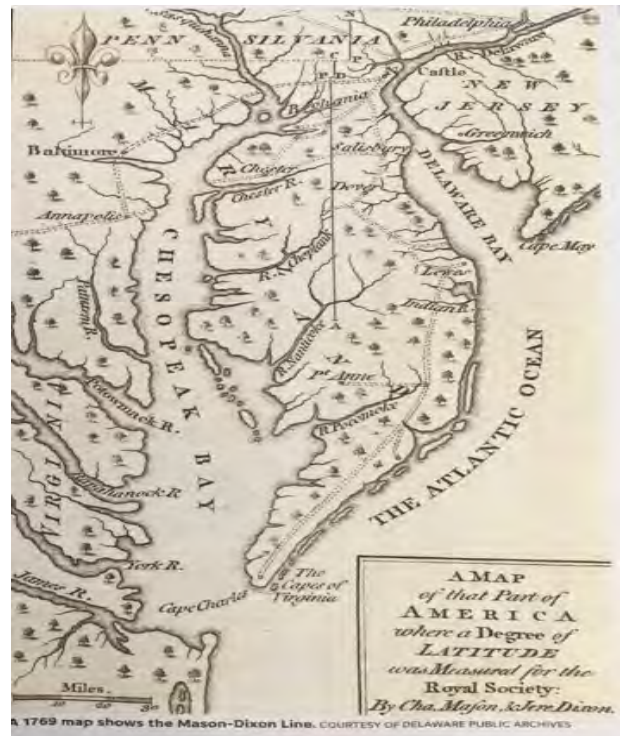
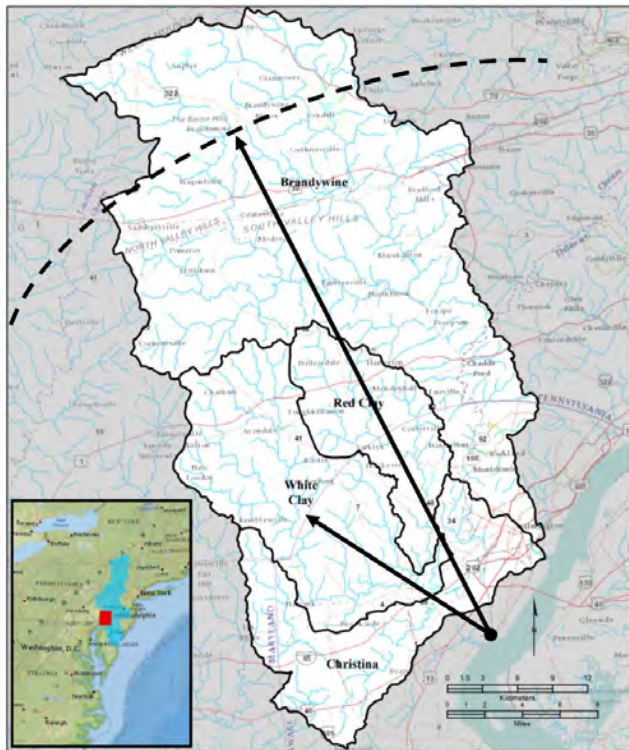






## WATER

WATER, LIKE THE FOREST, IS A RENEWABLE RESOURCE. IT FALLS TO EARTH AS RAIN OR SNOW WHERE SOME OF IT SOAKS DEEP INTO UNDERGROUND STREAMS TO EMERGE LATER IN THE FORM OF SPRINGS. THE REMAINING WATER RUNS OFF THE LAND INTO STREAMS AND PONDS, EVENTUALLY REACHING THE OCEAN. AS THE WATER FLOWS ACROSS THE LAND, SOME OF IT EVAPORATES TO FALL AGAIN AS RAIN. LAND MANAGEMENT PRACTICES ON THE NATIONAL FORESTS PROTECT THE FLOW OF PURE WATER FROM THE FOREST.



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



# 2017 CENSUS OF AGRICULTURE County Profile



## Chester County Pennsylvania



### Total and Per Farm Overview, 2017 and change since 2012

	2017	% change since 2012
Number of farms	1,646	-5
Land in farms (acres)	150,514	-8
Average size of farm (acres)	91	-4
<b>Total</b>	<b>(\$)</b>	
Market value of products sold	712,468,000	+8
Government payments	1,775,000	+9
Farm-related income	19,948,000	-36
Total farm production expenses	542,936,000	-1
Net cash farm income	191,254,000	+34
<b>Per farm average</b>	<b>(\$)</b>	
Market value of products sold	432,848	+13
Government payments		
(average per farm receiving)	10,820	+82
Farm-related income	28,336	-32
Total farm production expenses	329,852	+4
Net cash farm income	116,193	+41

### 9 Percent of state agriculture sales

#### Share of Sales by Type (%)

Crops	80
Livestock, poultry, and products	20

#### Land in Farms by Use (%) \*

Cropland	70
Pastureland	15
Woodland	9
Other	6

#### Acres irrigated: 1,191

1% of land in farms

#### Land Use Practices (% of farms)

No till	28
Reduced till	11
Intensive till	17
Cover crop	22

Chester County  
Pennsylvania, 2017  
Page 2

# 2017 CENSUS OF AGRICULTURE County Profile

### Market Value of Agricultural Products Sold

	Sales (\$1,000)	Rank in State *	Counties Producing Item	Rank in U.S. *	Counties Producing Item
<b>Total</b>	<b>712,468</b>	<b>2</b>	<b>67</b>	<b>53</b>	<b>3,077</b>
<b>Crops</b>	<b>570,929</b>	<b>1</b>	<b>67</b>	<b>25</b>	<b>3,073</b>
Grains, oilseeds, dry beans, dry peas	32,413	7	66	956	2,916
Tobacco	4,365	2	12	83	323
Cotton and cottonseed	-	-	-	-	647
Vegetables, melons, potatoes, sweet potatoes	6,266	7	67	294	2,821
Fruits, tree nuts, berries	1,845	12	66	338	2,748
Nursery, greenhouse, floriculture, sod	515,267	1	66	3	2,601
Cultivated Christmas trees, short rotation woody crops	605	14	64	69	1,384
Other crops and hay	10,166	10	66	245	3,040
<b>Livestock, poultry, and products</b>	<b>141,539</b>	<b>7</b>	<b>67</b>	<b>333</b>	<b>3,073</b>
Poultry and eggs	25,667	17	67	380	3,007
Cattle and calves	16,848	9	67	913	3,055
Milk from cows	83,698	5	63	99	1,892
Hogs and pigs	9,127	19	67	395	2,856
Sheep, goats, wool, mohair, milk	214	24	67	743	2,984
Horses, ponies, mules, burros, donkeys	5,881	2	63	24	2,970
Aquaculture	327	12	55	183	1,251
Other animals and animal products	667	9	67	239	2,878

### Total Producers \*

<b>2,856</b>	
<b>Sex</b>	
Male	1,726
Female	1,130
<b>Age</b>	
<35	429
35 - 64	1,845
65 and older	782
<b>Race</b>	
American Indian/Alaska Native	3
Asian	12
Black or African American	15
Native Hawaiian/Pacific Islander	2,817
White	9
More than one race	
<b>Other characteristics</b>	
Hispanic, Latino, Spanish origin	80
With military service	169
New and beginning farmers	707

### Percent of farms that:

Have internet access	<b>74</b>
Farm organically	<b>3</b>
Sell directly to consumers	<b>13</b>
Hire farm labor	<b>43</b>
Are family farms	<b>96</b>

### Top Crops in Acres \*

Forage (hay/haylage), all	35,439
Corn for grain	27,140
Soybeans for beans	15,567
Corn for silage or greenchop	8,323
Wheat for grain, all	5,121

### Livestock Inventory (Dec 31, 2017)

Broilers and other meat-type chickens	297,852
Cattle and calves	47,499
Goats	1,390
Hogs and pigs	21,550
Horses and ponies	7,142
Layers	113,599
Pullets	335,713
Sheep and lambs	1,771
Turkeys	67,372

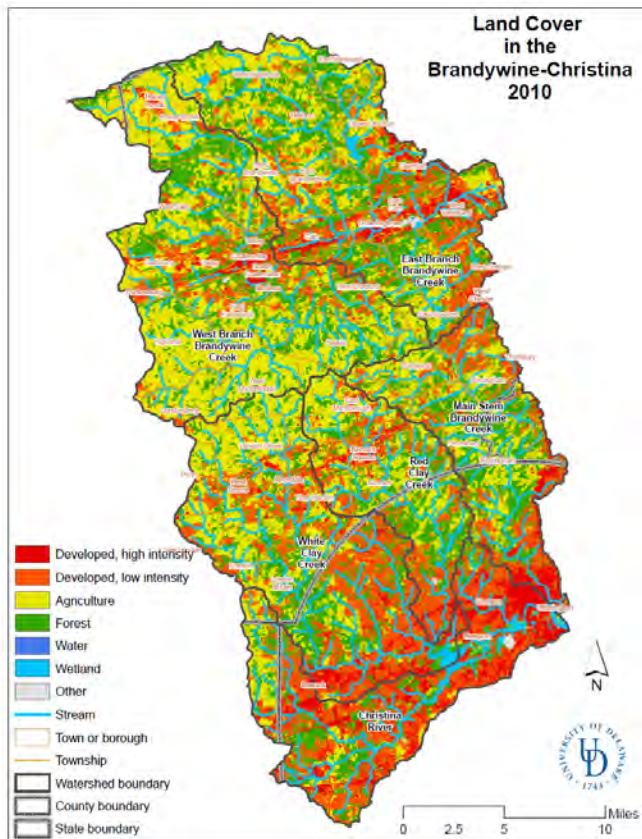
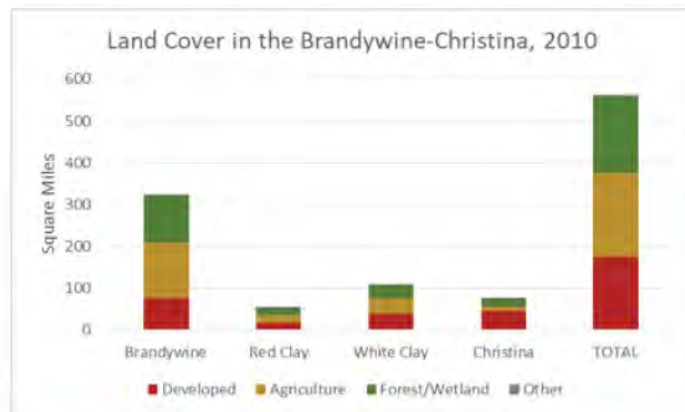
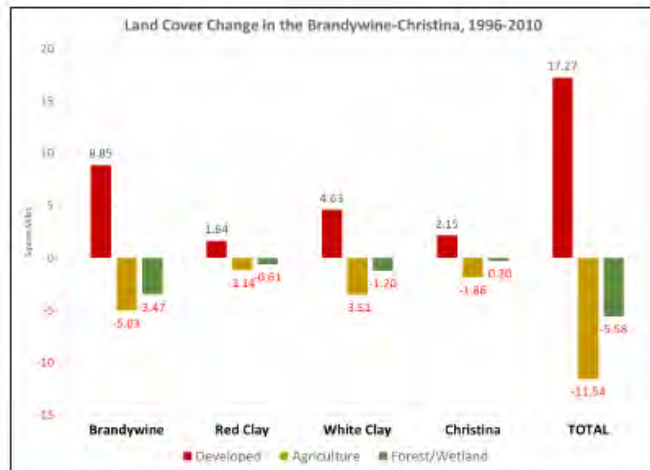
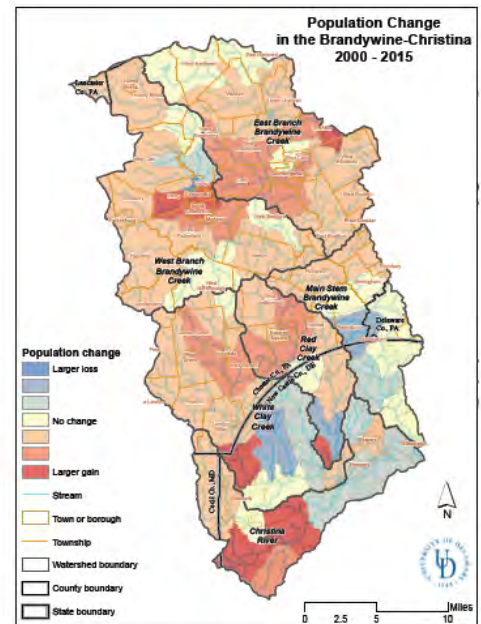
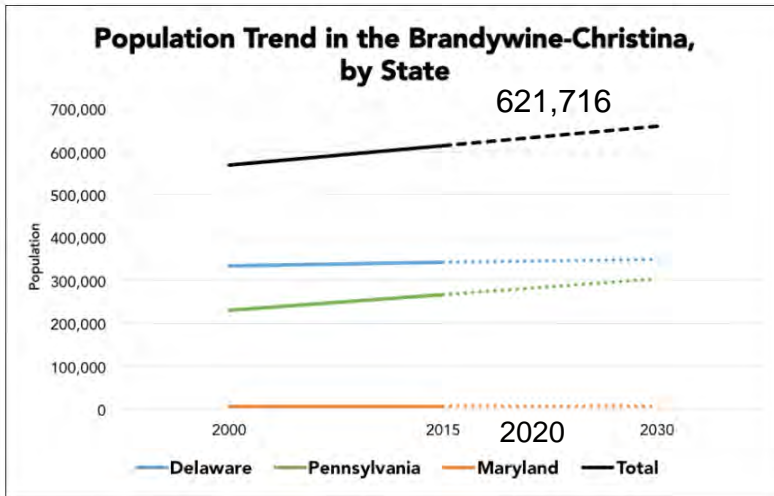


FIGURE S-1 Land cover in the Brandywine-Christina watershed, based on 2010 NOAA CSC C-CAP.





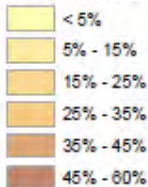


**Figure 2-9** Population change by sub-watershed in the Brandywine-Christina watershed, between 2000 and 2015. (US Census Bureau)

Pop. 2010	Pop. 2020	Change 2010-2020	% Change 2010-2020
599,441	621,716	22,275	4%

Percent Agricultural Land  
by Catchment in the  
Brandywine-Christina  
2010

% Agricultural



Stream

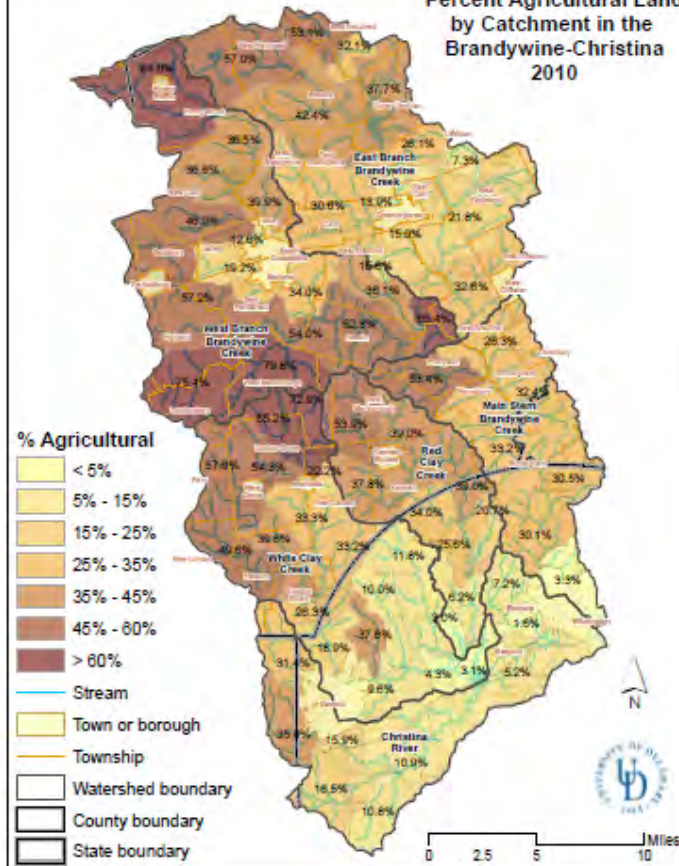
Town or borough

Township

Watershed boundary

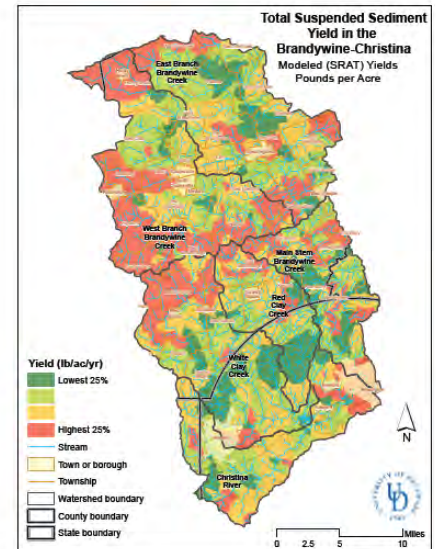
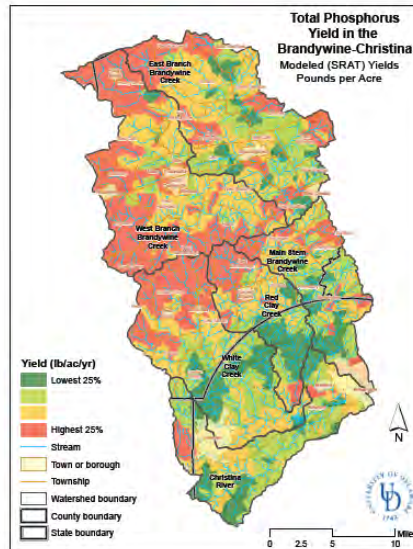
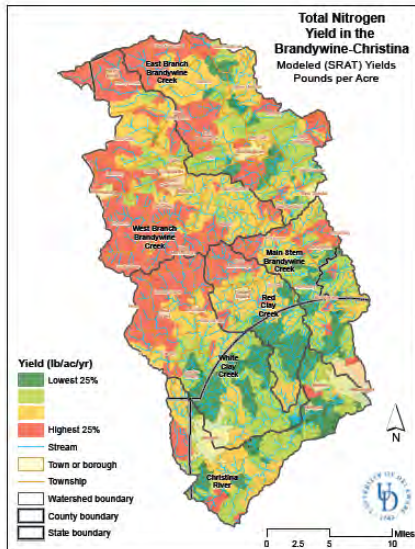
County boundary

State boundary



Up to 60% of the  
watershed is agriculture.





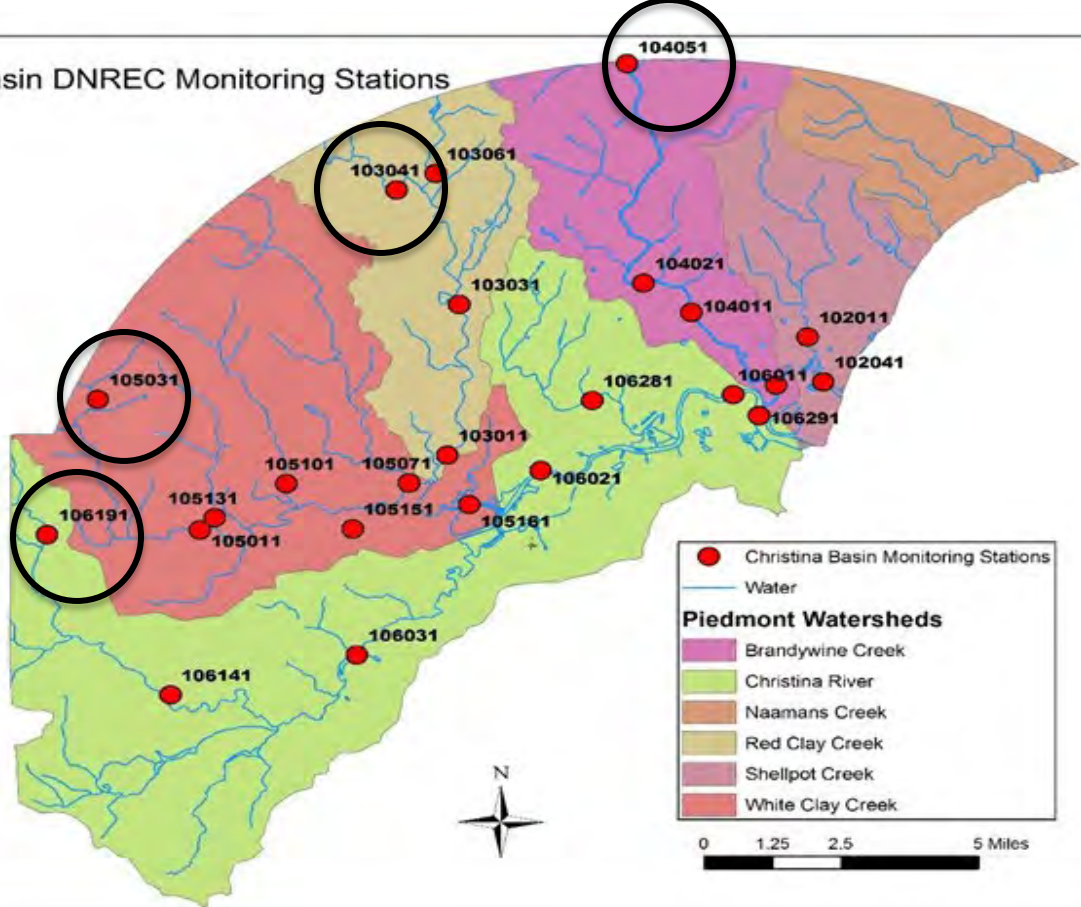
THE ANS SRAT model shows high yield of N, P, and TSS from the headwaters.

# Delaware Stream Water Quality Criteria

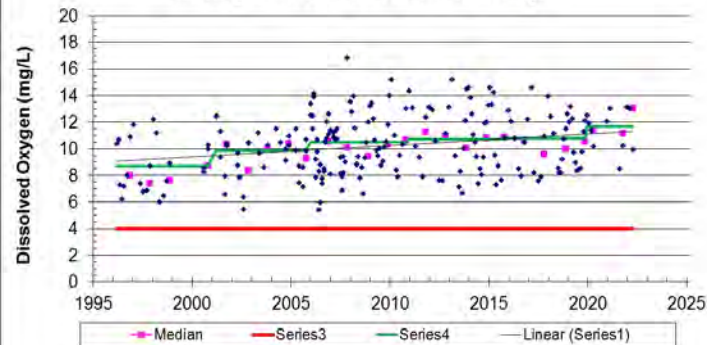
Dissolved Oxygen	4.0 mg/l	Fishable
Enterococcus Bacteria	100 col./100 ml	Swimmable
Total Phosphorus	0.05-0.10 mg/l	TMDL Target
Total Nitrogen	1.0-2.0 mg/l	TMDL Target
Total Susp. Sediment	5-20 mg/l	DE Inland Bays



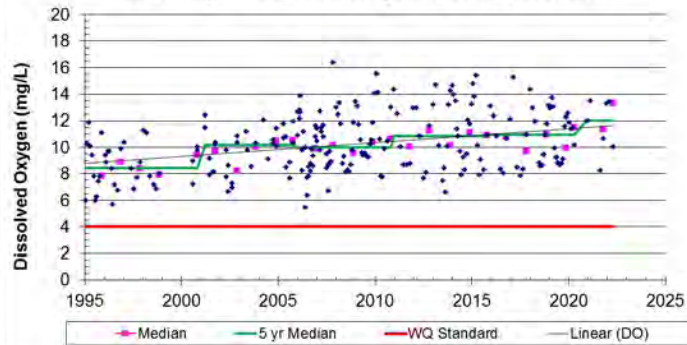
# Christina Basin DNREC Monitoring Stations



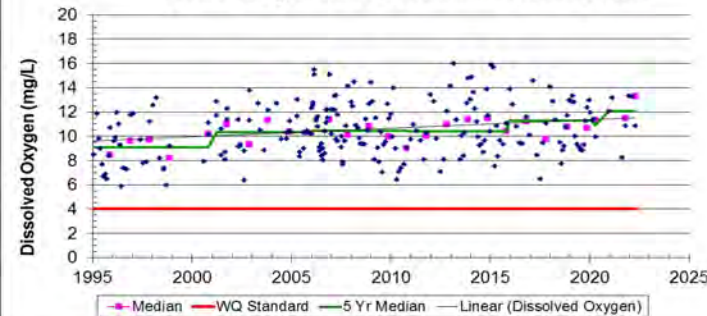
**Brandywine Creek at Smith Bridge**



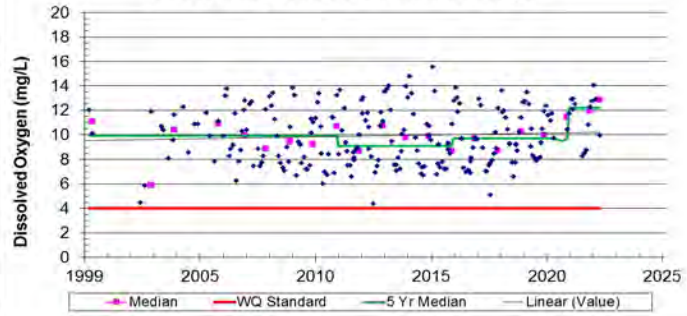
**Red Clay Creek at Barley Mill Road, Ashland**



**White Clay Creek at Chambers Rock Road**



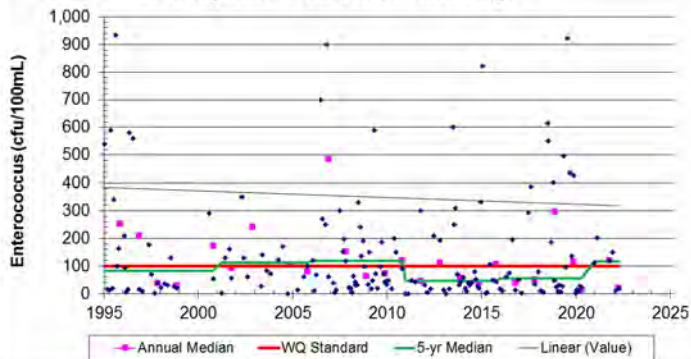
**Christina River at Cooches Bridge**



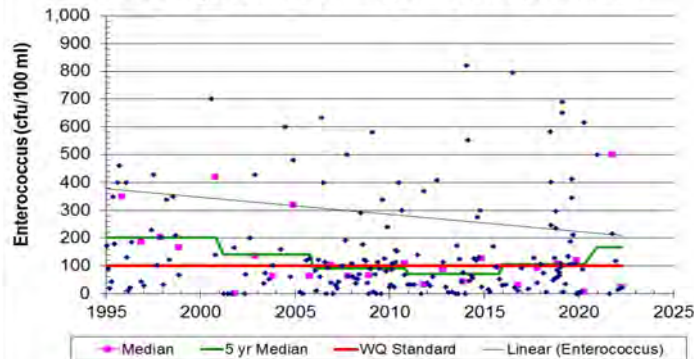
DO increased by 2 mg/l since 1995 and is well above the 4 mg/l fishable standard.



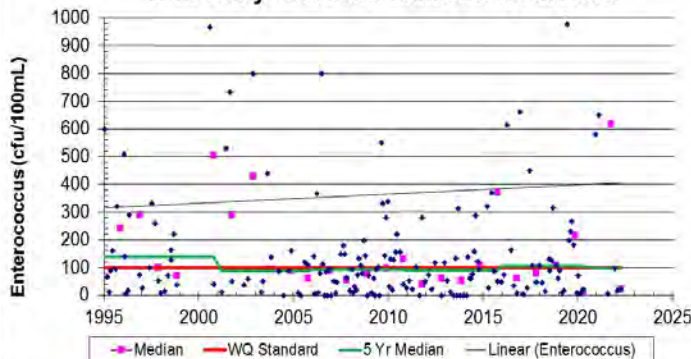
**Brandywine Creek at Smith Bridge**



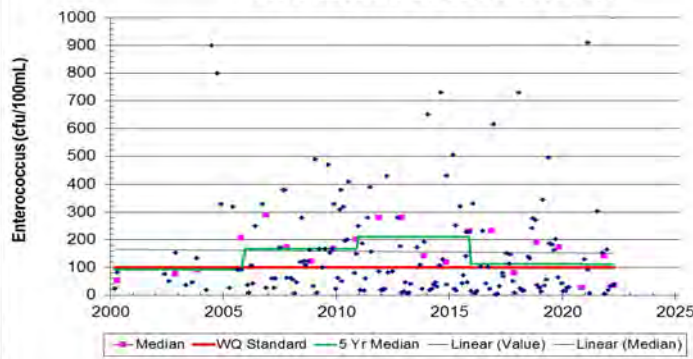
**Red Clay Creek at Barley Mill Road, Ashland**



**White Clay Creek at Chambers Rock Road**



**Christina River at Cooches Bridge**

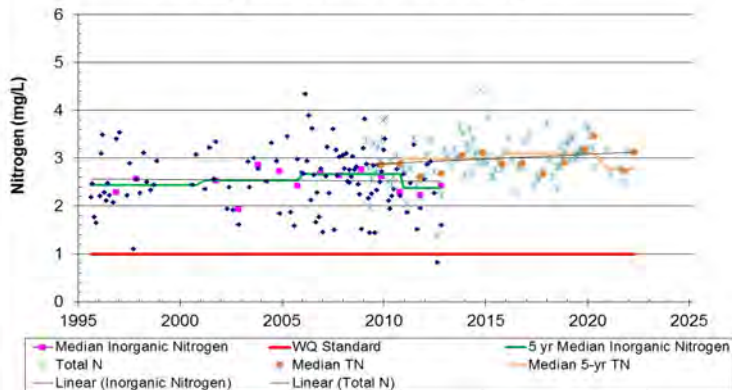


Bacteria declining, streams swimmable 3 to 5 days after storms.

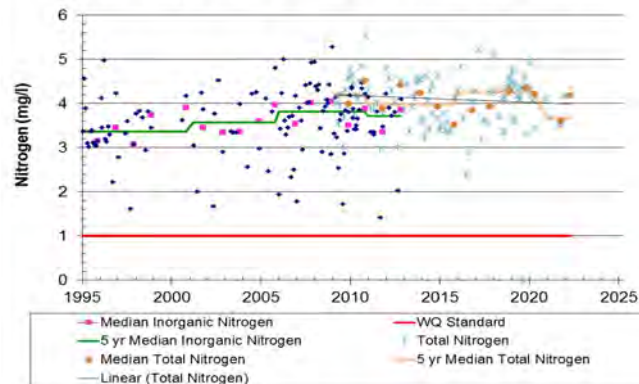




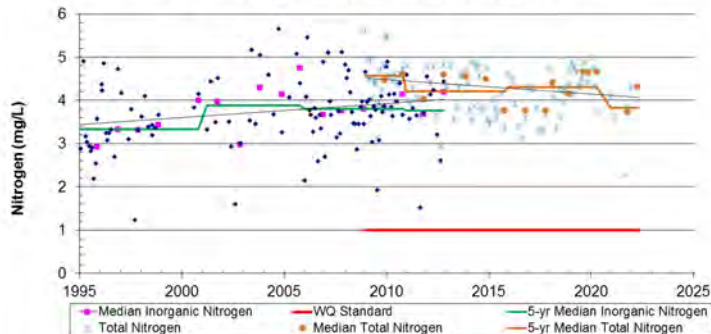
**Brandywine Creek at Smith Bridge**



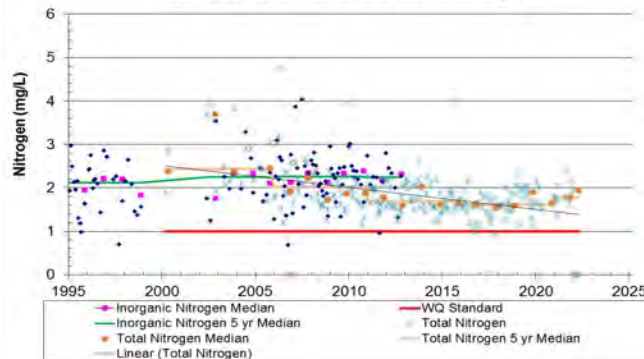
**Red Clay Creek at Barley Mill Road, Ashland**



**White Clay Creek at Chambers Rock Road**



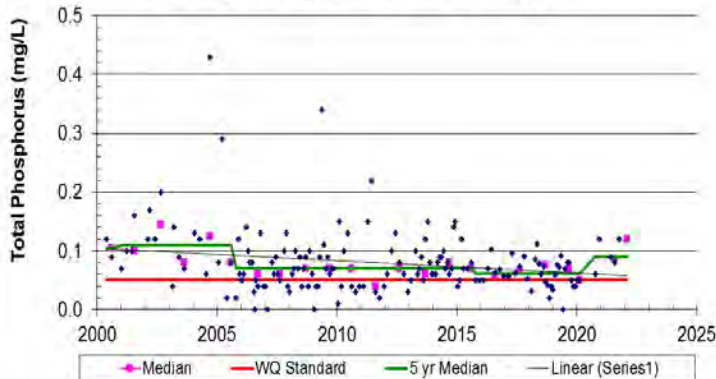
**Christina River at Cooches Bridge**



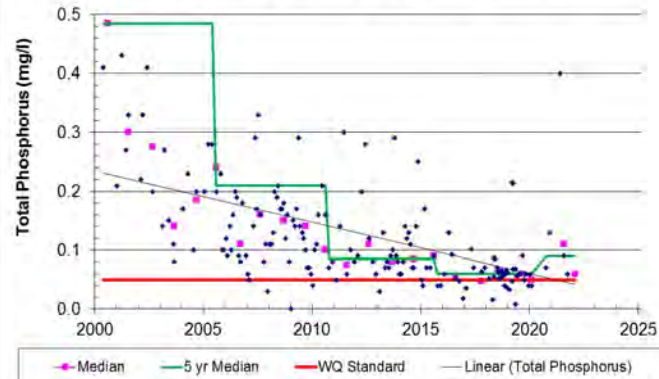
Nitrogen 2 to 4 times >TMDL target but have leveled off lately.



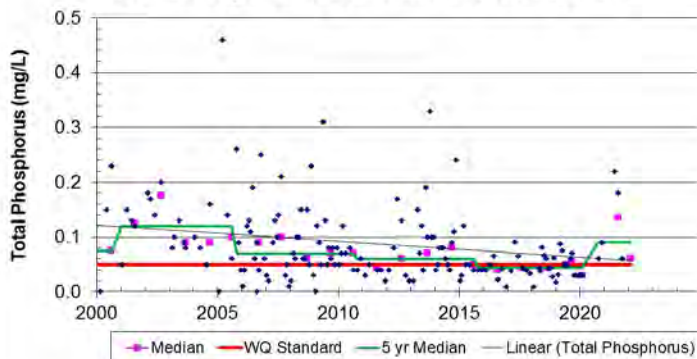
**Brandywine Creek at Smith Bridge**



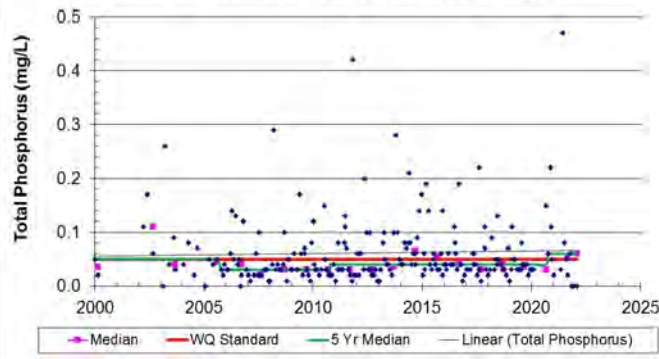
**Red Clay Creek at Barley Mill Road, Ashland**



**White Clay Creek at Chambers Rock Road**

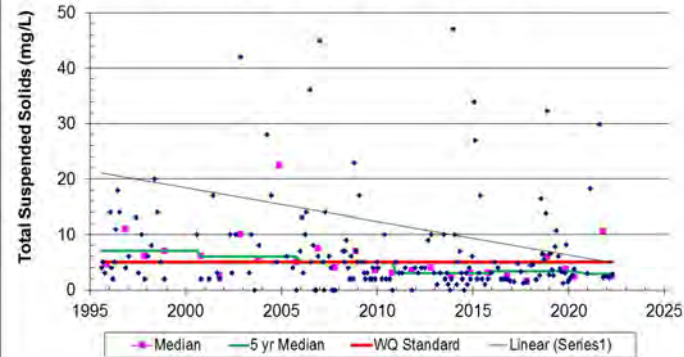


**Christina River at Cooches Bridge**

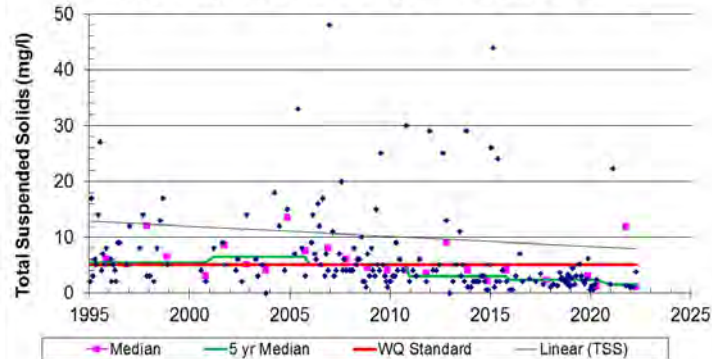


Phosphorus has markedly declined to the TMDL target level.

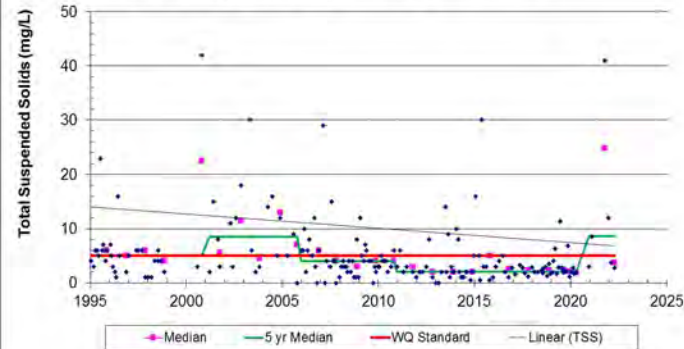
**Brandywine Creek at Smith Bridge**



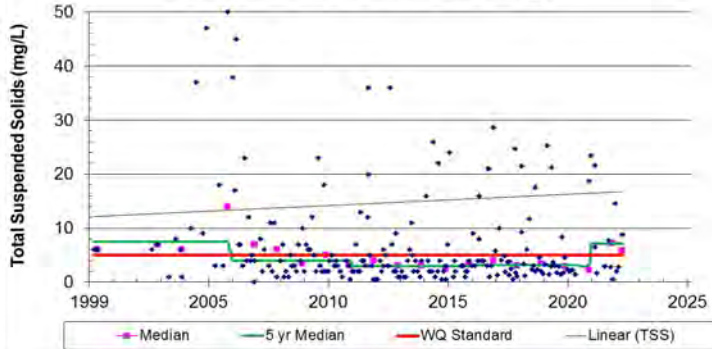
**Red Clay Creek at Barley Mill Road, Ashland**



**White Clay Creek at Chambers Rock Road**

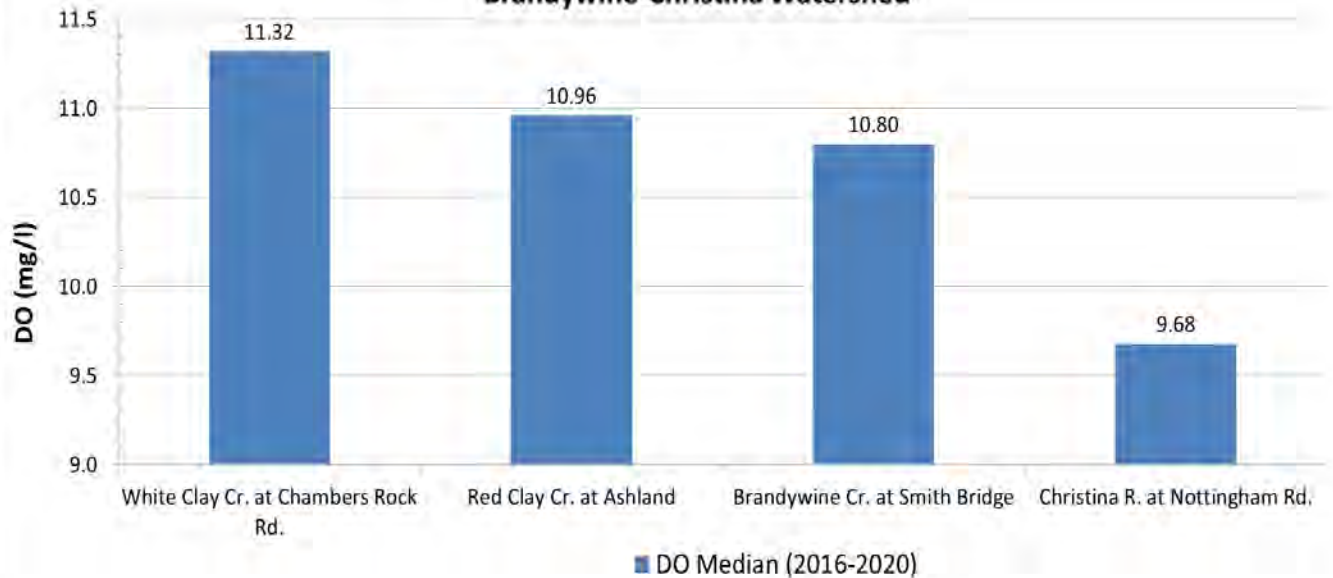


**Christina River at Cooches Bridge**



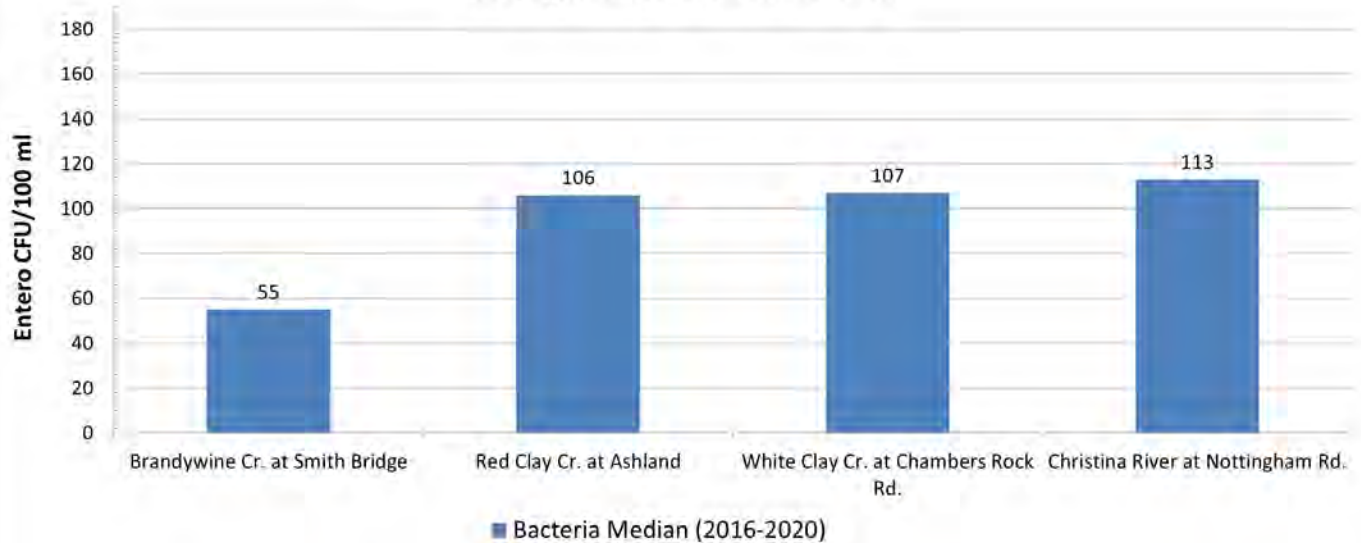
Sediment levels have declined but still high during storms.

### Dissolved Oxygen Medians Brandywine-Christina Watershed

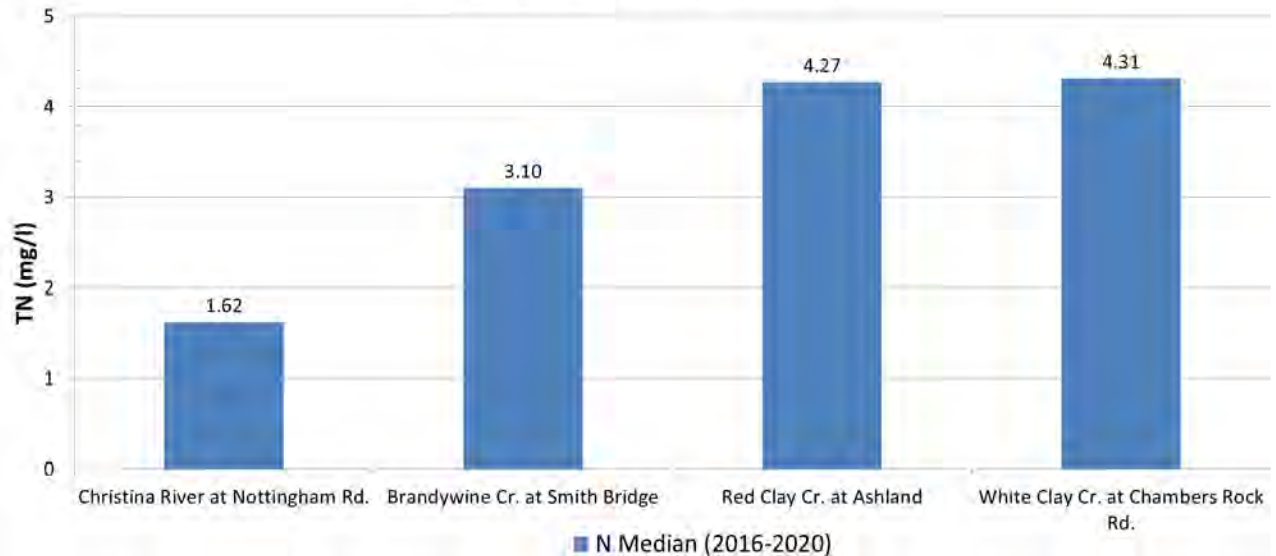




### Enterococcus Bacteria Medians Brandywine-Christina Watershed



### Total Nitrogen Medians Brandywine-Christina Watershed



### Total Phosphorus Medians Brandywine-Christina Watershed

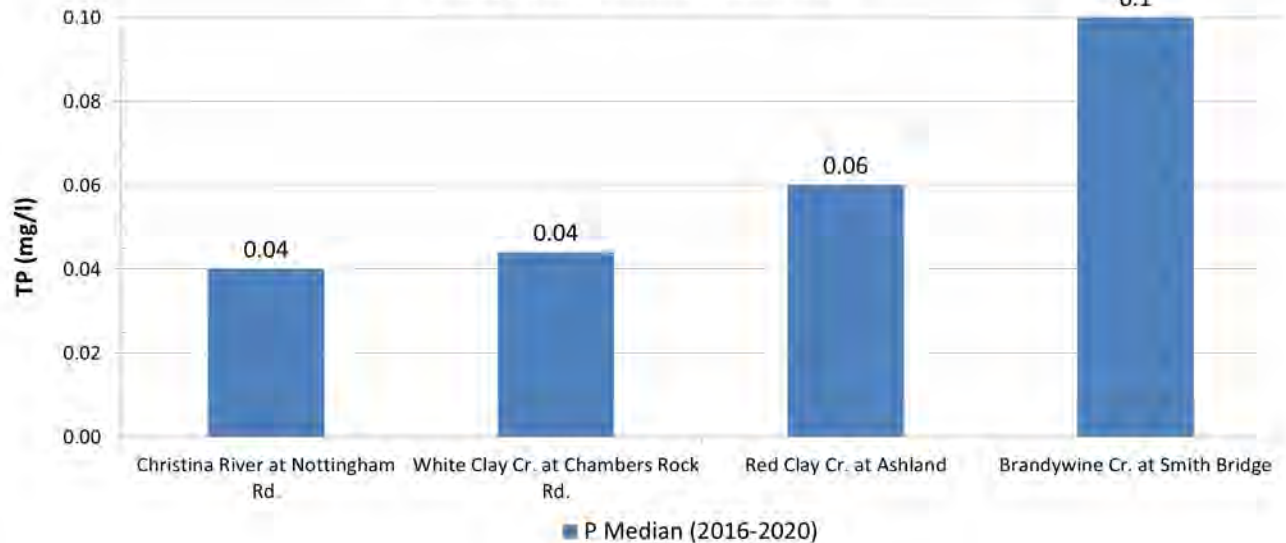











Table 2. Trend Analysis Results for TN and TP Concentrations at the C1 Monitoring Sites

C1 Site ID	Location description	Period (water year)	Estimated TN Change (mg/l)	Estimated TP Change (mg/l)	TN Trend*	TP Trend*
103031	Red Clay Creek at Lancaster Pike (Rt. 48)	1999 - 2019	-0.07	-0.177	~	
104021	Brandywine Creek at New Bridge Rd. (Rd. 279)	1999 - 2019	-0.19	-0.070		
105151	White Clay Creek at Delaware Park Blvd.	1999 - 2019	-0.63	-0.142		
106141	Christina River at Sunset Lake Rd. (Rt. 72)	1999 - 2019	-0.83	-0.026		

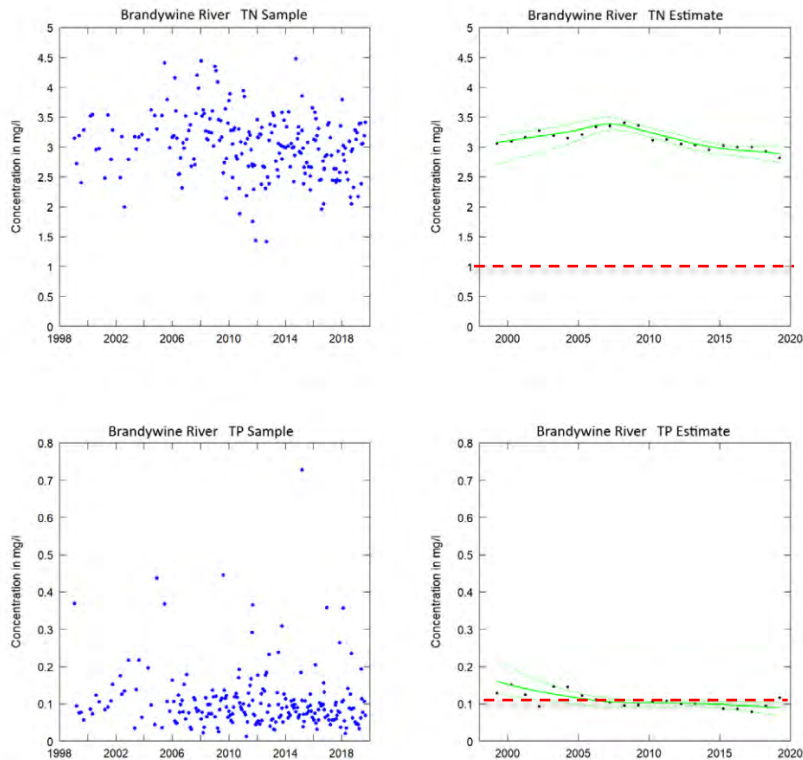


Figure 7. TN and TP sample concentrations (blue dots) at Brandywine River at New Bridge Road (site ID 104021), estimated annual mean (black dots) and flow normalized concentrations (green lines) with 90% confidence intervals (green dotted lines)

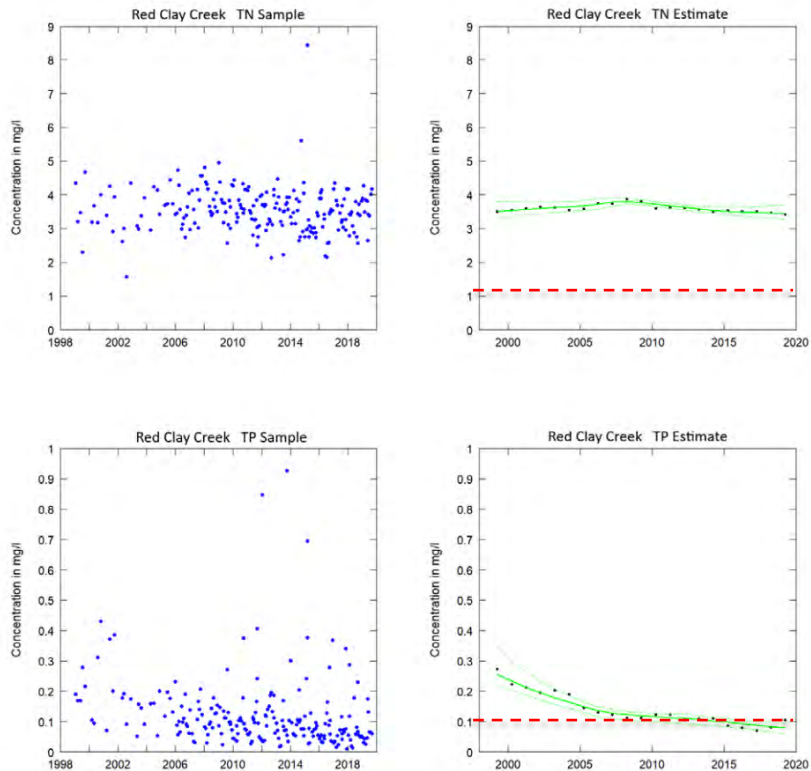


Figure 6. TN and TP sample concentrations (blue dots) at Red Clay Creek at Lancaster Pike (site ID 103031), estimated annual mean (black dots) and flow normalized concentrations (green lines) with 90% confidence intervals (green dotted lines)



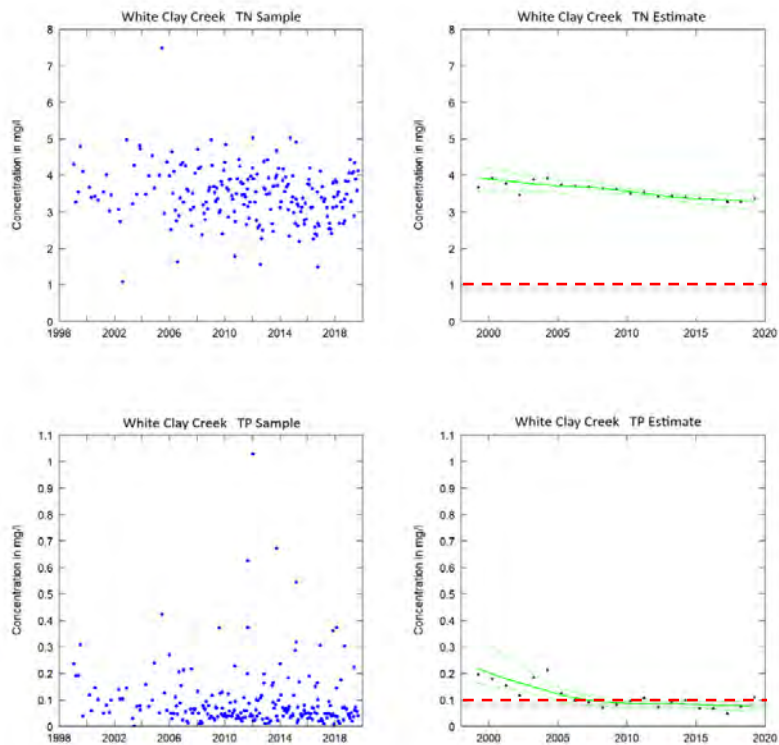


Figure 8. TN and TP sample concentrations (blue dots) at White Clay Creek at DE Park Boulevard (site ID 105151), estimated annual mean (black dots) and flow normalized concentrations (green lines) with 90% confidence intervals (green dotted lines)

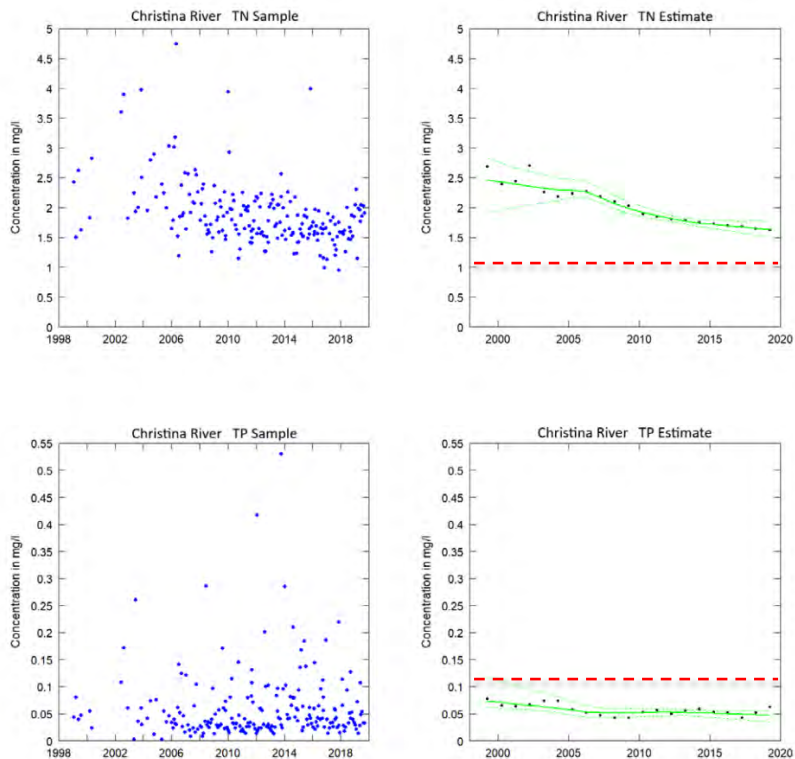
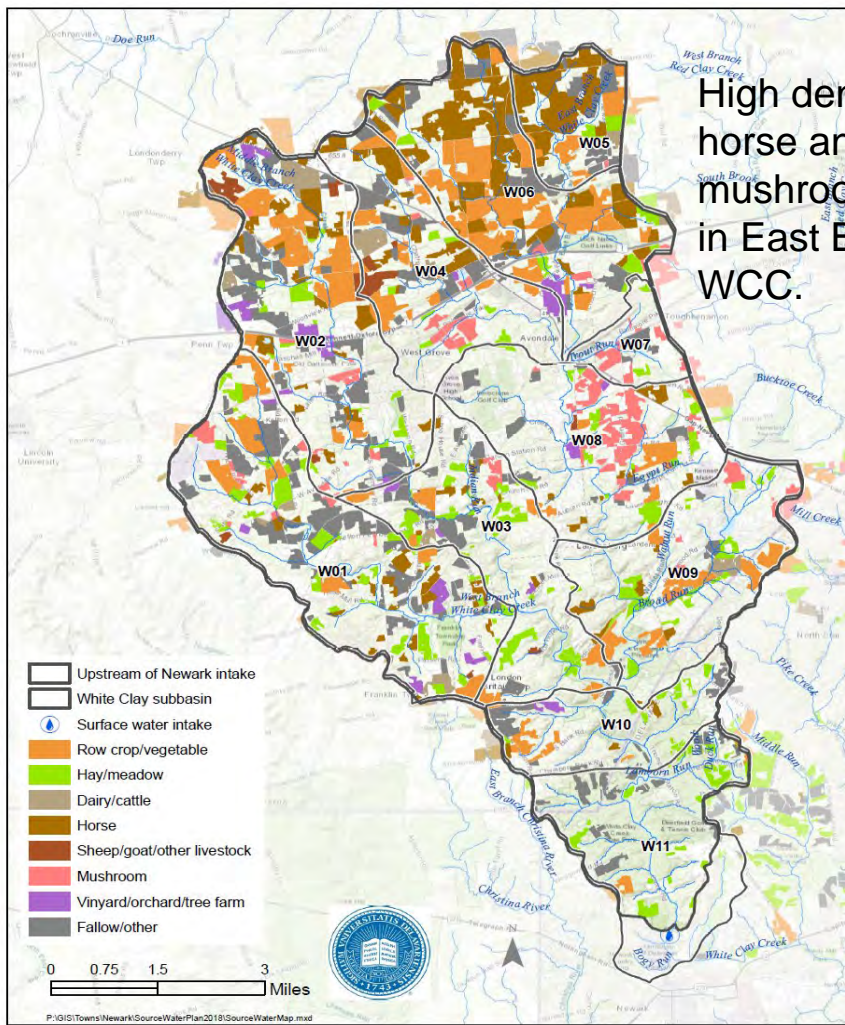


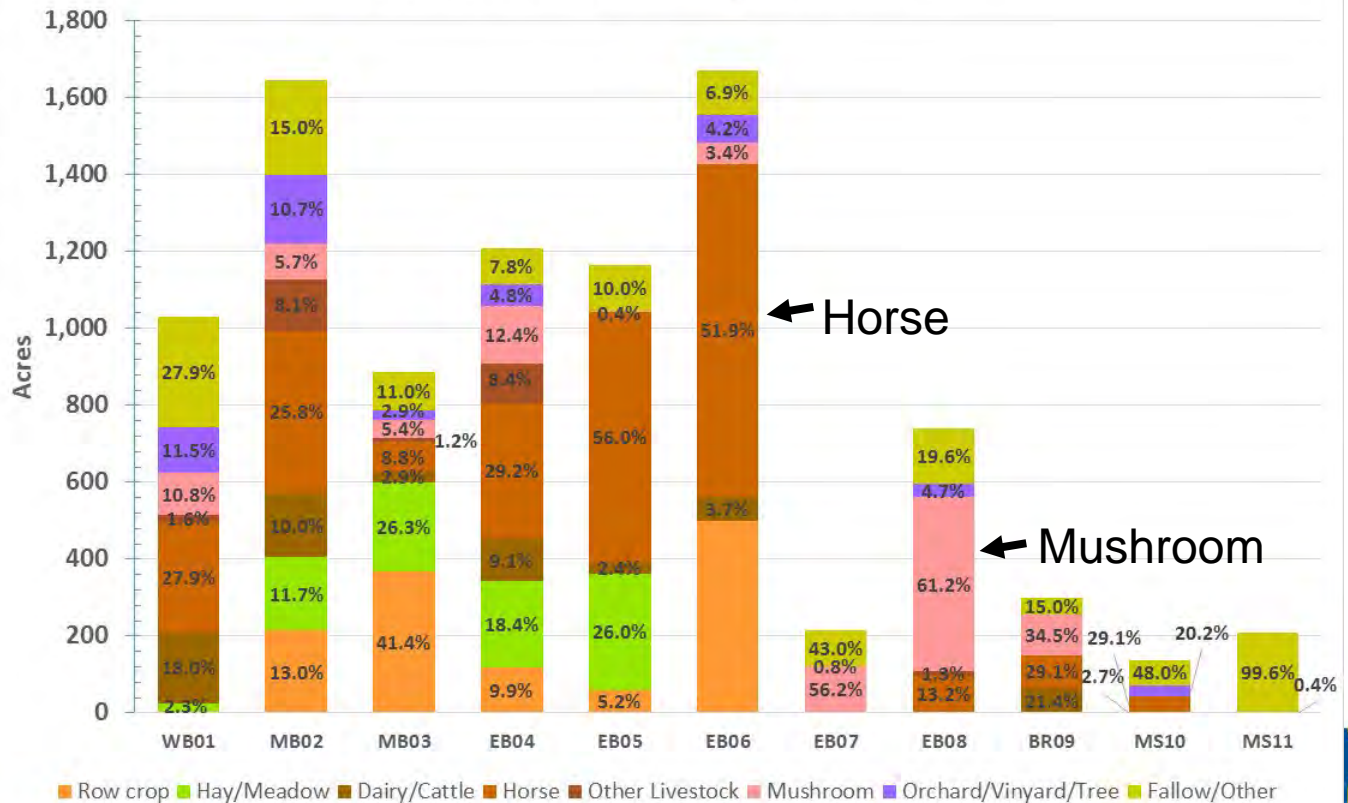
Figure 9. TN and TP sample concentrations (blue dots) at Christina River at Sunset Lake Road (site ID 106141), estimated annual mean (black dots) and flow normalized concentrations (green lines) with 90% confidence intervals (green dotted lines)

High density of horse and mushroom farms in East Branch WCC.





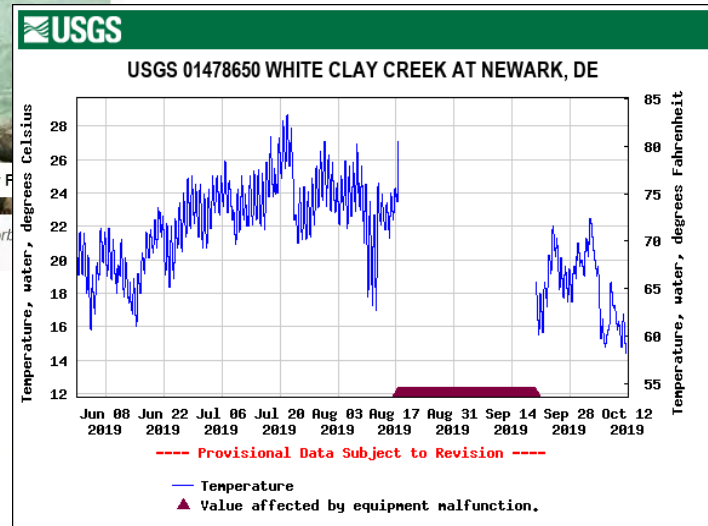
Farm Acres  
White Clay Creek Watershed  
Above Newark Drinking Water Intake





Newark Reservoir in 2017 was plagued with a blue-green algae bloom. (Photo: Jennifer Cortez / News Journal)

High nitrogen and high summer temps contribute to harmful algal blooms in Newark Reservoir cancelling triathlons and rendering drinking water unpotable.









August 19, 2009

Mr. Kyle Sonnenberg, City Manager  
Mr. Rich Lapointe, Public Works Director  
City of Newark  
220 Elkton Road  
Newark, DE 19711

RE: Stormwater Utility Feasibility Report

Dear Mr. Sonnenberg and Mr. Lapointe:

Enclosed is our revised report summarizing the feasibility of a stormwater utility for the City of Newark. The purpose of the stormwater utility is to equitably fund the City's stormwater programs to reduce flooding and stormwater problems and improve water quality. **In Newark, stormwater is drinking water.** Many of these City programs are conducted in accordance with Federal State laws like the Clean Water Act and Del. Stormwater and Sediment Control Regulations. Delaware municipalities are authorized to form stormwater utilities under Chapter 40, Title 7 of Delaware Code. Many college towns of similar character have successfully implemented stormwater utilities as dedicated and sustainable funding of stormwater, water quality, and floodplain management programs.

Based on a statistical GIS analysis of parcels and zoning districts and annual rates of \$0.01 to \$0.02 per square foot of impervious area, the stormwater utility would generate \$716,000 to \$1,432,000 per year for the City stormwater budget. The gross impervious cover of 7,500 parcels within 8.0 sq mi of the City is 34% (minus roads/railroads). At a penny per sq ft, the flat fee for single family residential parcels would be \$3.33 per month and nonresidential fees would be \$10.00 per 1000 sq ft per month. At two pennies per sq ft, the fee for single family residential would be \$6.75 per month and nonresidential fees would be \$20.00 per 1000 sq ft per month. The study includes a draft ordinance for consideration.

This report incorporates additional information presented at last night's City Council workshop.

Please do not hesitate to contact us at 302-831-4929 or [jerryk@udel.edu](mailto:jerryk@udel.edu).

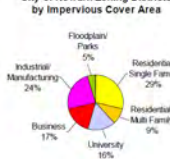
Warmly,

Gerald J. Knuthman, P. E.  
DirectorAndrew Homsey  
GIS ManagerCc: Roy Lopata, Newark Planning Department  
Roy Simonson, Newark Water Department

Dennis McFarland, Newark Finance Department

## Executive Summary

- Newark maintains a stormwater system in the Christina White Clay watersheds with 60 miles of sewers, 200 miles of curb/gutter, 3000 catch basins, 34 stormwater ponds, & 500 floodplain acres.
- The City proposes to adopt a stormwater utility as a dedicated funding source to recover \$1.6 million annually for operation of stormwater, water quality, and floodplain programs largely required by Federal and State laws and regulations.
- The goals of the Newark stormwater program are to: (a) prevent/reduce flood and stormwater problems, (b) improve water quality, (c) decrease pollutant loads to City drinking water sources.
- Stormwater utility advantages include: (a) treats stormwater as a utility resource (like drinking water) instead of waste stream, (b) equitable by stormwater contribution from impervious roof and pavement, (c) accrued to tax paying & tax exempt properties - both contribute stormwater runoff.
- There are more than 500 stormwater utilities throughout the USA.
  - The average stormwater fee for a single family home was \$3.67 per month.
  - College town monthly residential fees: \$1.50 (Burlington, VT), \$3.43 (Orono, ME), \$14.26 (Fr. Collins, CO).
  - USEPA survey in mid-Atlantic, residential stormwater fees range from \$2 to \$40 per quarter.
  - Wilmington and Philadelphia monthly residential fees are \$3.03 and \$10.80, respectively.
- About 34% of land on 7,500 parcels in Newark are covered by impervious area with breakdown:

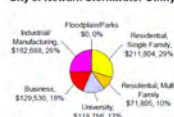
City of Newark Zoning Districts  
by Impervious Cover Area

ie family residential parcels in Newark is 4,000 sq ft which is 1 (ERU).

utility in the City of Newark would range from:  
impervious cover (\$3.33 per month single family residential), to  
impervious cover (\$6.75 per month single family residential).

City of Newark

2

Estimated Annual Revenue  
(\$716,174 at \$0.01 per sq ft)  
City of Newark Stormwater Utility

9. The following table lists possible options for a City of Newark stormwater utility fee:

Designation	Option 1 (\$0.01/sf) Stormwater Fee	Option 2 (\$0.02/sf) Stormwater Fee
Residential, One-family, detached, semi-detached	\$3.33 monthly	\$6.75 monthly
Multi-family Residential, University, Business, Manufacturing, Industrial, Office	\$10.00/1000 sf monthly	\$20.00/1000 sf monthly
Open floodway district (undeveloped)	No building permitted	No building permitted
Parkland, Roads/streets, Railroads, City-owned land, City-leased parking facilities	Exempt	Exempt
<b>Projected Annual Revenue</b>	<b>\$716,174</b>	<b>\$1,432,348</b>

- The City and WRA should initiate a public education program to inform property owners about the benefits of a stormwater utility to reduce flooding/stormwater problems and improve water quality.
  - Meet with commercial properties that generate high stormwater runoff and (2) tax exempt properties.
  - Establish a stormwater utility website.
  - Create a stormwater utility brochure to be sent to all customers before initial billing.
- Municipalities are authorized to form a stormwater utility in Chapter 40, Title 7, Delaware Code.
- The City should consider the water/sewer/electric or property assessment billing systems to assess the stormwater fee with the latter being the preferred mechanism.
- City Council should consider adopting a stormwater utility ordinance to recover annual costs of stormwater services provided to parcel owners with ordinance effective date January 1, 2010.

In 2009 UD submitted the first  
stormwater utility feasibility  
report to the City of Newark.

## Newark council approves monthly stormwater fee

Charge is equivalent to 7 percent tax hike for average resident

By Josh Shannon jshannon@chespub.com Oct 10, 2017 9



The stormwater fee approved Monday will raise \$1.4 million each year to improve stormwater facilities around the city. SUBMITTED PHOTO

f t e p i

Capping years of discussion, city council on Monday approved a plan to charge every landowner in the city a monthly fee to fund upgrades to the stormwater system.

Starting in January, homeowners will pay between \$1.77 and \$5.31 each month, which for the average resident is akin to a 7 percent tax increase, officials said.

The proposal passed 4-2, with opposing votes from Councilmen Stu Markham and Mark Morehead, who both said they support the idea in principle but had unresolved concerns. Councilman Luke Chapman was absent.

Supporters of the measure acknowledged it's not perfect but believed it was time to move forward.



Latest e-Edition

More Issues

Meter Number	Read Dates		Billing Days	Code	Meter Readings			Usage	Units	Power Factor
	Present	Previous			Present	Previous	Multiplier			
WATER: 0075575804	04/26/2019	03/19/2019	32	KR	0301853	0299043	1	2810	gallons	
STORMWATER	04/20/2019	03/19/2019	32							

BILLING SUMMARY			PREVIOUS BALANCE			
Previous Balance as of: 03/28/19	\$48.96		PAYMENT	04/18/2019		48.96
Payments & Adjustments 04/18/19	(\$48.96)		PAST DUE AMOUNT/BALANCE FORWARD			0.00
Balance Forward as of: 04/24/19	\$0.00					
Current Charges as of: 04/24/19	\$49.11					
Total Amount Due	\$49.11					

	Rate	Usage	Charges
WATER CHARGES:			
Water usage up to 3174 G	0.007140	2810	20.06
SEWER CHARGES:			
Sewer usage 1n G	0.008592	2810	24.14
STORMWATER CHG:			
SWR3-SINGLE FAMILY RESIDENTIAL			4.91
STORMWATER SUBTOTAL			4.91
CURRENT CHARGES			\$49.11
TOTAL AMOUNT DUE			\$49.11



065-00004957-01

BALANCE FORWARD DUE UPON RECEIPT AND IS SUBJECT TO IMMEDIATE DISCONNECTION AS A RESULT OF ANY PAST DUE OR OUTSTANDING BILL AMOUNT. 1.5% Late payment penalty will be applied to any unpaid balance if not paid by due date.

Bill Type	Account Type	Bill Date	Due Date	Amount Due	Payment Type
REGULAR	SINGLE FAMILY	04/24/2019	05/16/2019	49.11	DO NOT PAY - AUTO DEBIT

MESSAGES: Open or close your electric account through Customer Connect, at [www.newarkde.gov/payments](http://www.newarkde.gov/payments).

Committed To Service Excellence



## THE ROAD NOT TAKEN

Two roads diverged in a yellow wood,  
And sorry I could not travel both  
And be one traveler, long I stood  
And looked down one as far as I could  
To where it bent in the undergrowth;

Then took the other, as just as fair,  
And having perhaps the better claim,  
Because it was grassy and wanted wear;  
Though as for that, the passing there  
Had worn them really about the same,

And both that morning equally lay  
In leaves no step had trodden black.  
Oh, I kept the first for another day!  
Yet knowing how way leads on to way,  
I doubted if I should ever come back.

I shall be telling this with a sigh  
Somewhere ages and ages hence:  
Two roads diverged in a wood, and I –  
I took the one less traveled by,  
And that has made all the difference.

Copyright 1916, Copyright 1963 by Holt, Rinehart & Winston,  
Copyright 1964 by Robert Frost.  
Reprinted by permission of Henry Holt & Company, Inc.

