White Clay Creek
State of the Watershed

White Clay Creek Wild and Scenic River Management Committee

London Britain Township, PA

Jan 9, 2007

Data Analysis:

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Rain Garden

Welcome to the University of Delaware Rain Garden

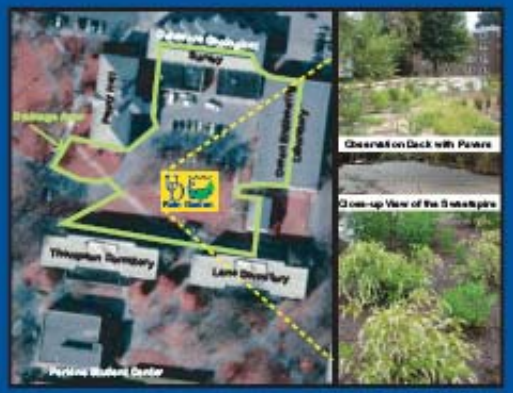
Delaware River Basin

Christina River Basin

White Clay Creek Watershed

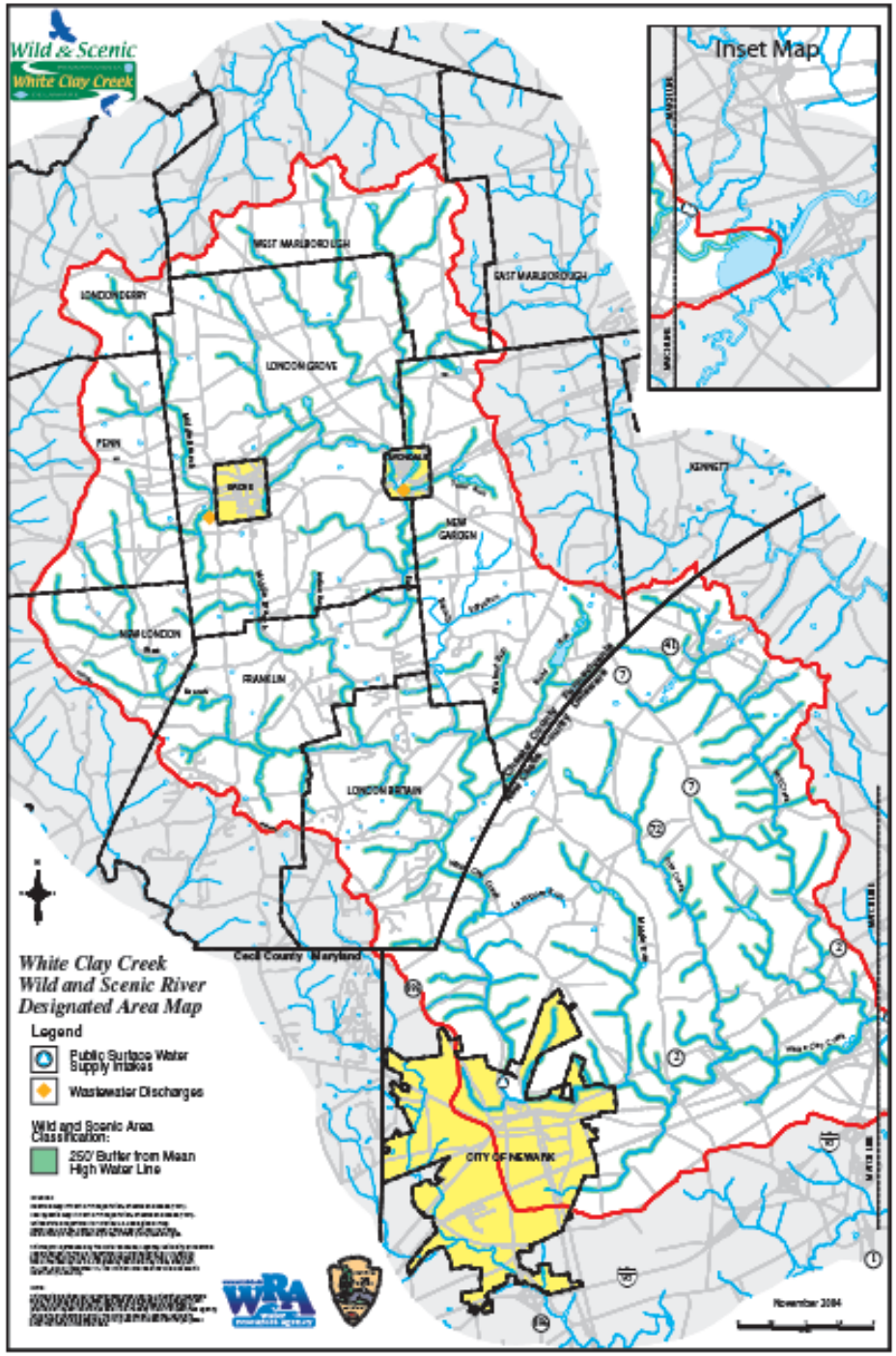
Cool Run Watershed

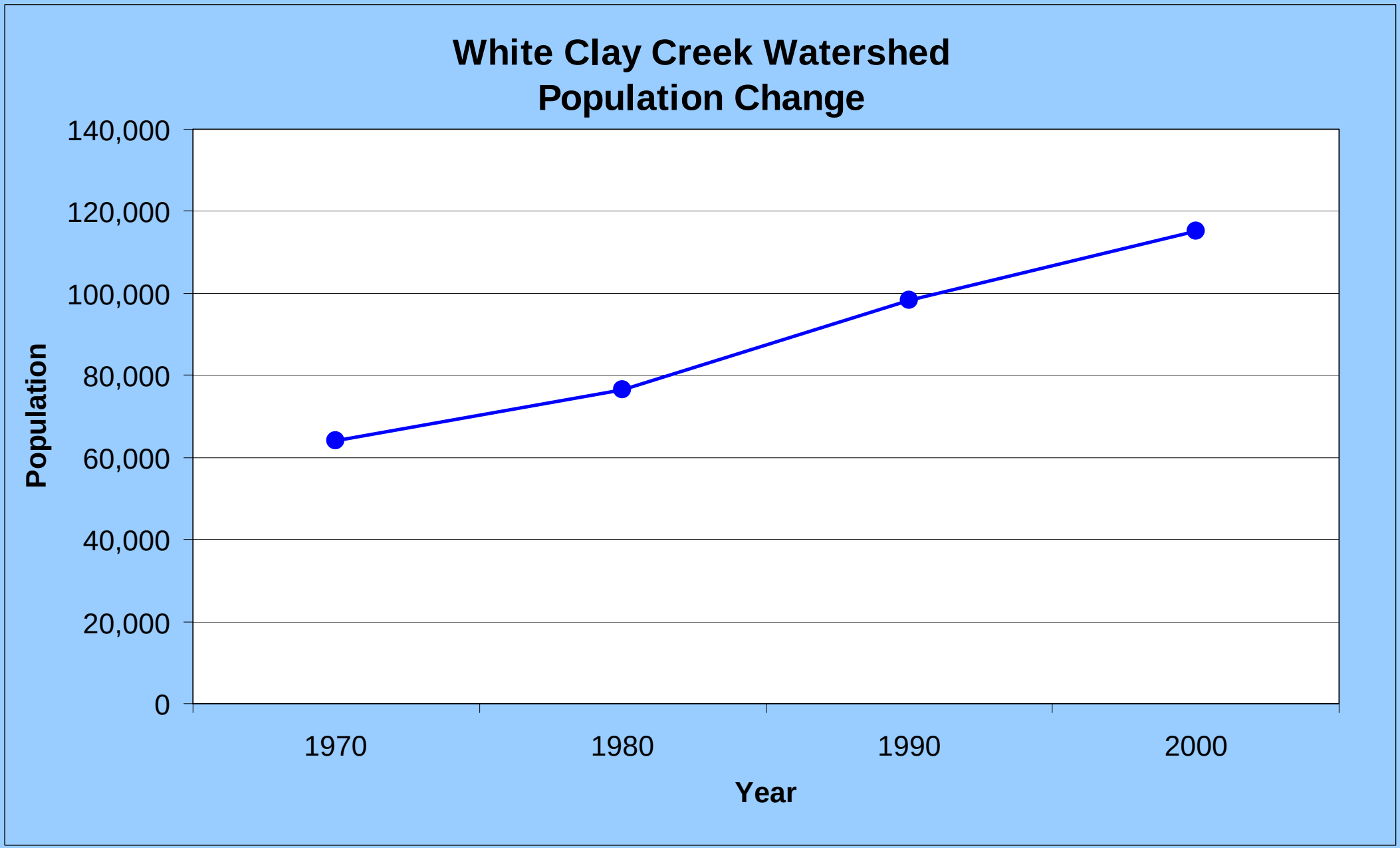
UD Rain Garden



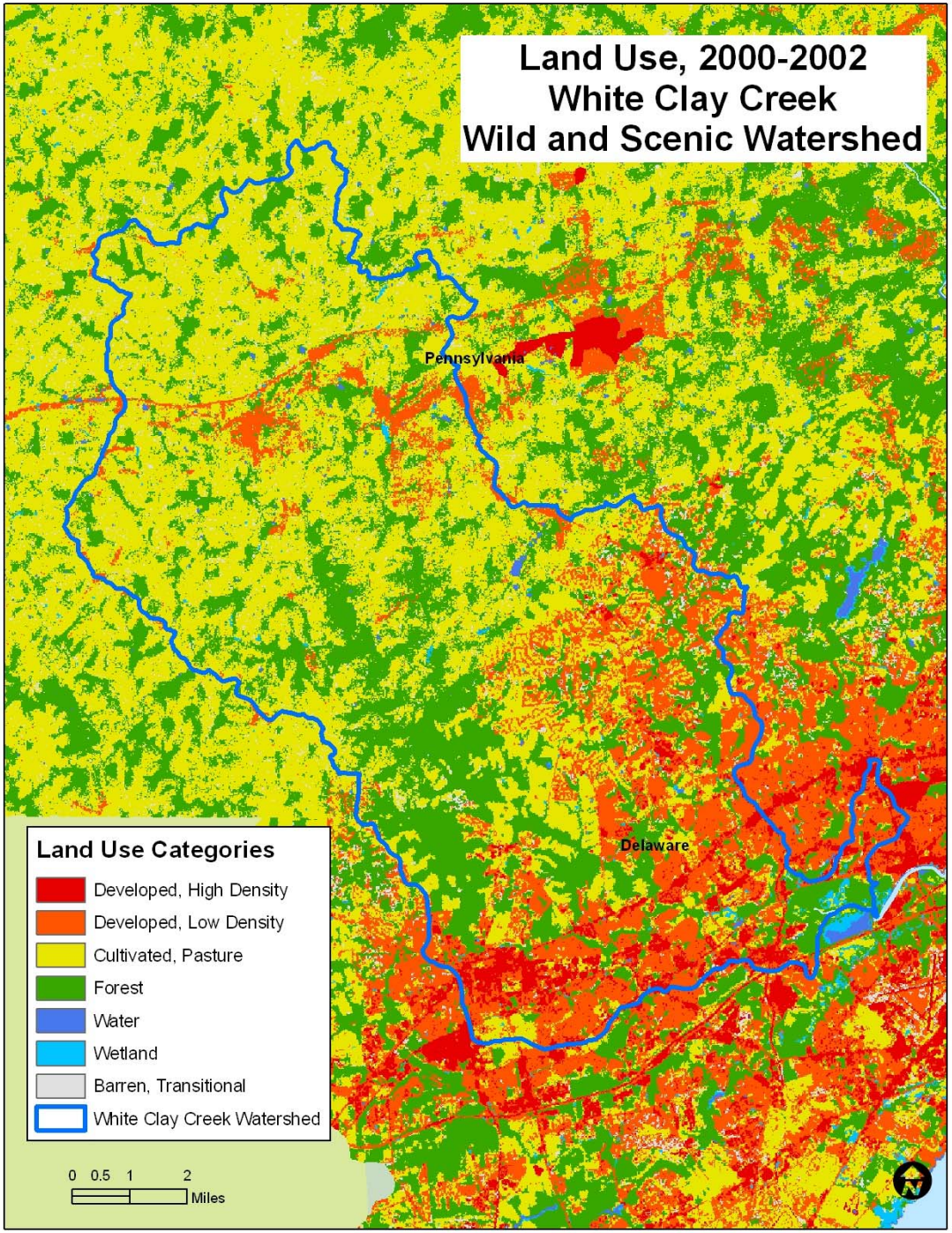
The UD Rain Garden, although small in stature, is part of a complex watershed system, ranging in increasing scale from the small Cool Run tributary, to the White Clay Creek watershed, to the Christina Basin, and finally to the Delaware River Basin. The UD Rain Garden is situated in the headwaters of Cool Run, a small, ephemeral stream that flows south past the Perkins Student Center and then under the Amtrak railroad tracks to the UD Agricultural Farm on its way to join White Clay Creek. As the UD campus developed, the stream has been manipulated and rerouted, sometimes into an underground pipe, as illustrated by the dashed blue line.

White Clay Creek, Delaware's only National Wild and Scenic River, is the first to be designated on a watershed basis instead of a single-river-segment basis. The 108-square-mile White Clay Creek watershed is an important source of drinking water for Newark's residents and is one of only six trout streams in Delaware. It is one of the four major streams in a larger watershed called the Christina River Basin. The White Clay Creek and sister watersheds Brandywine Creek, Red Clay Creek, and Christina River originate upstream in Pennsylvania before flowing through New Castle County, Delaware, on their way to the Delaware River. The Christina River Basin is, in turn, part of a larger watershed, the five-state Delaware River Basin, which includes parts of Maryland, Delaware, New Jersey, New York, and Pennsylvania.


Wild & Scenic
White Clay Creek
Inset Map
WEST MARLBOROUGH
EAST MARLBOROUGH
LONDONDERRY
LONDON GROVE
PENN
KENNETT
NEW GARDEN
NEW LONDON
FRANKLIN
LONDON BRITAIN
Cecil County, Maryland
CITY OF NEWARK
White Clay Creek
Wild and Scenic River
Designated Area Map
Legend
Public Surface Water Supply Intakes
Wastewater Discharges
Wild and Scenic Area Classification:
250' Buffer from Mean High Water Line
November 2004


White Clay Creek Watershed
Population Change
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Population
1970
1980
1990
2000
Year

WCC Population	1970	1980	1990	2000
EAST BR. ABOVE AVONDALE	4,728	4,932	5,461	7,297
EAST BR. BELOW AVONDALE	3,060	3,827	4,902	7,282
MAIN STEM ABOVE DELAWARE PARK	20,843	22,739	27,282	27,996
MAIN STEM ABOVE NEWARK	4,100	7,411	9,133	8,877
MAIN STEM AT CHURCHMANS MARSH	9,434	9,085	8,872	9,353
MIDDLE BRANCH	2,774	3,571	4,458	5,639
MIDDLE RUN	2,406	3,603	4,578	4,509
MILL CREEK	11,769	14,717	22,762	27,299
PIKE CREEK	5,040	6,546	10,744	16,804
	64,153	**76,431**	**98,193**	**115,056**


Land Use, 2000-2002
White Clay Creek
Wild and Scenic Watershed
Pennsylvania
Delaware
Land Use Categories
Developed, High Density
Developed, Low Density
Cultivated, Pasture
Forest
Water
Wetland
Barren, Transitional
White Clay Creek Watershed
0 0.5 1 2
Miles
N

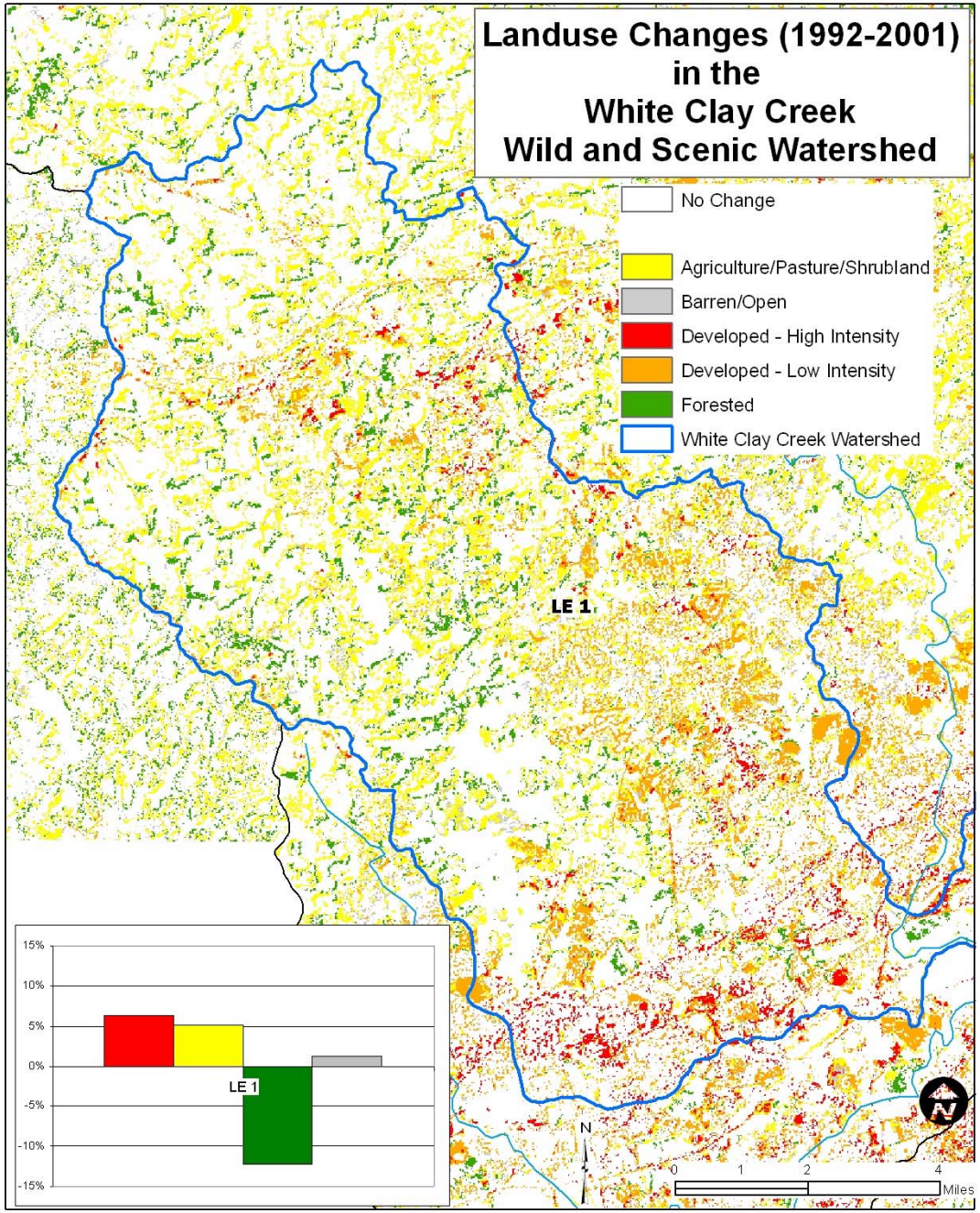

Landuse Changes (1992-2001)
in the
White Clay Creek
Wild and Scenic Watershed
No Change
Agriculture/Pasture/Shrubland
Barren/Open
Developed - High Intensity
Developed - Low Intensity
Forested
White Clay Creek Watershed
LE 1
15%
10%
5%
0%
-5%
-10%
-15%
LE 1
N
0
1
2
4
Miles

Table 3: Characteristics of the Delineated Source Water Area for the City of Newark Intake on the White Clay Creek

Characteristic	Description
Source Water	White Clay Creek
Total Source Water Area	DE 7 sq. mi. (10 %) PA 61 sq. mi. (90 %) MD less than 1 sq. mi Total 68 sq. mi. (100 %)
Total Source Water Area Land Use	Urban/Suburban 12 sq.mi. (18 %) Agriculture 34 sq.mi. (50 %) Wooded/Open Space 22 sq. mi. (32 %)
States	Delaware Pennsylvania Maryland
Counties	New Castle County, DE Chester County, PA Cecil County, MD
Municipalities	Newark, DE Avondale, PA West Grove, PA

White Clay Creek above Newark

Figure 3: Land Use in Level 1A & B

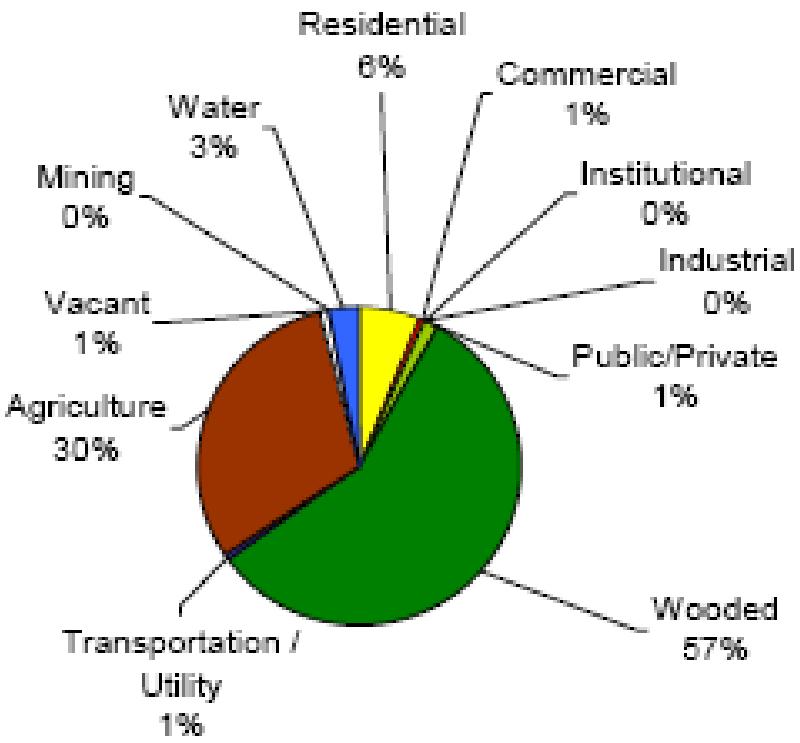


Figure 4: Land Use in Level 2

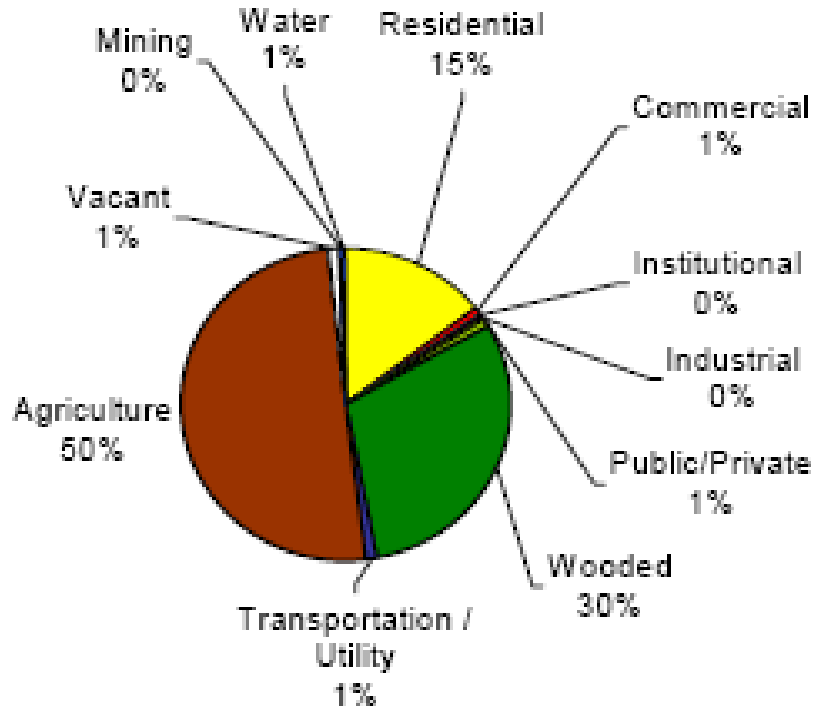


Table 3: Characteristics of the Delineated Source Water Area for the UWD at Stanton Intake on the White Clay/Red Clay Creeks

Characteristic	Description
Source Water	White Clay Creek Red Clay Creek
Total Source Water Area	DE 68 sq. mi. (42 %) PA 93 sq. mi. (58 %) MD less than 1 sq. mi. Total 161 sq. mi. (100 %)
Total Source Water Area Land Use	Urban/Suburban 53 sq. mi. (33 %) Agriculture 58 sq. mi. (36 %) Wooded/Open Space 50 sq. mi. (31 %)
States	Delaware Pennsylvania Maryland
Counties	New Castle County, DE Chester County, PA Cecil County, MD
Municipalities	Newark, DE Avondale, PA West Grove, PA Kennett Square, PA

White Clay Creek above Stanton

Figure 3: Land Use in Level 1A & B

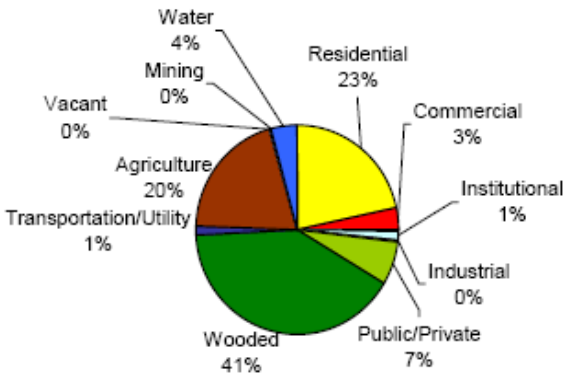
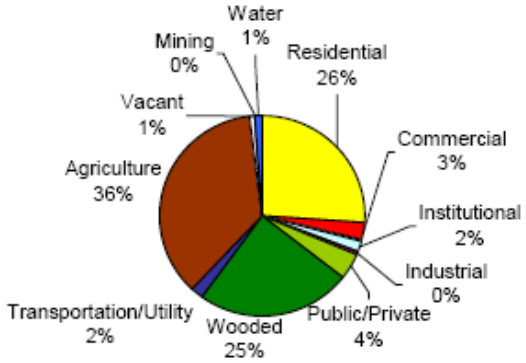
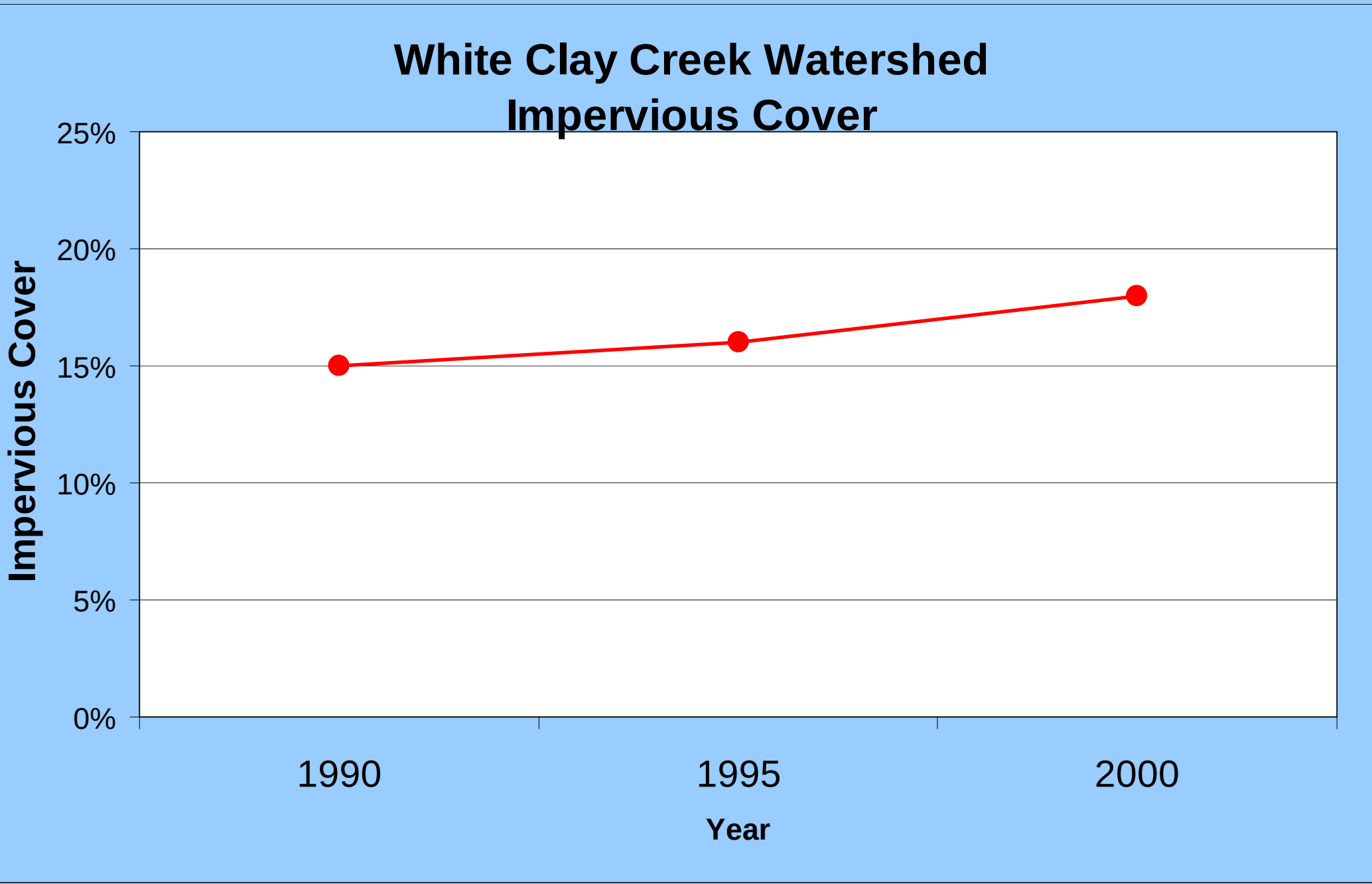
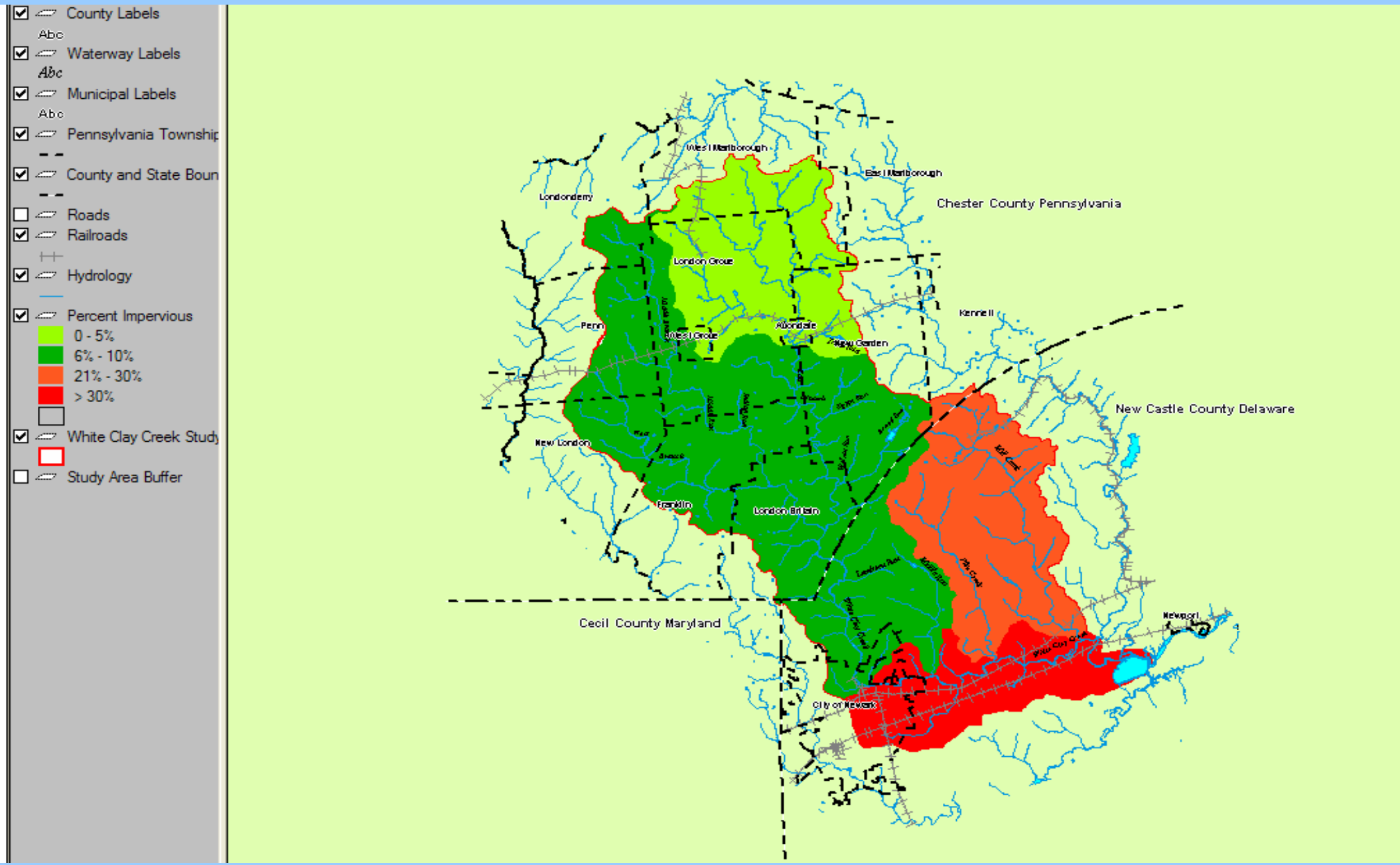


Figure 4: Land Use in Level 2




White Clay Creek Watershed
Impervious Cover
Impervious Cover
25%
20%
15%
10%
5%
0%
1990
1995
2000
Year


County Labels
Abc
Waterway Labels
Abc
Municipal Labels
Abc
Pennsylvania Township
County and State Boun
Roads
Railroads
Hydrology
Percent Impervious
0 - 5%
6% - 10%
21% - 30%
> 30%
White Clay Creek Study
Study Area Buffer
Chester County Pennsylvania
New Castle County Delaware
Cecil County Maryland
West Marlborough
East Marlborough
Londonderry
London Grove
New London
Franklin
London Britain
Kennett
Newport
City of Newark

White Clay Creek - % Impervious

Subwatershed	1990	1995	2000
E.B. above Avondale	6	7	9
E.B. below Avondale	9	11	13
Middle Branch in PA	7	8	9
West Branch in PA	8	9	9
Above Newark	8	9	10
Middle Run	6	8	9
Above Delaware Park	35	36	41
At Churchmans Marsh	50	49	52
Pike Creek	22	24	25
Mill Creek	27	28	30
Total	**15%**	**16%**	**18%**

Christina Basin
WQ Sampling Stations

Christina River

Rt. 273, Above Newark	CR_1
Smalley's Dam Spillway	CR_2
Rt. 141, Newport (USGS tide gage 01480065)	CR_3
Conrail Br. (USGS tide gage 01481602)	CR_4

Brandywine Creek

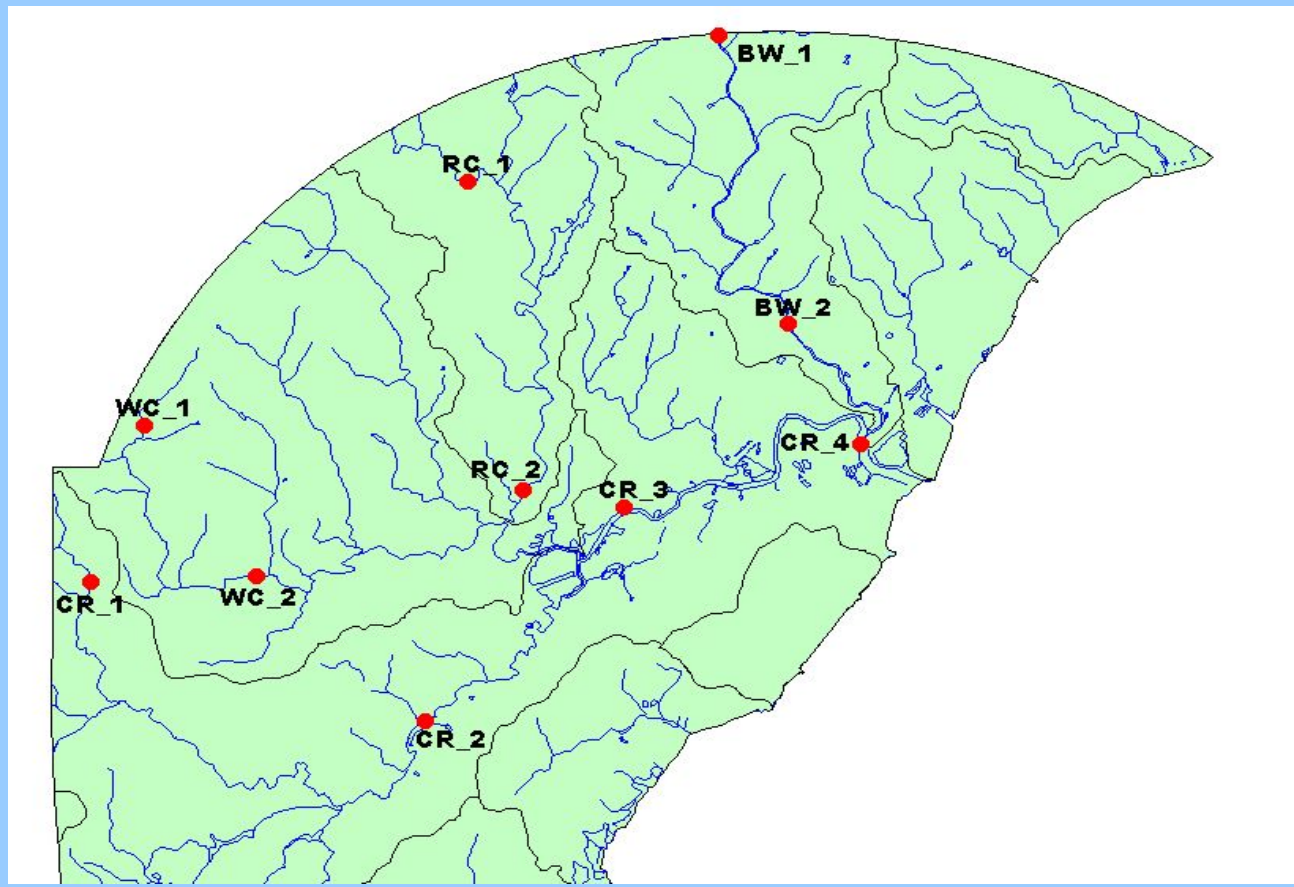
Smith Bridge	BW_1
Foot Bridge	BW_2

Red Clay Creek

Ashland, Rd. 258a	RC_1
Stanton, Rt. 4 (USGS gage 01480015)	RC_2

White Clay Creek

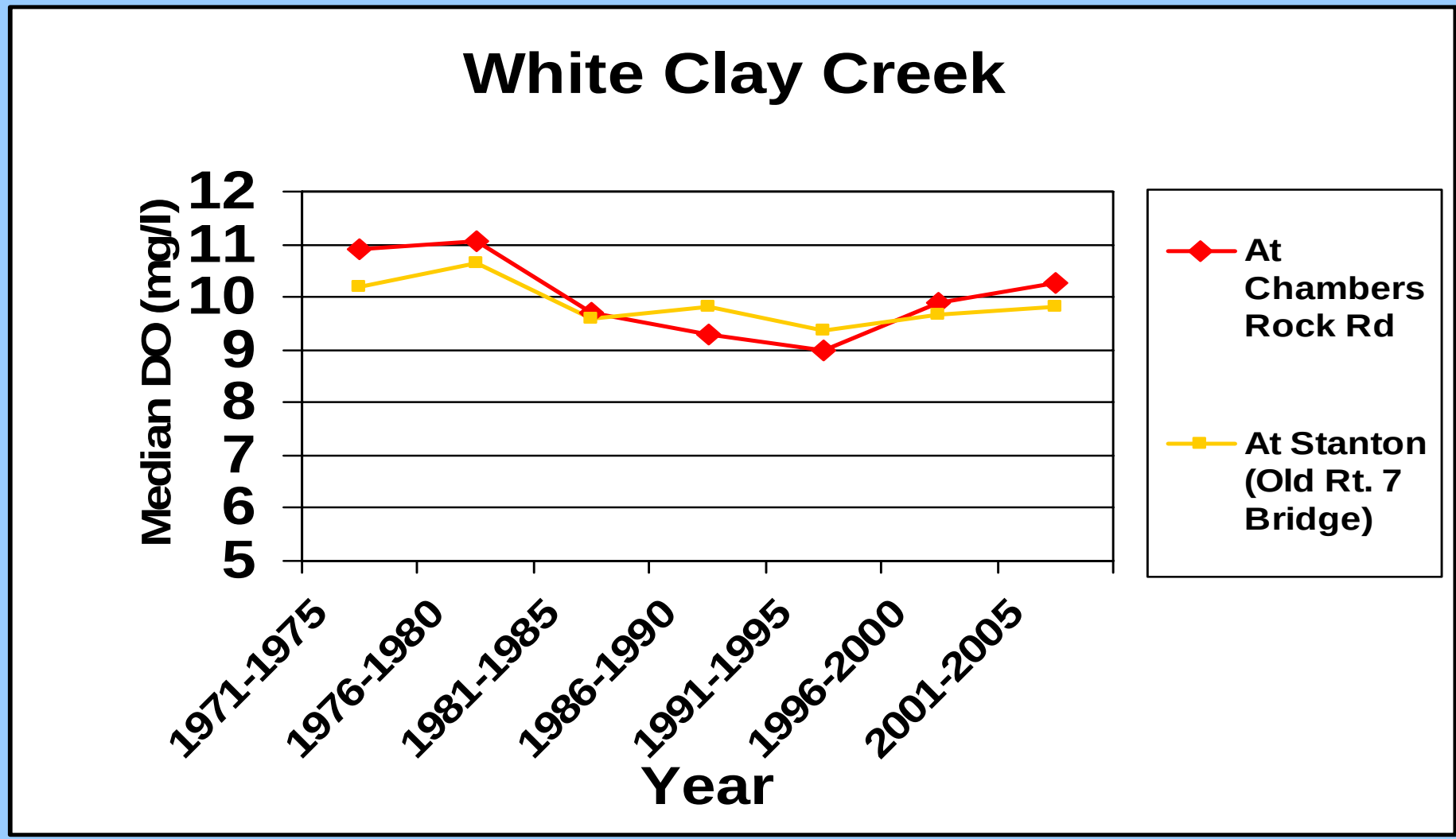
Chambers Rock Rd.	WC_1
Stanton, Old Rt. 7 Bridge	WC_2



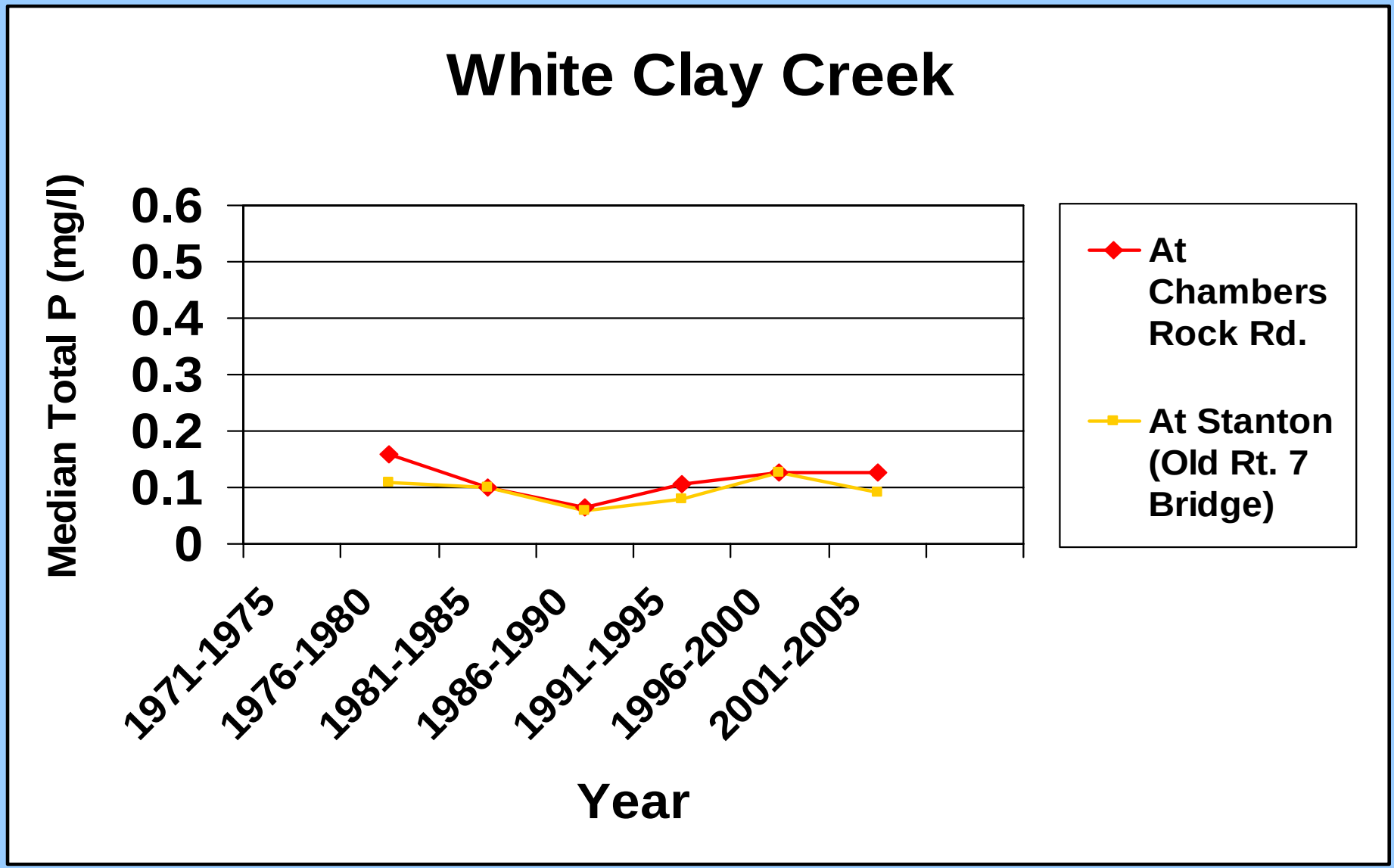
Site Locations

- White Clay Creek Basin
  - **East Branch at Avondale**.
  - **Middle Branch near Avondale**.

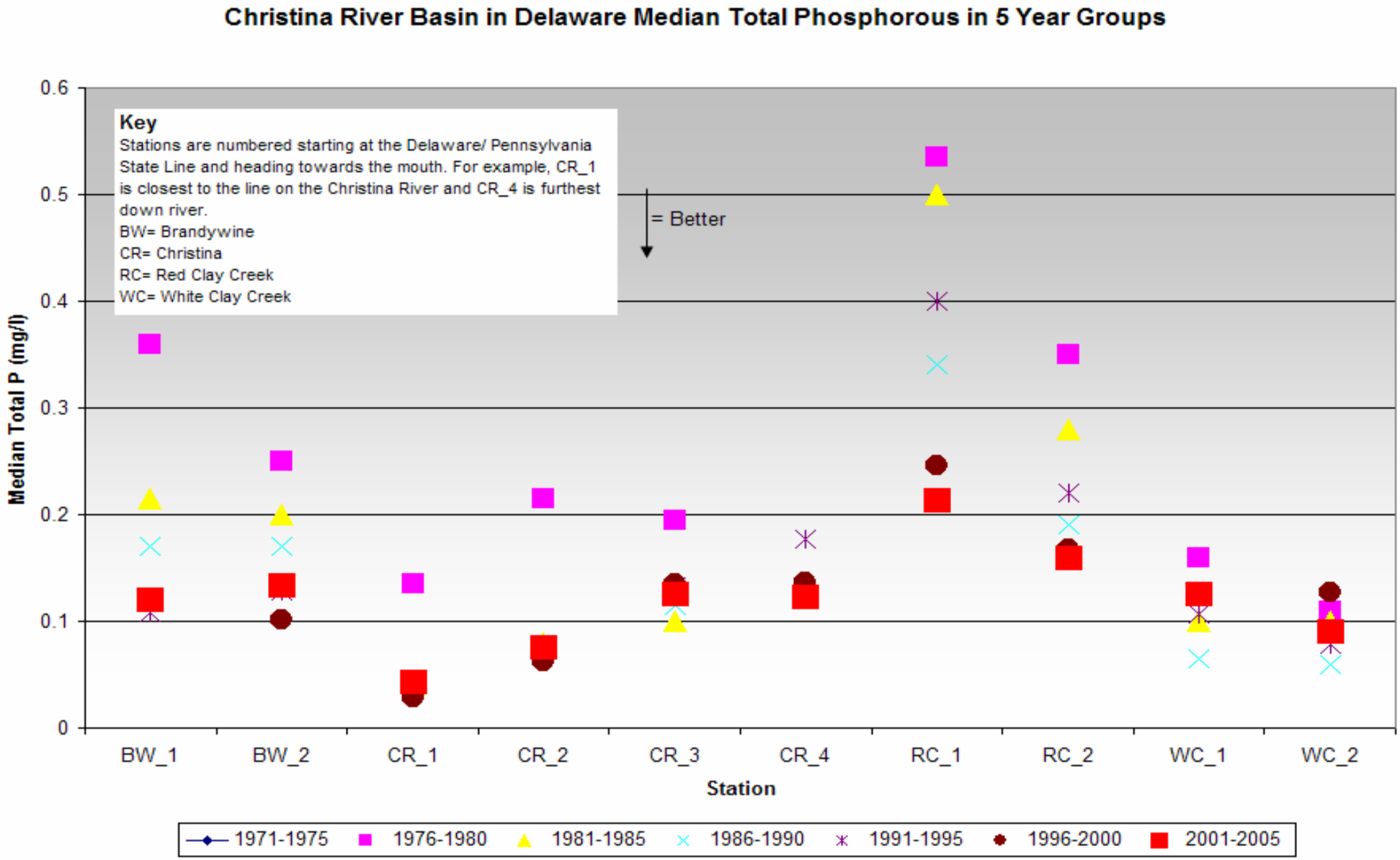
DO Status


White Clay Creek
Median DO (mg/l)
12
11
10
9
8
7
6
5
1971-1975
1976-1980
1981-1985
1986-1990
1991-1995
1996-2000
2001-2005
Year
At Chambers Rock Rd
At Stanton (Old Rt. 7 Bridge)

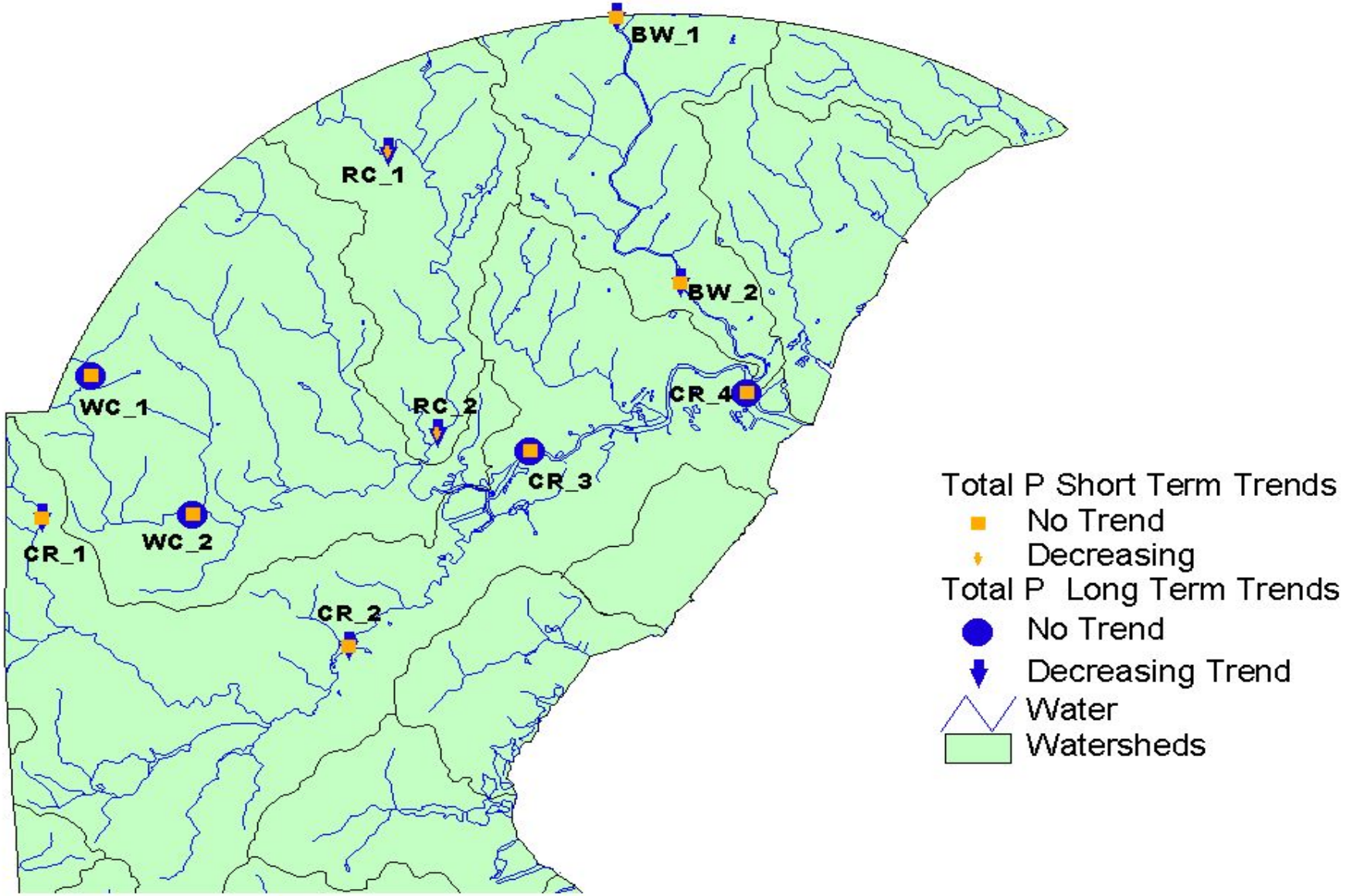
Total P Status



Total P Status

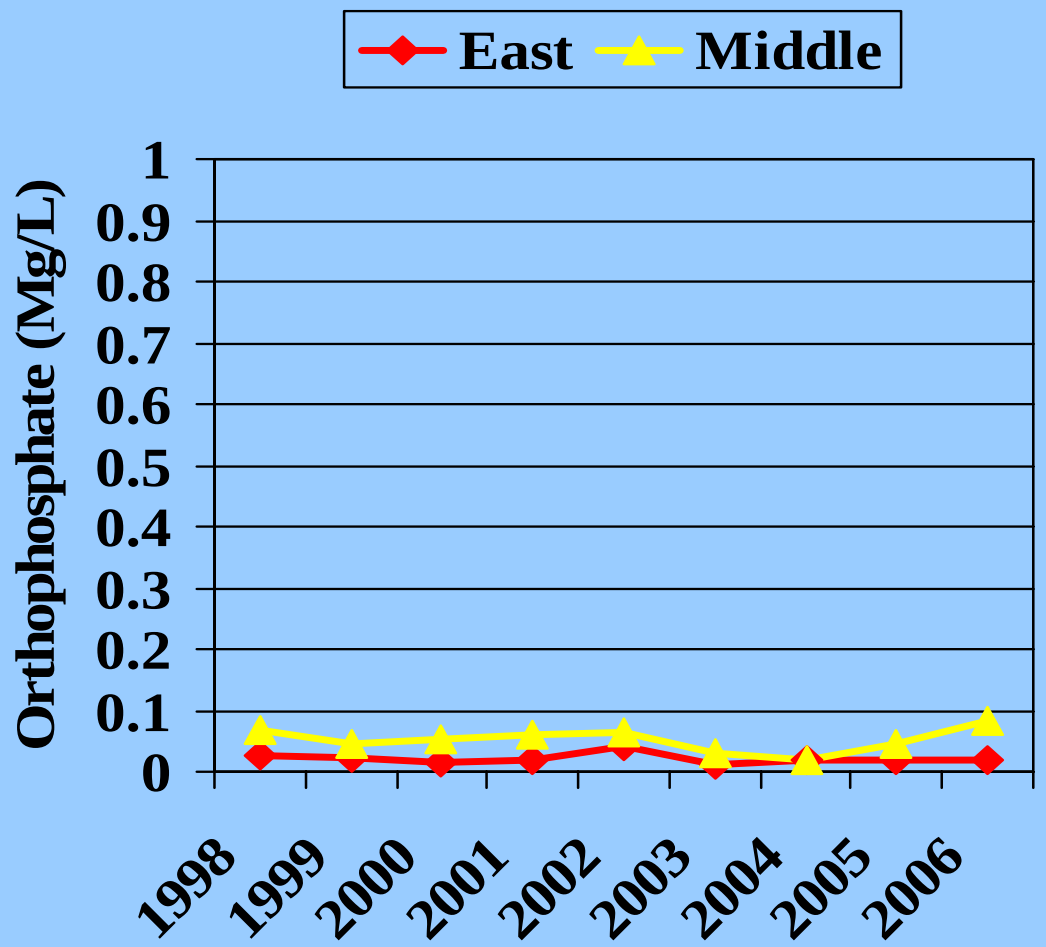


Total PhosphorousTrends in the Delaware Portion of the Christina Basin



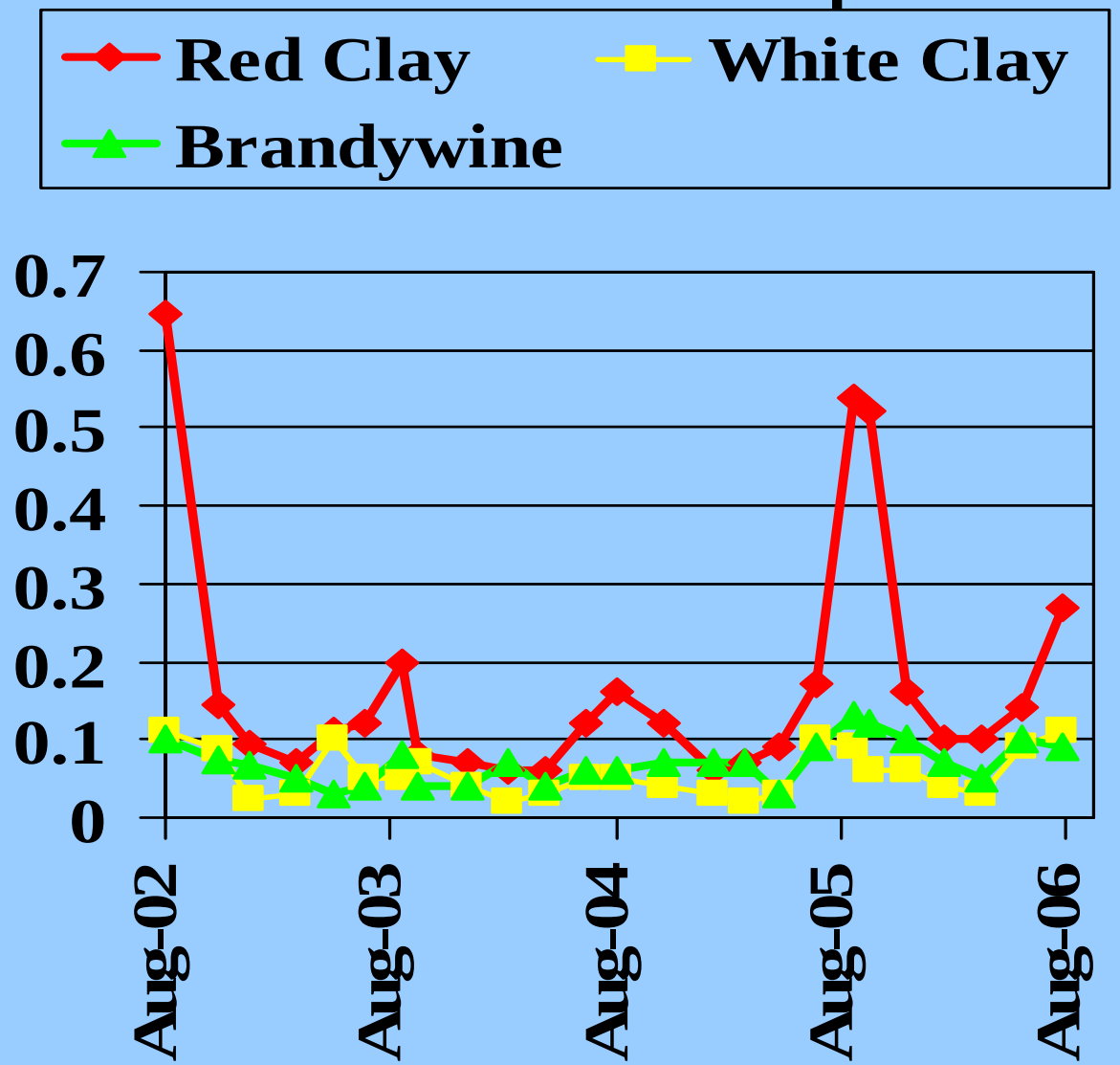
Current Status – White Clay

- Ortho-Phosphate
  - No trends
  - Generally low Ortho-Phosphate concentrations.
  - East Branch has the lowest concentrations

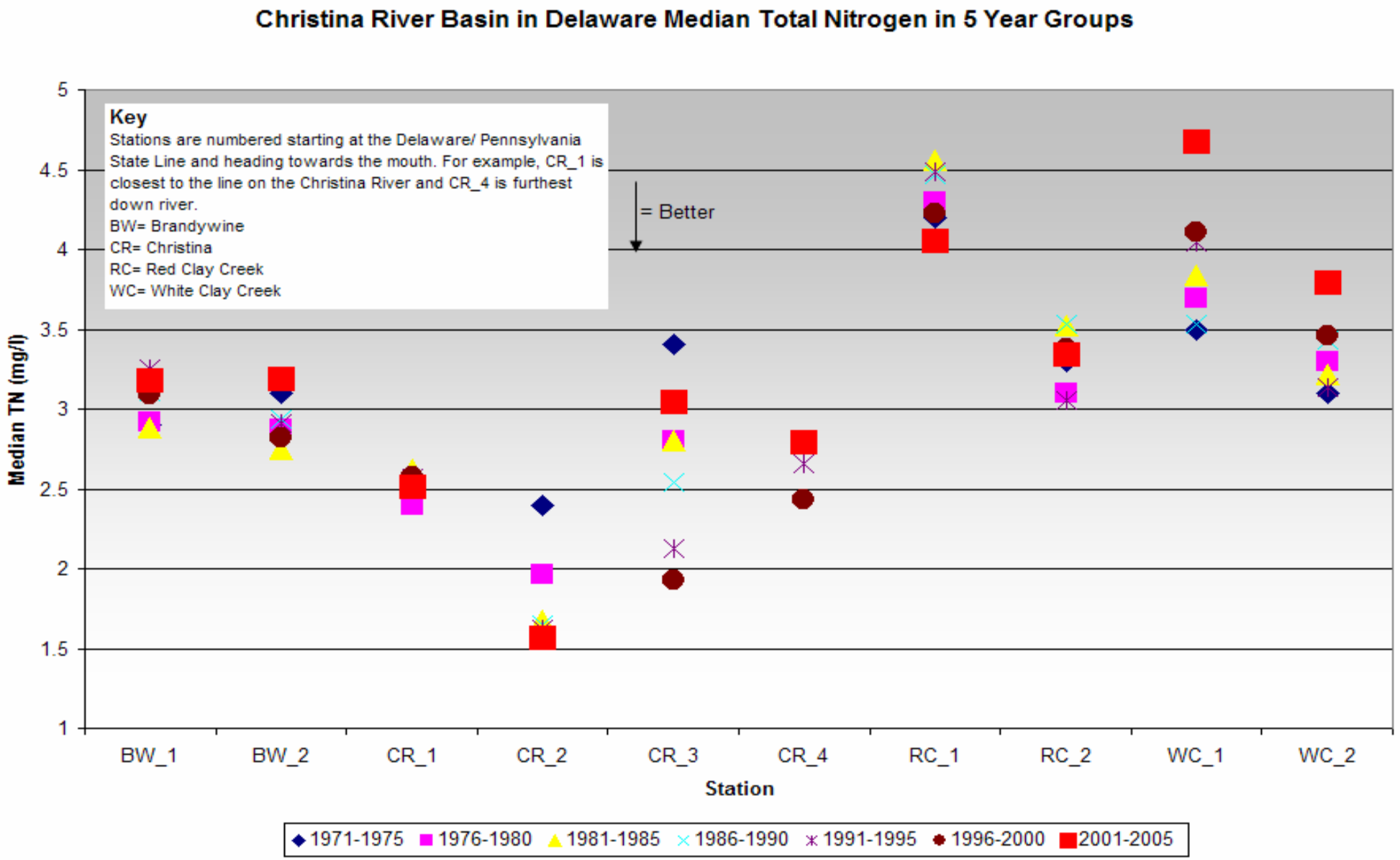


WQN Data – Ortho-Phosphate

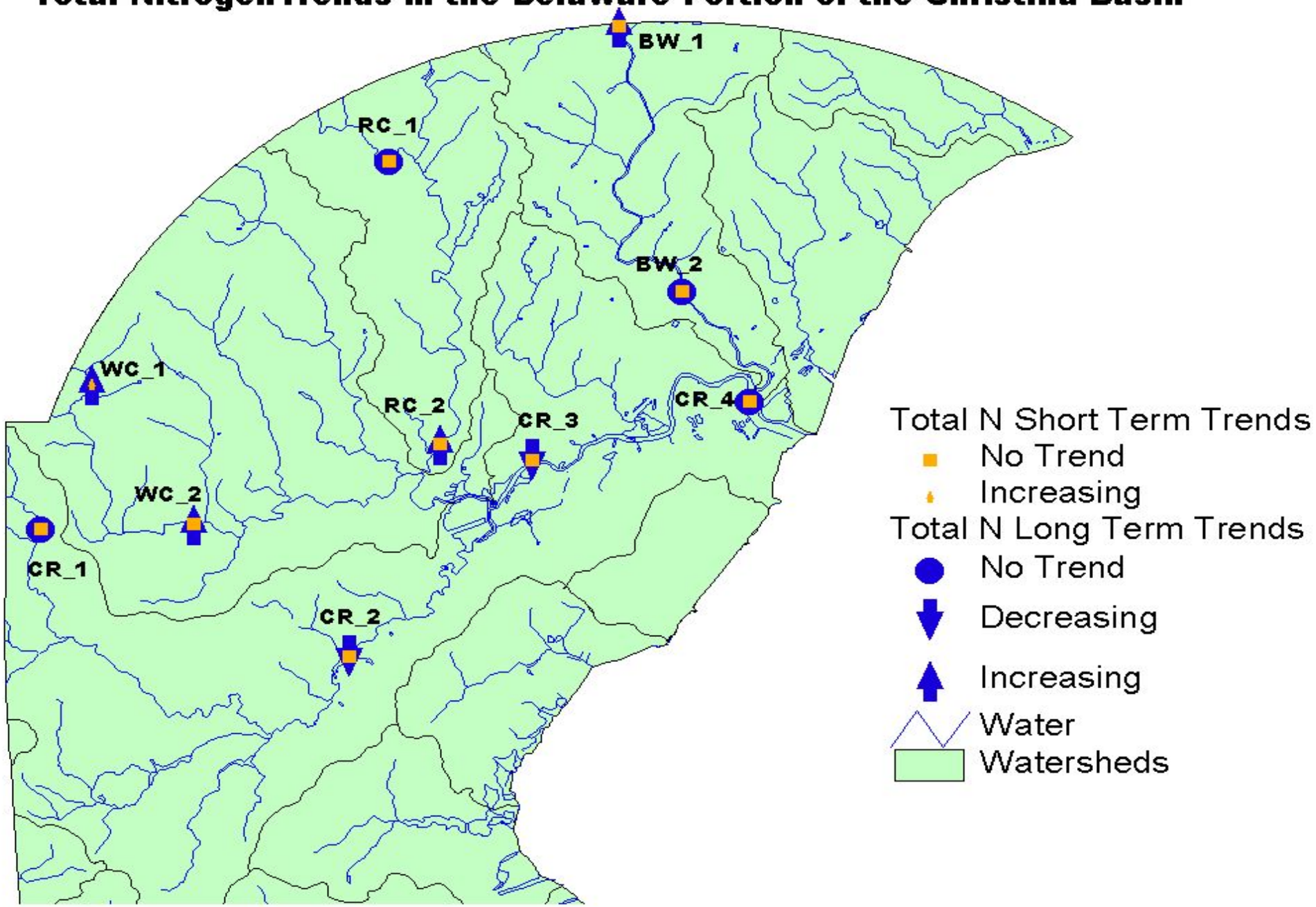
– Red Clay has occasional spikes in O-P and slightly higher ambient concentrations



Total N Status



Total NitrogenTrends in the Delaware Portion of the Christina Basin



Current Status – White Clay

- Nitrate

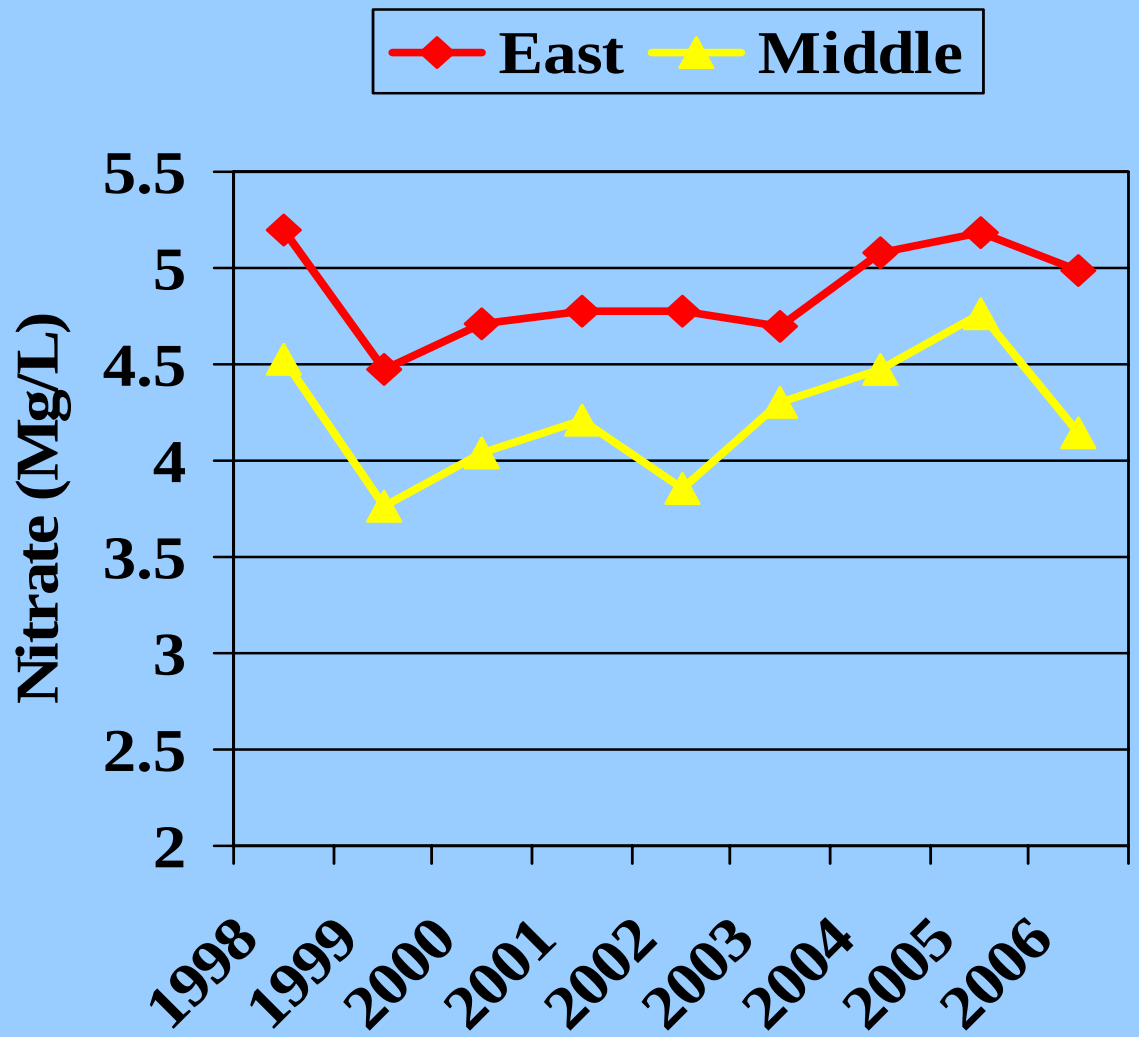
East Branch

– Elevated concentrations with no trend. Slightly upwards since 2003?

Middle Branch

– Rising slowly since 1999

Increases may be due to increased flows.

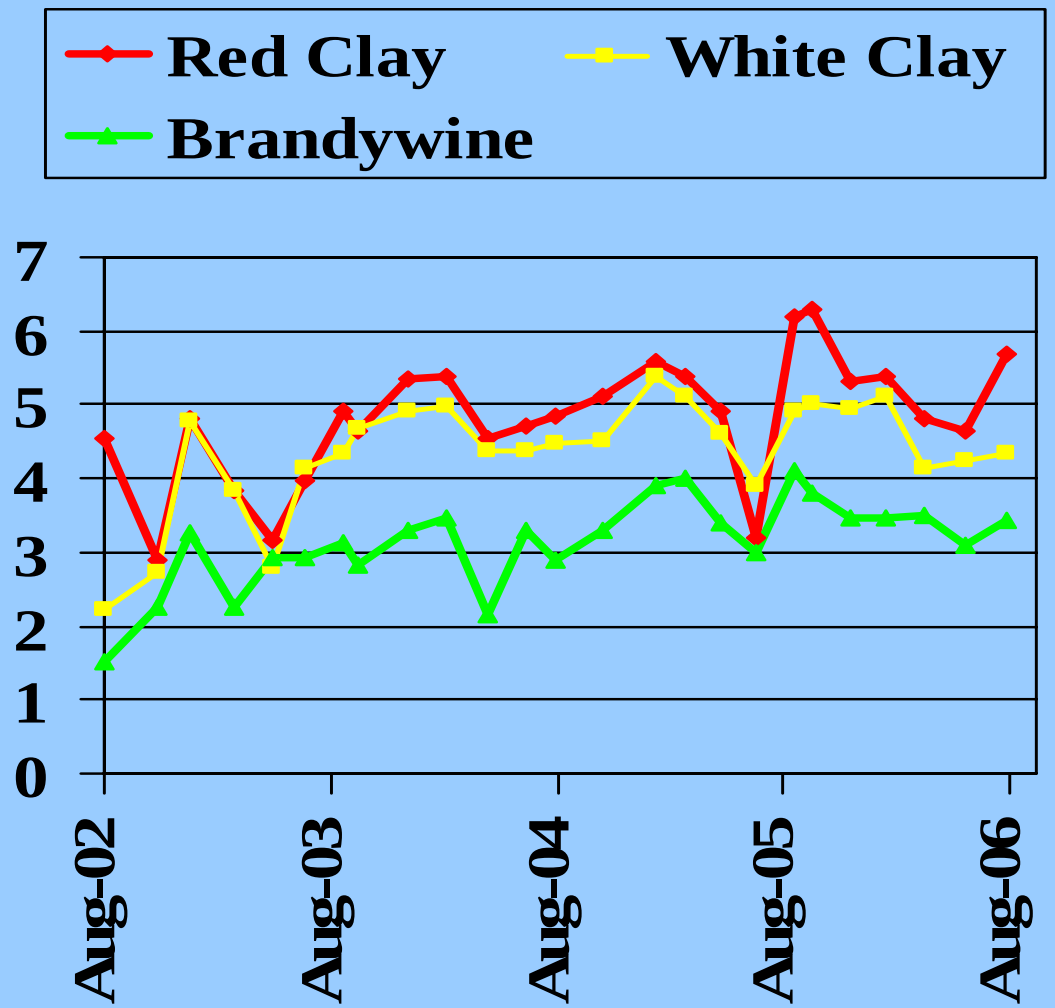


WQN Data - Nitrate

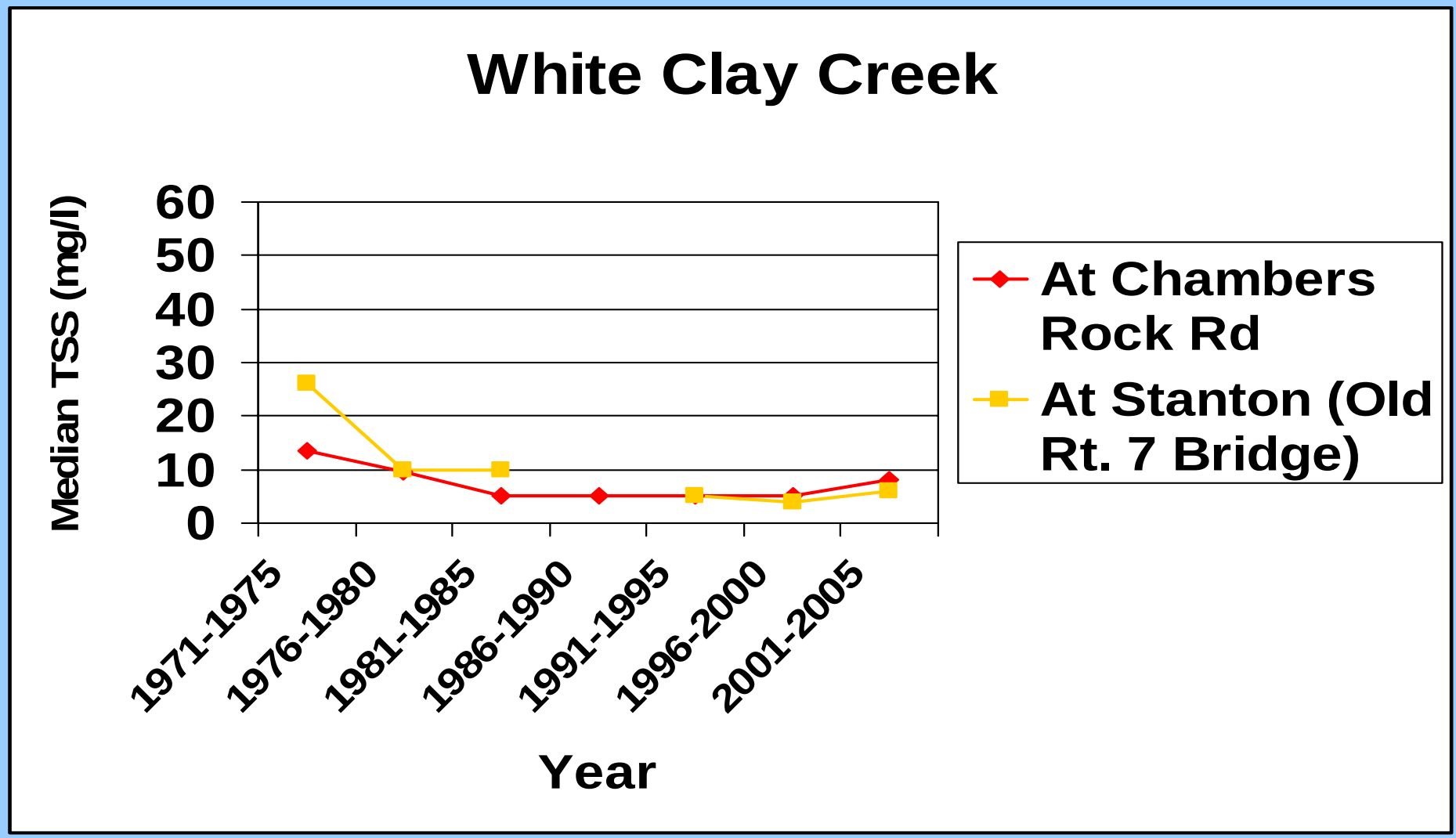
Nitrate lowest in Brandywine.

Higher in Red/White Clay

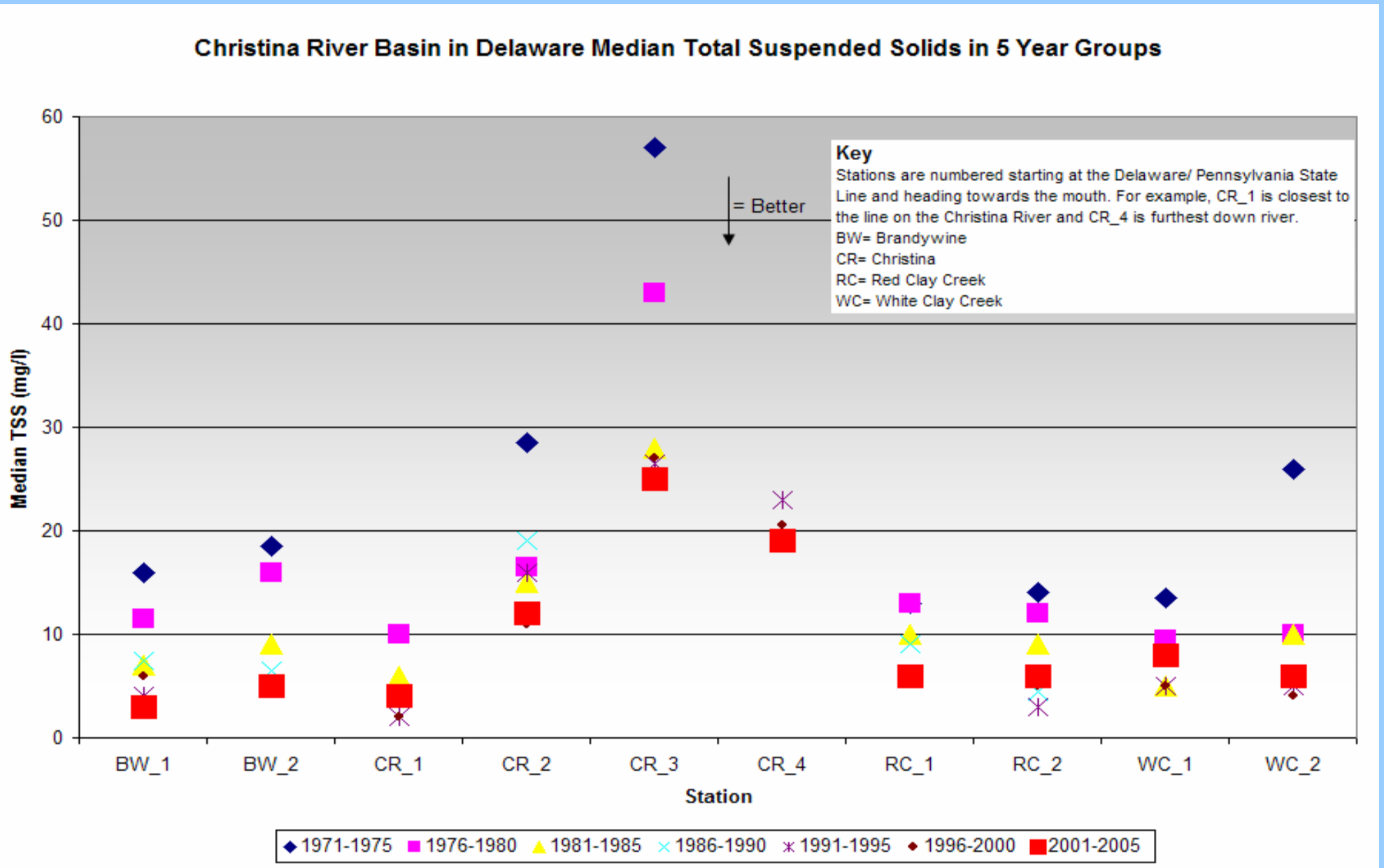
Possible upward trend.



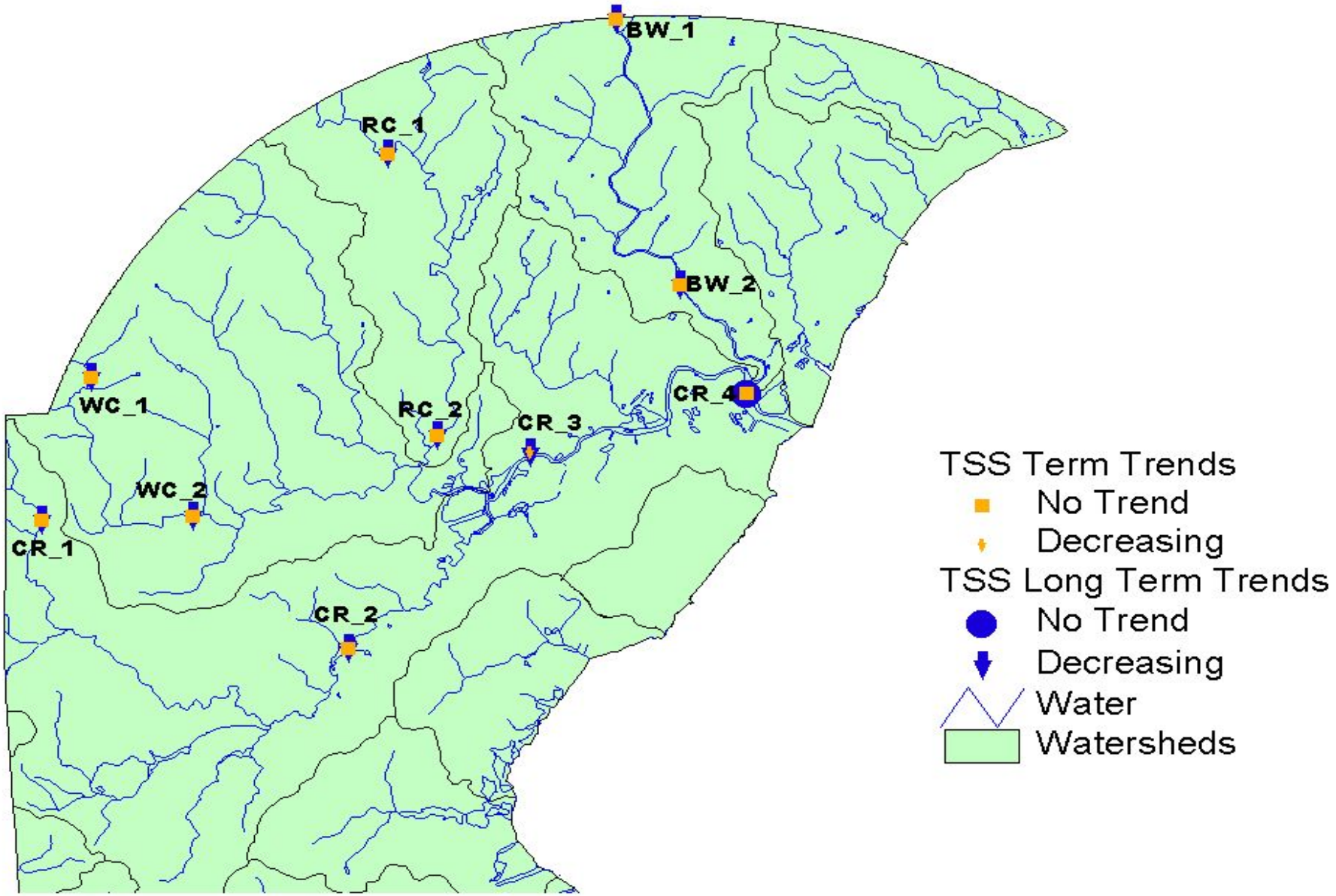
Total Suspended Solids

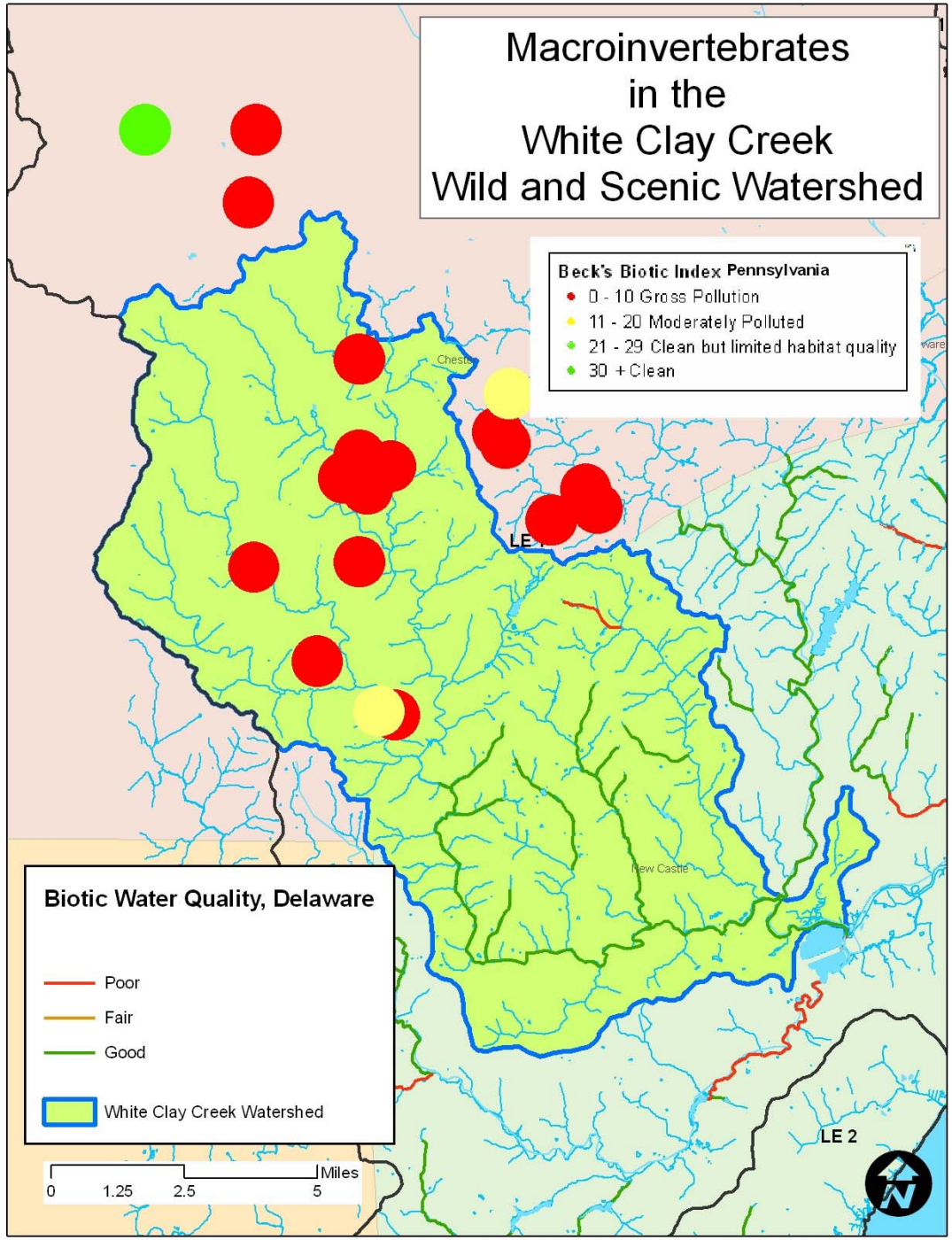


TSS Status


Christina River Basin in Delaware Median Total Suspended Solids in 5 Year Groups
Median TSS (mg/l)
60
50
40
30
20
10
0
= Better
Key
Stations are numbered starting at the Delaware/ Pennsylvania State Line and heading towards the mouth. For example, CR_1 is closest to the line on the Christina River and CR_4 is furthest down river.
BW= Brandywine
CR= Christina
RC= Red Clay Creek
WC= White Clay Creek
BW_1
BW_2
CR_1
CR_2
CR_3
CR_4
RC_1
RC_2
WC_1
WC_2
Station
1971-1975
1976-1980
1981-1985
1986-1990
1991-1995
1996-2000
2001-2005

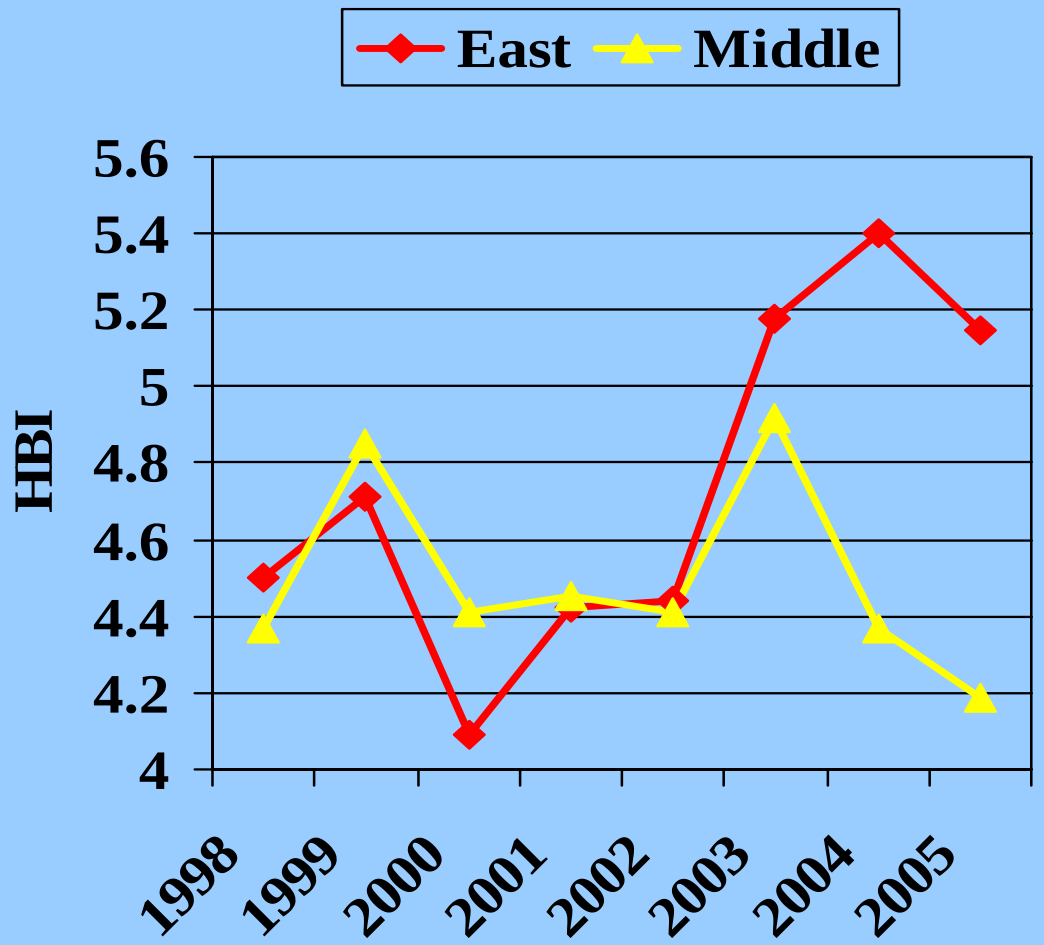
Total Suspended Solids Trends in the Delaware Portion of the Christina Basin




Macroinvertebrates
in the
White Clay Creek
Wild and Scenic Watershed
Beck's Biotic Index Pennsylvania
0 - 10 Gross Pollution
11 - 20 Moderately Polluted
21 - 29 Clean but limited habitat quality
30 + Clean
Biotic Water Quality, Delaware
Poor
Fair
Good
White Clay Creek Watershed
Miles
0
1.25
2.5
5
LE 1
LE 2
New Castle

Current Status – White Clay

- Macroinvertebrates
  - All samples have HBI values that indicate moderate organic pollution.
  - Increasing HBI (decreasing QW) in the East Branch samples (not statistically significant).



WQN Data - HBI

Brandywine samples consistently indicate better invertebrate communities

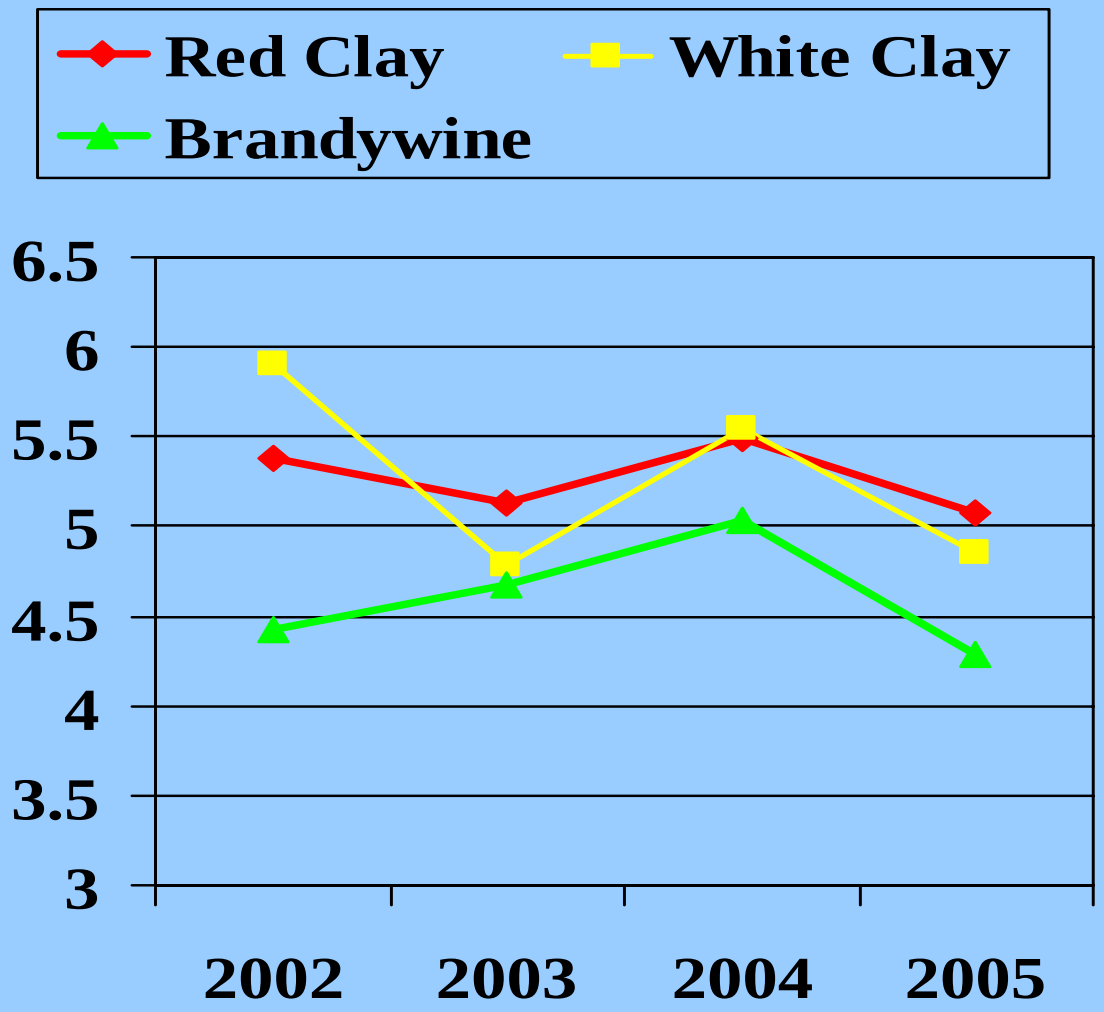
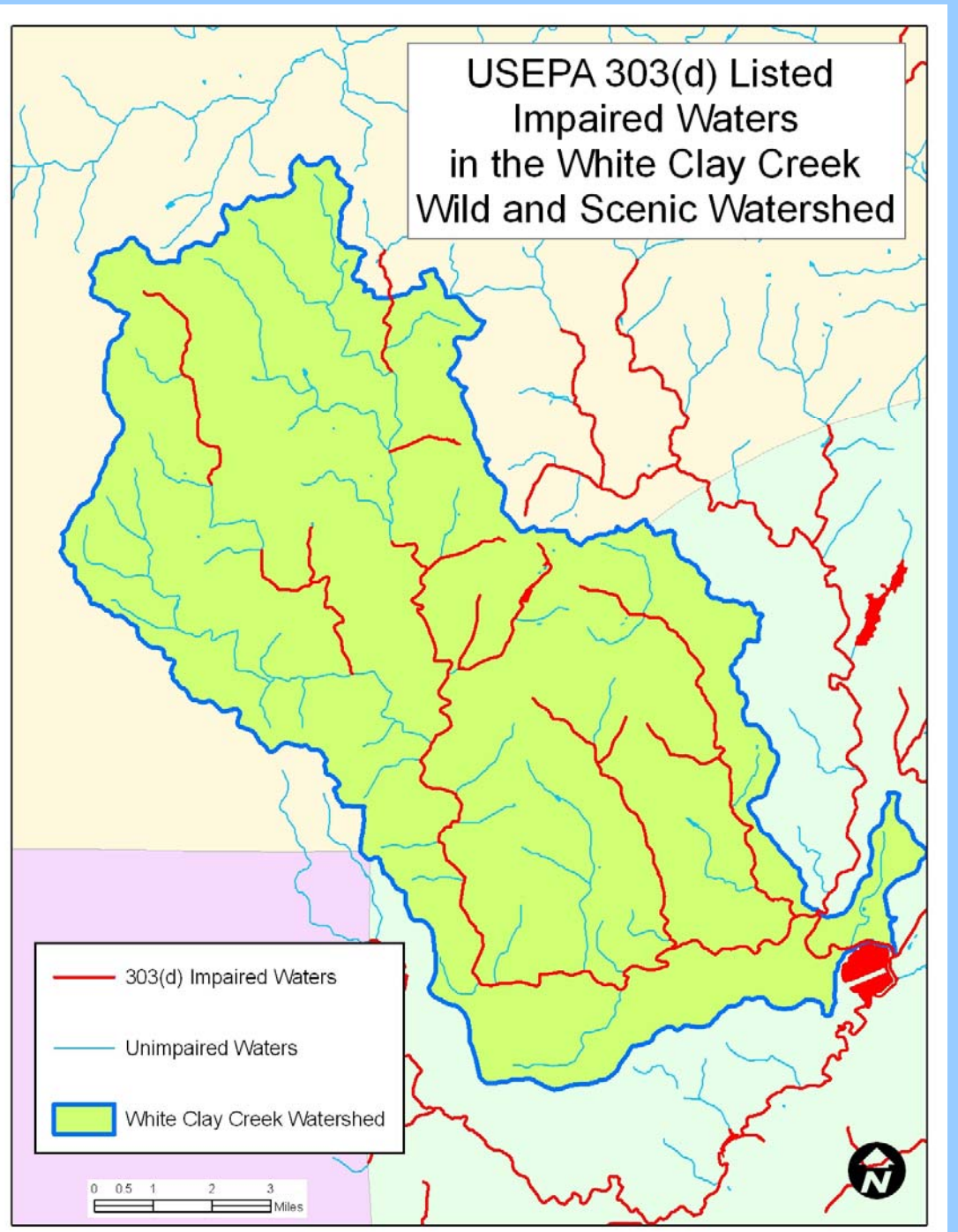


Table 9: Summary of Substances Detected in the Untreated Water White Clay Creek above Newark (1990-2001)

Contaminant Category	Substance	Potential Sources
Above Detection Level		
Nutrients	Nitrate Nitrogen	Fertilizer, Septic Tanks, Wastewater Treatment
	Nitrite Nitrogen	Fertilizer, Septic Tanks, Wastewater Treatment
	Nitrate + Nitrite	Fertilizer, Septic Tanks, Wastewater Treatment
PCBs	Polychlorinated biphenyls	Railroads, Electric Transmission Equipment
Other Organics	Dibromochloromethane	Wastewater Treatment
Metals	Arsenic	Natural Deposits, Orchard Runoff
	Copper	Household Plumbing/Wastewater Treatment
	Zinc	Industries
Other Inorganics	Chloride	Road Salt, Deicing Chemicals
	Sulfate	Natural Deposits
Above 50% MCL/RBCL		
Metals	Lead	Plumbing/Wastewater Treatment, Brake Linings
Above 100% MCL/RBCL		
Pathogens	Enteroccocus	Human and Animal Fecal Waste
Other Organics	Bromodichloromethane	Wastewater Treatment
	Chloroform	Wastewater Treatment
Metals	Aluminum	Erosion of Natural Deposits
	Iron	Erosion of Natural Deposits
	Manganese	Erosion of Natural Deposits

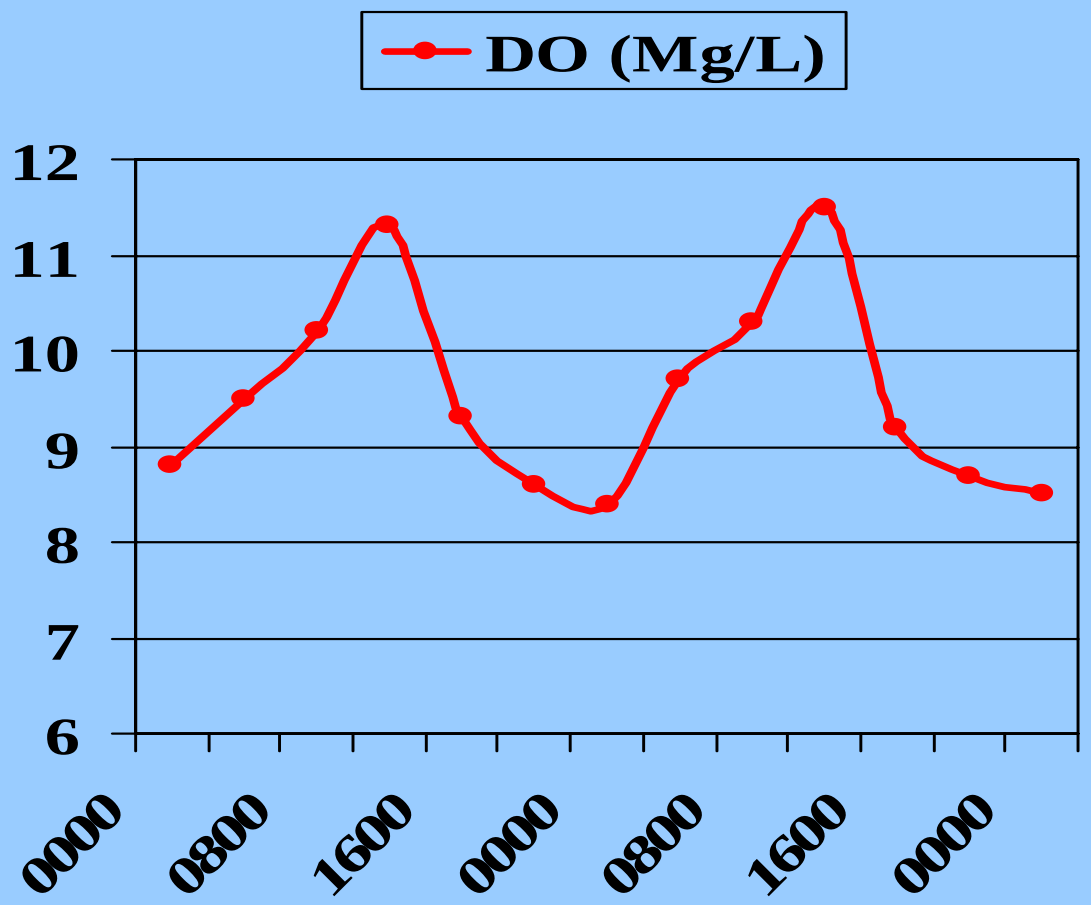
Table 9: Summary of Substances Detected in the Untreated Water
White Clay/Red Clay Creeks above United Water Delaware Stanton Intake (1990-2001)

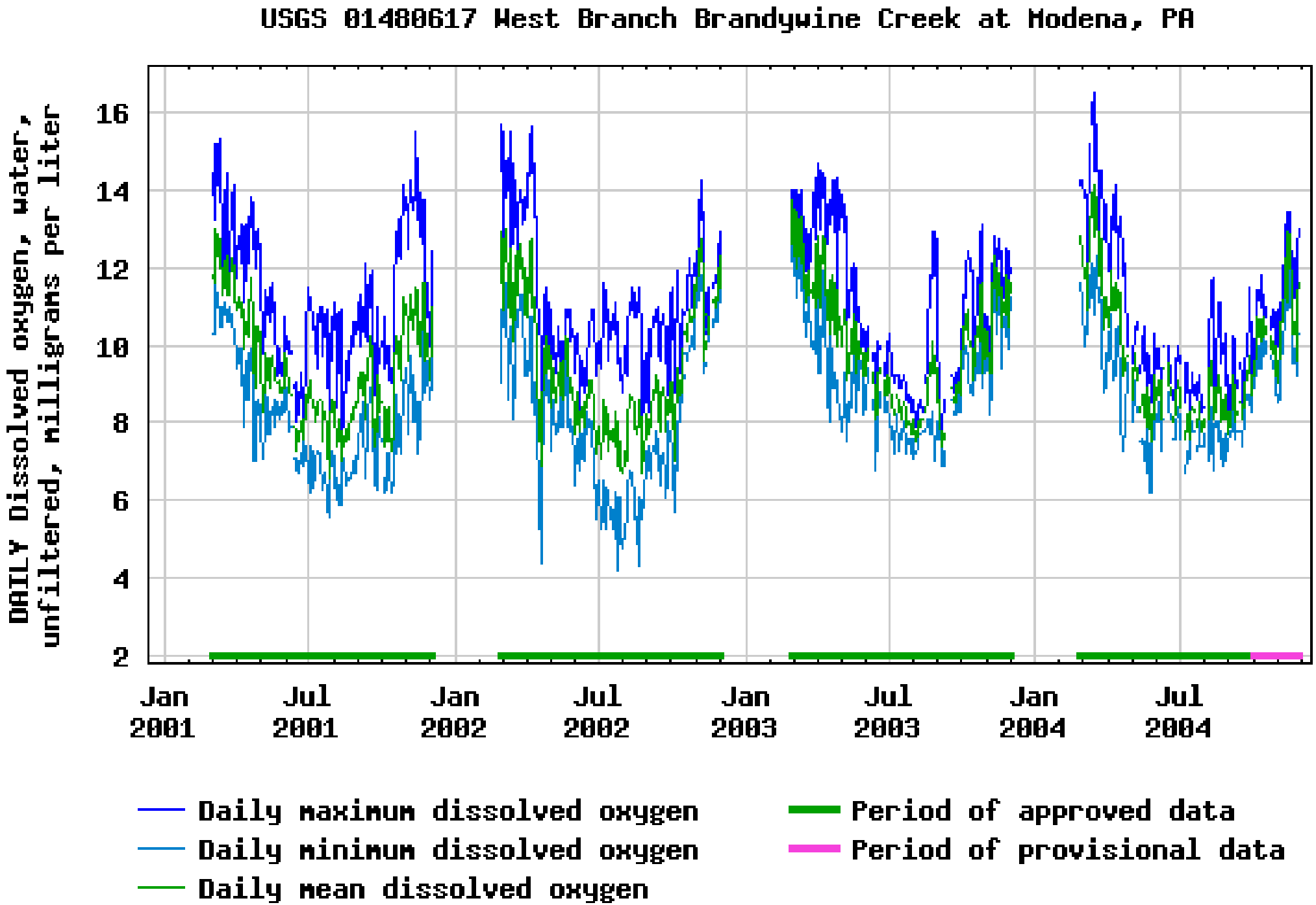
Contaminant Category	Substance	Potential Sources
Above Detection Level		
Nutrients	Nitrate	Fertilizer, Wastewater Treatment
	Nitrite	Fertilizer, Wastewater Treatment
	Nitrate + Nitrite	Fertilizer, Wastewater Treatment
PCBs	Polychlorinated biphenyls	Railroads, Electric Transmission Equipment
Other Organics	Dibromochloromethane	Wastewater Treatment
Metals	Arsenic	Natural Deposits, Orchard Runoff
	Copper	Household Plumbing, Wastewater Treatment
	Zinc	Industries
Other Inorganics	Sulfate	Natural Deposits
	Fluoride	Natural Deposits, Fertilizer Factories
Above 50% MCL/RBCL		
Other Inorganics	Chloride	Road Salt, Deicing Chemicals, Delaware River
	Cyanide	Metal Factories
Above 100% MCL/RBCL		
Other Organics	Bromodichloromethane	Wastewater Treatment
	Chloroform	Wastewater Treatment
Metals	Aluminum	Natural Deposits
	Cadmium	Natural Deposits, Metal Refinery, Galvanized Pipe
	Iron	Natural Deposits
	Lead	Plumbing/Wastewater Treatment, Brake Linings
	Manganese	Natural Deposits


USEPA 303(d) Listed
Impaired Waters
in the White Clay Creek
Wild and Scenic Watershed
303(d) Impaired Waters
Unimpaired Waters
White Clay Creek Watershed
0 0.5 1 2 3
Miles
N

USGS QW Monitors

- QW gages on the Brandywine have been in operation since 1972
- Continuous monitoring is needed to accurately measure trends in DO values.




USGS 01480617 West Branch Brandywine Creek at Modena, PA
DAILY Dissolved oxygen, water, unfiltered, milligrams per liter
16
14
12
10
8
6
4
2
Jan 2001
Jul 2001
Jan 2002
Jul 2002
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Daily maximum dissolved oxygen
Daily minimum dissolved oxygen
Daily mean dissolved oxygen
Period of approved data
Period of provisional data

White Clay Creek above Newark

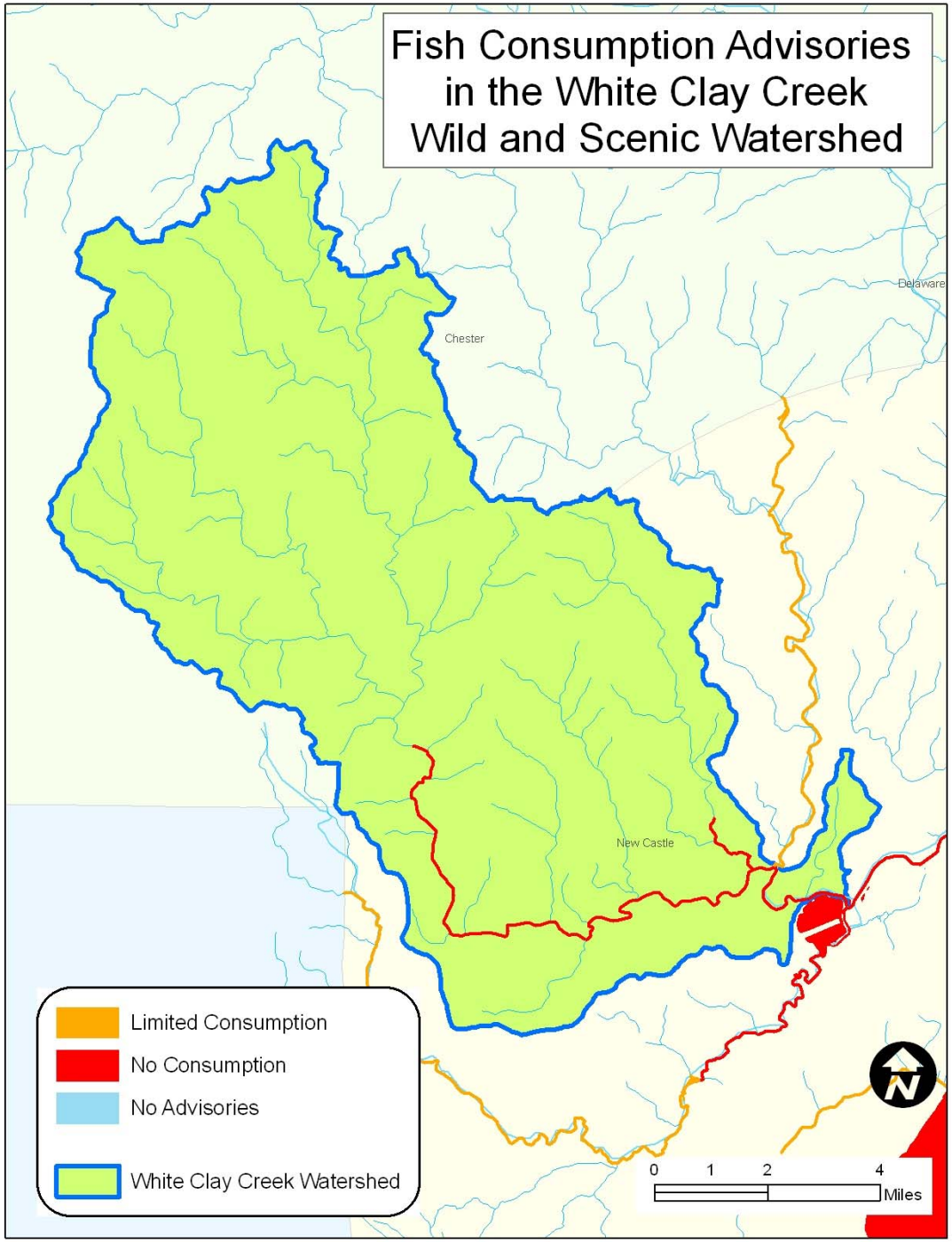
Table 5: Number of Discrete Sources by Category

	DE		PA	
Site Type	**Level 1**	**Level 2**	**Level 1**	**Level 2**
Hazardous Substance Sites (Superfund and SIRB)	0	3	*	*
Underground Storage Tanks	1	10	*	2*
Landfills/Dumps	0	0	0	5
NPDES Wastewater Discharges	2	**	38	**
Waste Water Outfalls	0	**	4	**
Tire Piles	0	0	*	*
Hazardous Waste Generators	0	0	*	*
Toxic Release Inventory (TRI) Sites	0	0	*	*
Salvage Yards	0	0	*	*
Pesticide Loading, Mixing Areas	0	0	*	*
Large On-Site Septic Systems	0	0	1	16
Waste Water Spray Irrigation	0	0	8	2
Waste Sludge Application	0	0	*	*
Confined Animal Feed Operations (CAFOs)	0	0	*	*
Combined Sewer Overflows	0	0	*	*
Dredge Spoils	0	0	*	*
Domestic Septic Systems	*	*	*	*
SARA Title III Sites	*	*	*	*

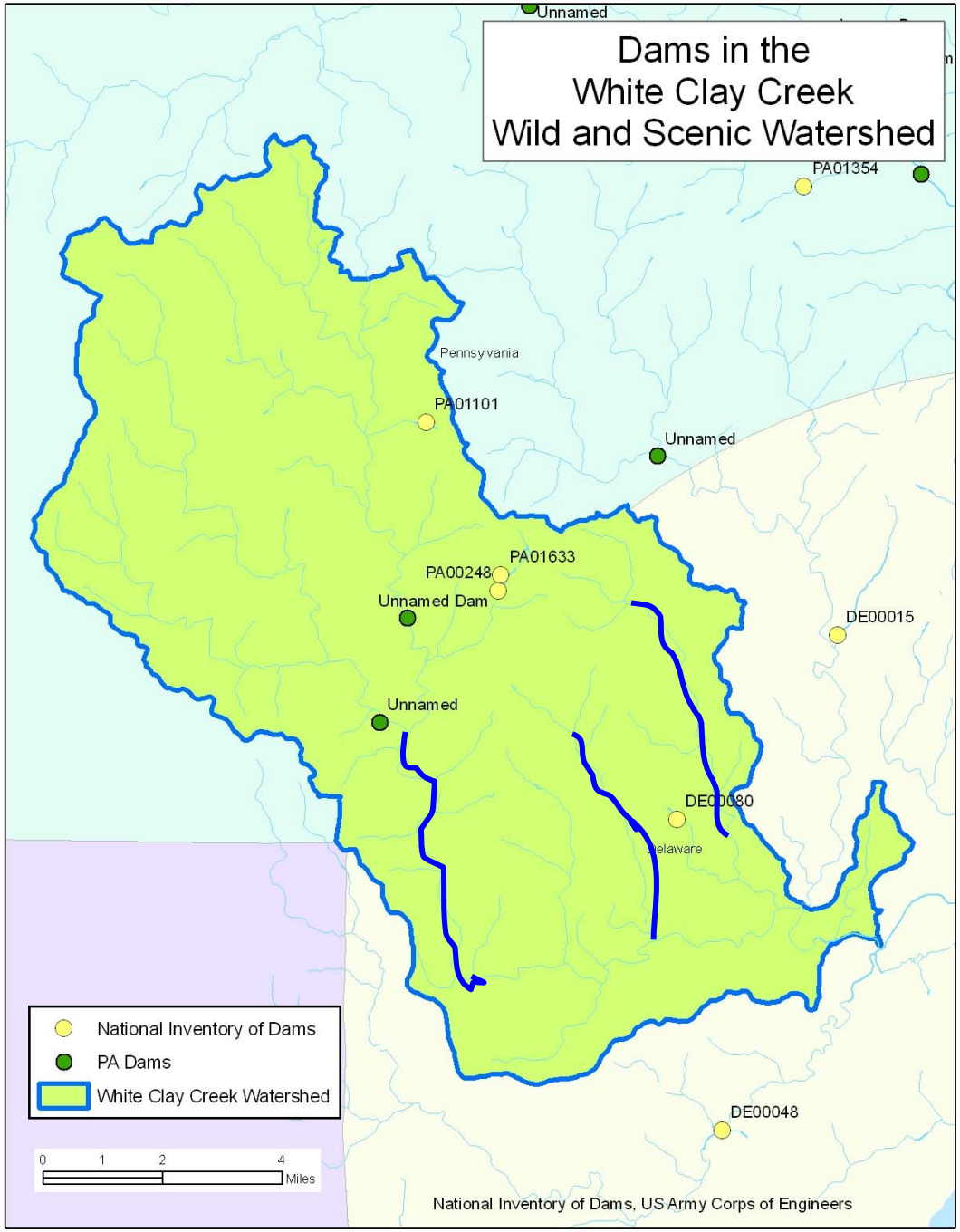
White Clay Creek above Stanton

Table 5: Number of Discrete Sources by Category

Site Type	DE		PA	
	Level 1	Level 2	Level 1	Level 2
Hazardous Substance Sites (Superfund and SIRB)	7	30	*	*
Underground Storage Tanks	25	277	*	*
Landfills/Dumps	0	3	1	1
NPDES Wastewater Discharges	9	**	21	**
Waste Water Outfalls	0	**	21	**
Tire Piles	1	0	*	*
Hazardous Waste Generators	32	118	*	*
Toxic Release Inventory (TRI) Sites	2	7	*	*
Salvage Yards	1	0	*	*
Pesticide Loading, Mixing Areas	0	0	*	*
Large On-Site Septic Systems	0	0	5	16
Waste Water Spray Irrigation	0	0	1	2
Waste Sludge Application	0	1	*	*
Confined Animal Feed Operations (CAFOs)	0	0	*	*
Combined Sewer Overflows	0	0	*	*
Dredge Spoils	0	0	*	*
Domestic Septic Systems	*	*	*	*
SARA Title III Sites	*	*	*	*


Fish Consumption Advisories
in the White Clay Creek
Wild and Scenic Watershed
Chester
Delaware
New Castle
Limited Consumption
No Consumption
No Advisories
White Clay Creek Watershed
0
1
2
4
Miles

2006 Delaware Fish Consumption Advisories				
Waterbody	**Species**	**Geographical Extent**	**Contaminants of Concern**	**Advice**
Tidal White Clay Creek	All Finfish	River Mouth to Route 4	PCBs	No Consumption
Non-tidal White Clay Creek	All Finfish	Route 4 to DE/PA Line	PCBs	No more than one 8-ounce meal per month
Designated Trout Streams and Ponds other than Christina Creek	Stocked Trout	Designated Trout Stocking Areas are listed in the Delaware 2006 Fishing Guide and at http://www.dnrec.state.de.us/fw/Trout/TroutMaps.htm	PCBs	No more than one 8-ounce meal per month

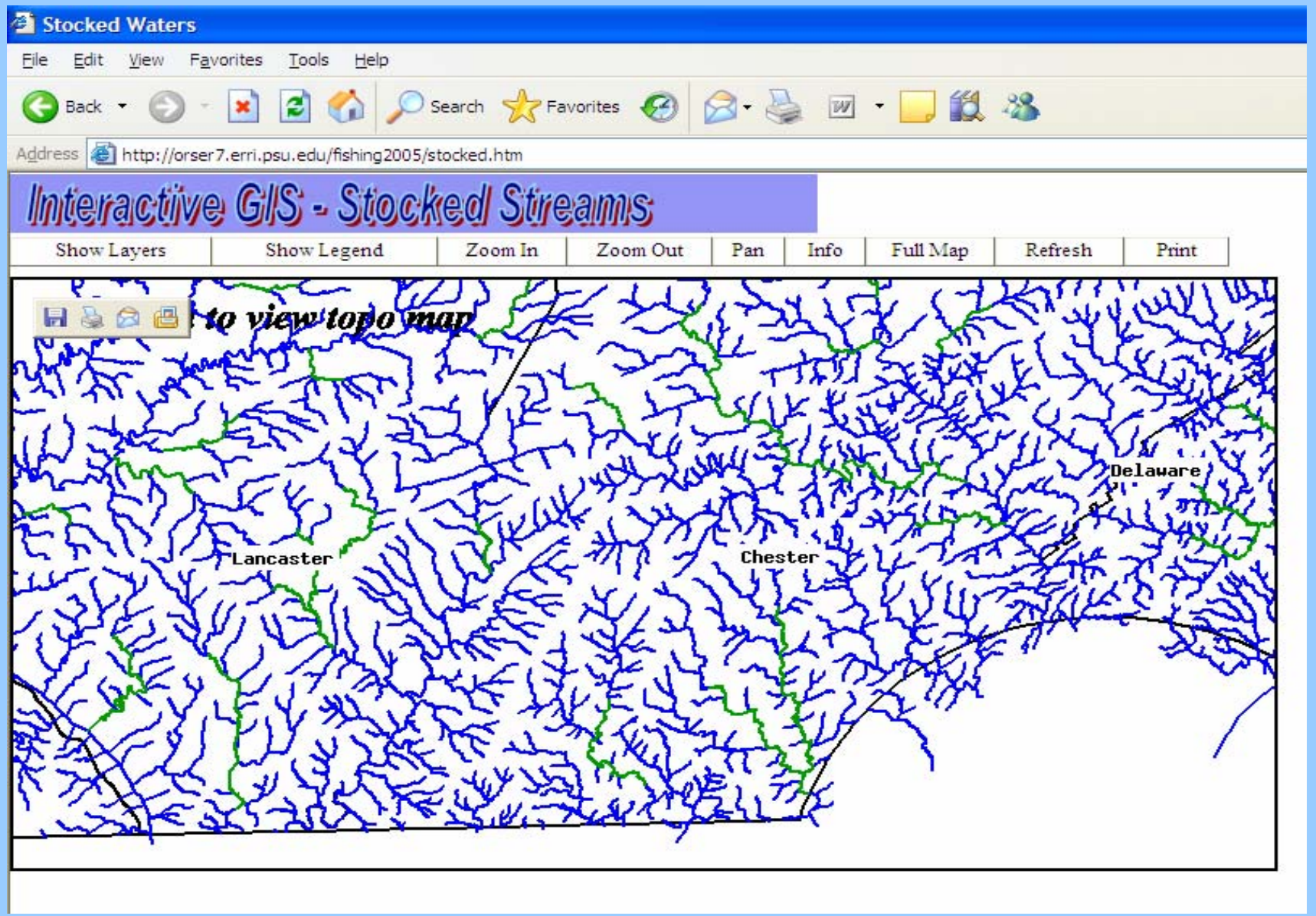


Put and Take Trout Streams In Delaware:

White Clay Creek above Newark

Pike Creek

Mill Creek

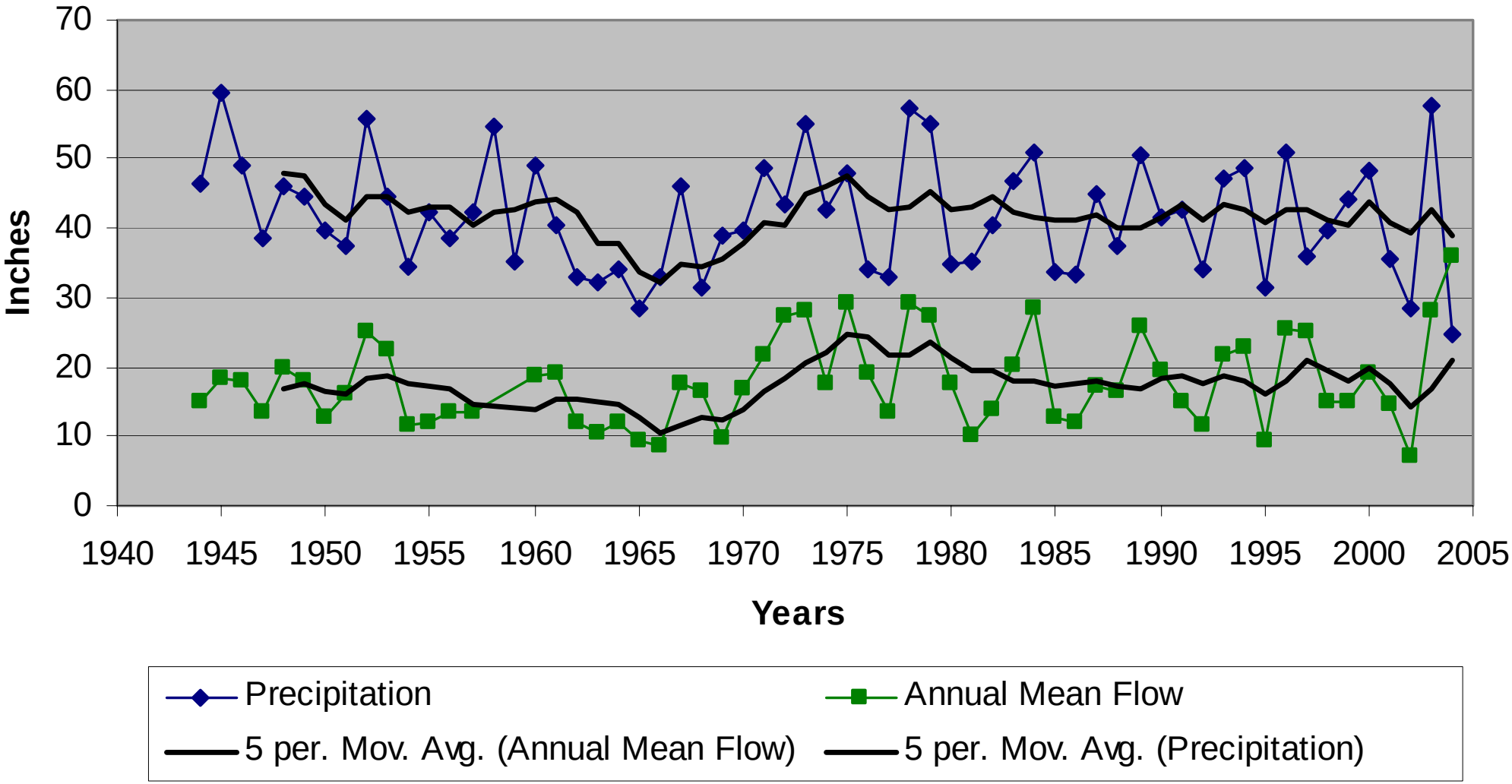


Stocked Trout Streams in PA:
Middle and East Branches of White Clay Creek

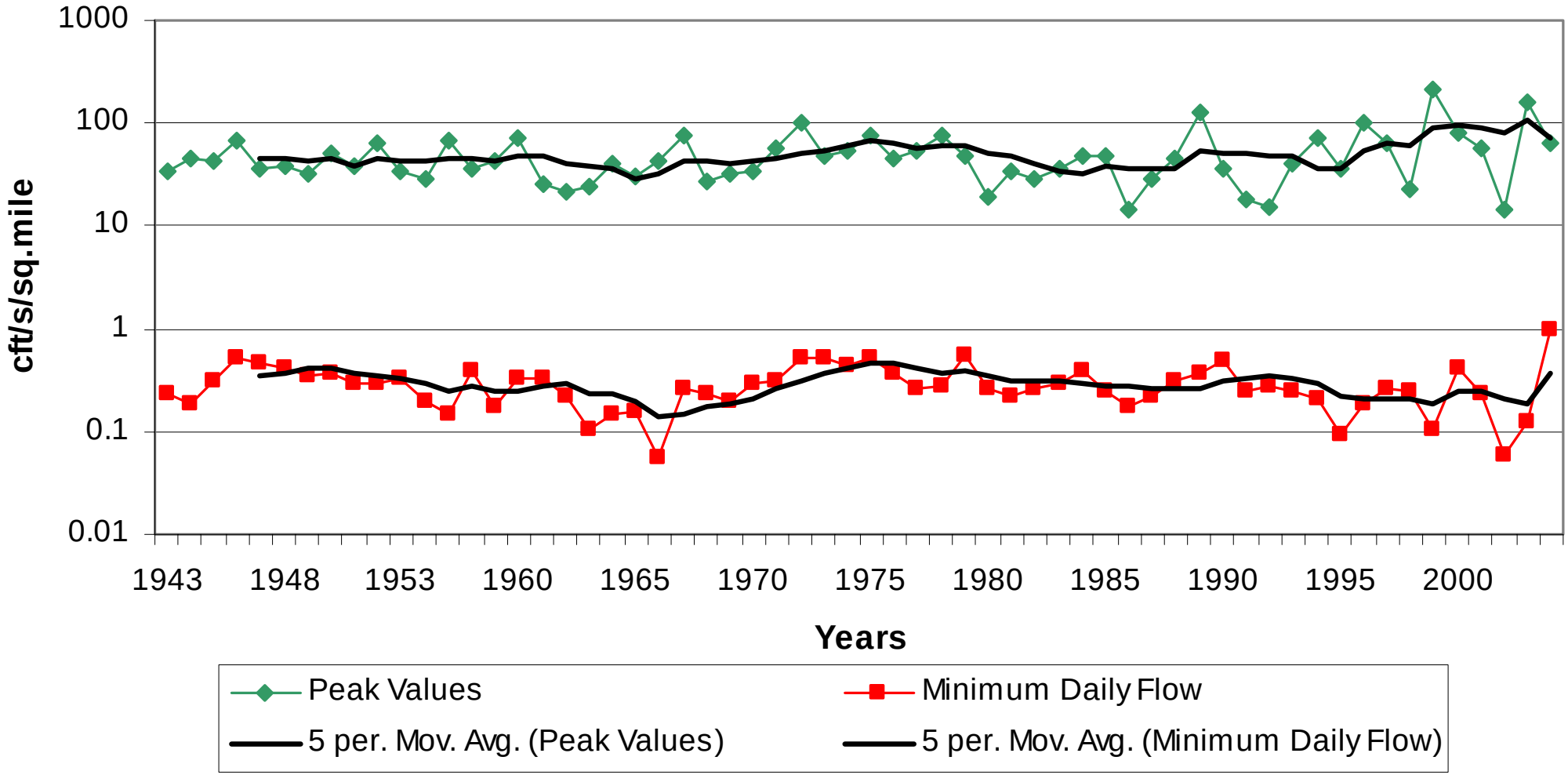
Stream (source: FEMA Flood Insurance Study for New Castle County, DE)	Feet above Mouth	Name of Dam	Height of Dam (ft)
White Clay Creek	22,300	DE Pk. Race Track (No. 1)	8
	40,200	Kirkwood Hwy (No. 2)	3
	50,000	No. 3	4
	53,300	Rt 72 Paper Mill Rd (No. 4)	6
	58,400	No. 5	10
	61,300	No. 6	3
	67,000	No. 7	6

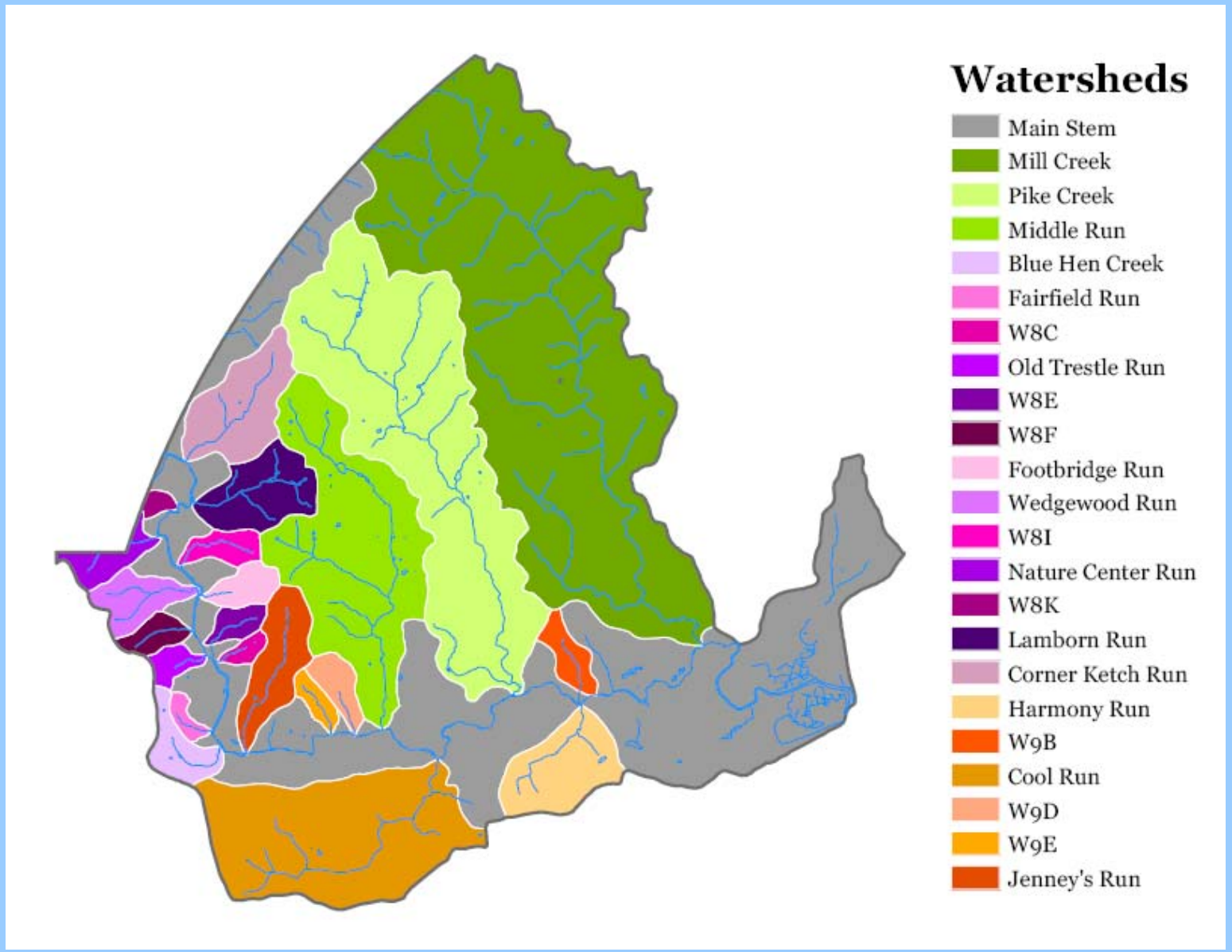
USGS Sub watershed ID	Sub watershed Area (sq mi)	Groundwater Availability (mgd/sq mi) (mgd)	Groundwater Withdrawal (mgd/sq mi) (mgd)	Remaining Groundwater (mgd/sq mi) (mgd)	Available Groundwater Used (%)
DB-124 WCC	104.0	0.275 (28.6)	0.021 (2.18)	0.253 (26.31)	7.9%

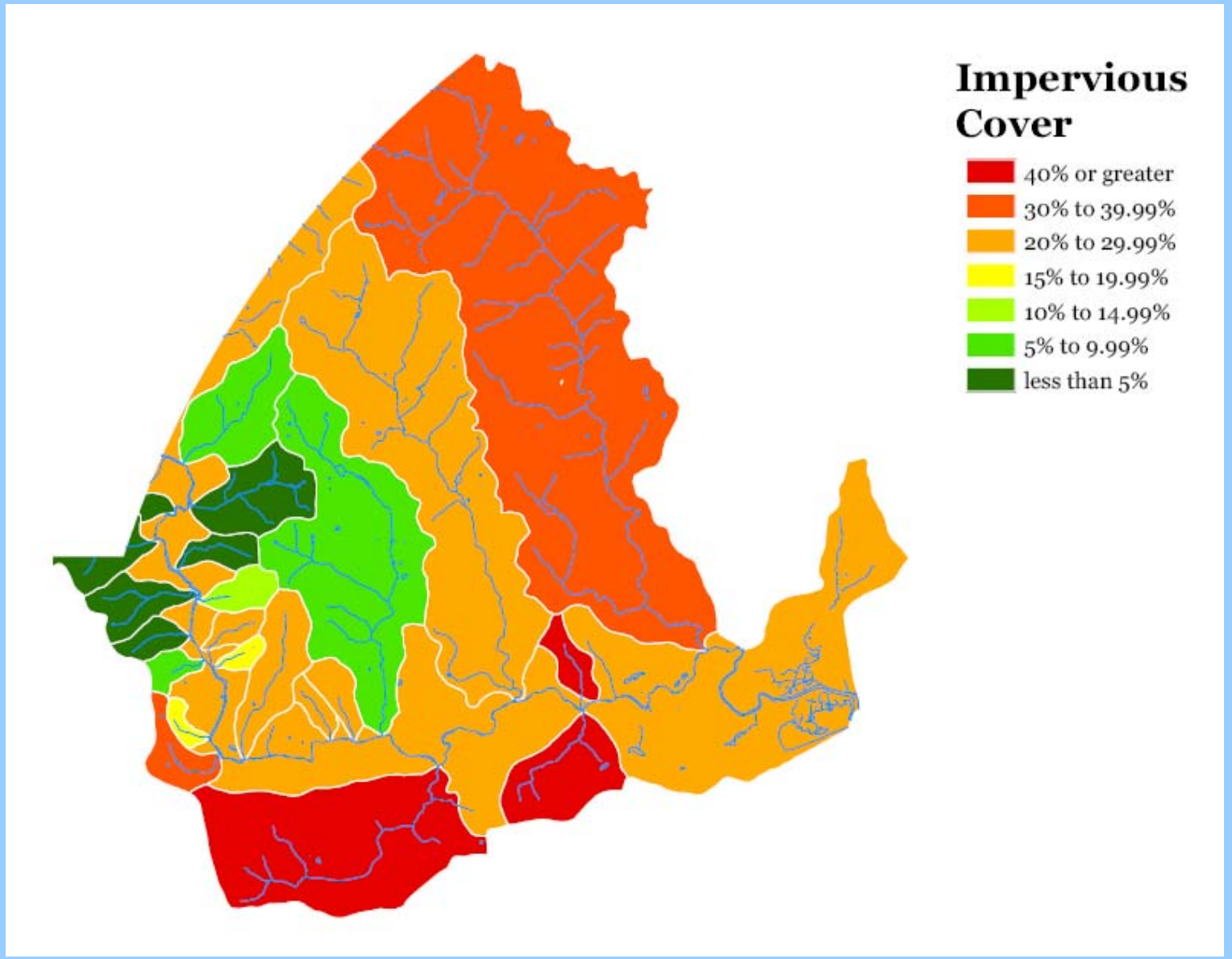
Precipitation and Annual Mean Flow for White Clay Creek Near Newark, DE
USGS Station 01479000

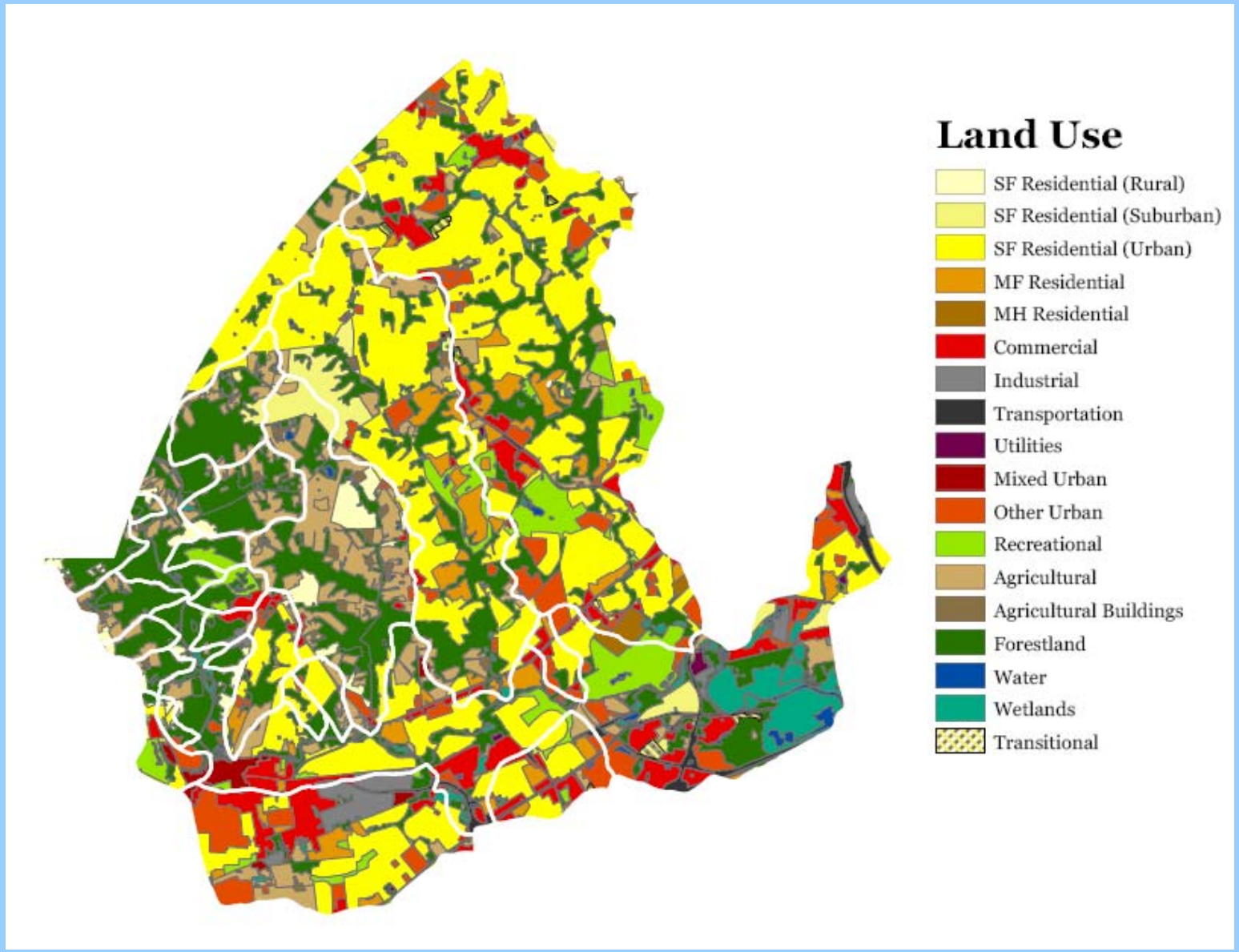


Peak Flow and Minimum Daily Flow, White Clay Creek Near Newark, DE
USGS Station 01479000

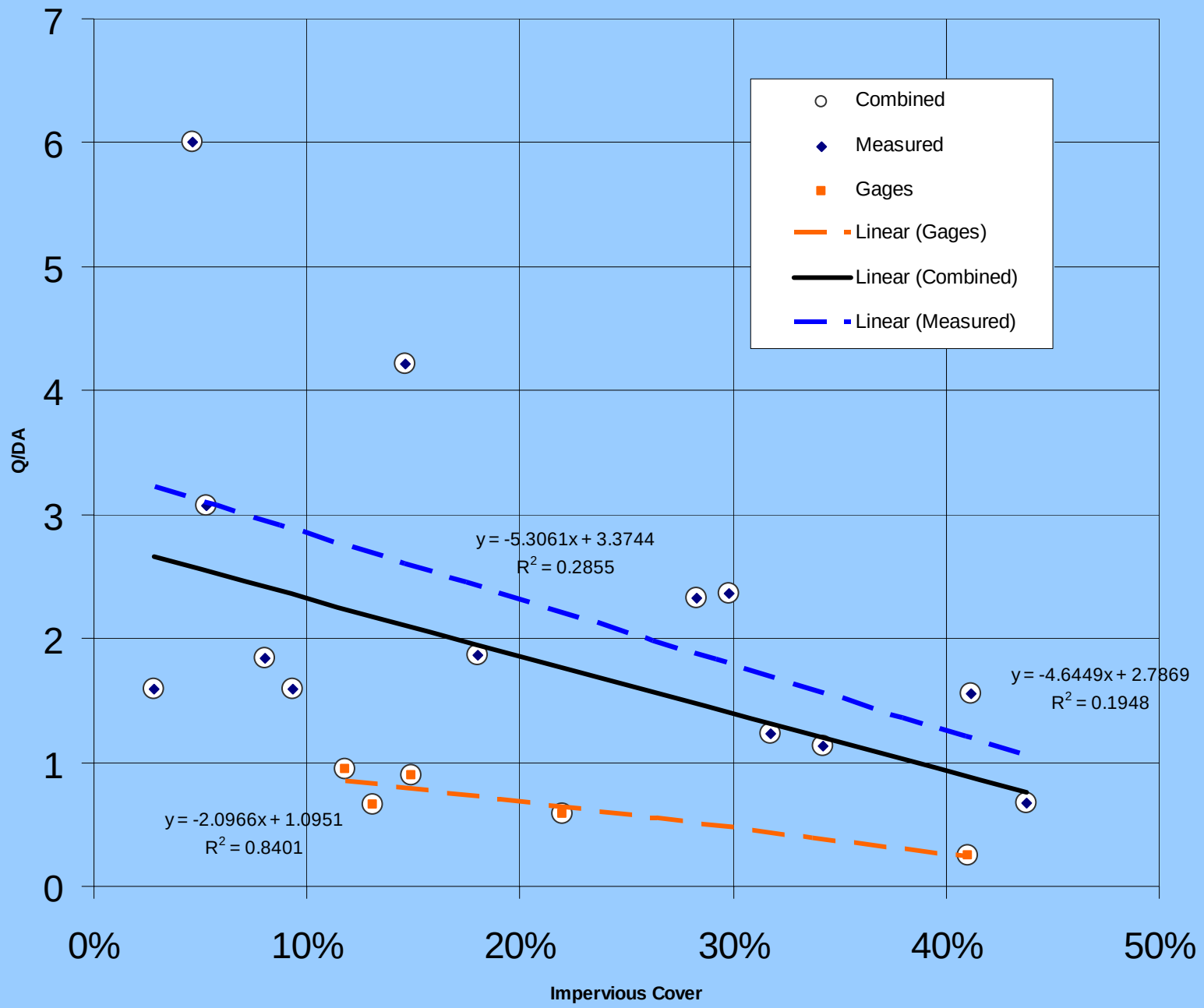


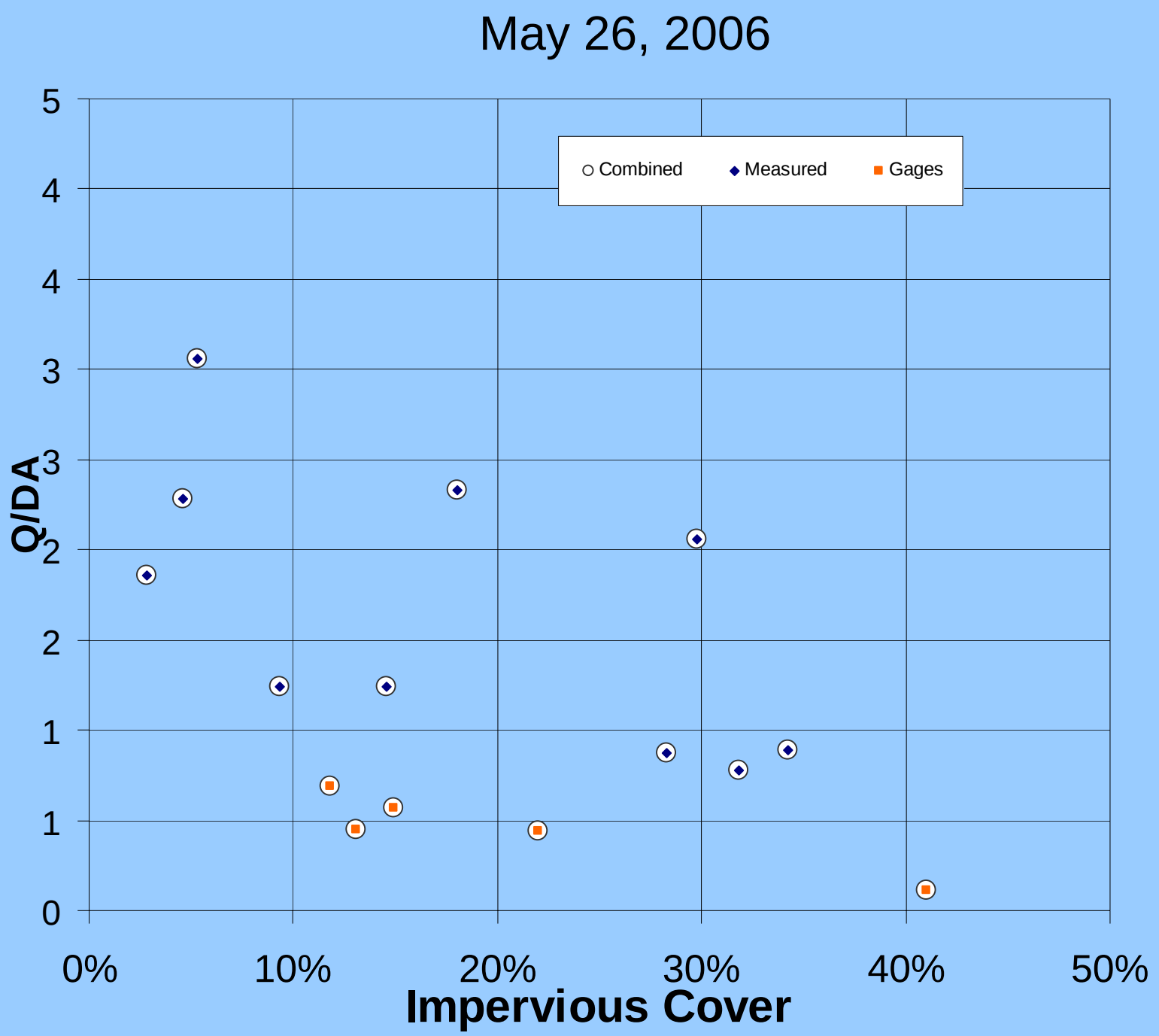

Watersheds
Main Stem
Mill Creek
Pike Creek
Middle Run
Blue Hen Creek
Fairfield Run
W8C
Old Trestle Run
W8E
W8F
Footbridge Run
Wedgewood Run
W8I
Nature Center Run
W8K
Lamborn Run
Corner Ketch Run
Harmony Run
W9B
Cool Run
W9D
W9E
Jenney's Run

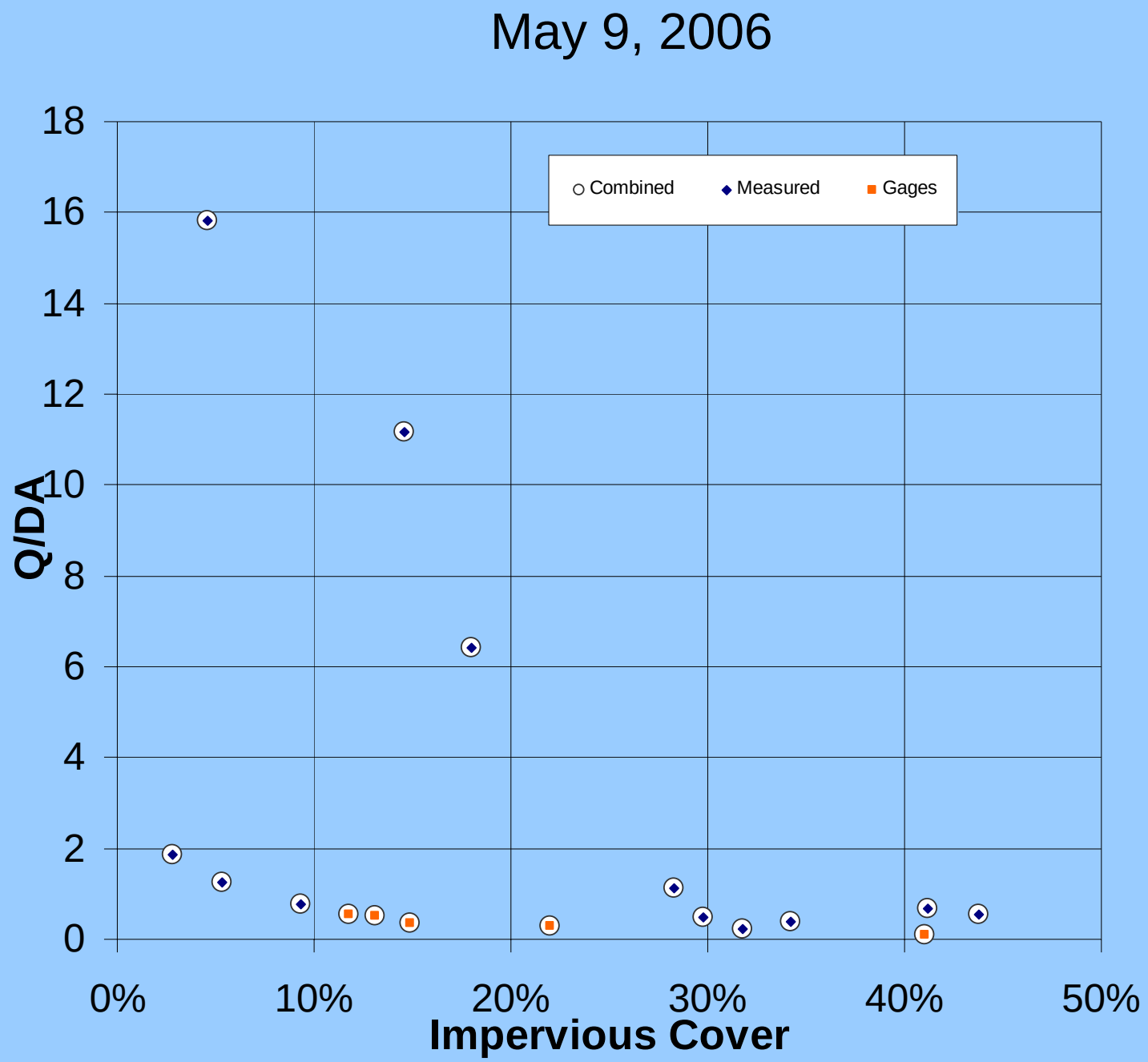

Impervious Cover
40% or greater
30% to 39.99%
20% to 29.99%
15% to 19.99%
10% to 14.99%
5% to 9.99%
less than 5%


Land Use
SF Residential (Rural)
SF Residential (Suburban)
SF Residential (Urban)
MF Residential
MH Residential
Commercial
Industrial
Transportation
Utilities
Mixed Urban
Other Urban
Recreational
Agricultural
Agricultural Buildings
Forestland
Water
Wetlands
Transitional

May 2, 2006


Combined
Measured
Gages
Linear (Gages)
Linear (Combined)
Linear (Measured)
y = -5.3061x + 3.3744
R2 = 0.2855
y = -4.6449x + 2.7869
R2 = 0.1948
y = -2.0966x + 1.0951
R2 = 0.8401
Q/DA
Impervious Cover
0
1
2
3
4
5
6
7
0%
10%
20%
30%
40%
50%

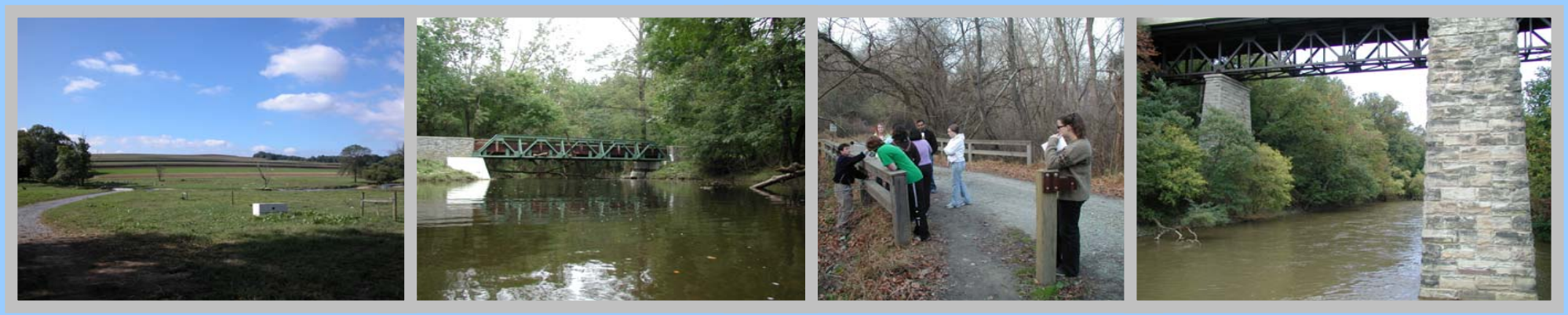

May 26, 2006
Combined
Measured
Gages
Q/DA
Impervious Cover
0
1
1
2
2
3
3
4
4
5
0%
10%
20%
30%
40%
50%


May 9, 2006
Combined
Measured
Gages
Q/DA
Impervious Cover
0
2
4
6
8
10
12
14
16
18
0%
10%
20%
30%
40%
50%

Grade	Water Quality	Basis of Rating
A	Excellent	So pure one could drink water from stream.
B	Good	Meets fishable/swimmable standards, supports cold water trout fishery.
C	Average	Clean enough to support warm water fishery, not swimmable.
D	Unsatisfactory	Polluted, okay for boating not swimming or fishing
F	Poor	Polluted, has raw sewage and floating trash

	W5. Mill Creek	W6. Pike Creek	W7. Middle Run	W8. White Clay Cr. Ab. Newark	W9. White Clay Cr. below Newark	W10. White Clay Creek Tidal
Total Nitrogen	**B**	**C**	**B**	**C**	**C**	**C**
Total Phosphorus	**B**	**B**	**B**	**C**	**C**	**C**
Chlorophyll	**C**	**B**	**C**	**C**	**C**	**C**
Maximum Copper	**-**	**-**	**-**	**A**	**-**	**A**
Maximum Lead	**-**	**-**	**-**	**C**	**-**	**F**
Maximum Zinc	**-**	**-**	**-**	**A**	**-**	**B**
Dissolved Oxygen	**B**	**A**	**A**	**B**	**B**	**B**
Enterococcus Bacteria	**D**	**C**	**C**	**C**	**C**	**C**
Total Susp. Solids	**D**	**C**	**C**	**C**	**F**	**F**
Aquatic Life Support	**F**	**C**	**C**	**F**	**F**	**F**
ERES Waters	**C**	**C**	**C**	**A**	**C**	**C**
Cold Water Fishery	**A**	**A**	**C**	**A**	**C**	**C**
Fish Consumption Advisories	**A**	**A**	**A**	**A**	**C**	**F**
Biological Index	**D**	**D**	**C**	**C**	**C**	**C**
Habitat Index	**C**	**C**	**B**	**B**	**B**	**B**
Superfund Sites	**-**	**-**	**-**	**B**	**-**	**F**
Imperviousness	**D**	**D**	**B**	**B**	**D**	**F**
Population Density	**F**	**F**	**D**	**C**	**F**	**F**
Forest/Open Space	**D**	**D**	**B**	**B**	**D**	**C**
Grade	**C**	**C^{+}**	**B^{-}**	**B**	**C^{-}**	**C^{-}**

Questions?



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