

Christina Basin Trends, 1995-2010

- Population
- Land Use
- Water Quality
- Water Temperature
- Streamflow

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S. Mack, M. Narvaez, and G. Kauffman (University of Delaware)

BRANDYWINE: A CREEK AT RISK AS PA. AND DEL. DEBATE WHAT TO DO, THE POLLUTION FLOWS ON.

Source: Rich Henson, INQUIRER STAFF WRITER

In a corner of Chester County, on either side of a tree-lined ridge that stretches out from the Welsh Hills, the East and West Branches of the Brandywine Creek gurggle from the ground as cold, pristine springs.

For the next 20 miles, the two branches meander south through one of the most picturesque and fastest-developing areas in the Philadelphia region - past forests, meadows, farmland, industrial sites, housing developments and small towns, finally converging just north of Chadds

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EPA Environmental News

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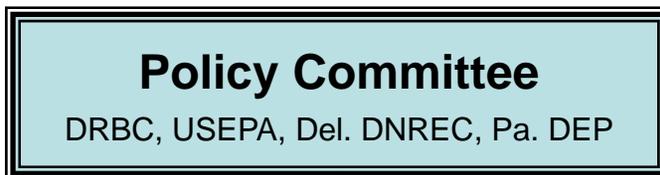
Report Shows Progress Exceeding Plans in Christina River Basin

(PHILADELPHIA, February 5, 2009) – The U.S. Environmental Protection Agency, announced today that the Christina River Basin Clean Water Partnership in Pennsylvania and Delaware has made significant progress in reducing pollution from storm water runoff to the Christina River basin.

A recent report by the University of Delaware and the Delaware River Basin Commission shows that, throughout the past four years, the Partnership, with the assistance of a \$1 million EPA grant, has implemented numerous projects to reduce the harmful effects of stormwater runoff pollution on drinking water supplies, recreation, fisheries, and wildlife.

For every federal dollar invested in the project, the Partnership leveraged more than two dollars, allowing them to exceed the original goals, some by more than 50 percent.]

Christina Basin Clean Water Partnership

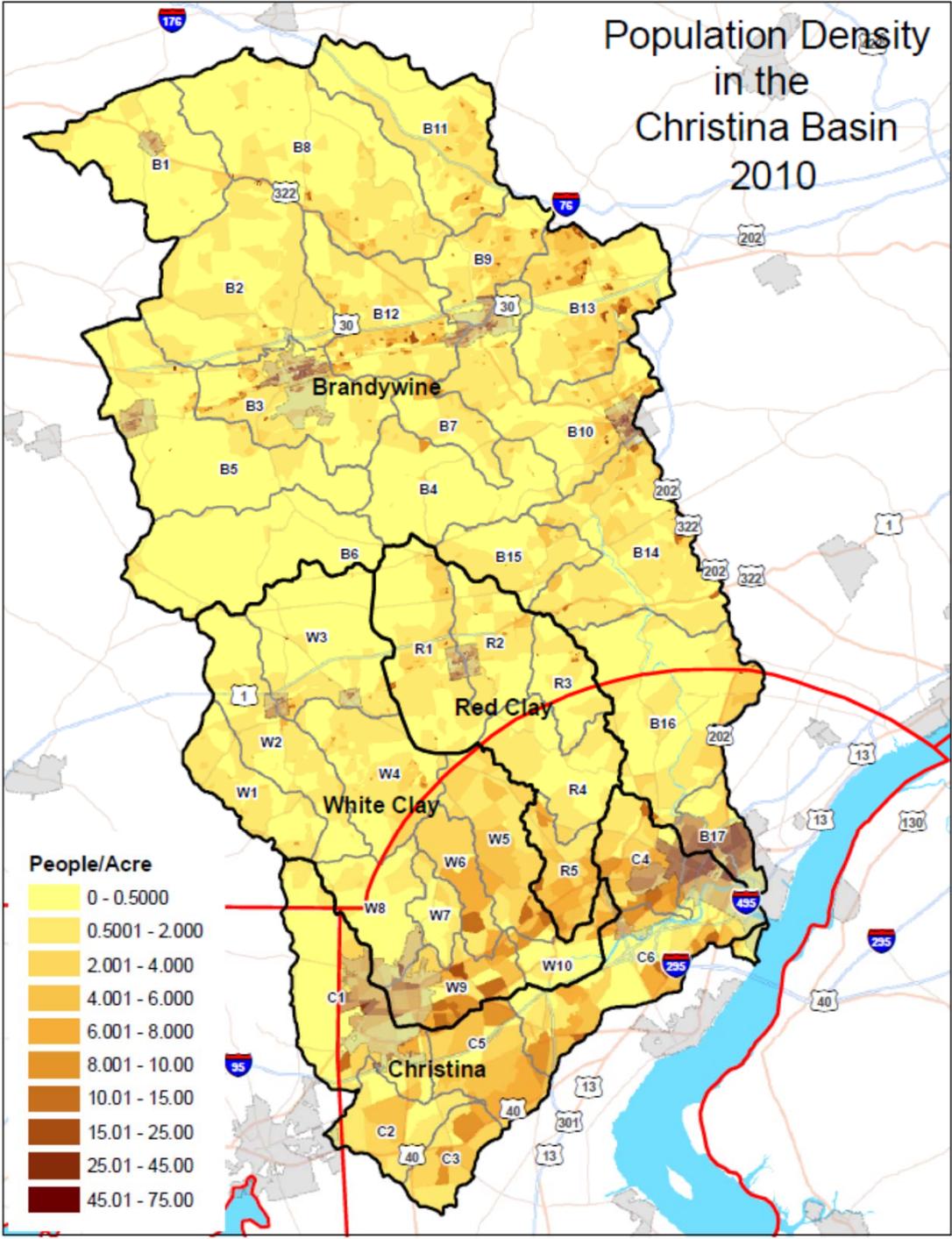


Christina Basin Population

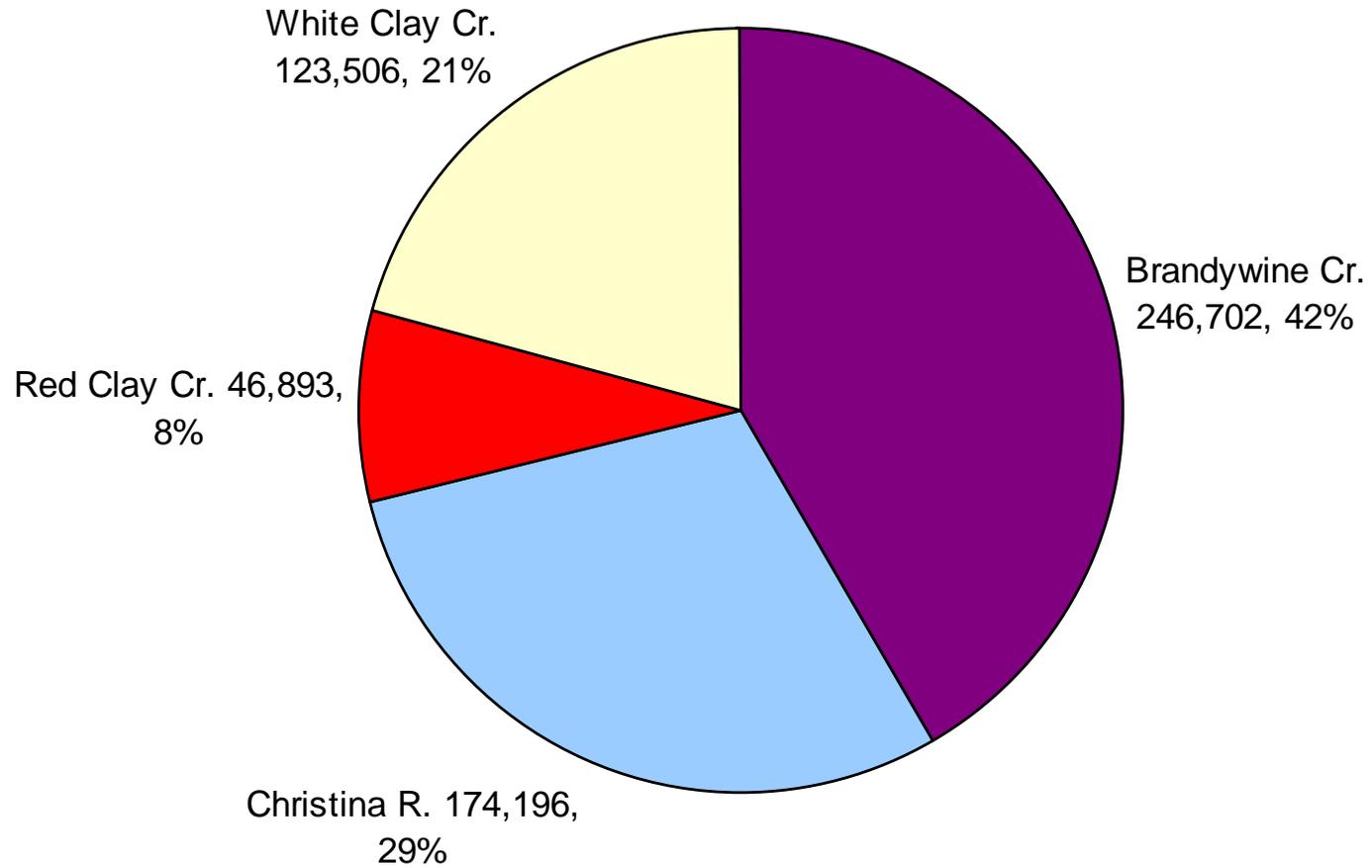
Watersheds	sq mi	2000 pop.	2010 pop.	Change	2000 p/sm	2010 p/sm
Brandywine Creek	326	221,413	246,702	25,289	679	757
Christina River	78	166,435	174,196	7,761	2,134	2,233
Red Clay Creek	54	42,630	46,893	4,263	789	868
White Clay Creek	107	118,579	123,506	4,927	1,109	1,155
Christina Basin	565	549,057	591,297	42,240	972	1,047

Source: U. S. Census

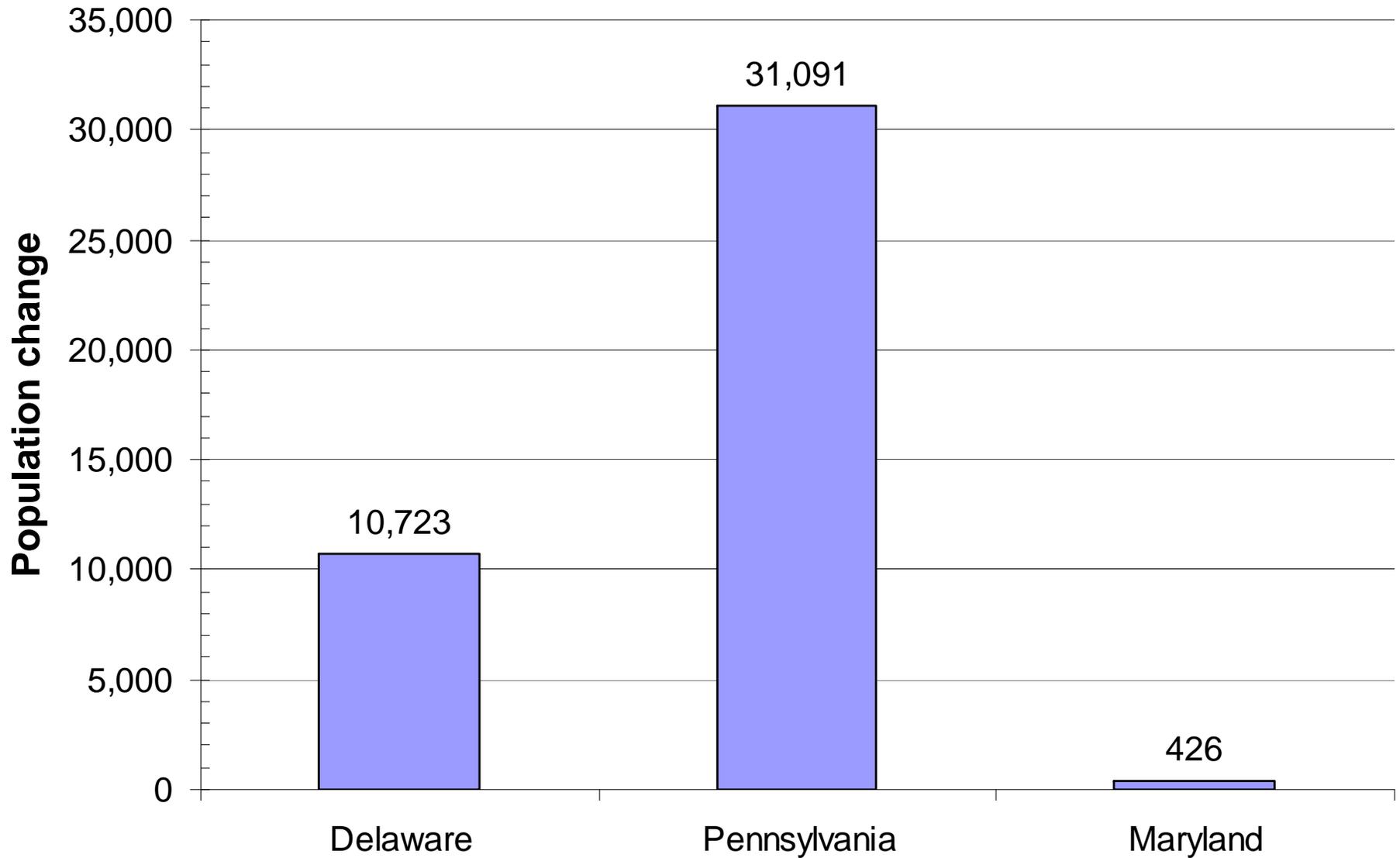
Population Density in the Christina Basin 2010



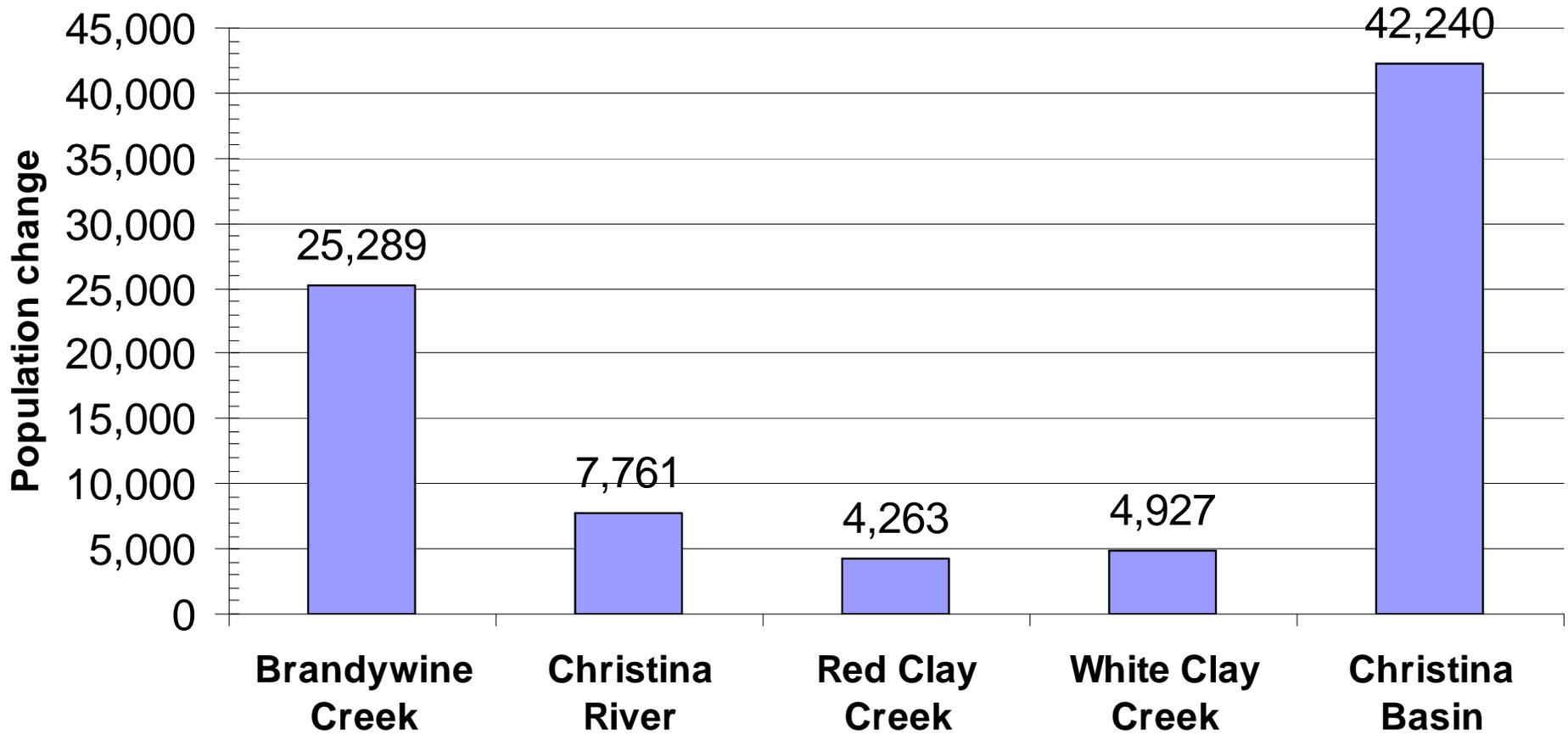
Christina Basin Population, 2010



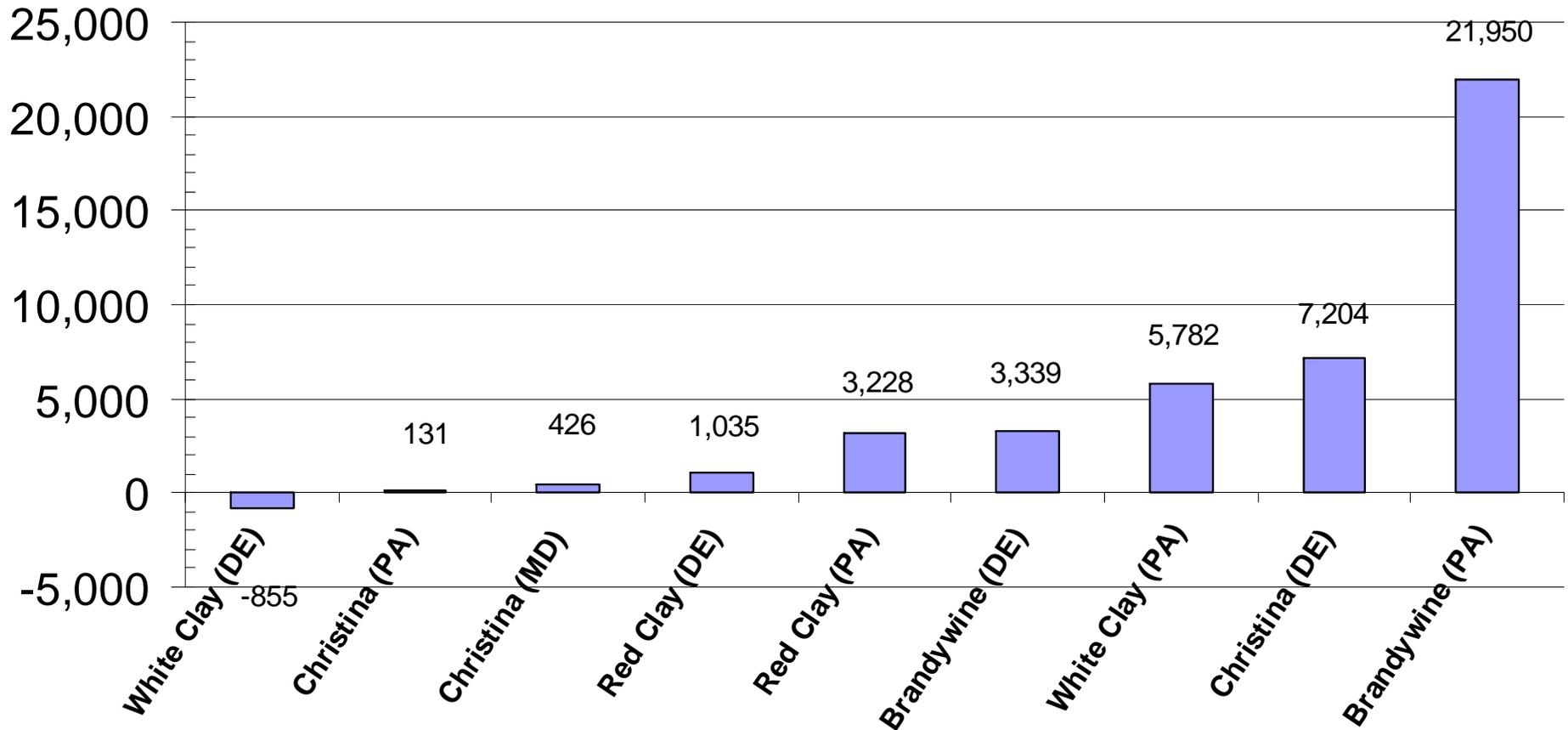
Christina Basin Population Change, 2000-2010



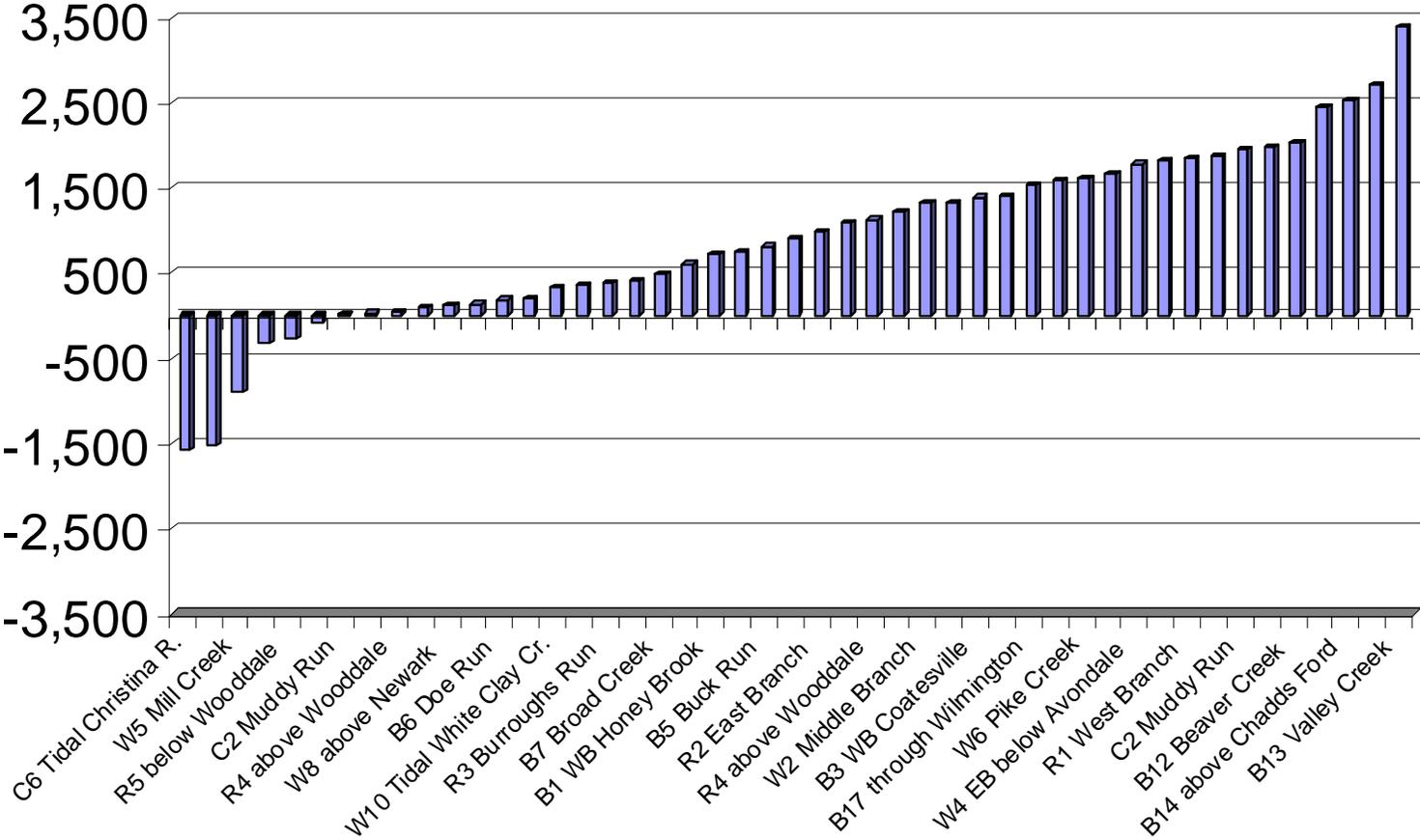
Christina Basin Population Change, 2000-2010



Christina Basin Population Change, 2000-2010



Christina Basin Population Change, 2000-2010

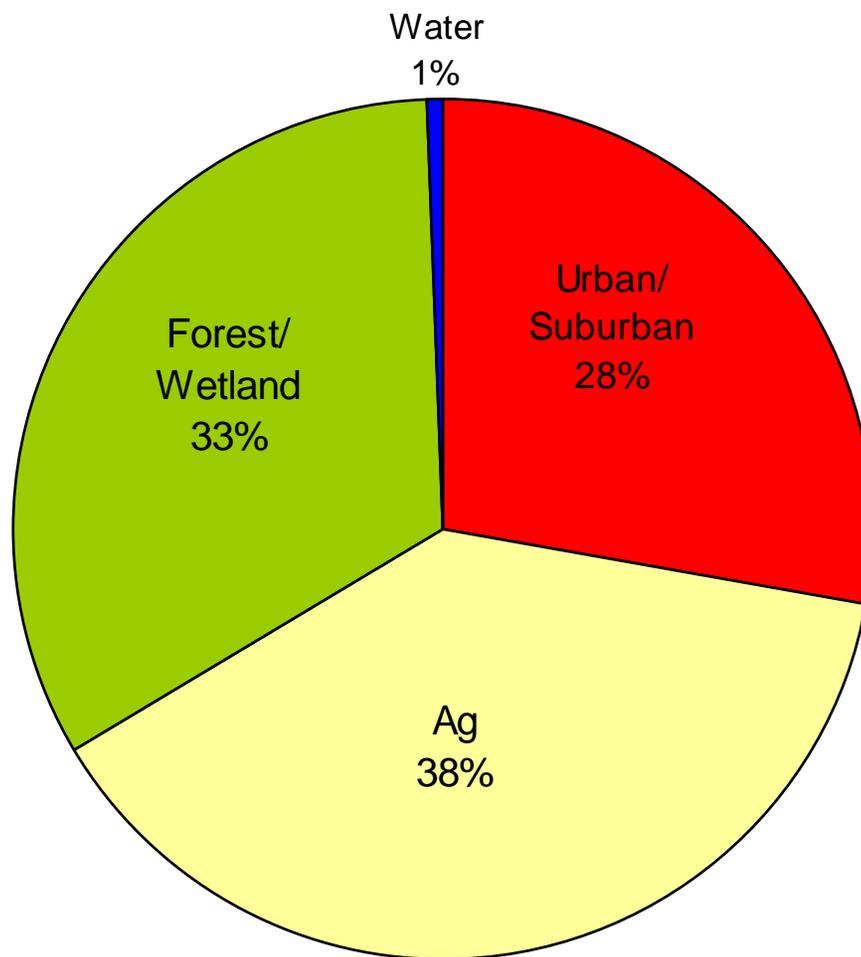


Christina Basin Land Use

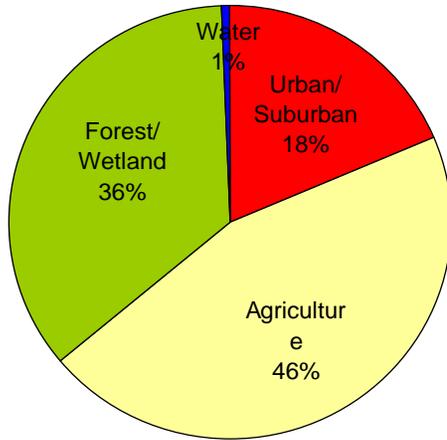
2005 Land Use									
Watershed	Urb/Sub	Ag	For/Wet	Water	Total	Urb/Sub	Ag	For/Wet	Water
Brandywine	60.1	147.7	115.9	1.6	325.4	18%	45%	36%	0%
Christina	45.2	11.2	19.9	0.8	77.1	59%	15%	26%	1%
Red Clay	14.7	20.9	18.1	0.3	54.1	27%	39%	33%	1%
White Clay	36.8	38.1	32.0	0.3	107.3	34%	36%	30%	0%
--	0.6	0.0	0.1	0.0	0.7	92%	0%	8%	0%
Total	156.8	218.0	185.9	3.1	563.8	28%	39%	33%	1%

Source: NOAA CSC

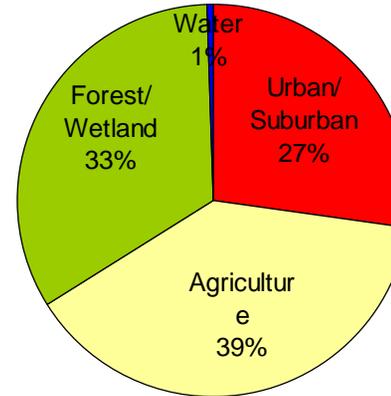
Christina Basin Land Use, 2005



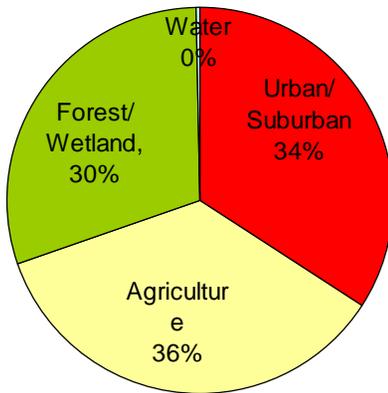
**Brandywine Creek
Land Use 2005**



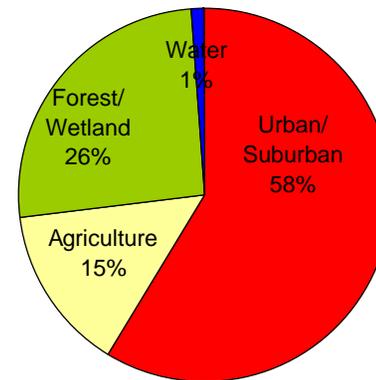
**Red Clay Creek
Land Use 2005**



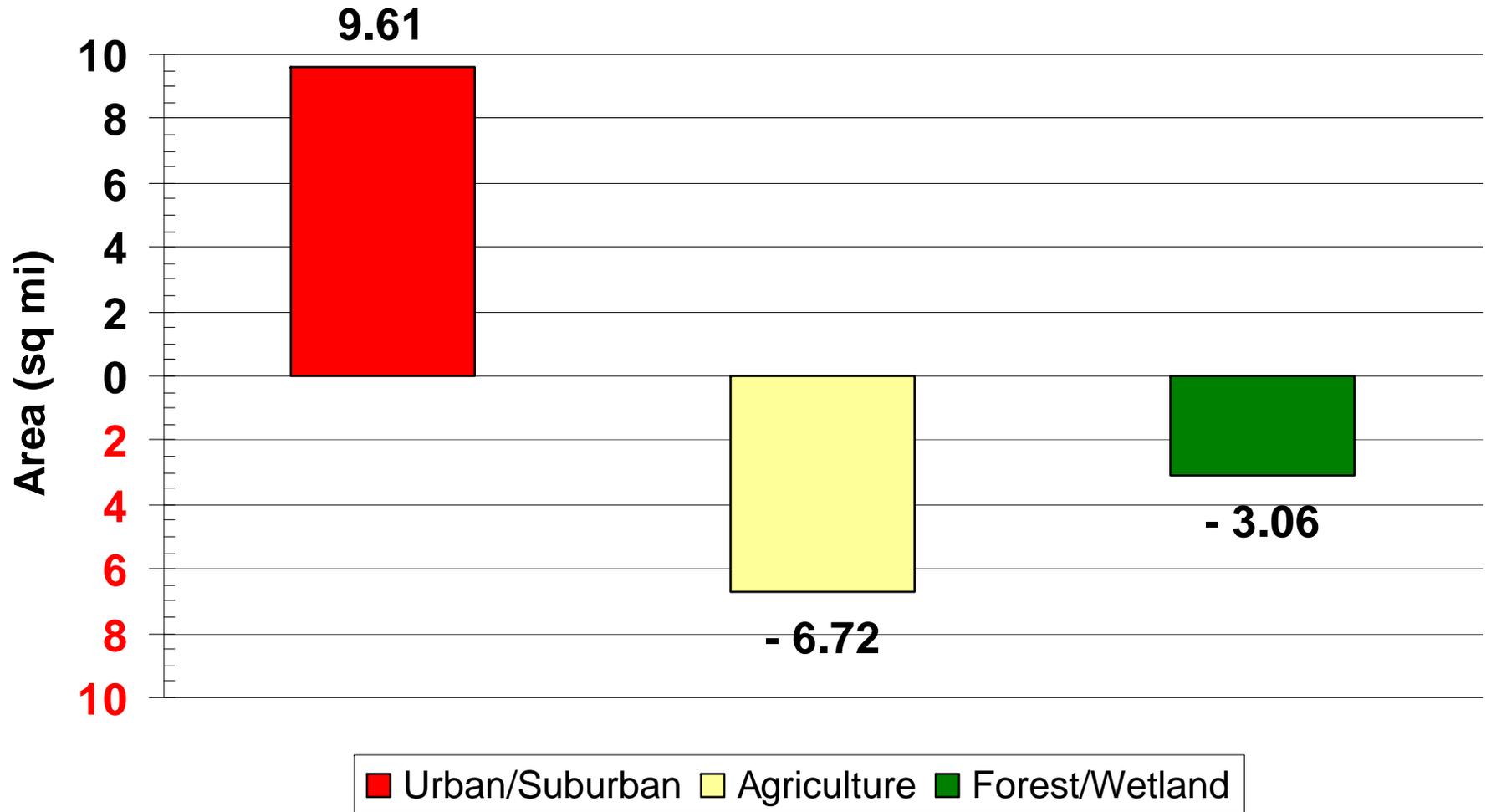
**White Clay Creek
Land Use 2005**



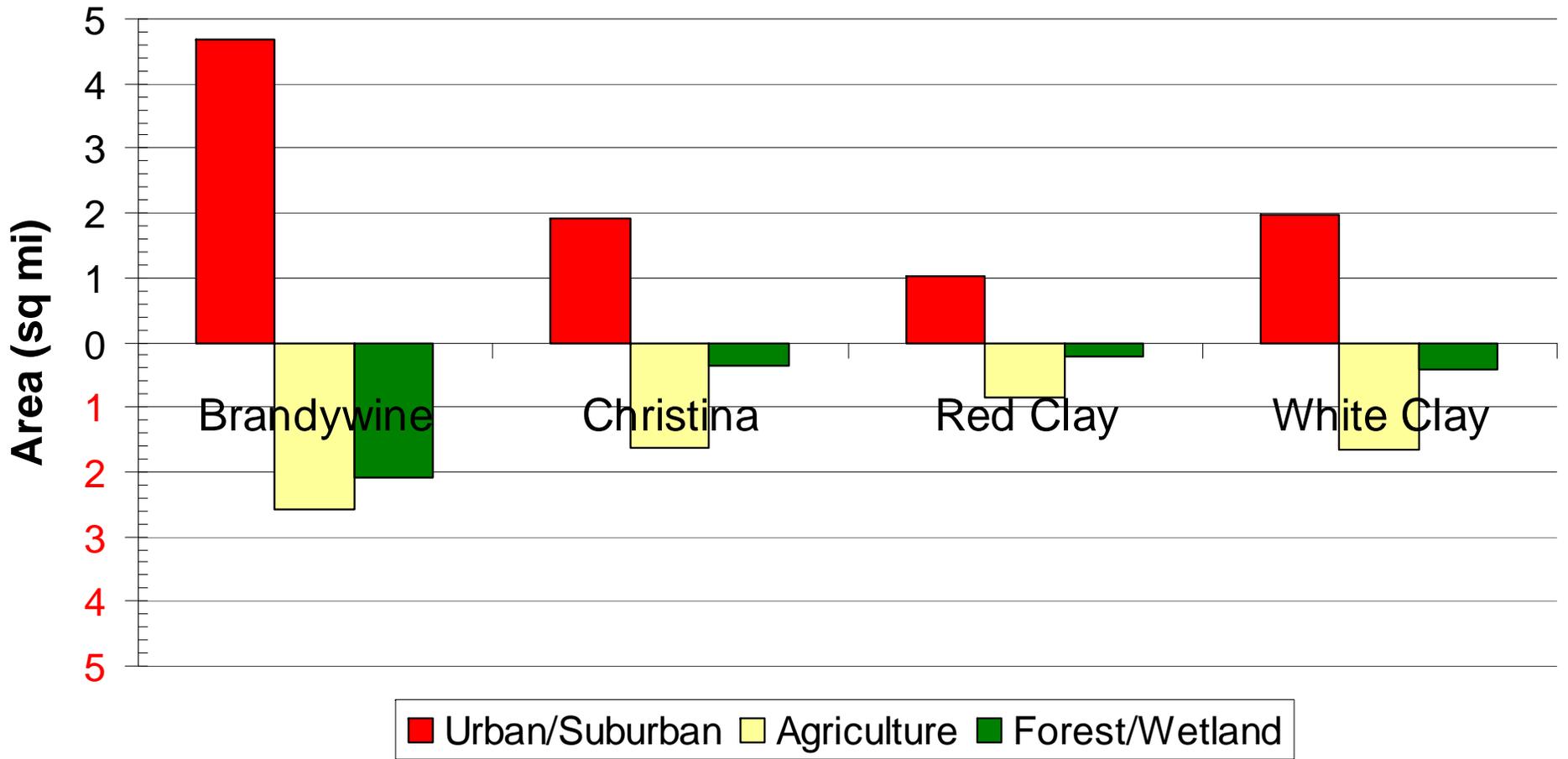
**Christina River
Land Use 2005**



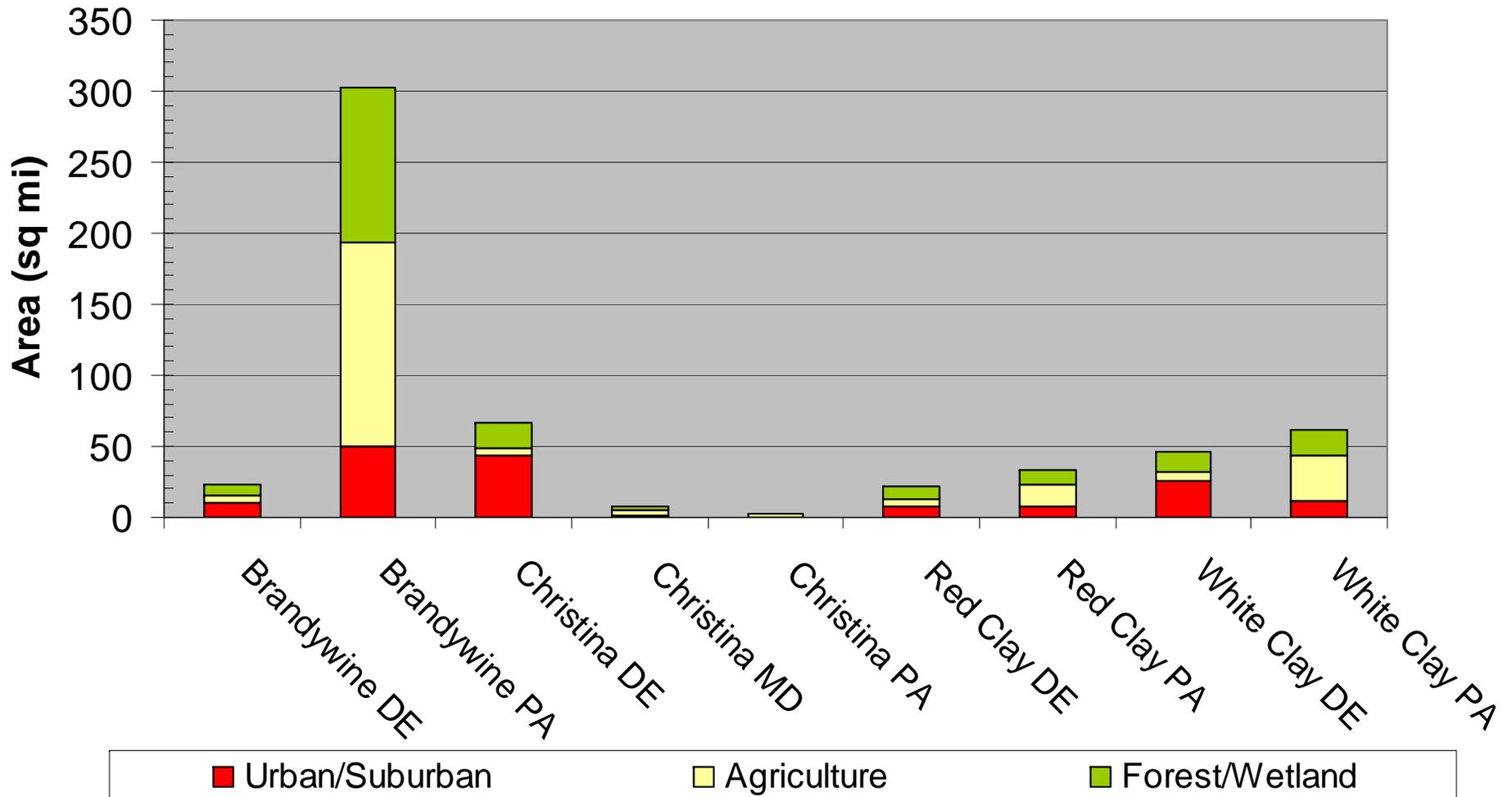
Christina Basin Land Use Change, 1996 - 2005



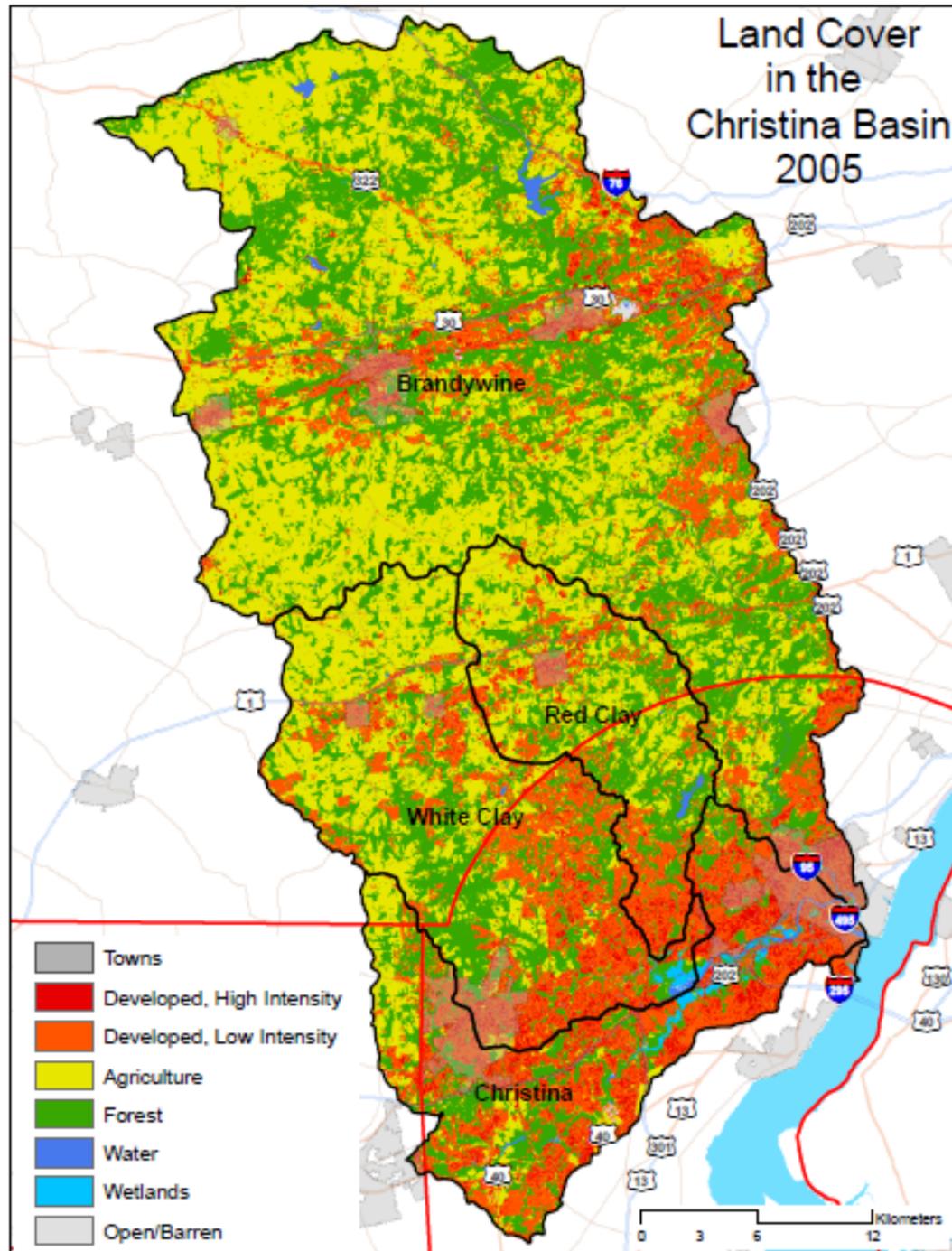
Christina Basin Land Use Change, 1995 - 2010



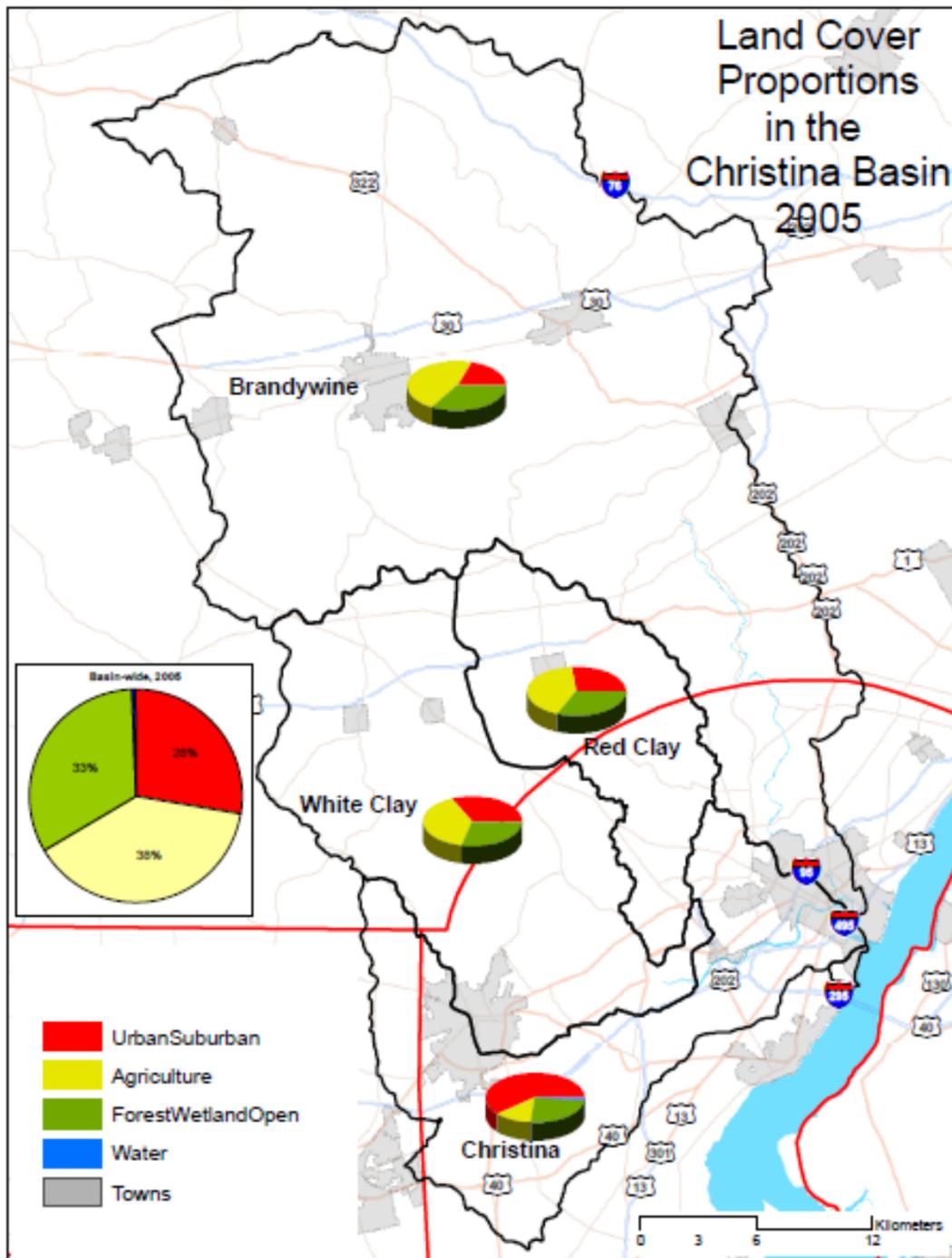
Christina Basin Land Use by State and Watershed, 2005



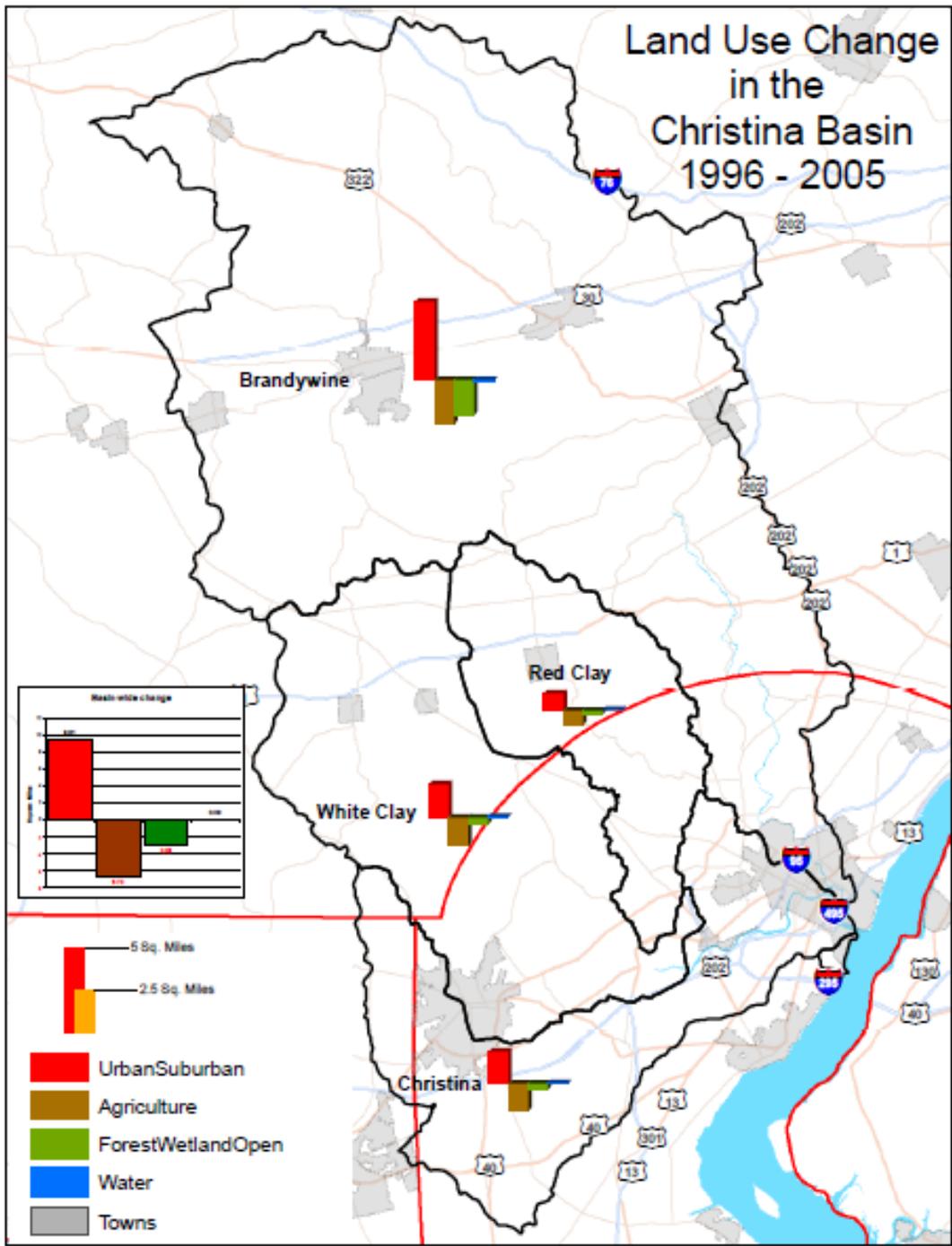
Land Cover in the Christina Basin 2005



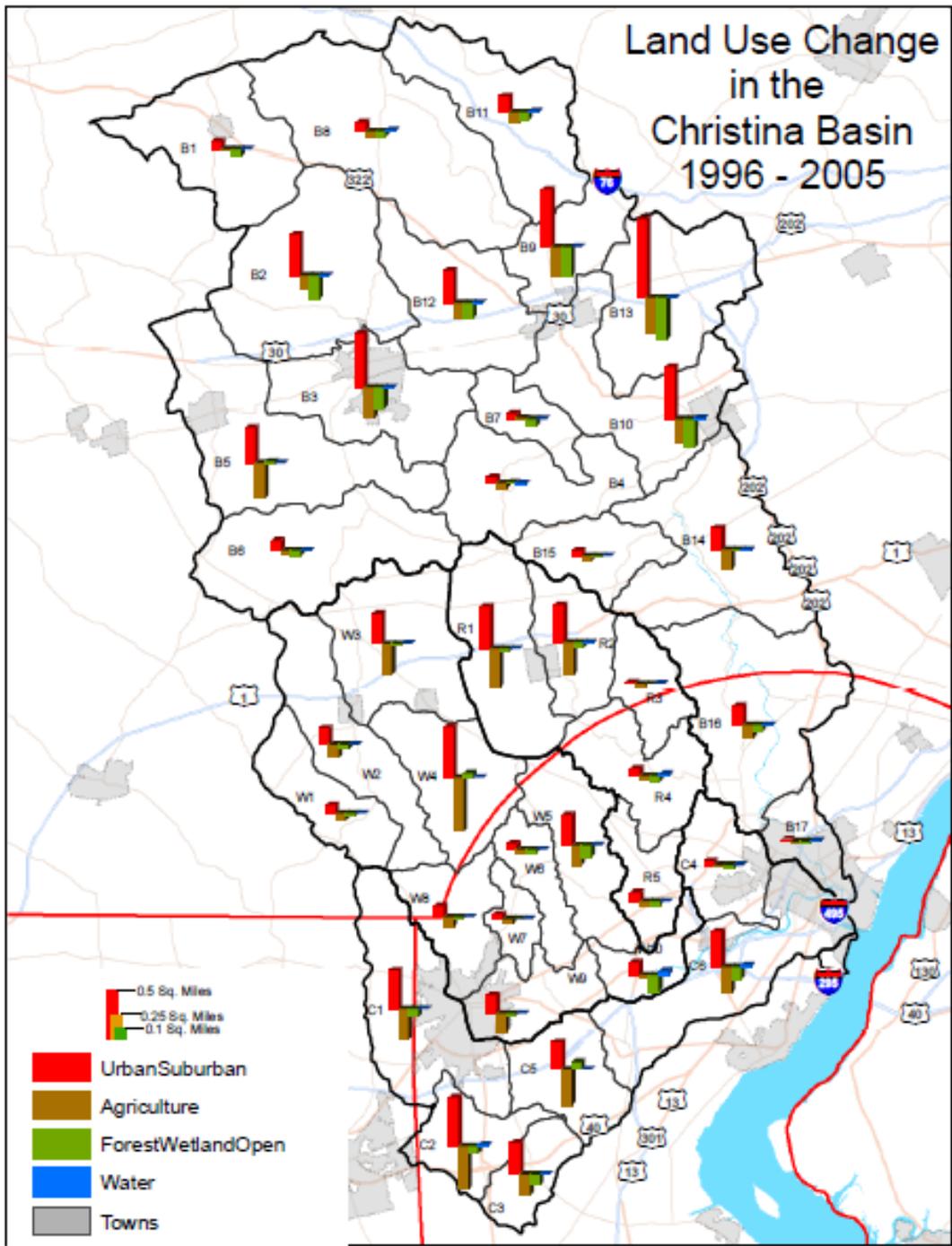
Land Cover Proportions in the Christina Basin 2005



Land Use Change in the Christina Basin 1996 - 2005



Land Use Change in the Christina Basin 1996 - 2005



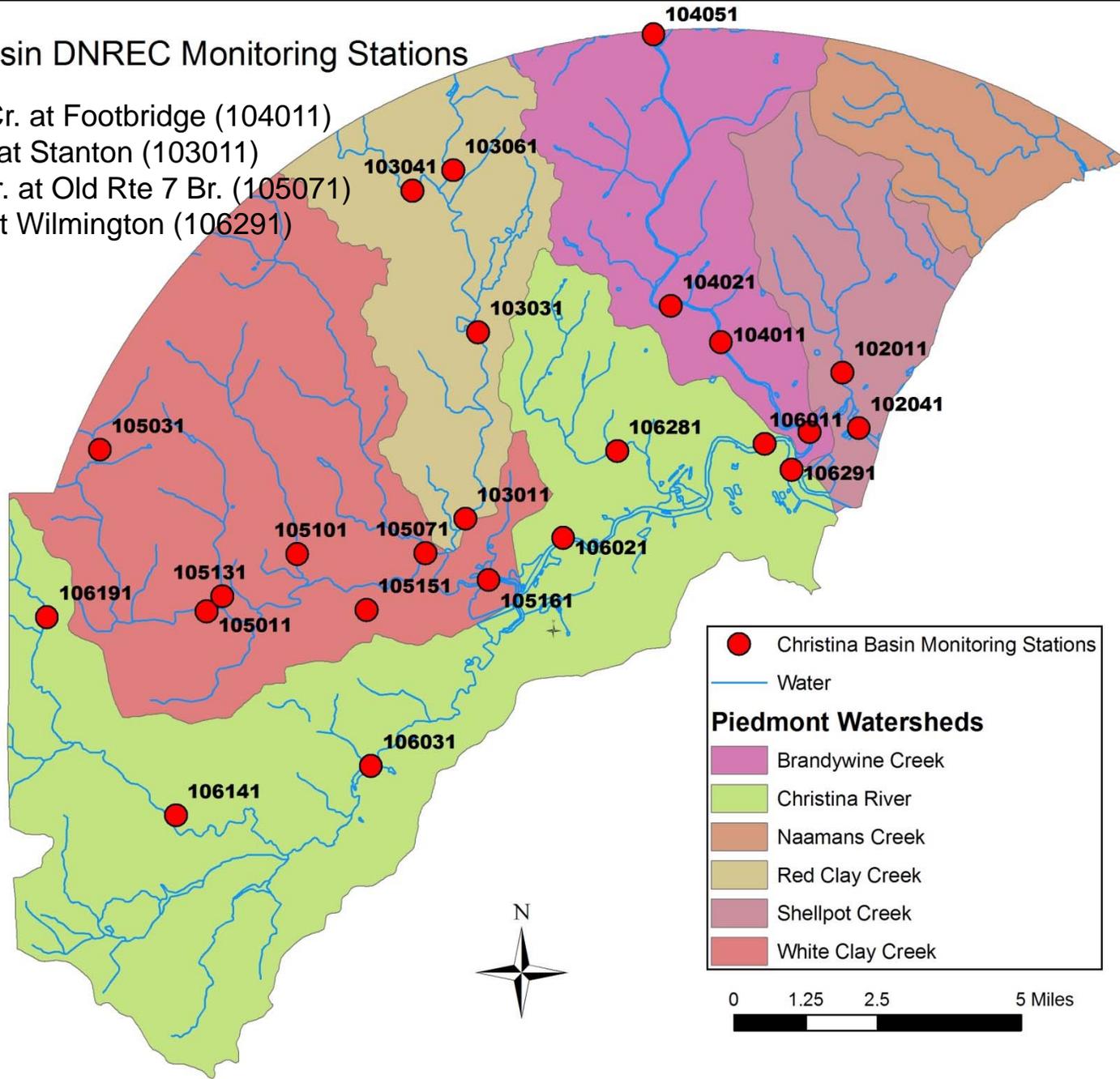
Christina Basin Water Quality

- Dissolved Oxygen
- Total Suspended Sediment
- Enterococcus Bacteria
- Nitrogen
- Phosphorus

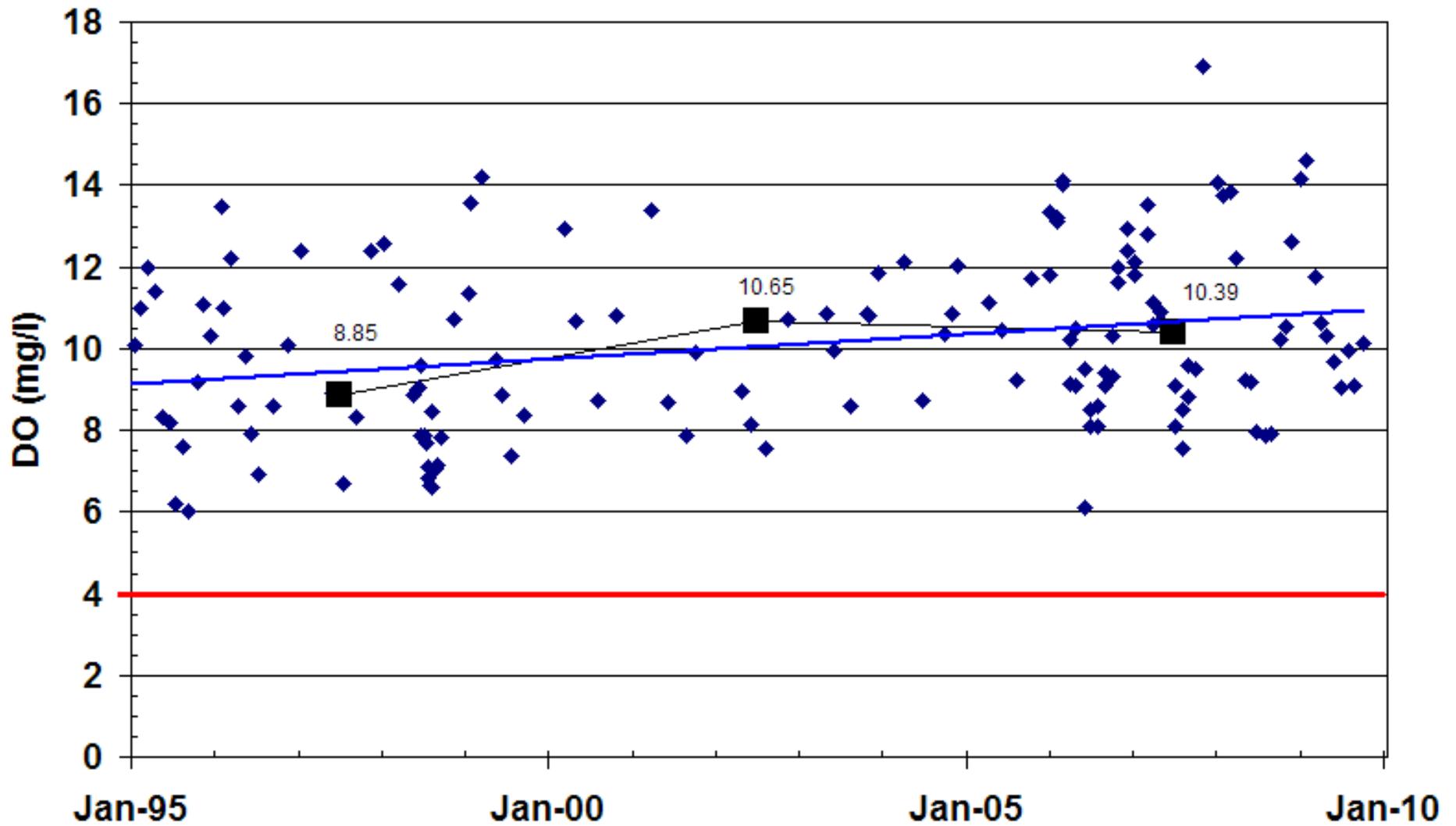
Source: DNREC STORET Monitoring Stations

Christina Basin DNREC Monitoring Stations

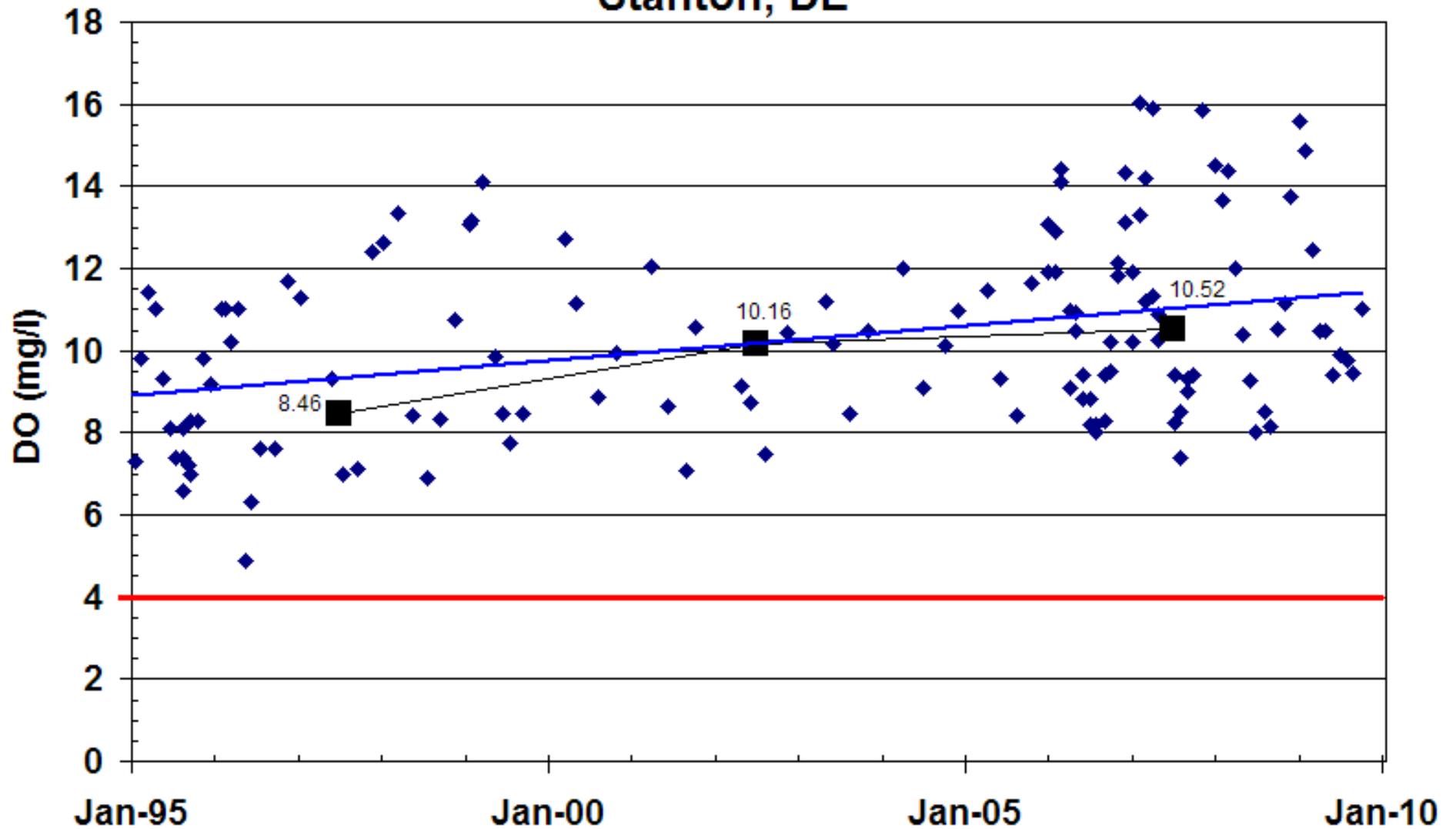
Brandywine Cr. at Footbridge (104011)
Red Clay Cr. at Stanton (103011)
White Clay Cr. at Old Rte 7 Br. (105071)
Christina R. at Wilmington (106291)



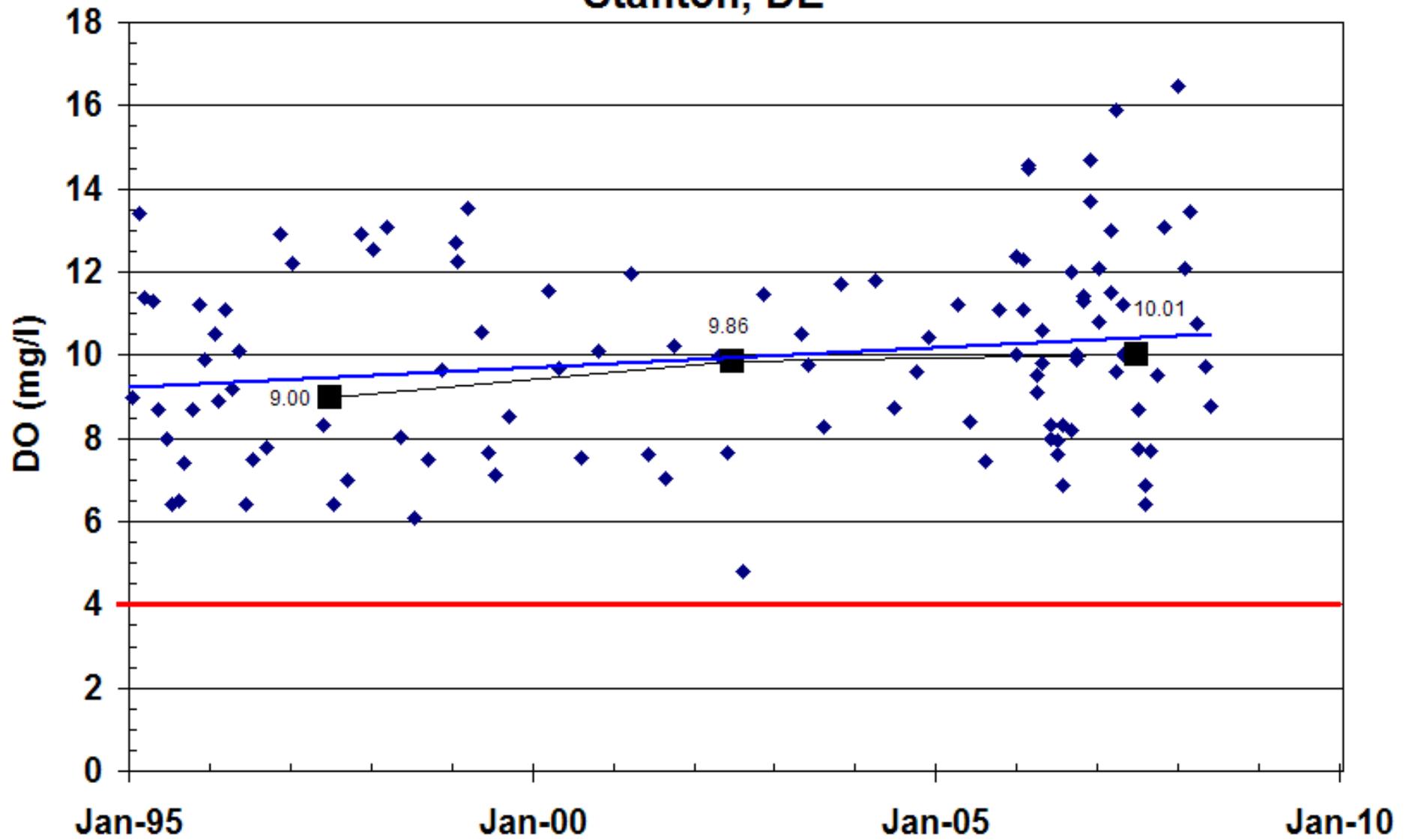
Brandywine Creek at Footbridge Wilmington, DE



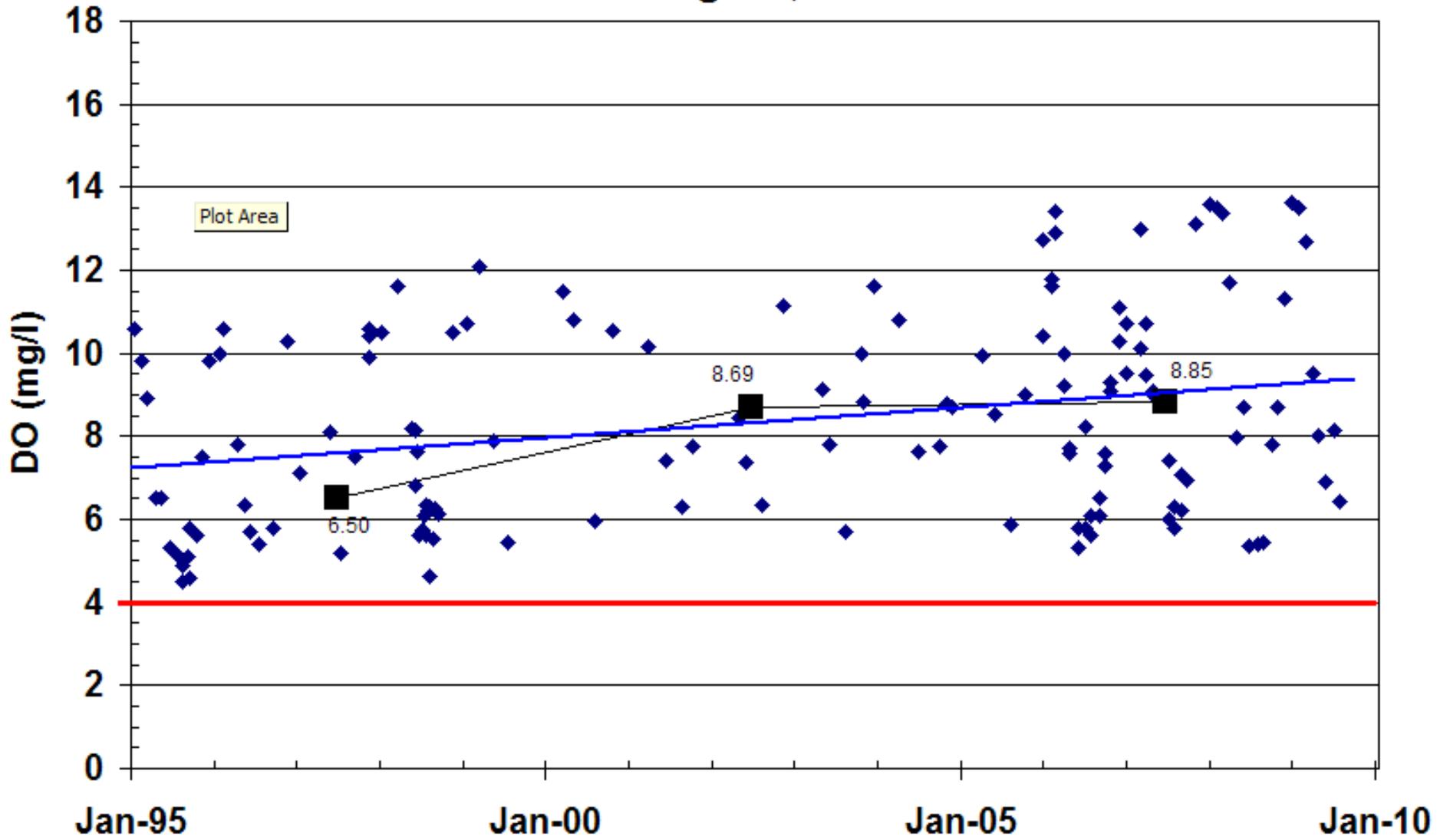
Red Clay Creek at Route 4 Bridge Stanton, DE



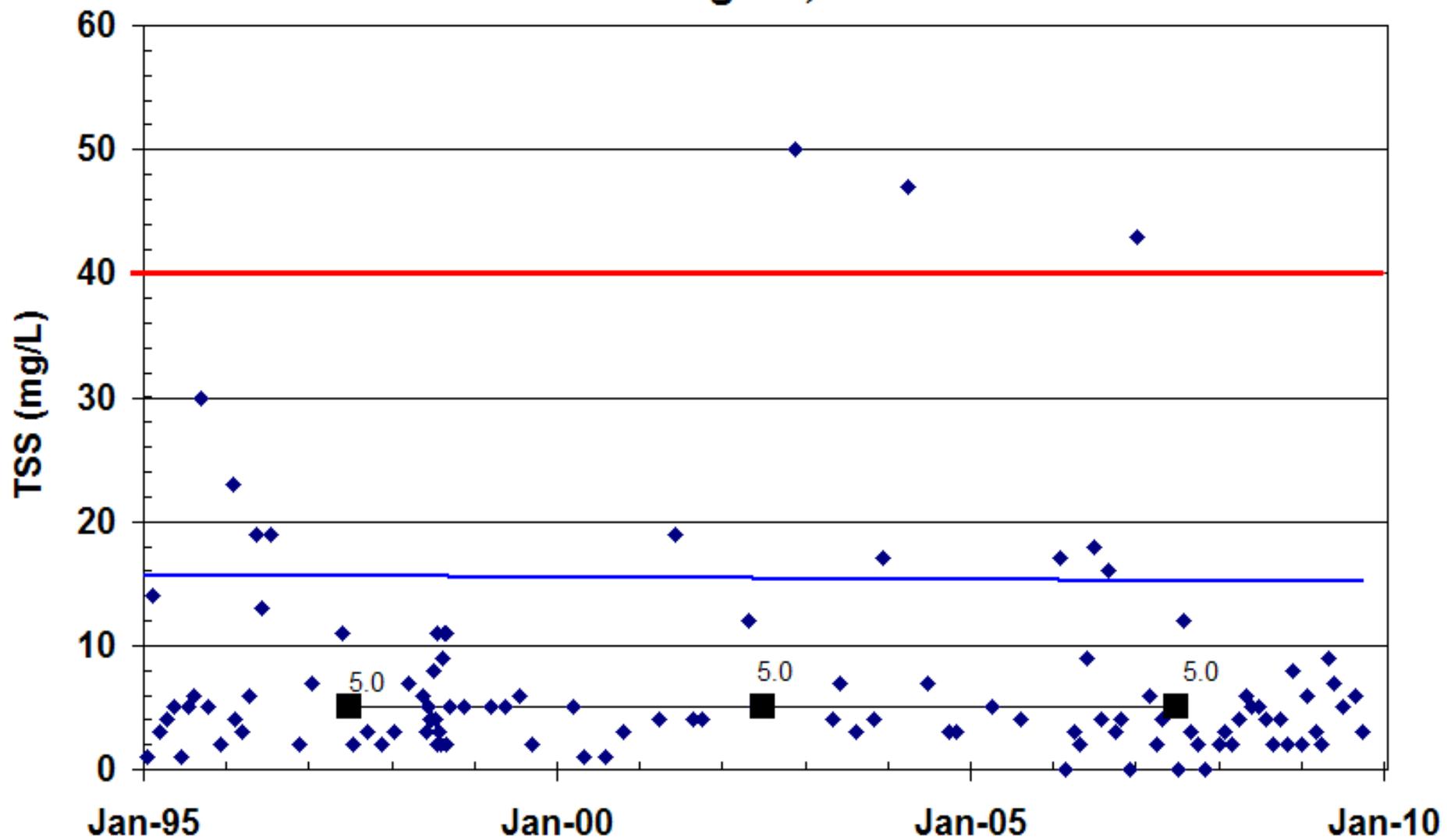
White Clay Creek at Rt 7 Bridge Stanton, DE



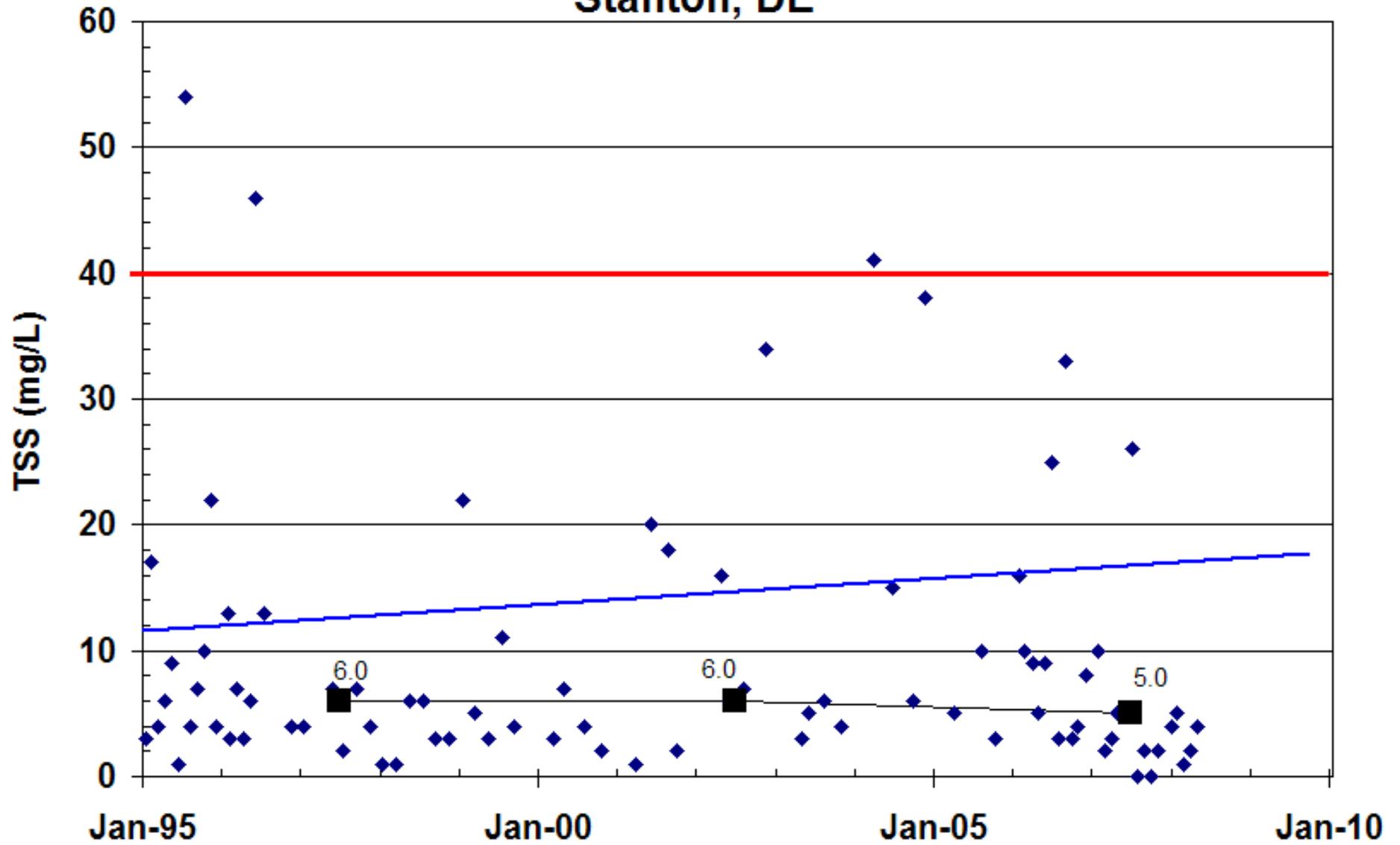
Christina River at 3rd St. Rt 13 Bridge Wilmington, DE



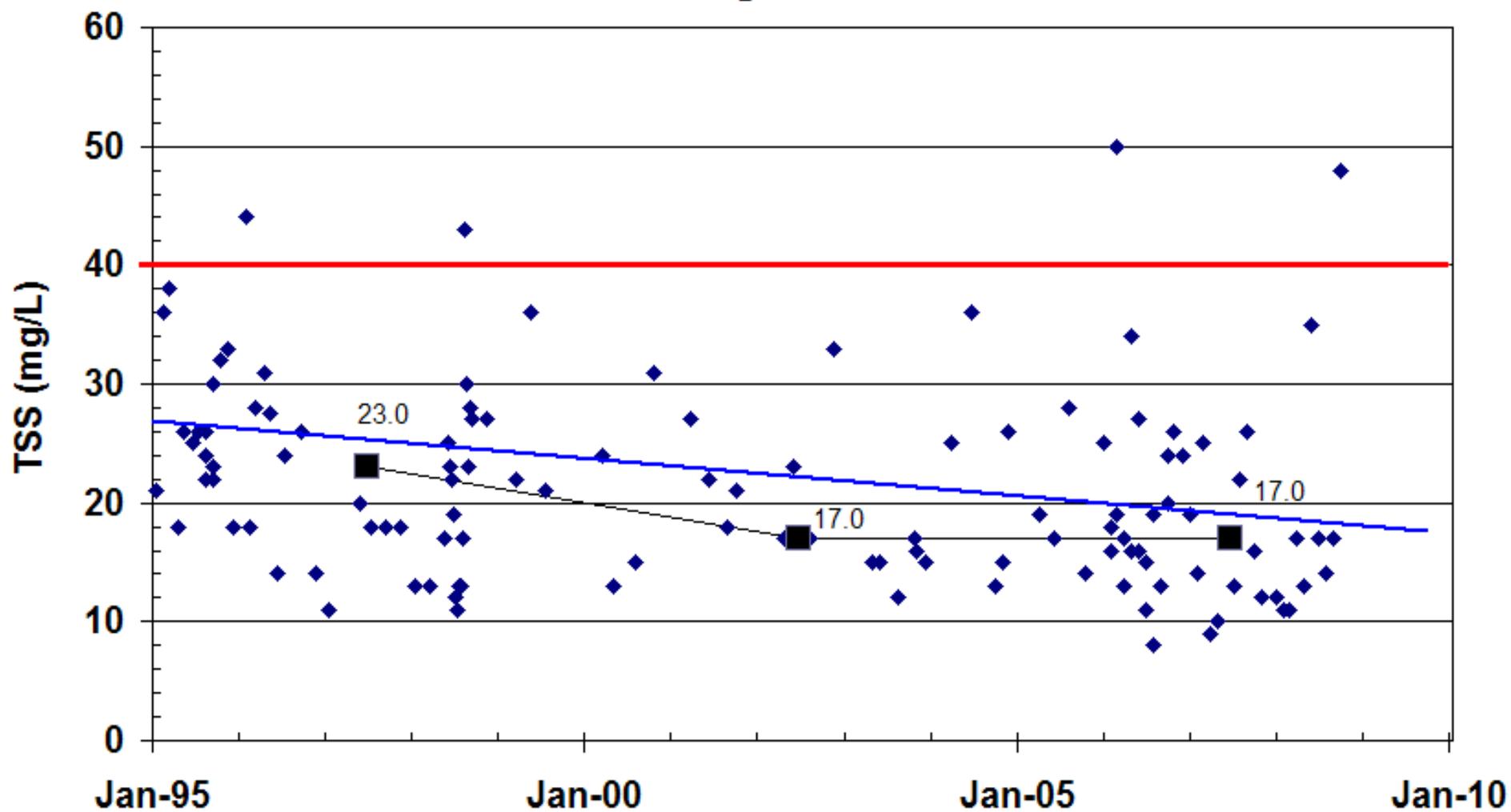
Brandywine Creek at Footbridge Wilmington, DE



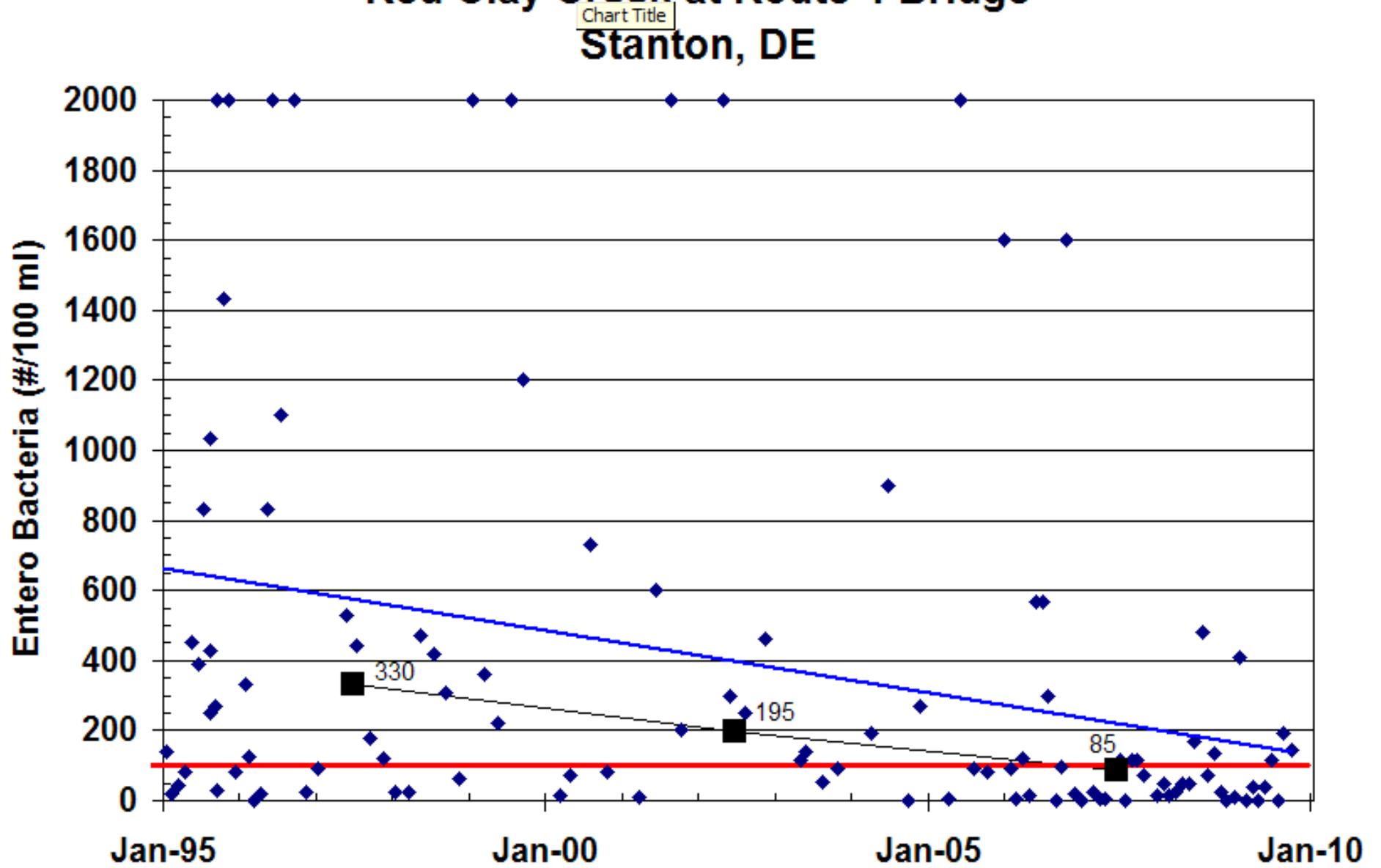
White Clay Creek at Rt 7 Bridge Stanton, DE



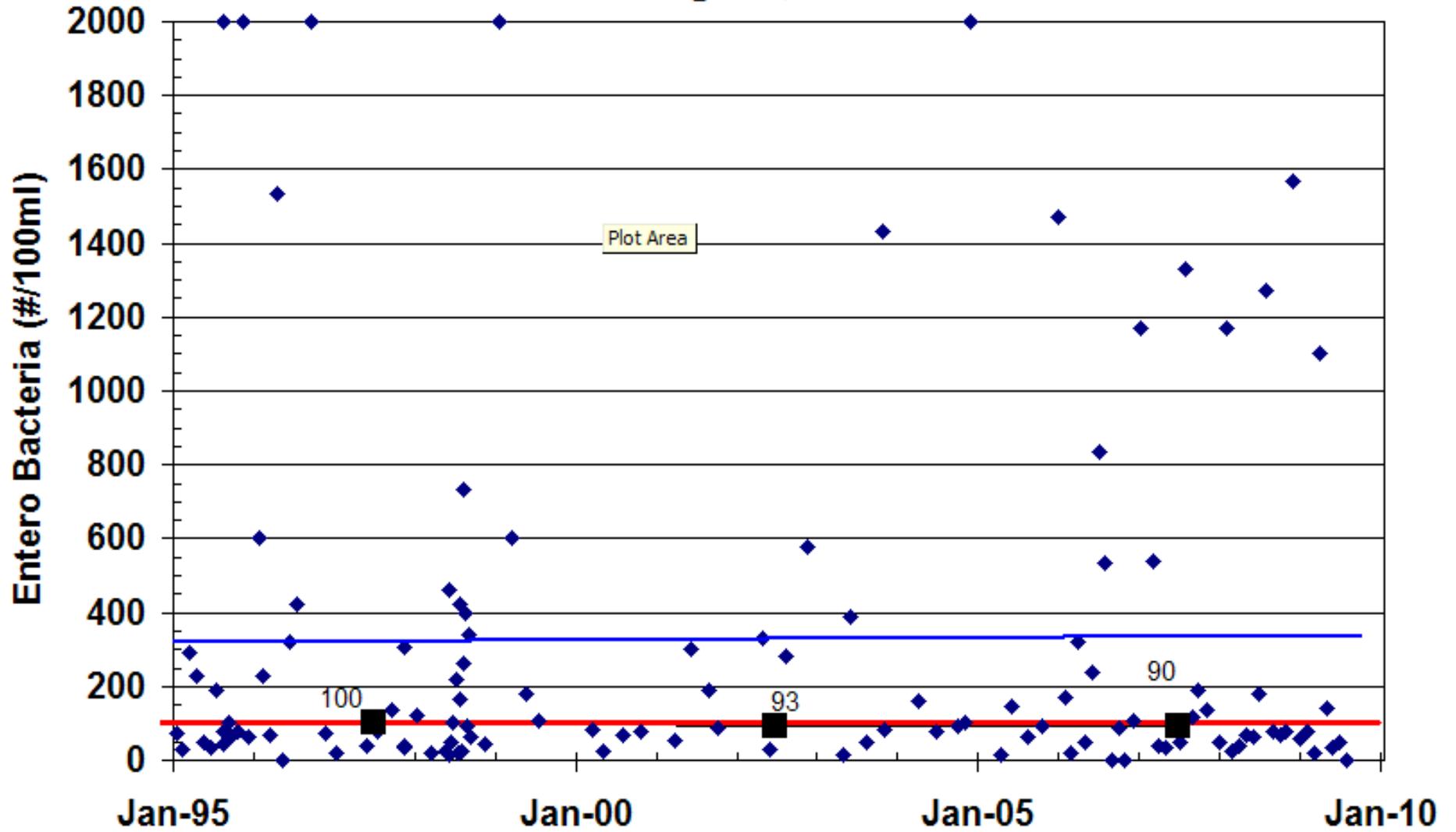
Christina River at 3rd St. Rt 13 Bridge Wilmington, DE



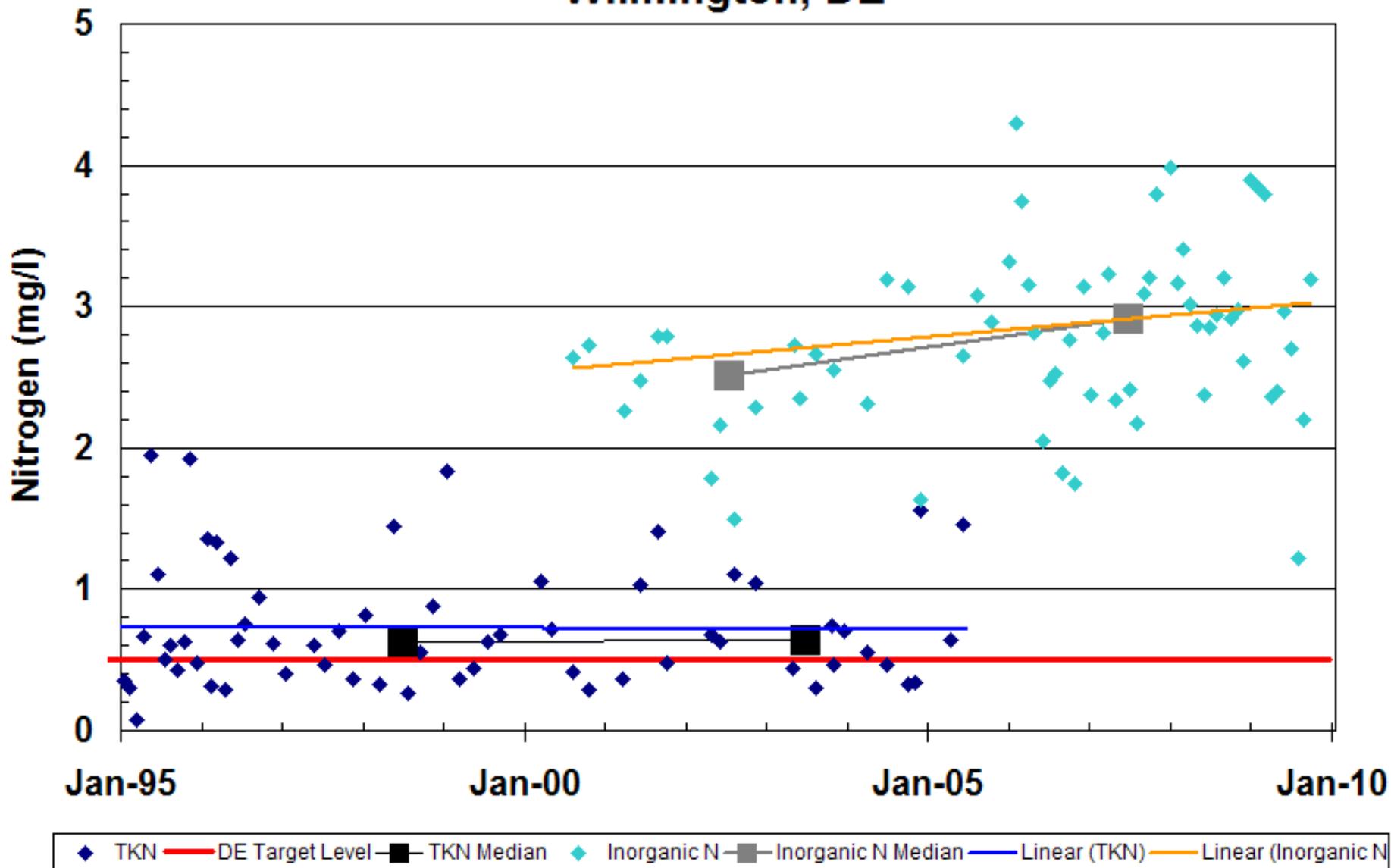
Red Clay Creek at Route 4 Bridge Stanton, DE



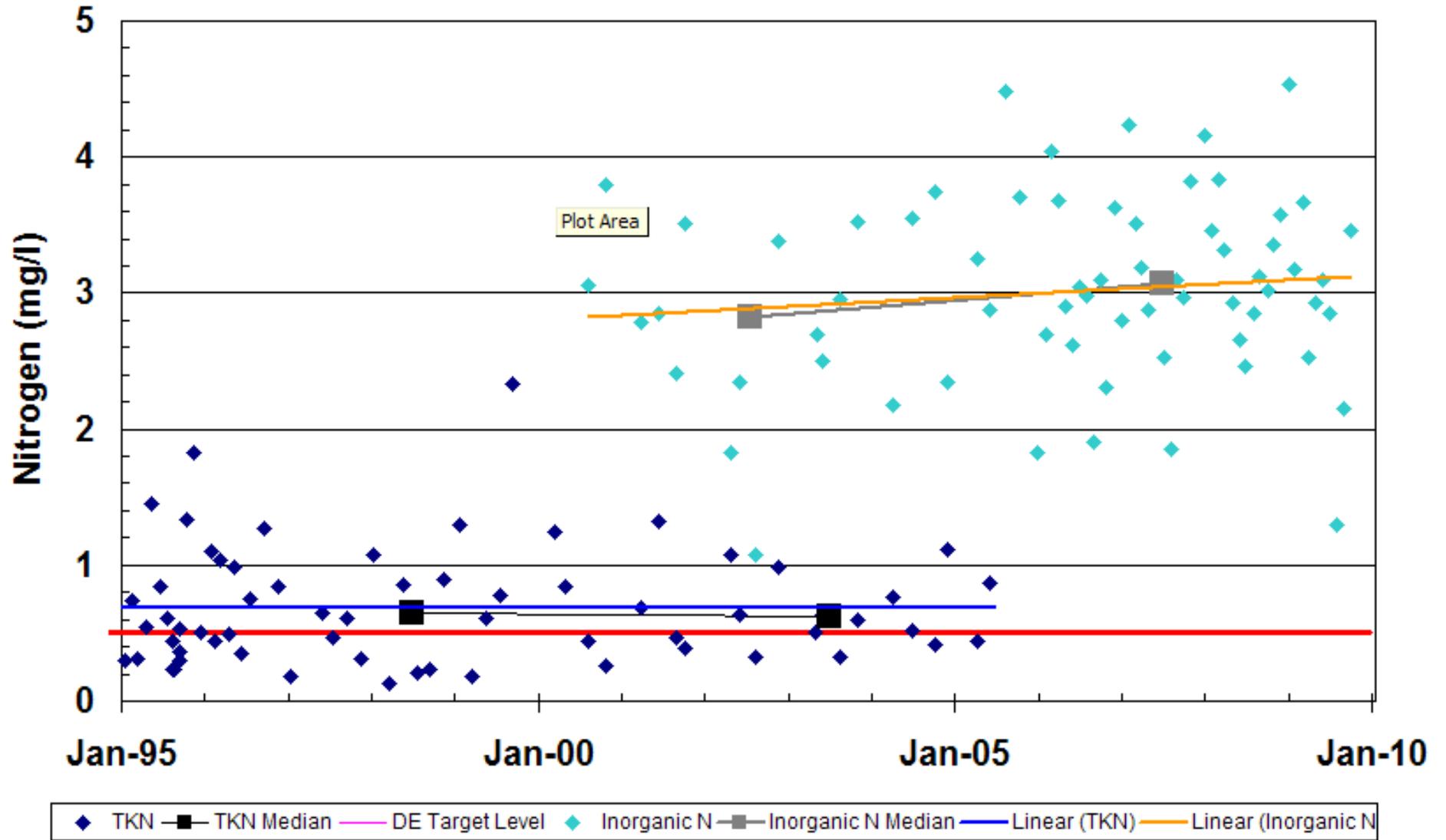
Christina River at 3rd St. Rt 13 Bridge Wilmington, DE



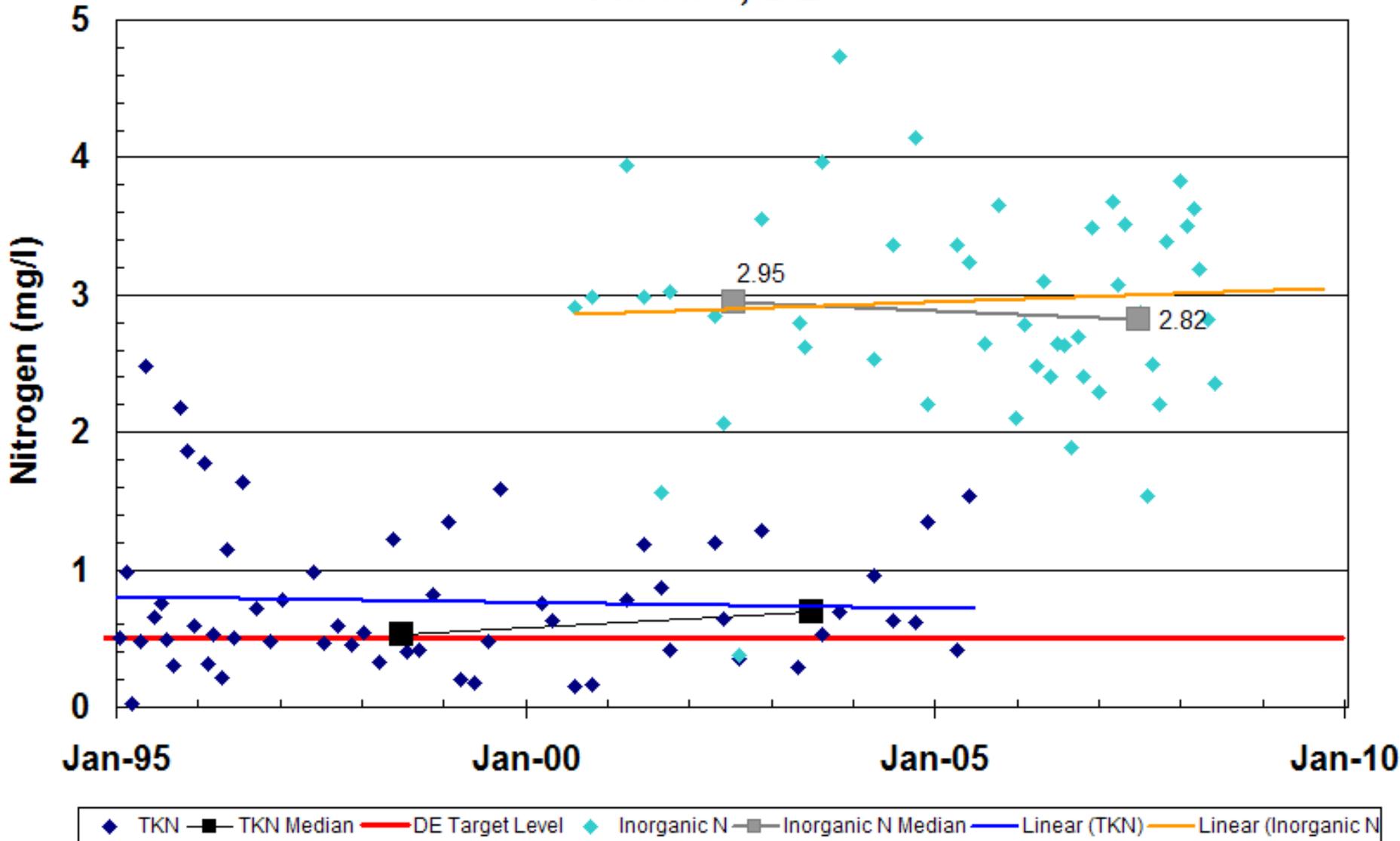
Brandywine Creek At Footbridge Wilmington, DE



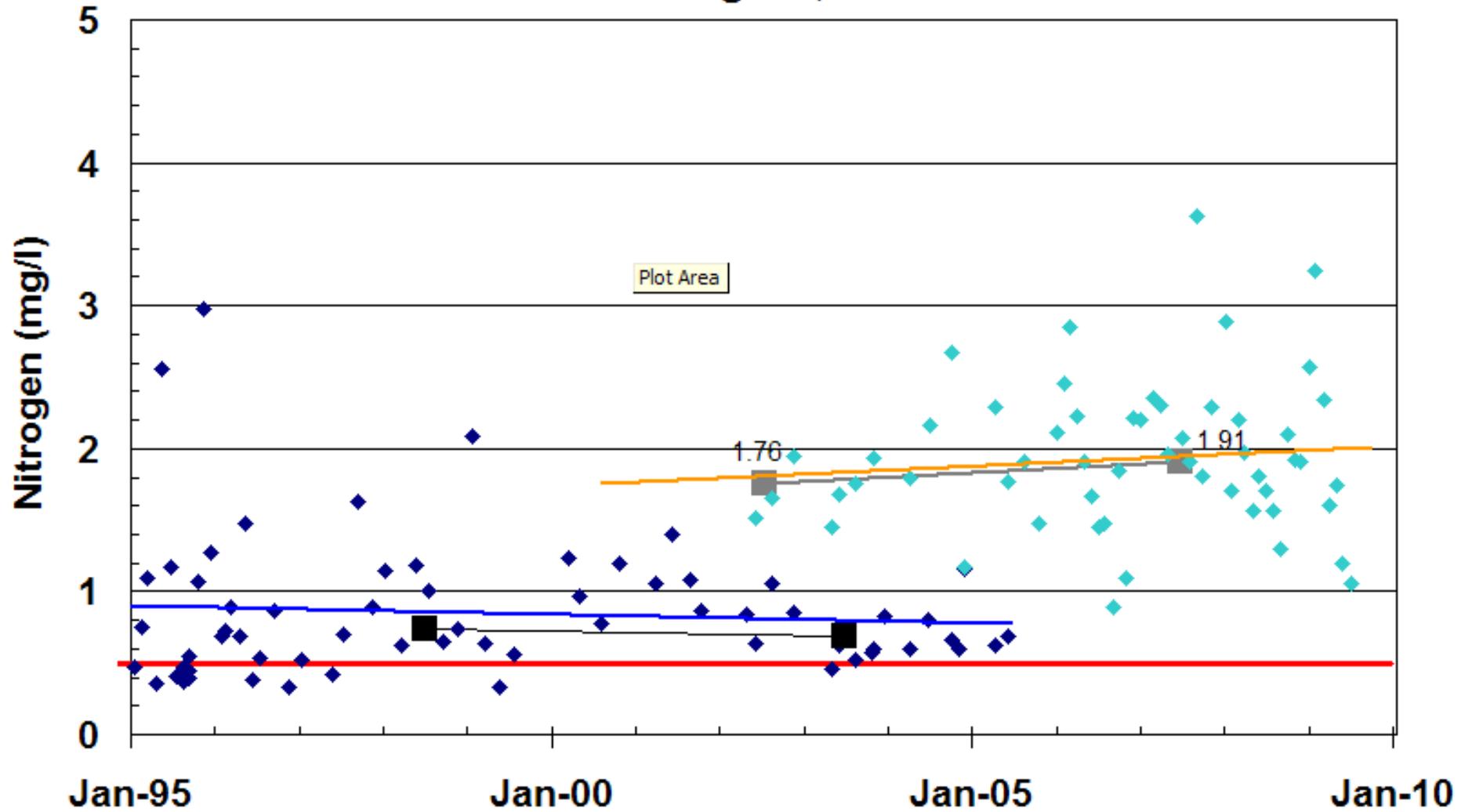
Red Clay Creek at Rt 4 Bridge Stanton, DE



White Clay Creek At Rt 7 Bridge Stanton, DE

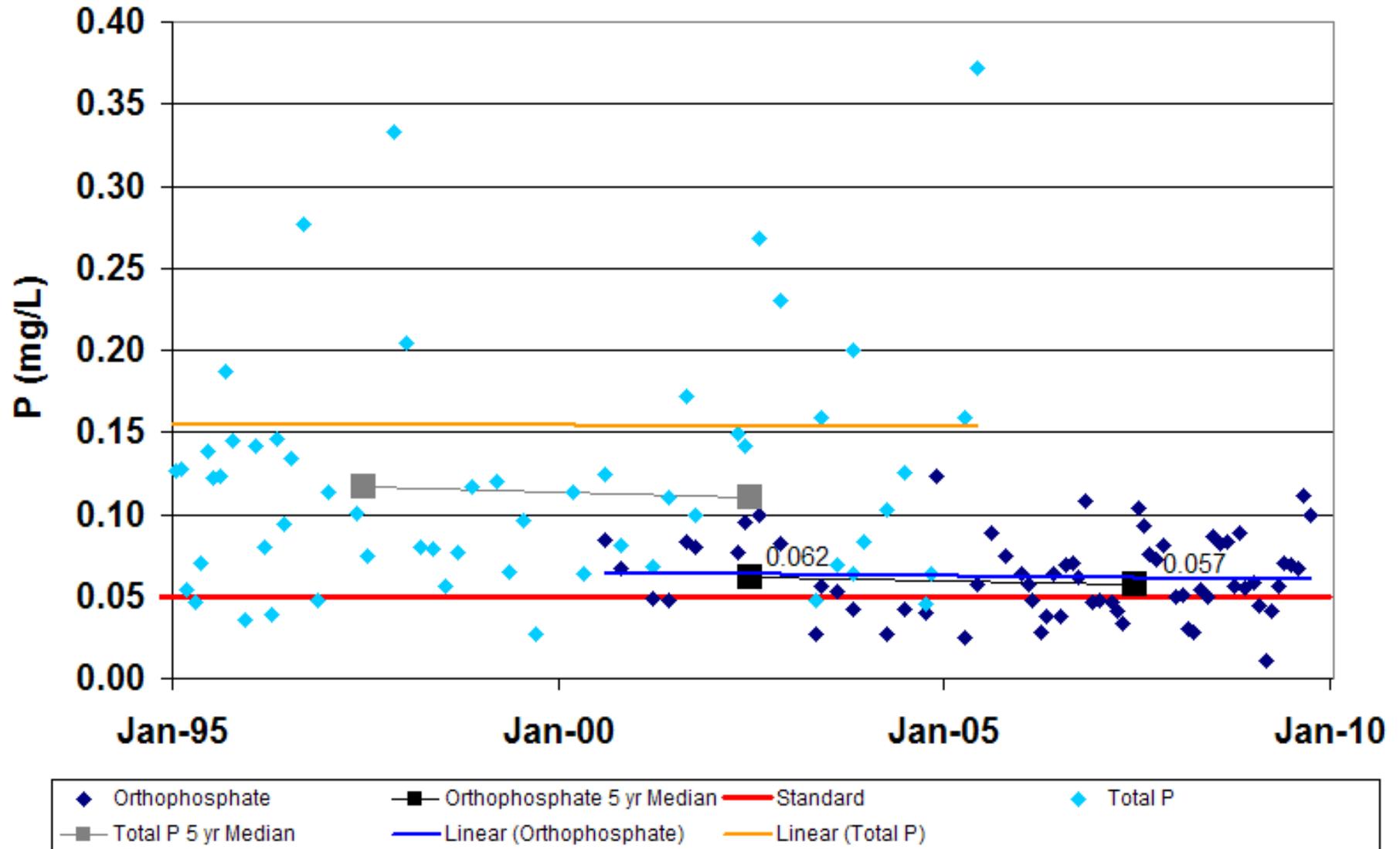


Christina River at 3rd St Rt.13 Bridge Wilmington, DE

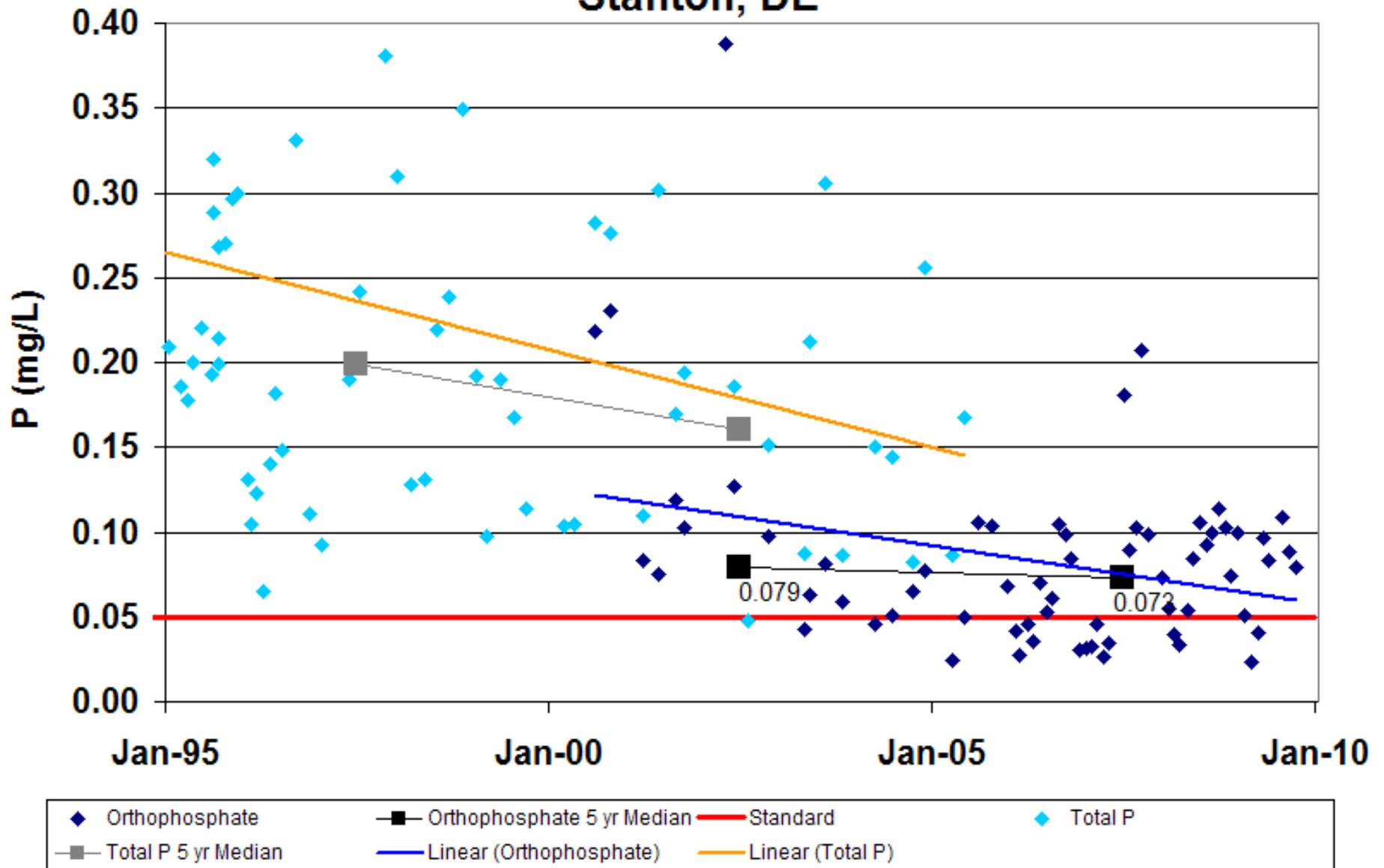


◆ TKN ■ TKN Median — DE Target Level ■ Inorganic N Median ◆ Inorganic N — Linear (TKN) — Linear (Inorganic N)

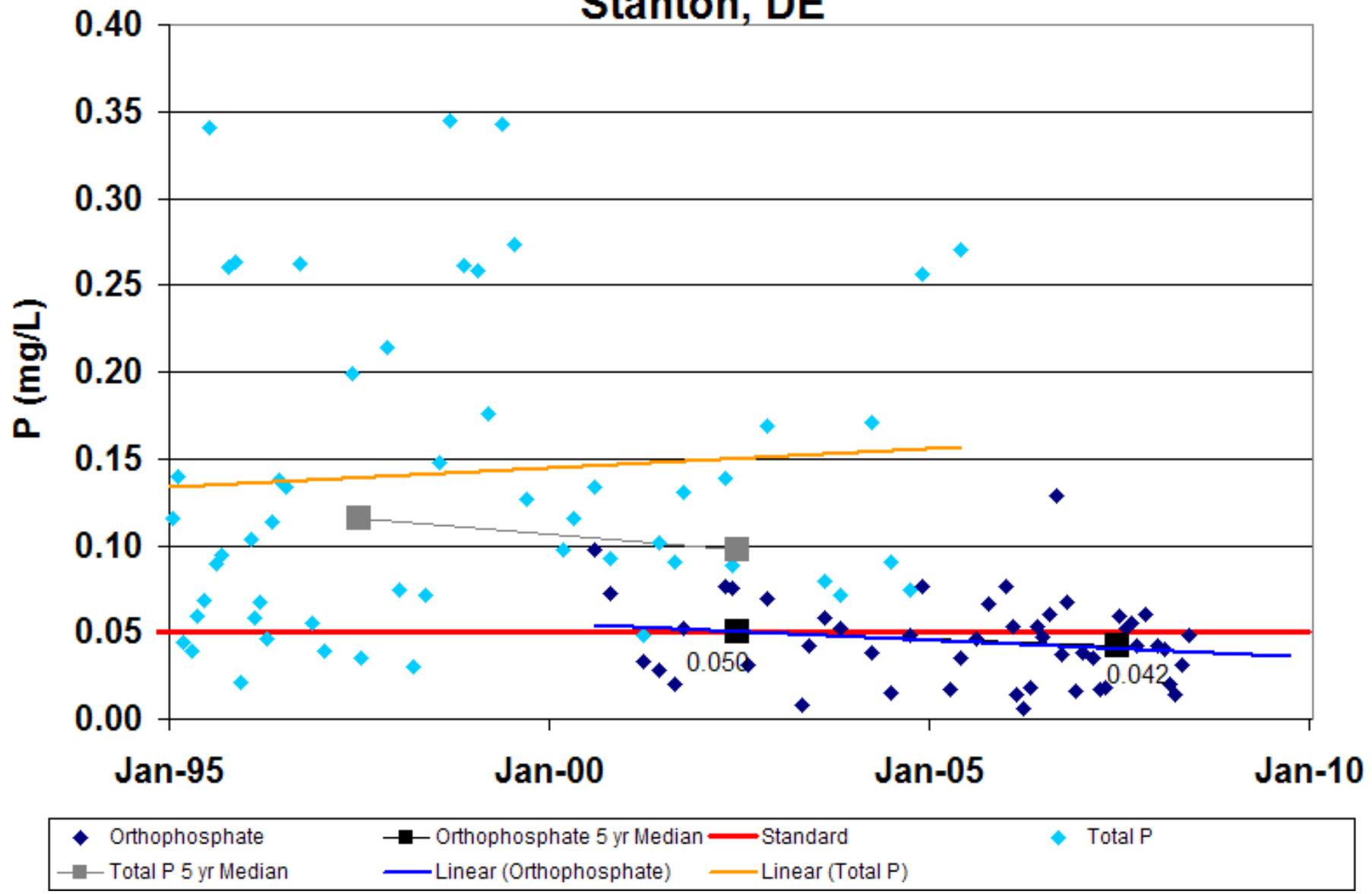
Brandywine Creek at Footbridge Wilmington, DE



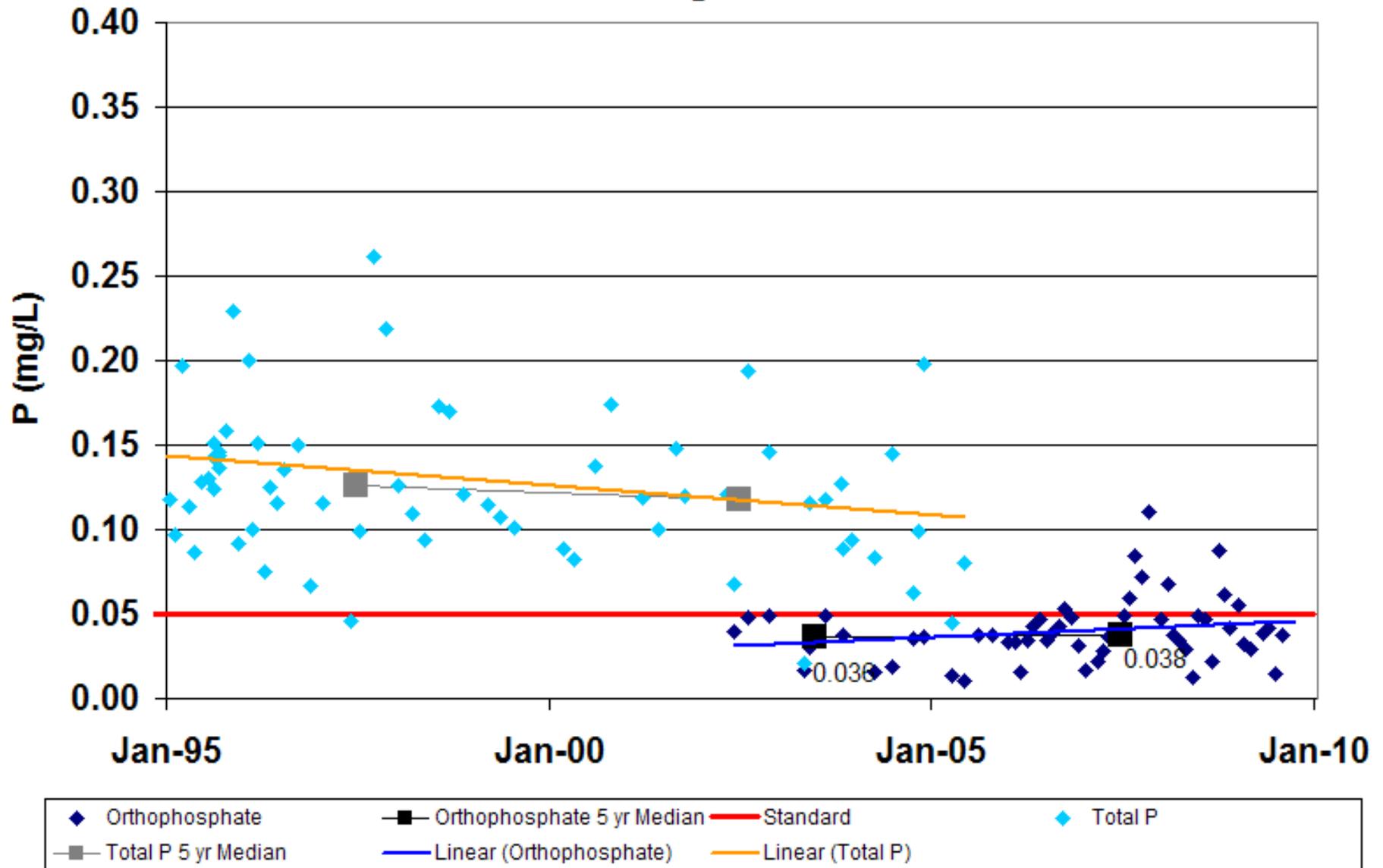
Red Clay Creek at Route 4 Bridge Stanton, DE



White Clay Creek at Rt 7 Bridge Stanton, DE



Christina River at 3rd St. Rt 13 Bridge Wilmington, DE



Seasonal Kendall Test for Dissolved Oxygen, 1995-2009

	Median Value	Variance	Z	P	P (adjusted)	Median Annual Sen slope	5% Confidence Limit	95% Confidence Limit
Red Clay Creek	10.0825	1128.0000	5.9847	0.0000	0.0000	0.3491	-99.9900	0.0000
Brandywine Creek	10.1000	1244.0000	4.2812	0.0000	0.0017	0.1861	-99.9900	0.0000
White Clay Creek	9.7500	718.3333	3.4699	0.0005	0.0044	0.0177	-99.9900	0.0000
Christina River	8.1675	1147.6667	4.0735	0.0000	0.0001	0.0983	-99.9900	0.0000

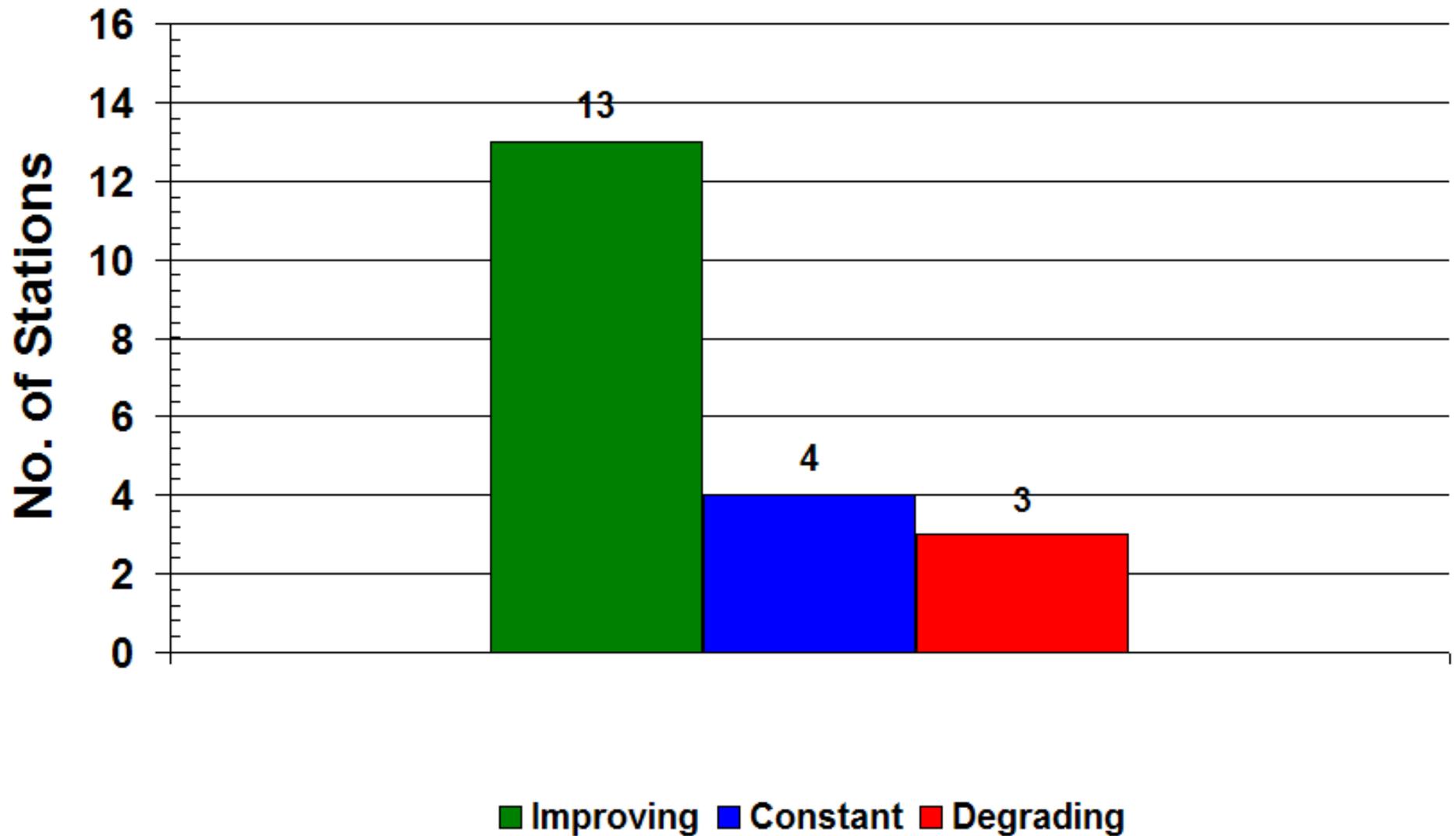
The Red Clay Creek, Brandywine Creek, White Clay Creek, and Christina River all had had statistically significant improvement in DO with a $p < .01$.

Christina Basin Water Quality Trends, 1995-2009

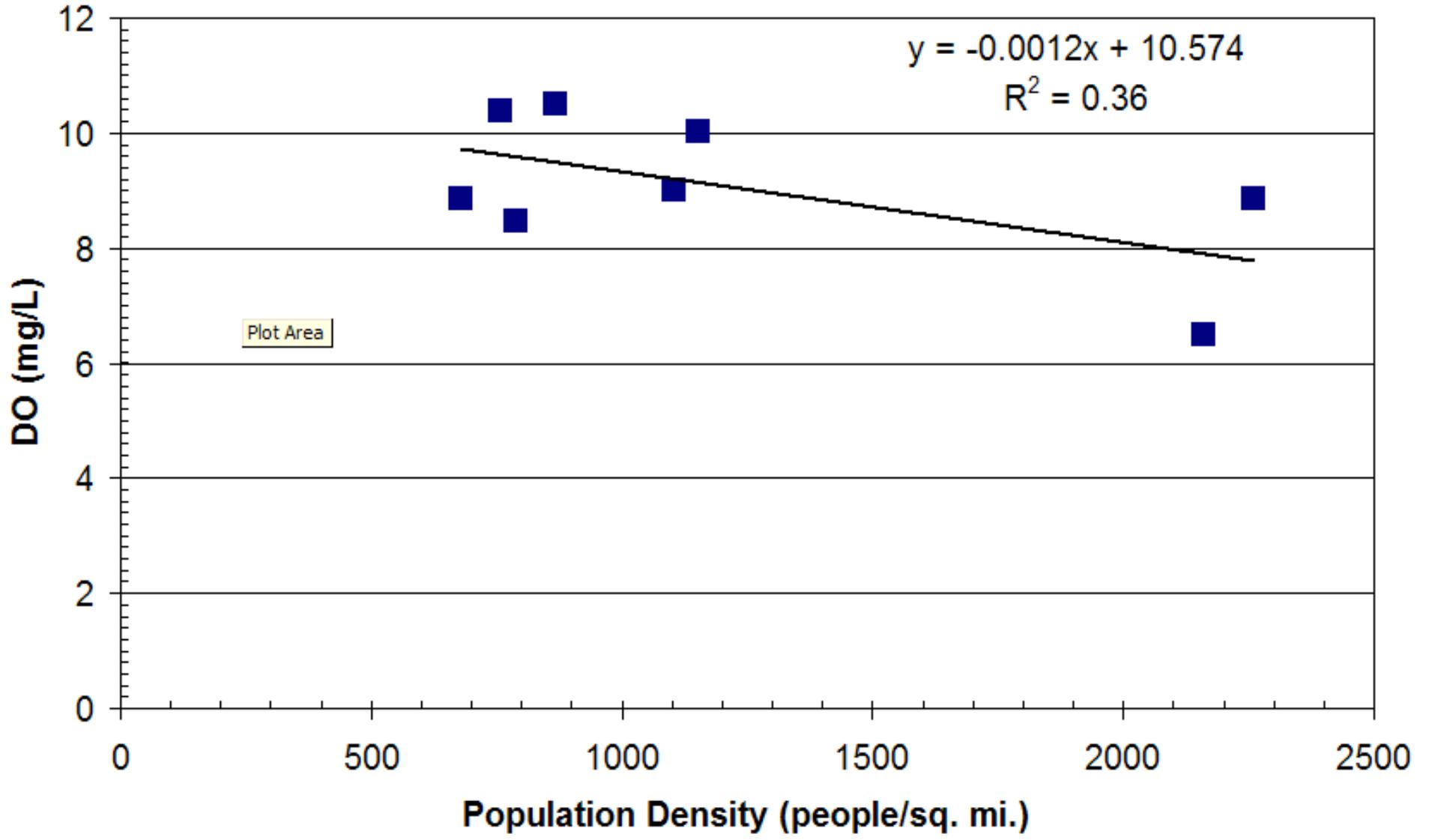
Watershed	DO (mg/L)		TSS (mg/L)		Bacteria (#/100ml)		Inorg. N (mg/L)		Ortho P (mg/L)	
	Brandywine Creek	10.4	▲*	5	●	97	▲	2.90	▼	0.06
Red Clay Creek	10.5	▲*	4	▲*	85	▲*	3.10	▼	0.07	●*
White Clay Creek	10.0	▲*	5	▲*	93	▲*	2.82	●	0.04	▲
Christina River	8.9	▲*	17	▲*	90	▲	1.91	▼	0.04	●*
▲ Improving	4/4 (100%)		3/4 (75%)		4/4 (100%)		0/4 (0%)		2/4 (50%)	
● Constant	0/4 (0%)		1/4 (25%)		0/4 (0%)		1/4 (25%)		2/4 (50%)	
▼ Degrading	0/4 (0%)		0/4 (0%)		0/4 (0%)		3/4 (75%)		0/4 (0%)	

* statistically significant at $p \leq 0.10$

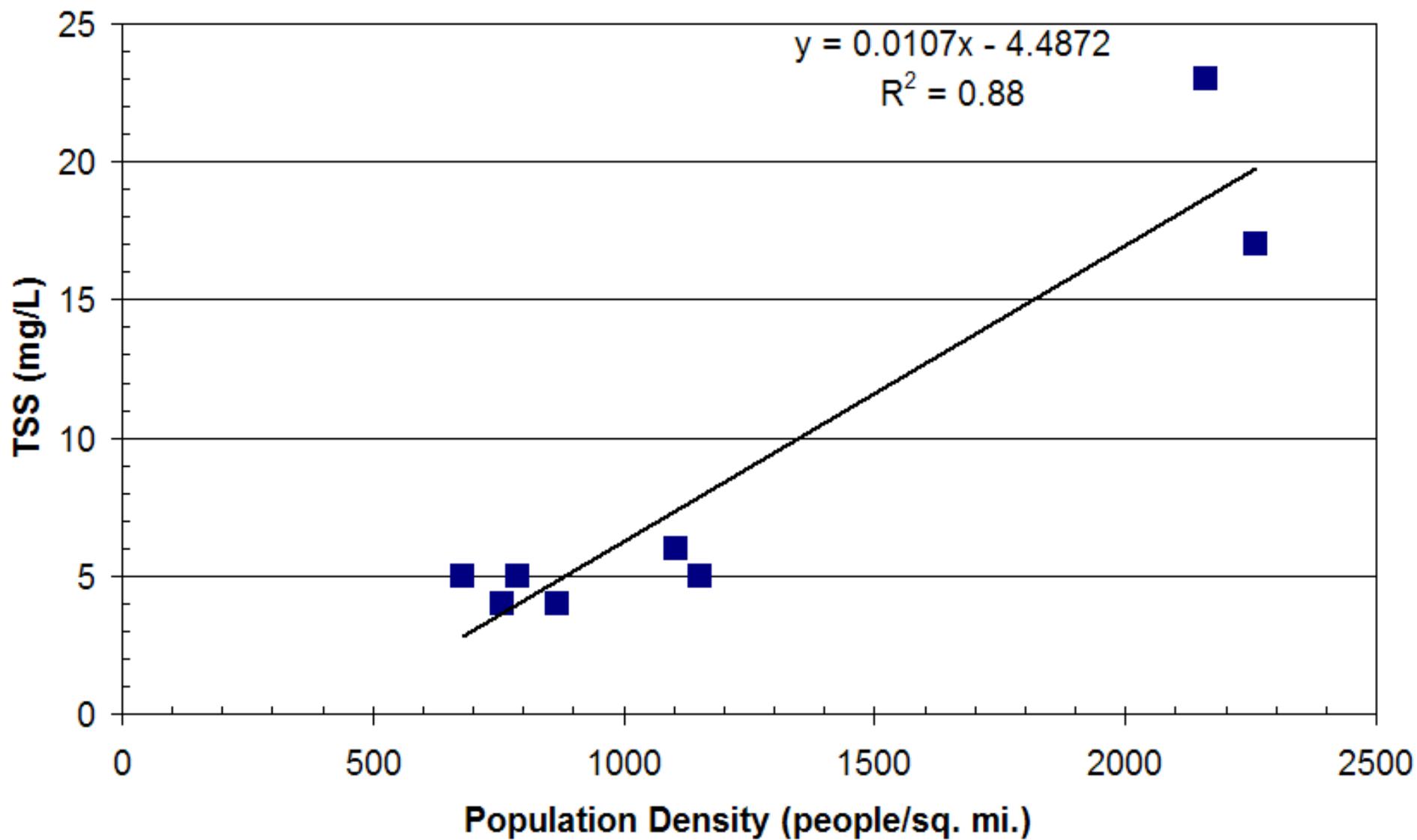
Christina Basin Water Quality Trends, 1995-2009



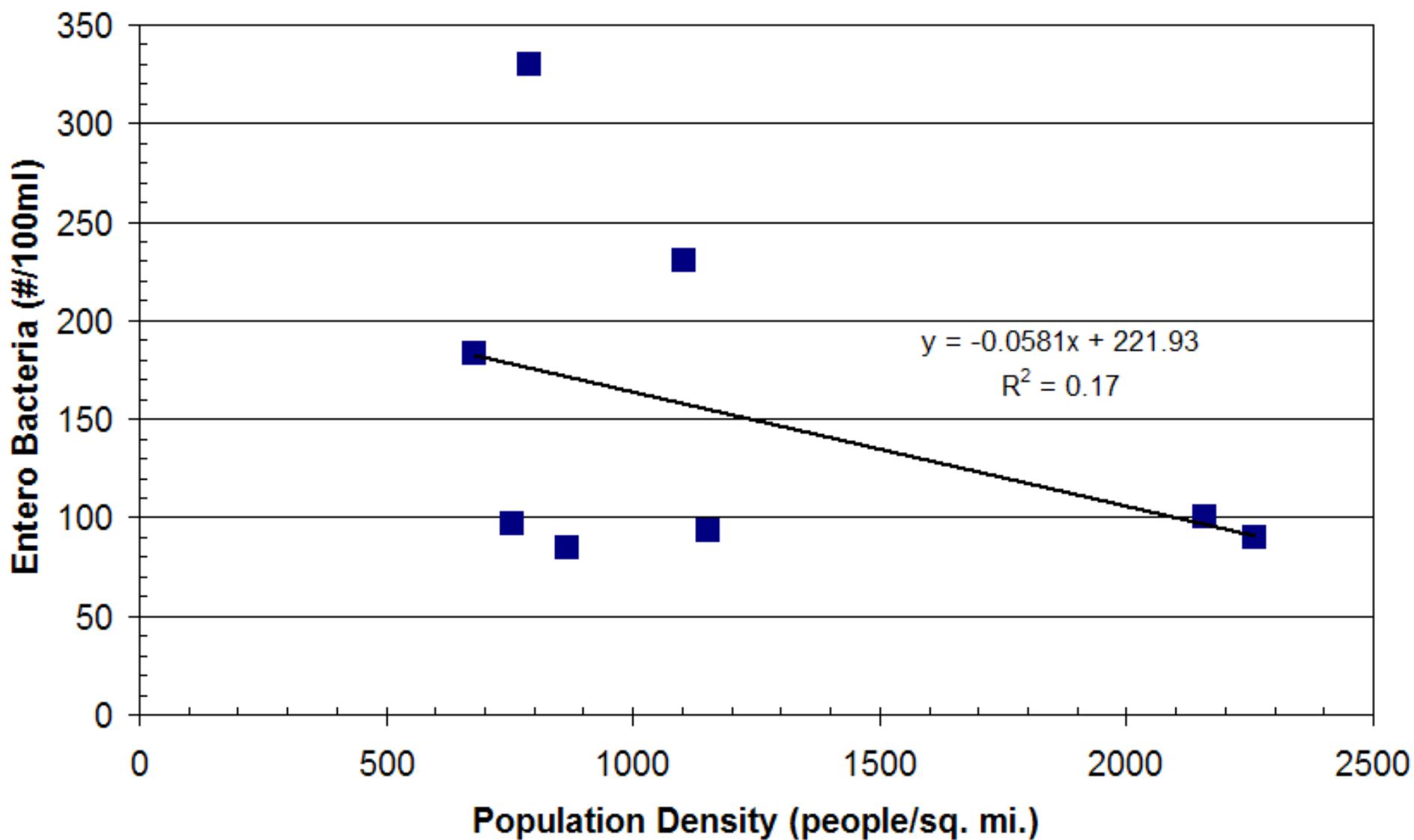
Population Density vs. DO



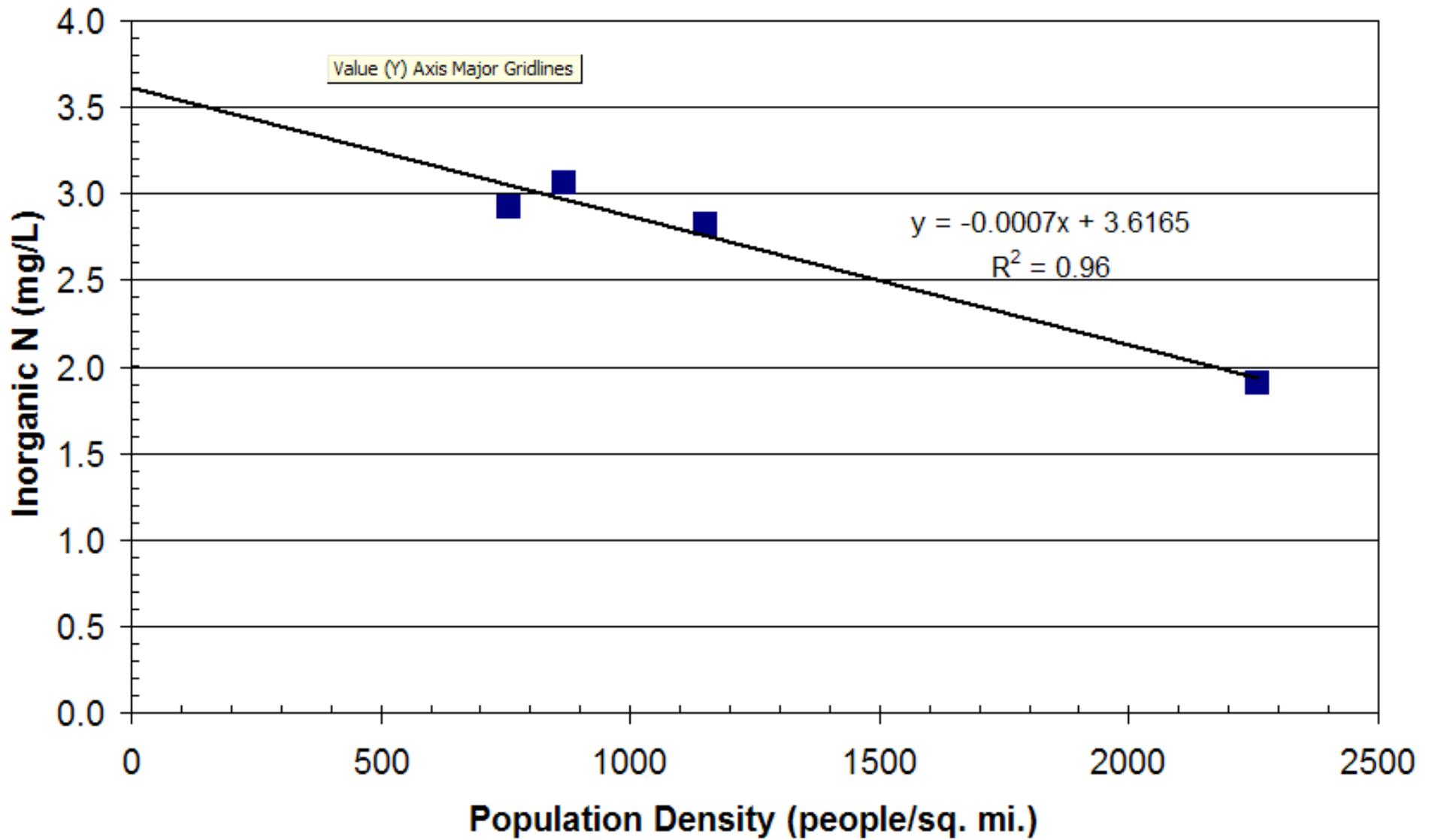
Population Density vs. TSS



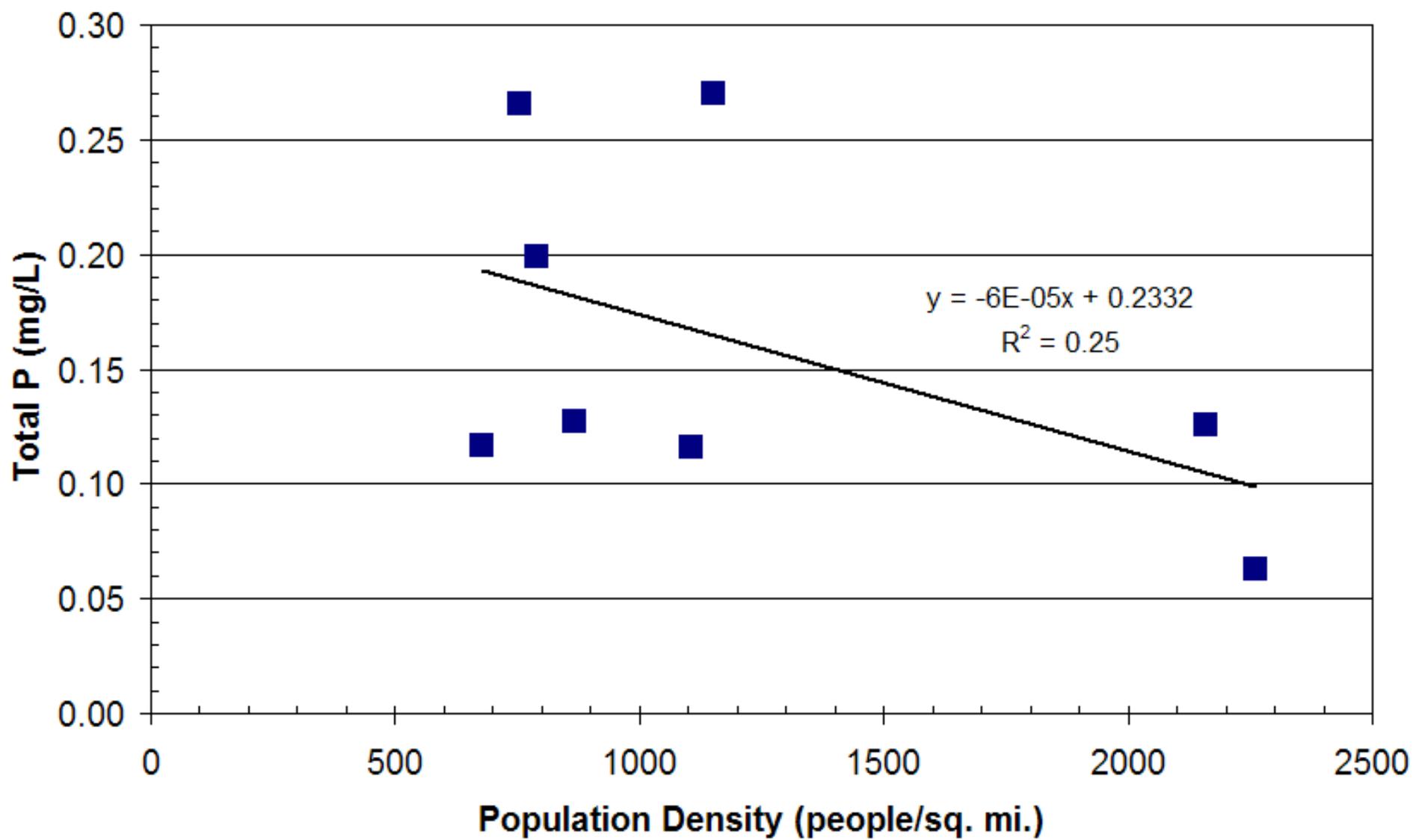
Population Density vs. Enterococcus Bacteria



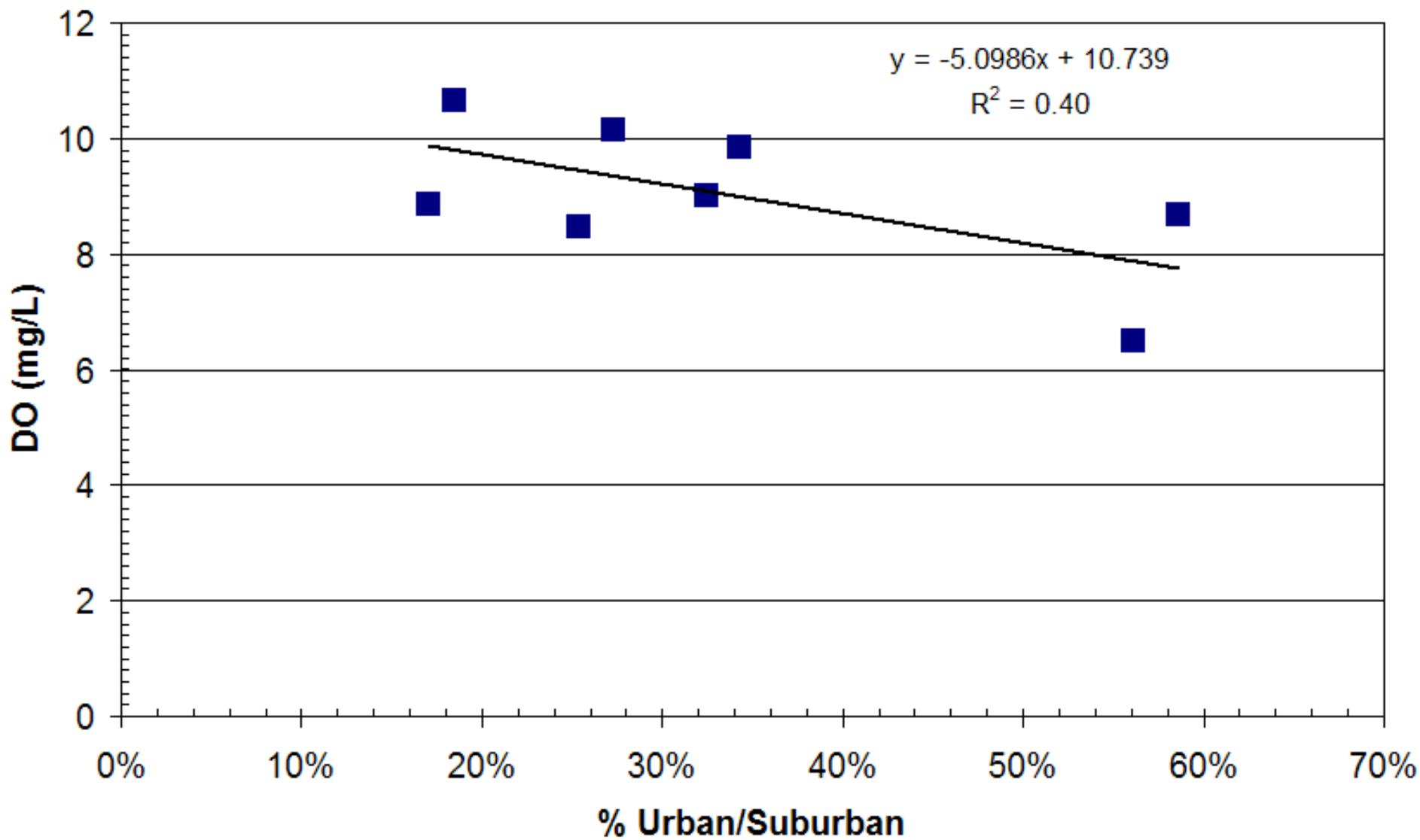
Population Density vs. Inorganic N



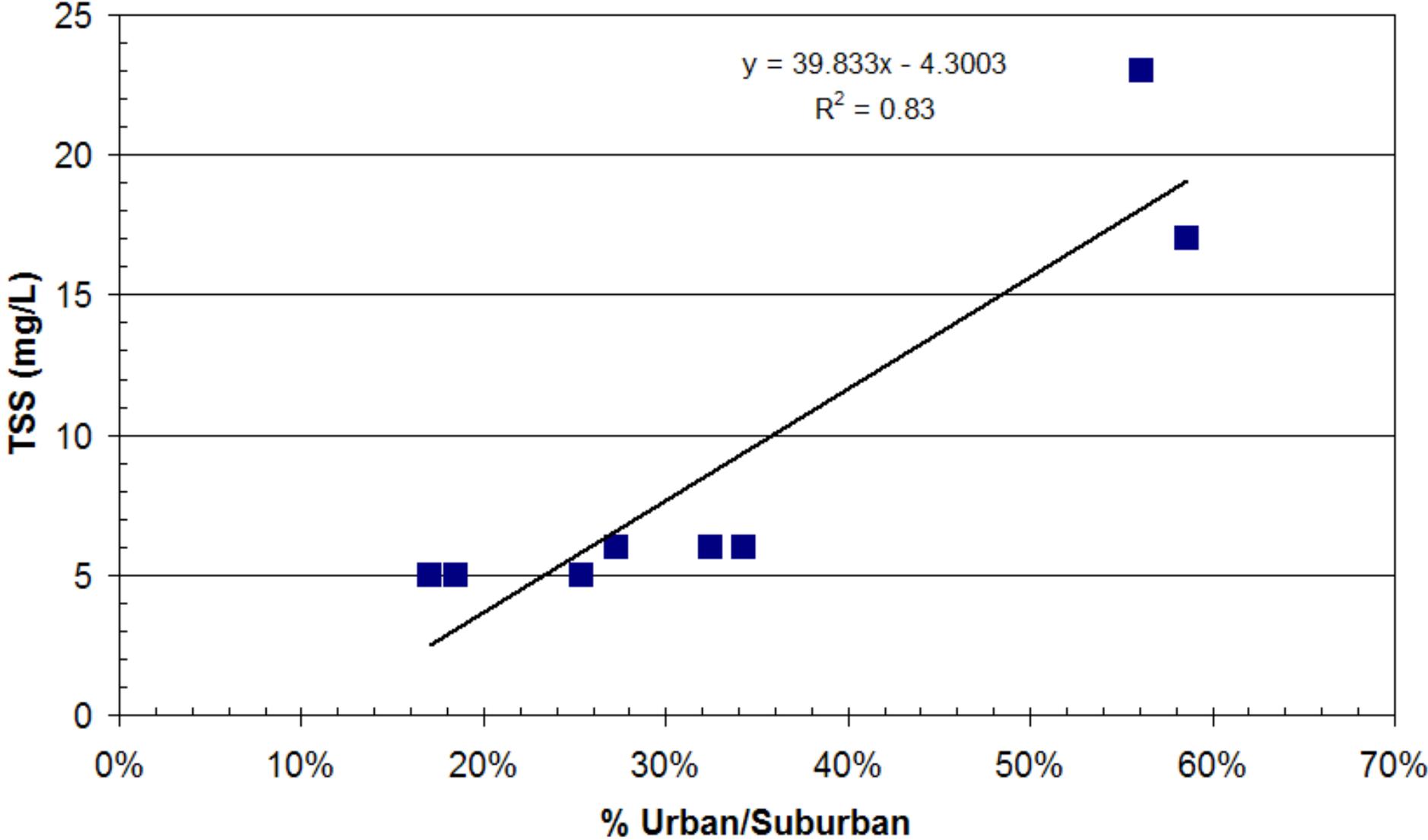
Population Density vs. Total P



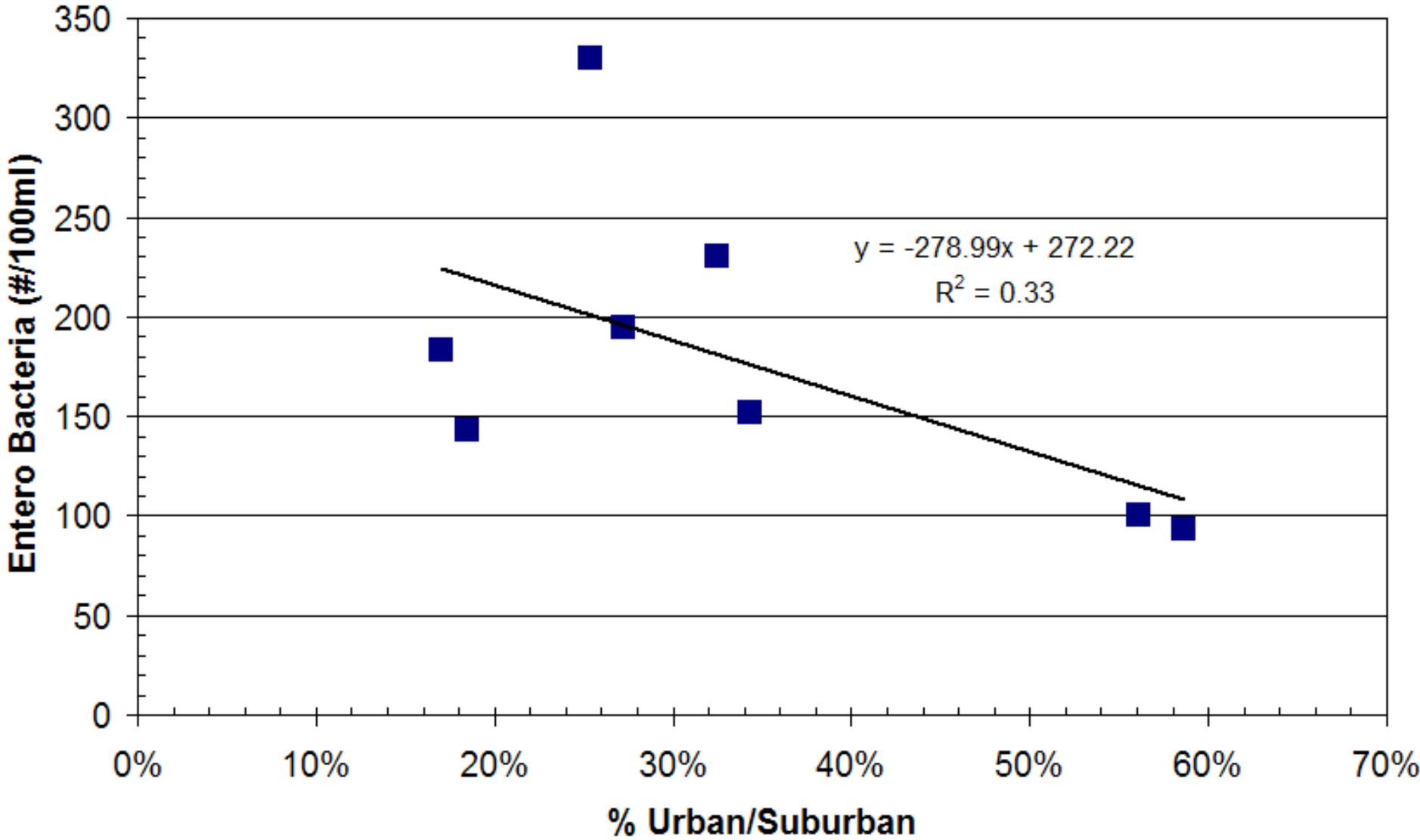
% Urban/Suburban vs. DO



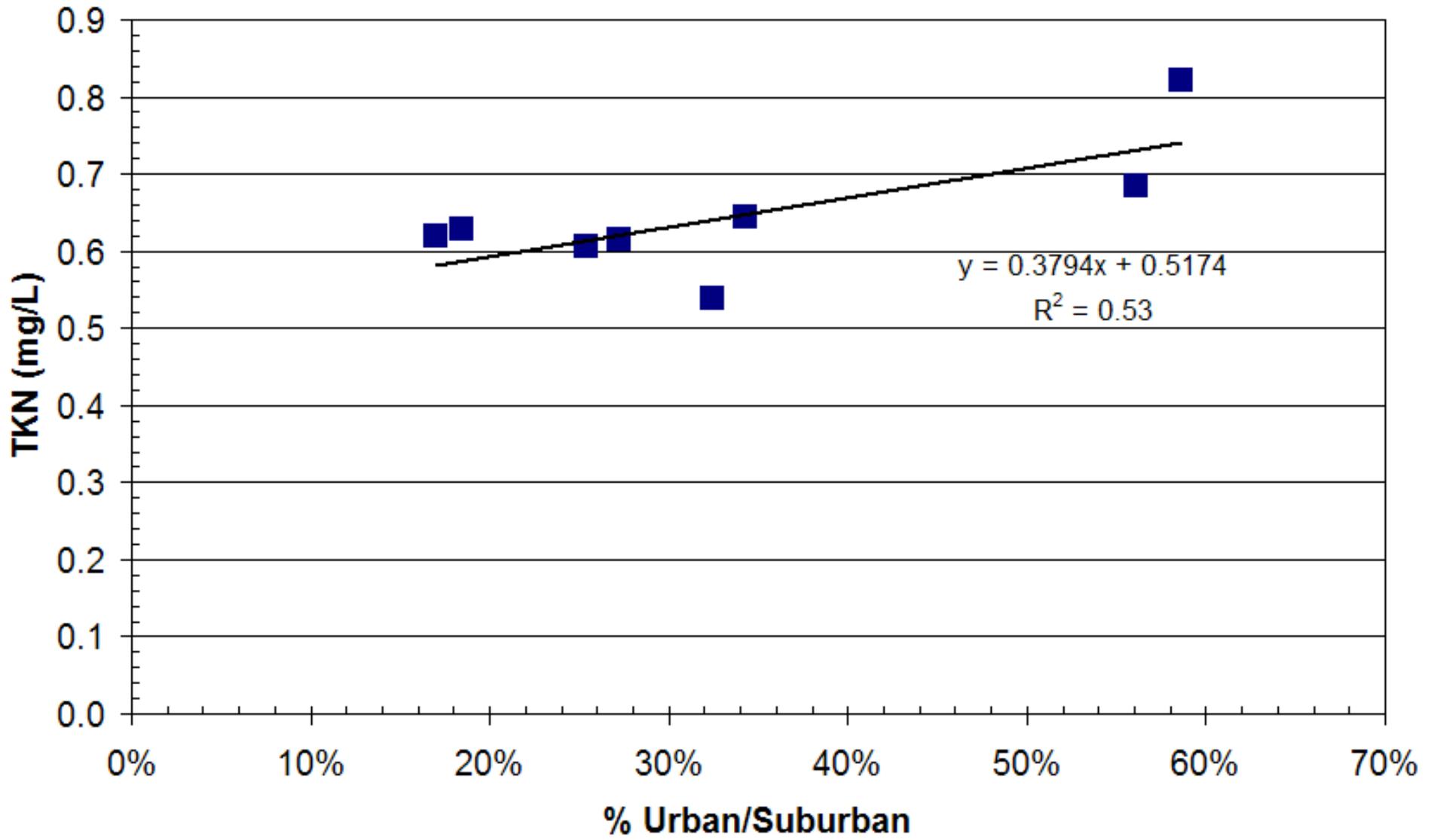
% Urban/Suburban vs. TSS



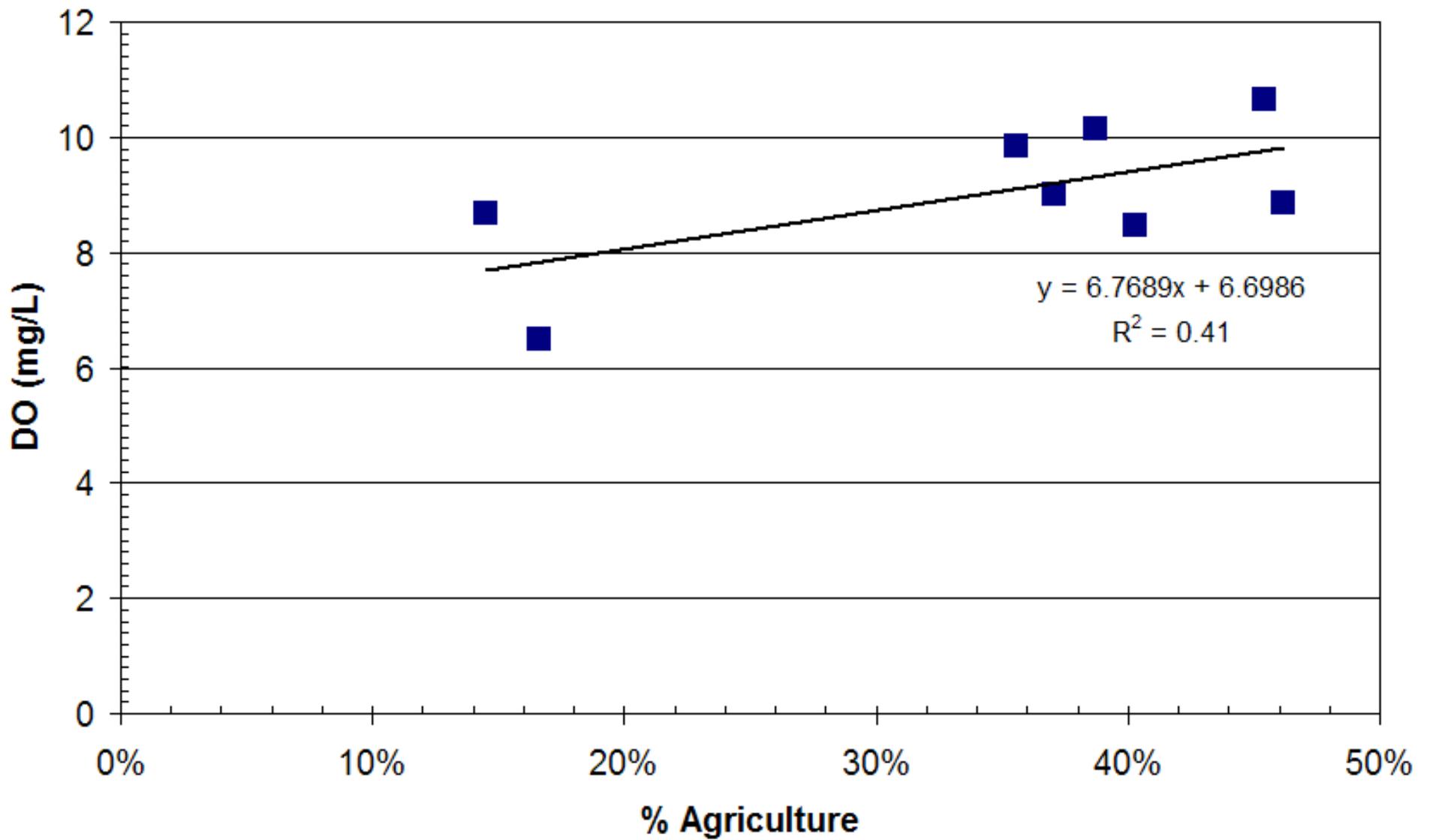
% Urban/Suburban vs. Enterococcus Bacteria



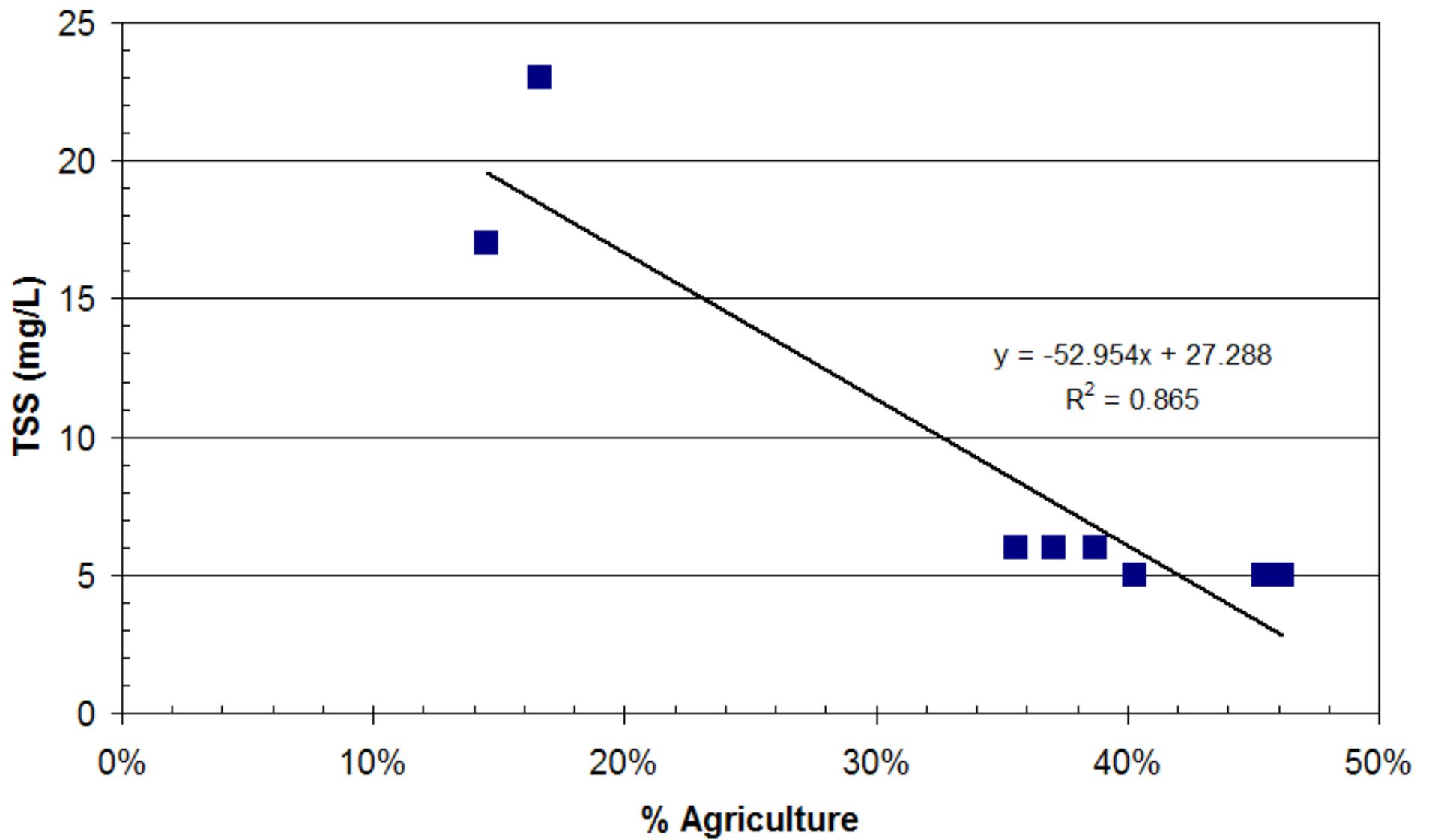
% Urban/Suburban vs. TKN



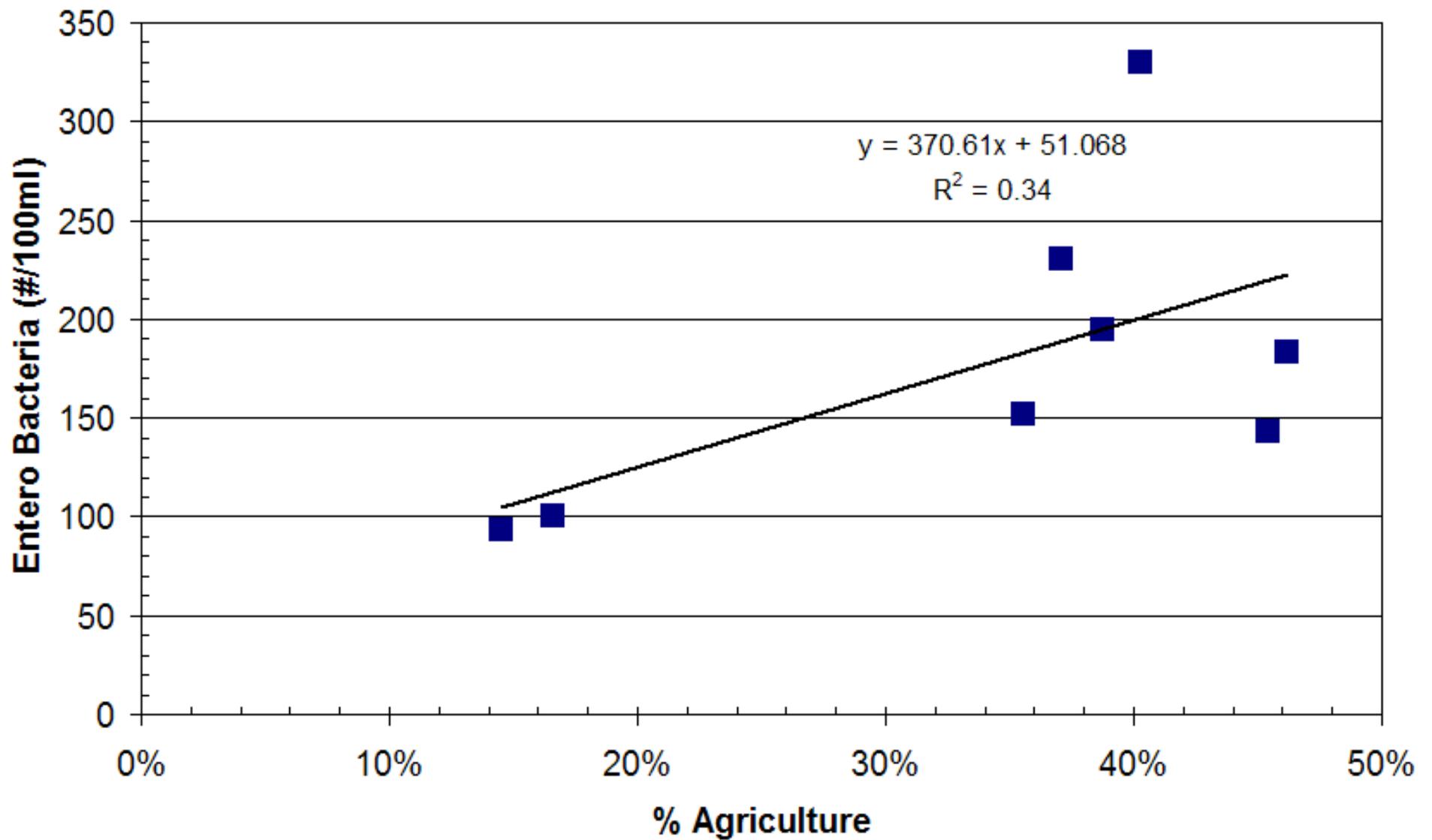
% Agriculture vs. DO



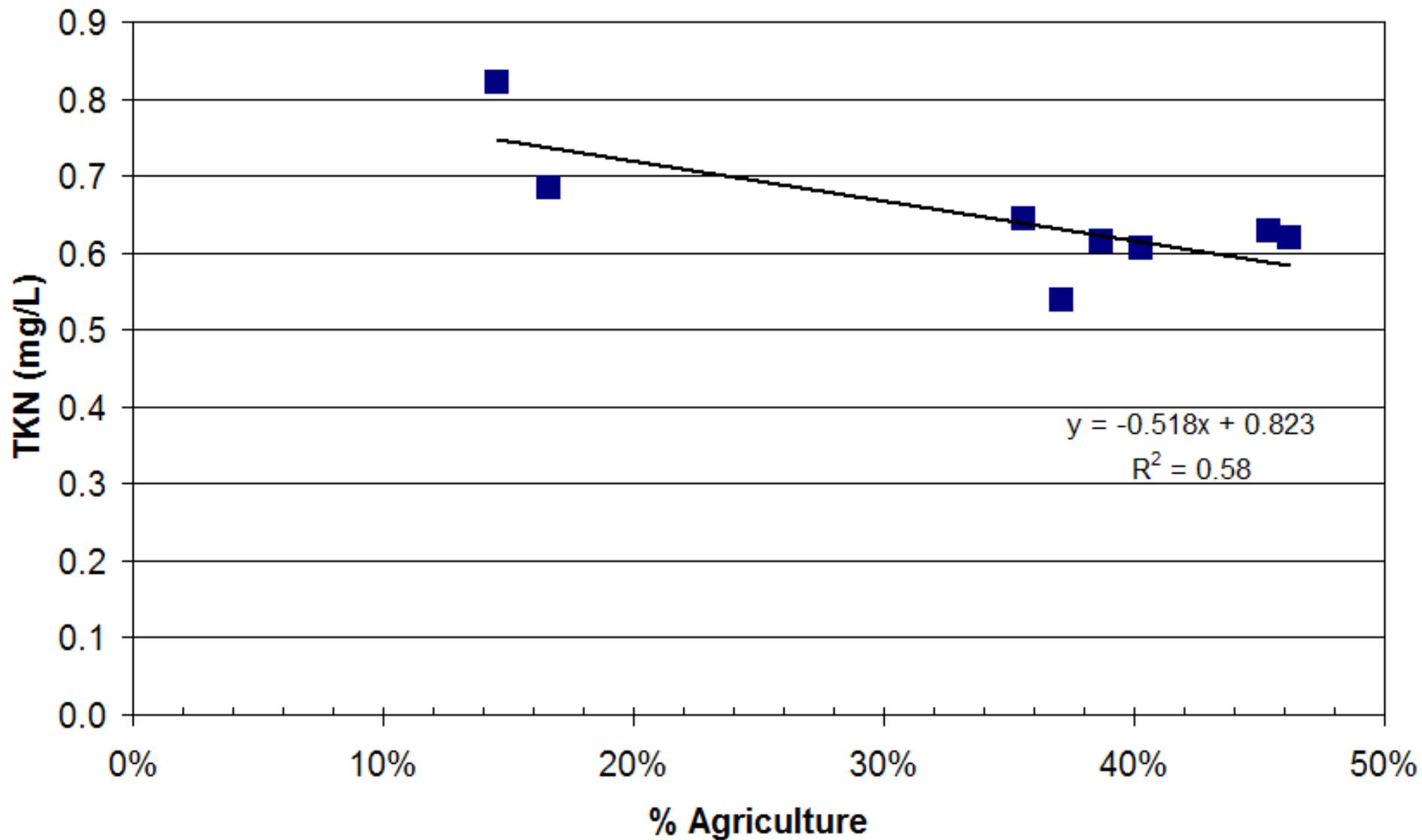
% Agriculture vs. TSS



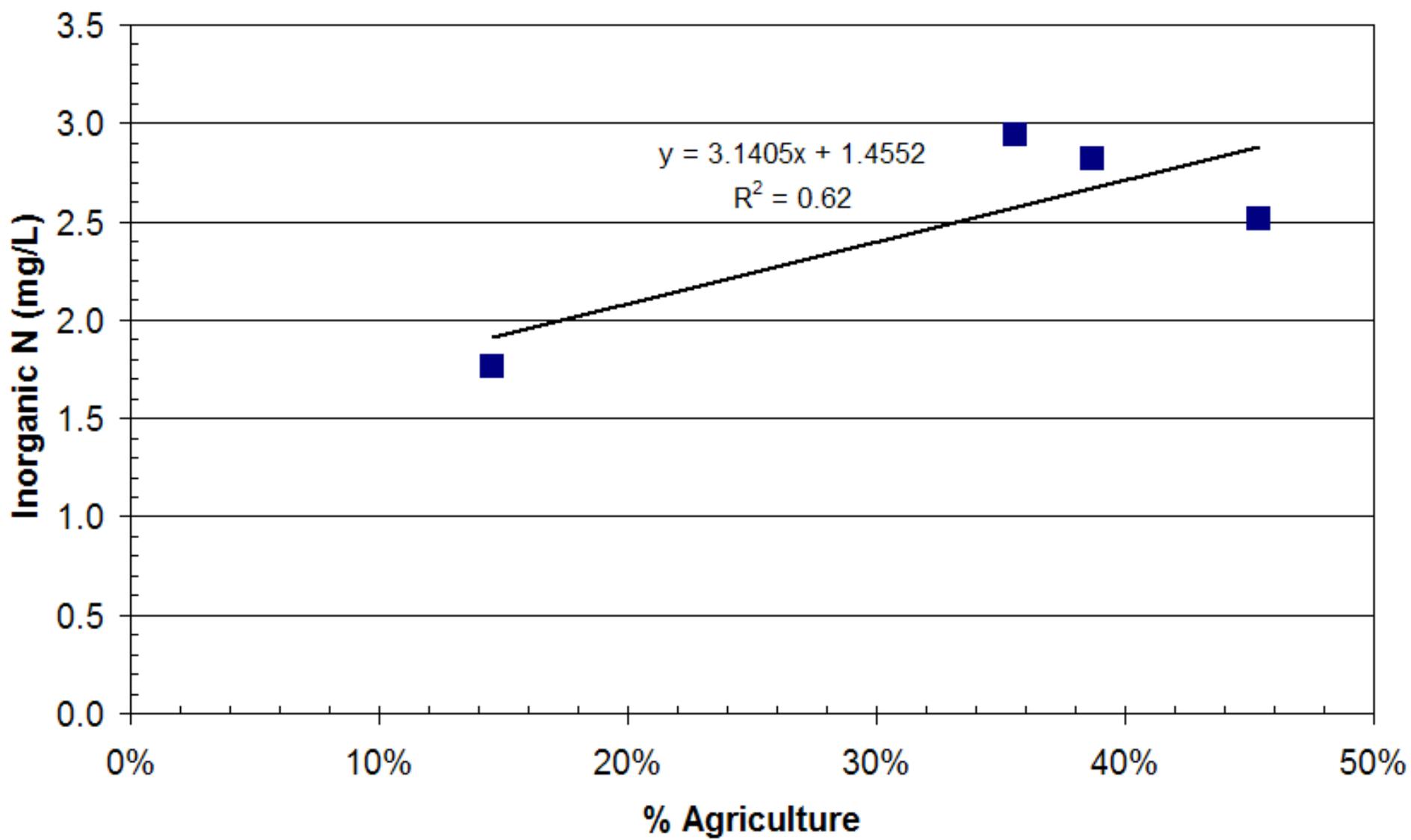
% Agriculture vs. Enterococcus Bacteria



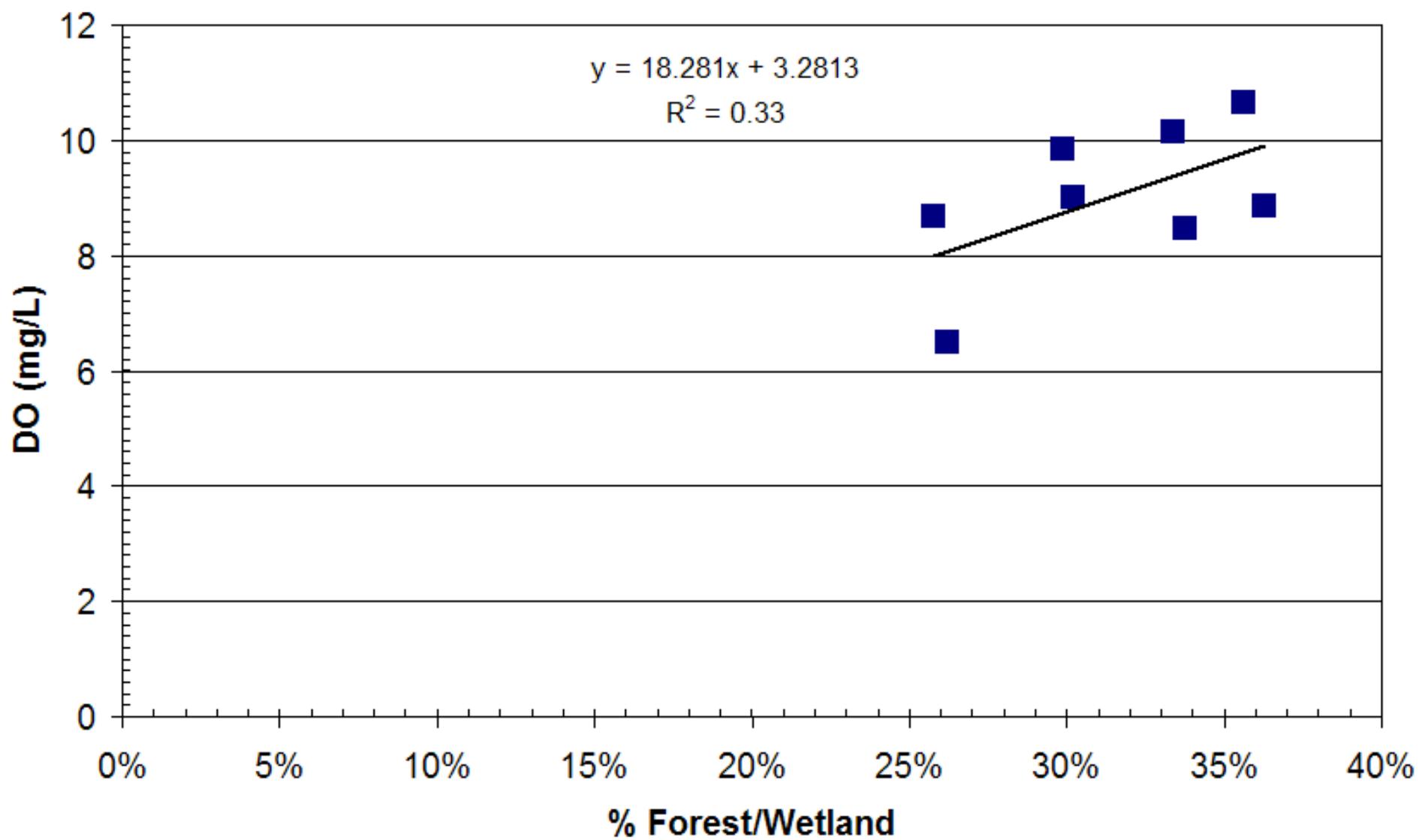
% Agriculture vs. TKN



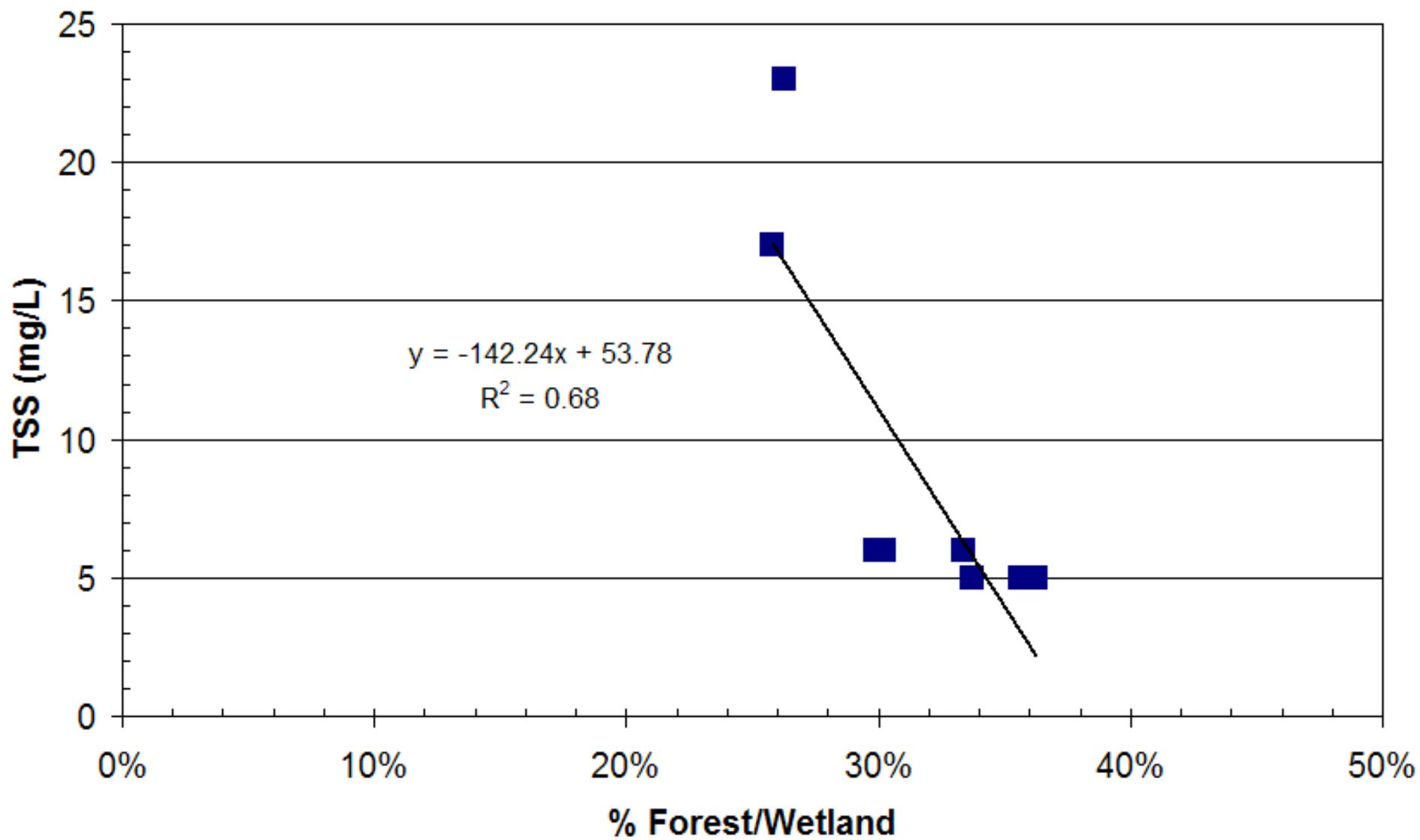
% Agriculture vs. Inorganic N

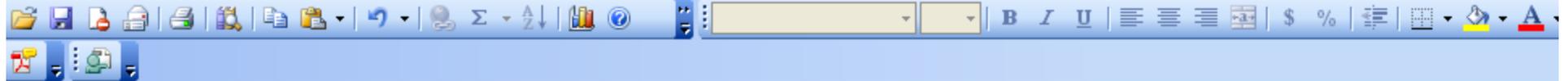


% Forest/Wetland vs. DO



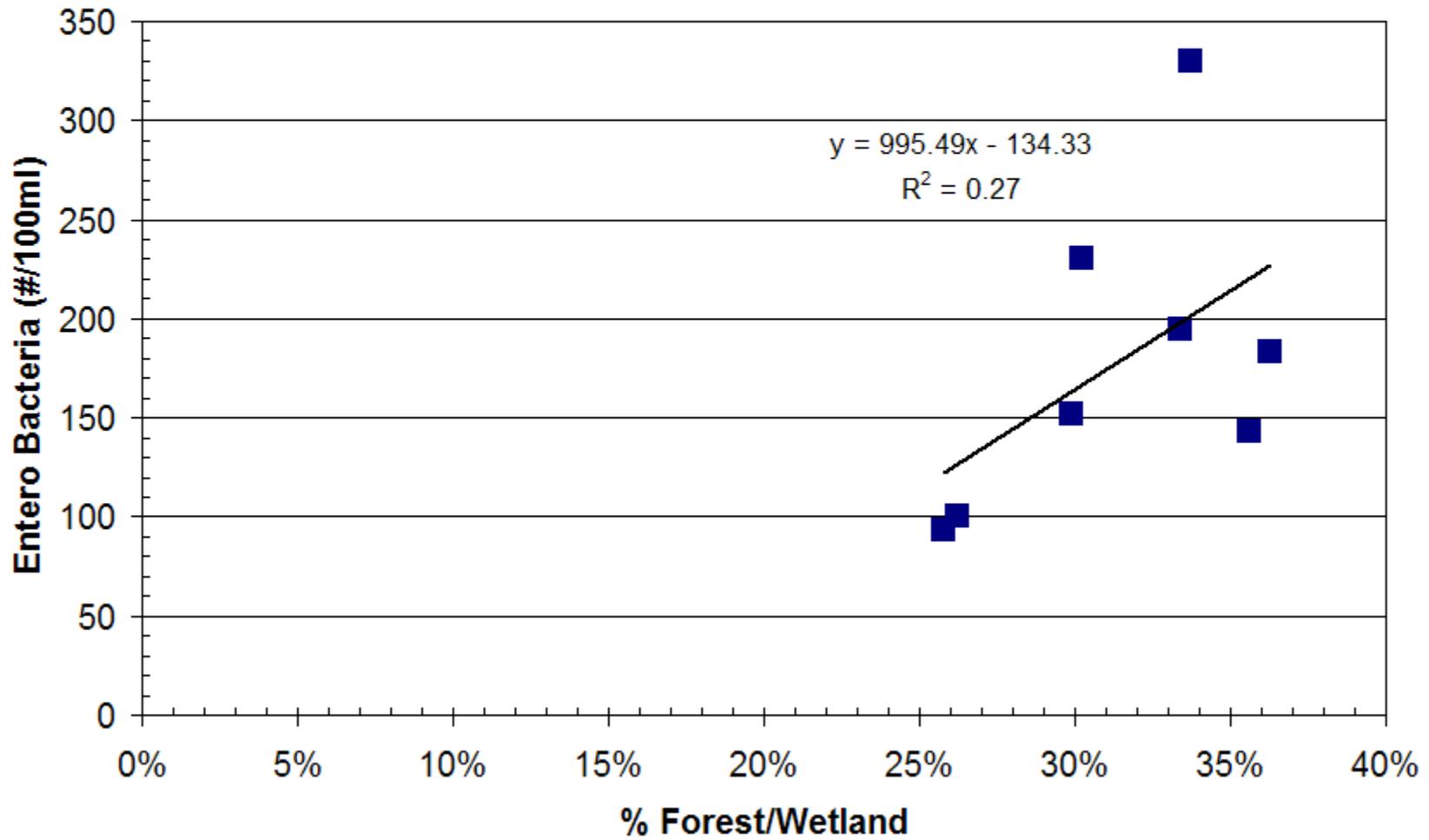
% Forest/Wetland vs. TSS





fx

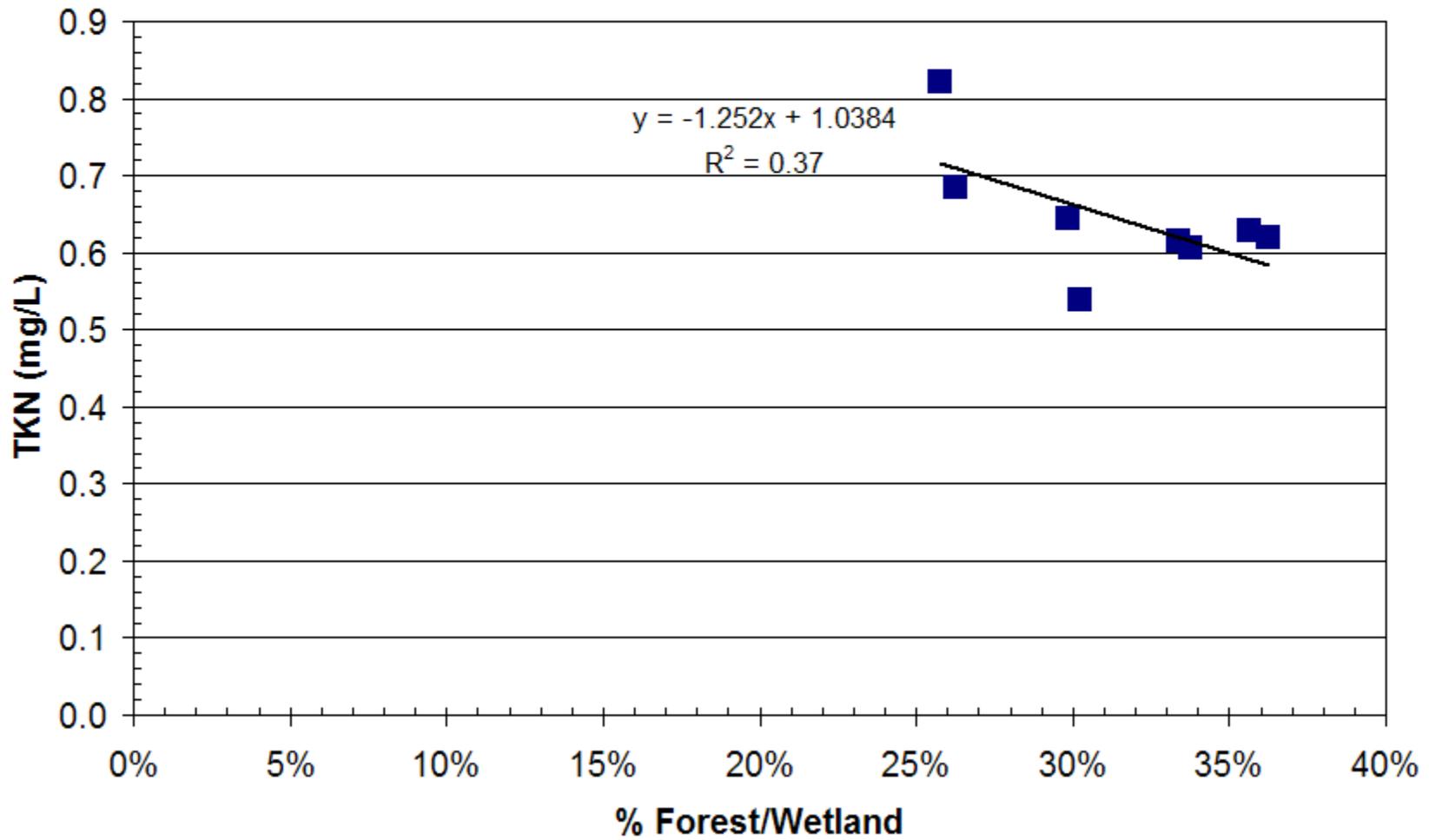
% Forest/Wetland vs. Enterococcus Bacteria





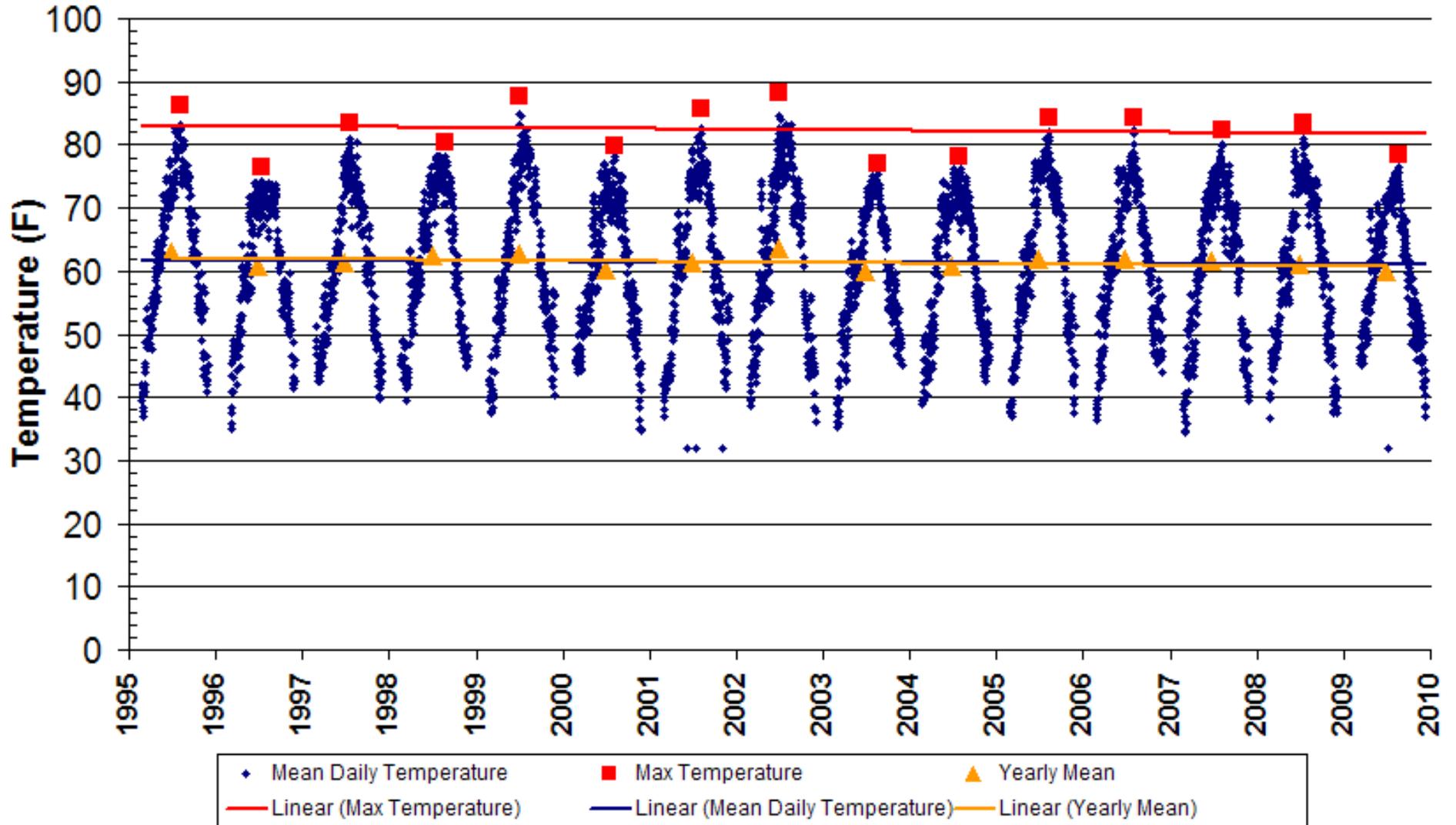
fx

% Forest/Wetland vs. TKN



Water Temperature

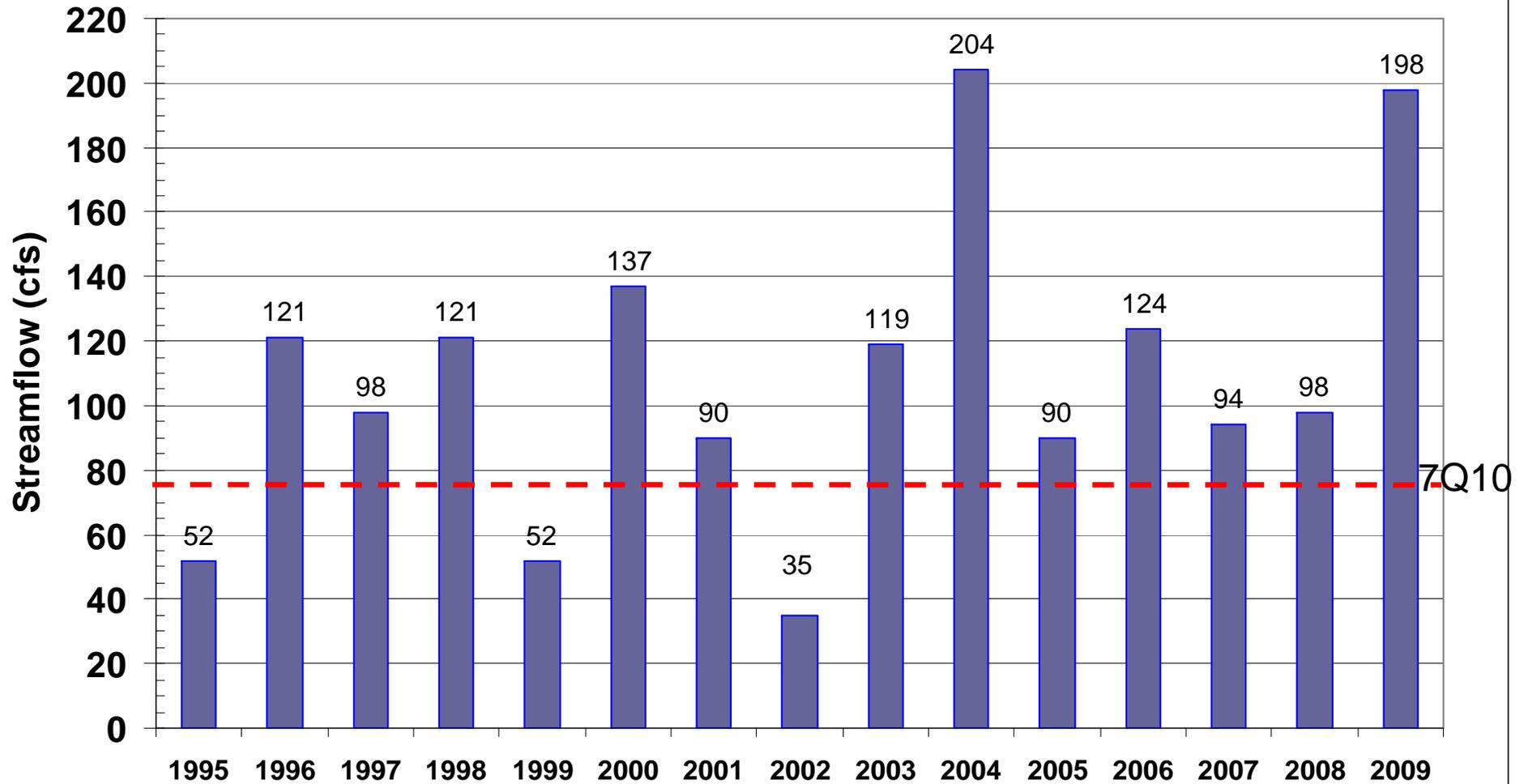
Brandywine Creek at Chadds Ford Water Temperature, 1995-2009



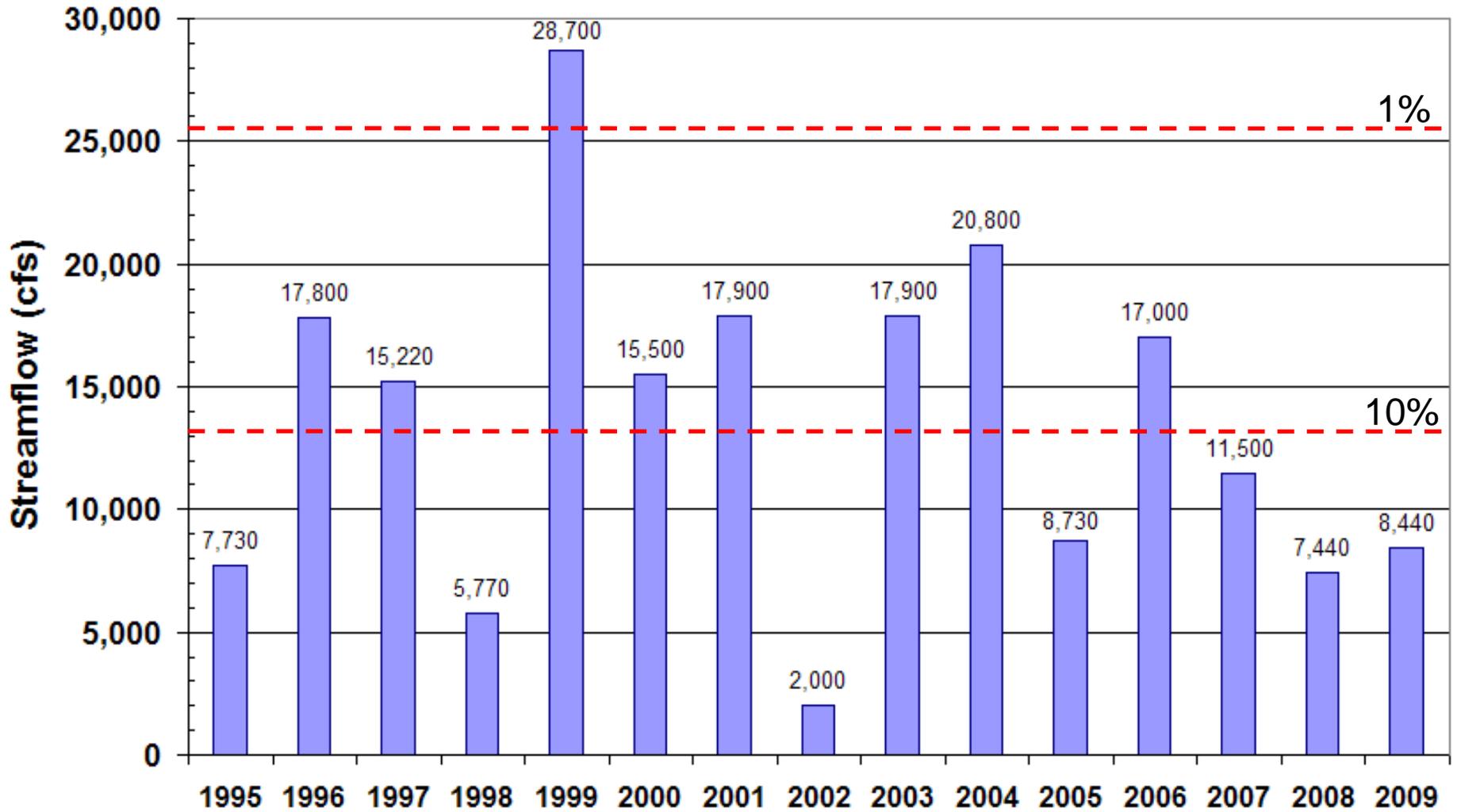
Streamflow

- Annual Low Flow (Drought)
- Annual Peak Flow (Flood)

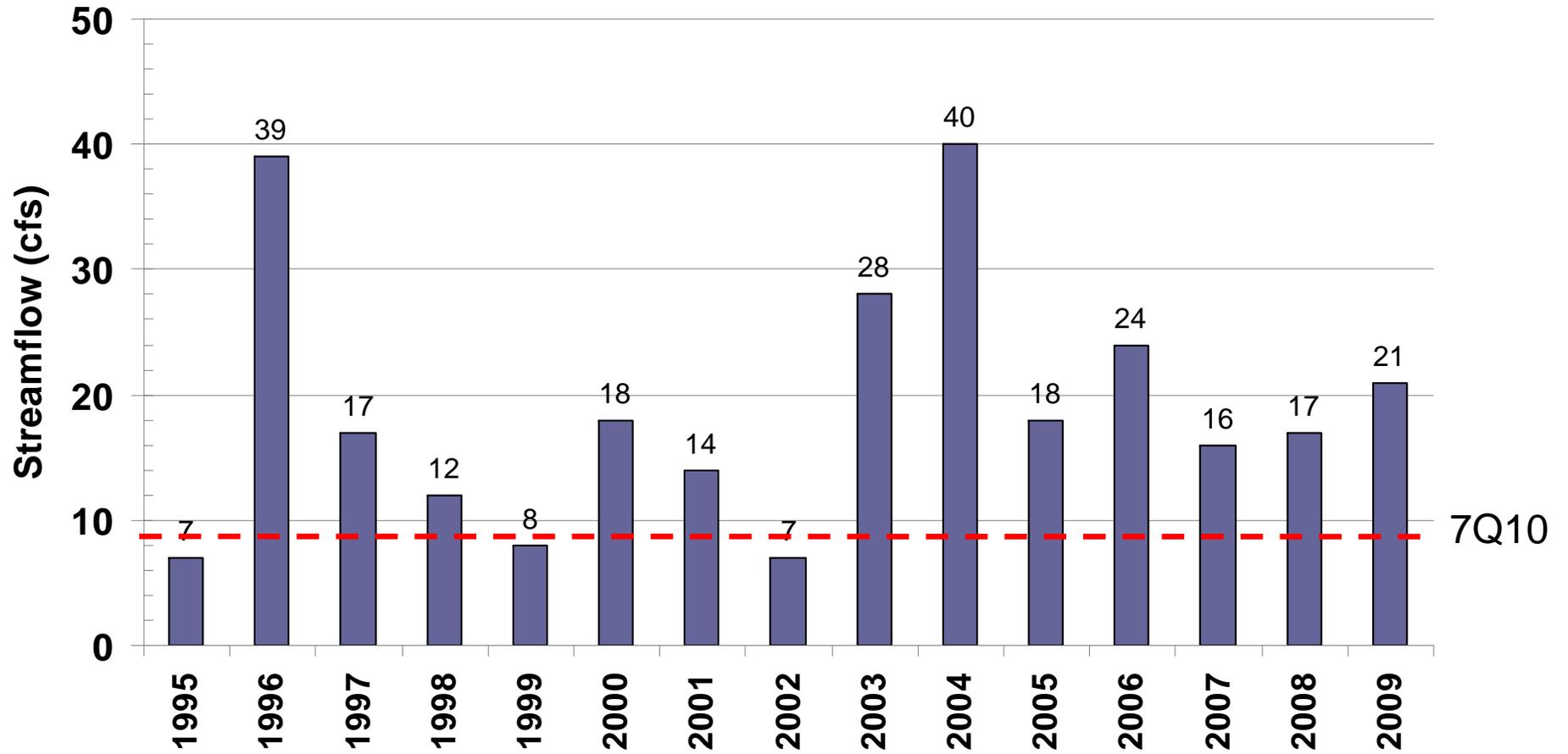
Brandywine Creek at Wilmington Annual Low Streamflow



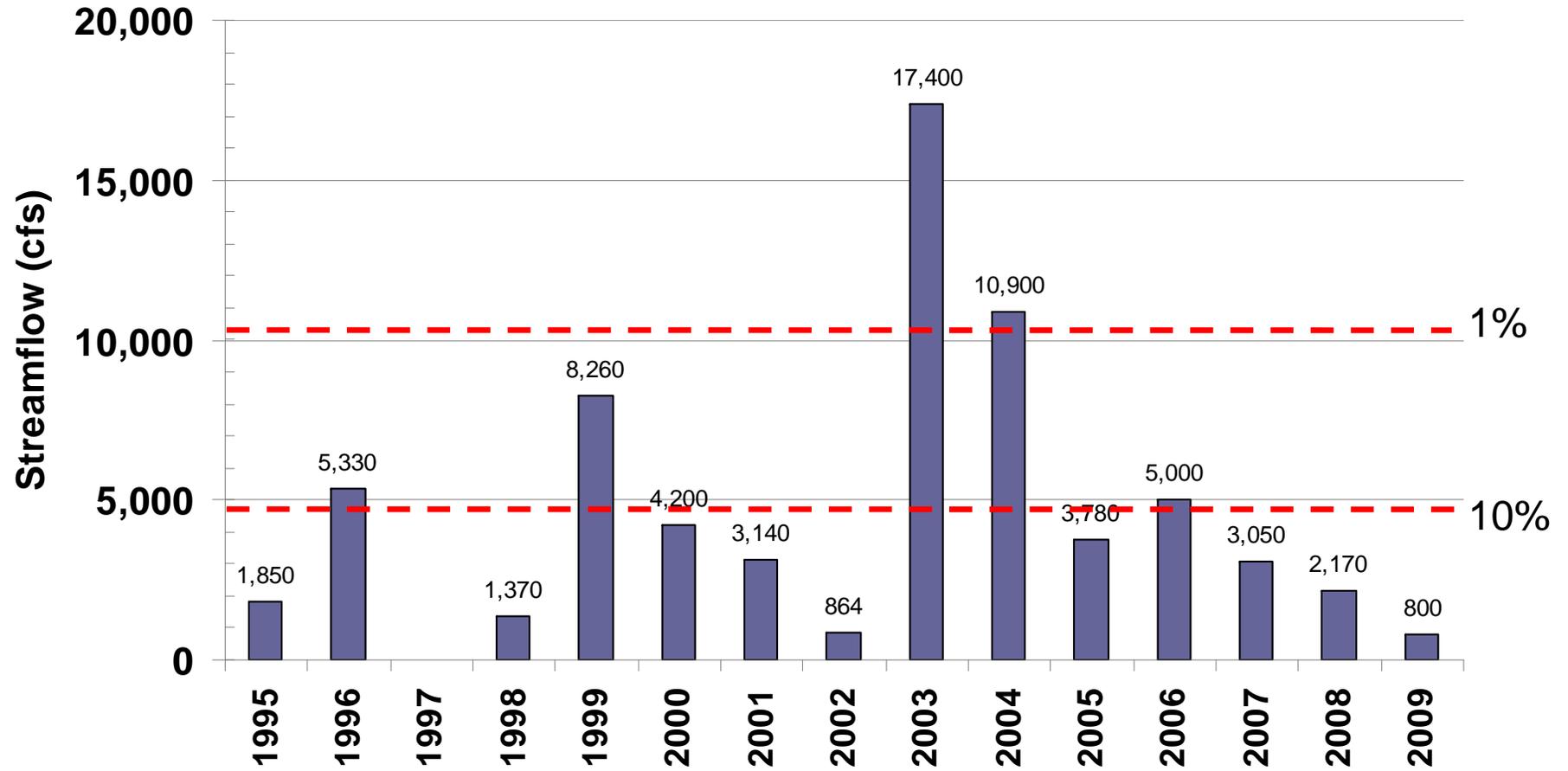
Brandywine Creek at Wilmington Annual Peak Streamflow



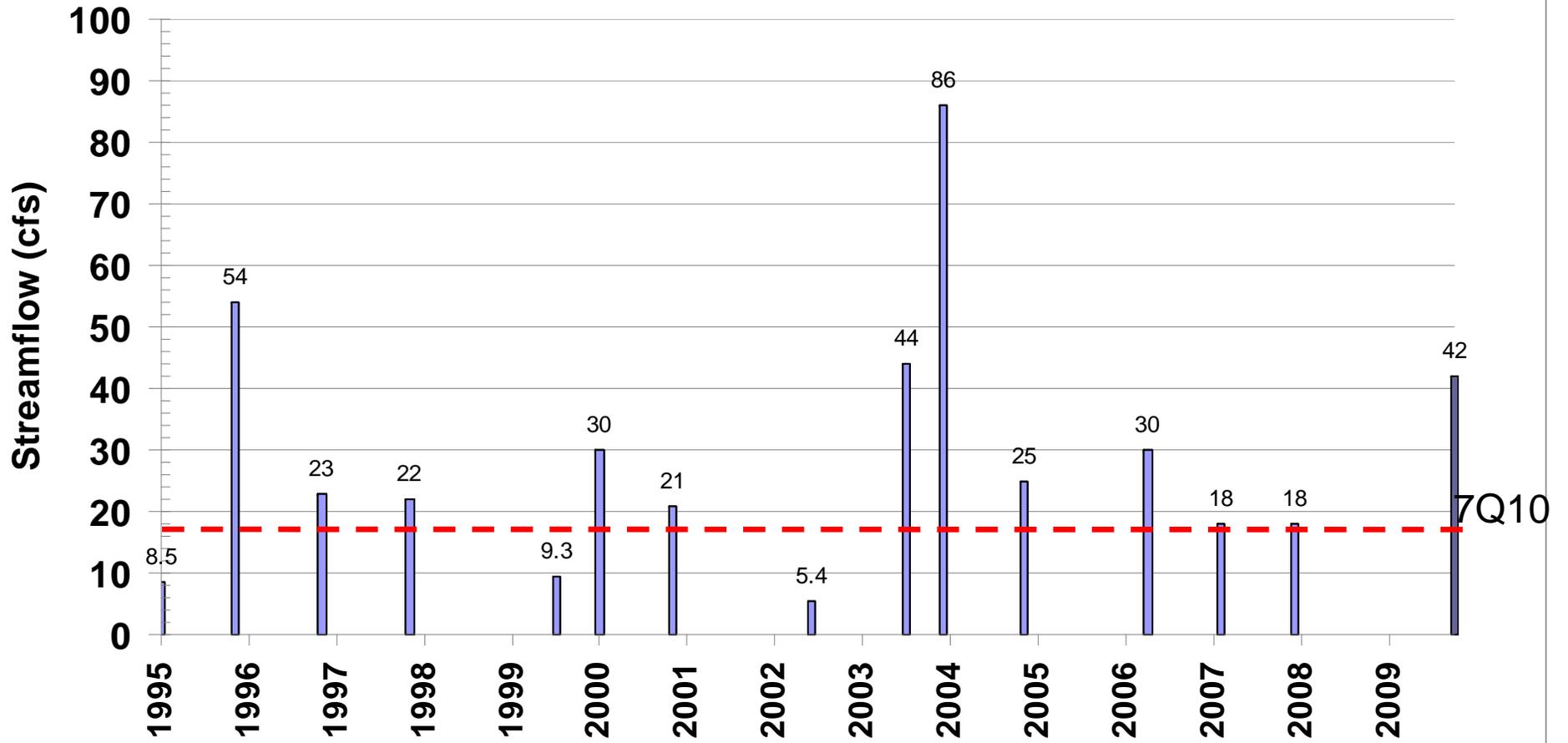
Red Clay Creek at Stanton Annual Low Streamflow



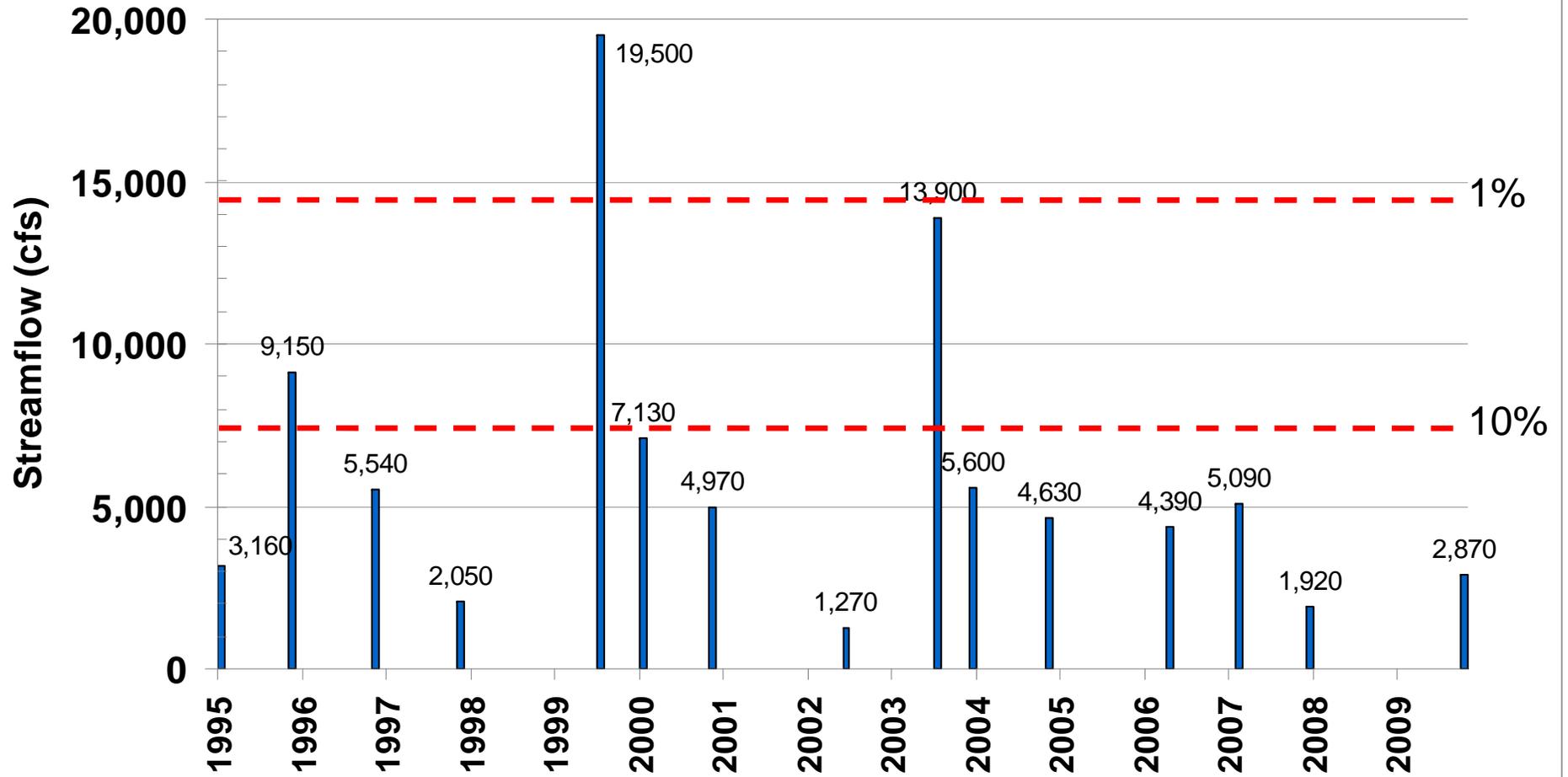
Red Clay Creek at Stanton Annual Peak Streamflow



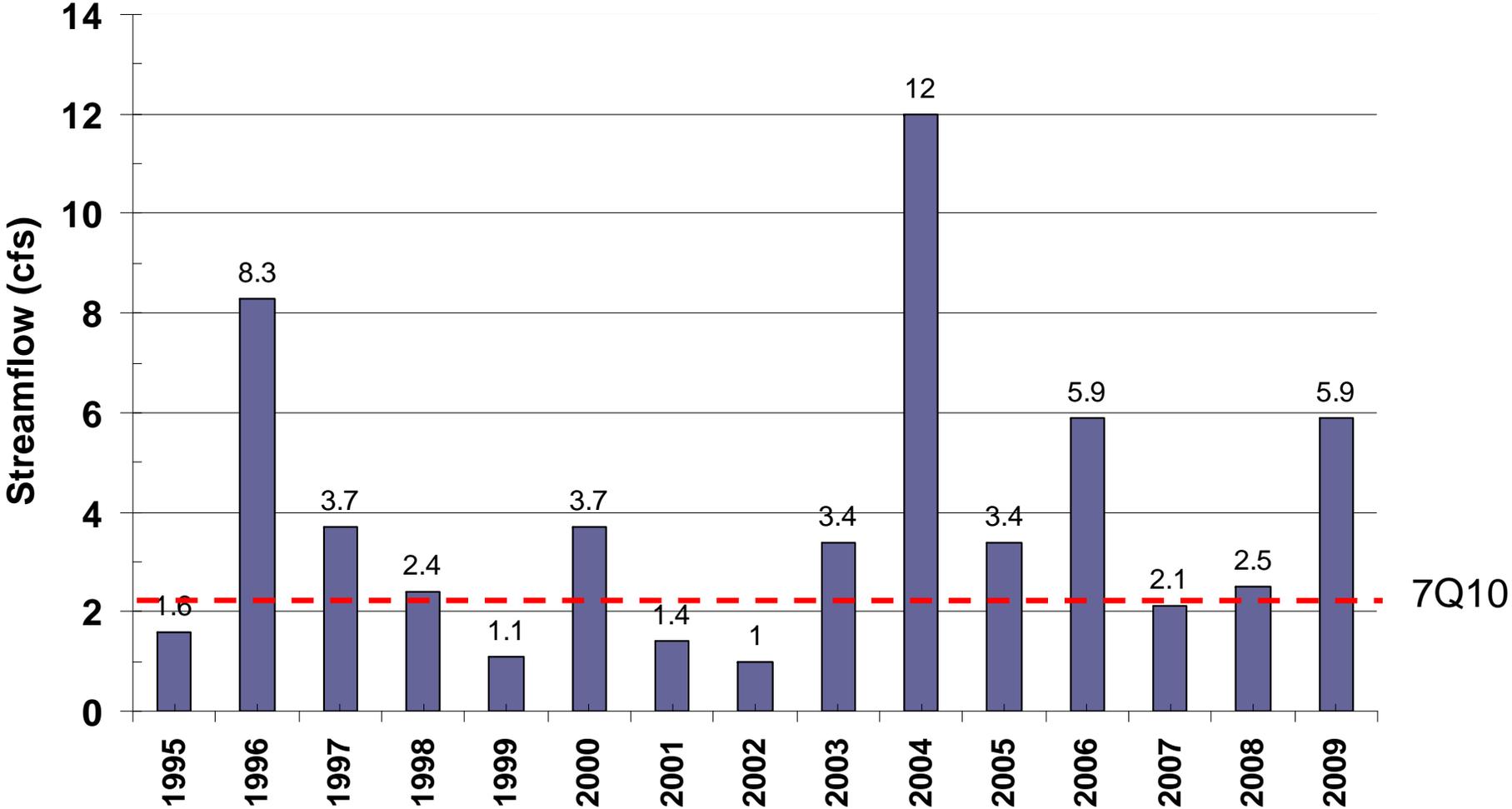
White Clay Creek near Newark Annual Low Streamflow



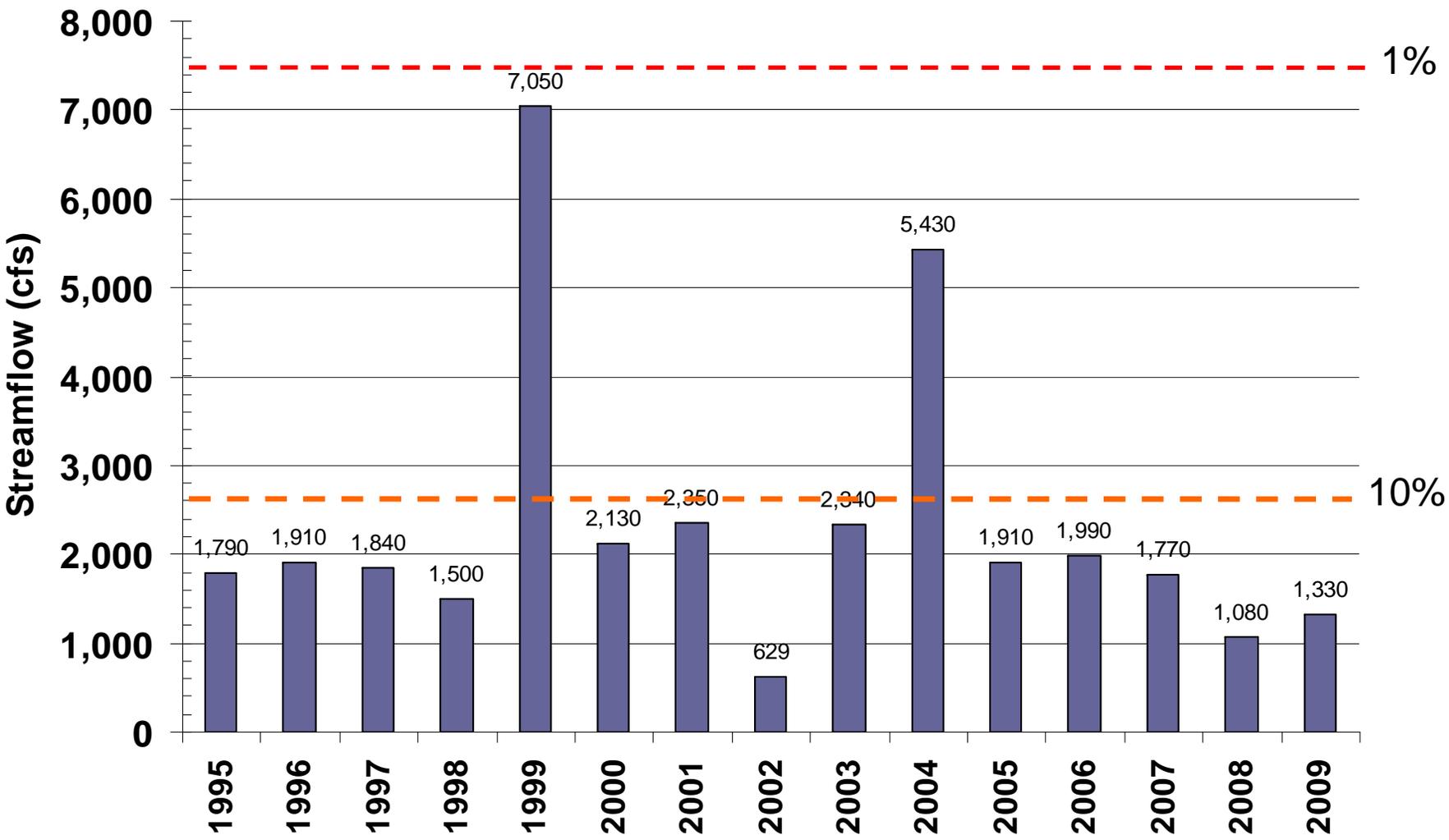
White Clay Creek near Newark Annual Peak Streamflow



Christina River at Coochs Bridge Annual Low Flow



Christina River at Coochs Bridge Annual Peak Streamflow



Summary

- Water quality improvements are congruent with 15-year contributions of CBCWP.
- Water quality has improved even with 42,000 increase in population (2000-2010) and 9 mi² increase in urban/suburban land (1996-2005).
- Nitrogen levels are degrading probably due to atmospheric deposition (not good) and/or conversion of ammonia to forms of N with rising DO levels (a good thing!).
- No low flows since drought of 2002.